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An UGC Autonomous Institute
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PROJECT REPORTS OF CIVIL

A Major Project Report

On

DYNAMIC ANALYSIS OF IRREGULAR RC STRUCTURE USING ETABS

SUBMITTED TO

Jawaharlal Nehru Technological University

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

by

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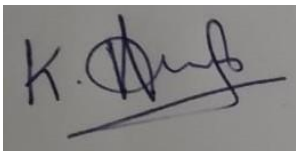
This is to certify that the project entitled Interlinking of Krishna and Godavari rivers: An Irrigation Project is being submitted by1.**Ms. N. Shivani (17K81A0146) 2. Mr. V. Vamshi Krishna (18K85A0111) 3. Mr. B. Venkat (17K81A0108) 4. Mr. D. Sandeep (17K81A0120)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY** in Civil Engineering is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.



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DECLARATION

We, the student of **Bachelor of Technology** in Department of 'Civil Engineering', session: 2017 – 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled Interlinking of Krishna and Godavari rivers: An Irrigation Project is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

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ABSTRACT

Analysis and design of buildings for static forces is a routine affair these days because of availability of affordable computers and specialized programs which can be used for the analysis. On the other hand, dynamic analysis is a time-consuming process and requires additional input related to mass of the structure, and an understanding of structural dynamics for interpretation of analytical results. Reinforced concrete (RC) frame buildings are most common type of constructions in urban India, which are subjected to several types of forces during their lifetime, such as static forces due to dead and live loads and dynamic forces due to the wind and earthquake.

During an earthquake, failure of structure starts off-evolved at factors of weak spot. This weak point arises due to discontinuity in mass, stiffness and geometry of structure. The systems having this discontinuity are termed as irregular systems. Irregular structures contribute a massive portion of city infrastructure. Vertical irregularities are one of the essential motives of failures of systems during earthquakes. The effect of vertically irregularities within the seismic overall performance of systems will become definitely vital. Peak-wise changes in stiffness and mass render the dynamic traits of those buildings exceptional from the ordinary building. The irregularity within the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building.

The analysis can be done in Staad Pro software, ETABS software SAP 2000 software and Tekla software. As ETABS is known widely throughout the country, it is one of the best softwares for structural analysis. Validation of the ETABS software has been done with respect to a reference paper and comparison of Storey overturning moment, storey drift, Storey displacements and storey shear has been done.

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LIST OF ABBREVATIONS

<RC>	Reinforced Concrete
<RCC>	Reinforced Cement Concrete
<HYSD>	High Yield Strength Deformed
<ETABS>	Extended Three Dimensional Analysis of Building System
<GSI>	Geographical Survey of India
<CADD>	Computed Aided Design and Drafting
<DL>	Dead Loads
<LL>	Live Load
<SPT>	Standard Penetration Test

CHAPTER 1

INTRODUCTION

1.1 Overview of the Project

Earthquakes are caused by tectonic movements in the Earth's crust. The main cause is that when tectonic plates collide, one rides over the other, causing earthquakes and volcanoes. The earthquakes are caused by the vibrations set up in the earth's crust which spread outwards in all directions from the source of disturbance. Some of the earthquakes are artificial, while others are natural. But it is undoubtedly true that all the earthquakes are caused due to the disequilibrium in the earth's crust.

During strong earthquake motion response of the multistorey building depends on the distribution of strength stiffness and weight of the building in both horizontal and vertical planes. Structural engineers have created trust in the plan of structures in which those dispersions are more or less uniform. The structure with regular configuration, uniformly distributed mass and stiffness in plan and in elevation are considered to endure substantially lesser harm than structure with irregular configuration. The structural irregularity is broadly seen in buildings because of architectural and service necessity in the design process, mistakes and adjustment during the development stage and changes in building use all through its service life. The design in the structures leads to the non-uniform distributions in their masses, stiffness and strength due to which the structure are prone to damage during earthquake. Thus, in present investigation an attempt has been made to investigate the seismic response of such structures situated in extreme seismic zone. The proposed G+15 story building of this investigation is situated in seismic zone IV.

One of the latest earthquakes happened was in Assam. The earthquake occurred as a result of oblique-slip faulting at a shallow depth just at the foothills of the Himalayas. A magnitude of 6.0 earthquake struck 11 km (7 miles) away from Dhekiajuli, Assam, India at 07:51 on April 28, 2021. The quake struck at a depth of 34 km (21 miles), 140 km (86 miles) north of the main city of Guwahati.

Fig:1: Assam Earthquake

Response of reinforced concrete framed structures will experience to seismic action is dynamic in nature that depends on the duration, magnitude, intensity, and frequency content of the exciting ground motion. It is important to estimate and stipulate these lateral forces on the structure in order to design the structure to resist an earthquake. The building codes often suggested equivalent static load analysis for design of buildings in seismic zones due to its simplicity. However dynamic analysis becomes even more complicated, questionable and accurate when nonlinearity in materials and geometry is considered. Therefore, the analytical tools such as Staad Pro, ETABS, and Sap were used for further development and enhancement in earthquake engineering with significant advances achieved in recent years. Haroon and Umesh (2012) seismic analysis was carried out on reinforced concrete (RC) frame building with different model such as bare frame, infilled frame and open first storey frame. Results showed that the infilled frames must be preferred in seismic regions than the open first storey frame, because the storey drift of first storey is very large than the upper storeys, this may most likely cause the collapse of structure. Mohit Sharma and Maru (2014) performed the static and dynamic analysis of RCC framed structure in zone II and III and the results obtained from the dynamic analysis are higher than the values as obtained from static analysis. Amin (2014) performed the pushover analysis of an asymmetric building and results showed that the maximum displacements of the buildings which are obtained from pushover analysis are higher than the response spectrum analysis. Sunayana Varma et al (2014) studied the seismic response of reinforced concrete framed structures in different seismic zone and comparisons were between the Staad pro and ETABS results.

1.1 Seismic zones

Seismic zone is an area of seismicity potentially sharing a common cause. It may also be a region on a map for which a common areal rate of seismicity is assumed for the purpose of calculating probabilistic ground motions.

The seismic zone is another factor on which destruction of the structure depends. The Geological Survey of India (G. S. I.) first published the seismic zoning map of the country in the year 1935. With numerous modifications made afterwards, this map was initially based on the amount of damage suffered by the different regions of India because of earthquakes. Colour coded in different shades of the colour red, this map shows the four distinct seismic zones of India. Following are the varied seismic zones of the nation,

Which are prominently shown in the map:

Zone - II: This is said to be the least active seismic zone.
Zone - III: It is included in the moderate seismic zone.
Zone - IV: This is considered to be the high seismic zone.
Zone - V: It is the highest seismic zone.

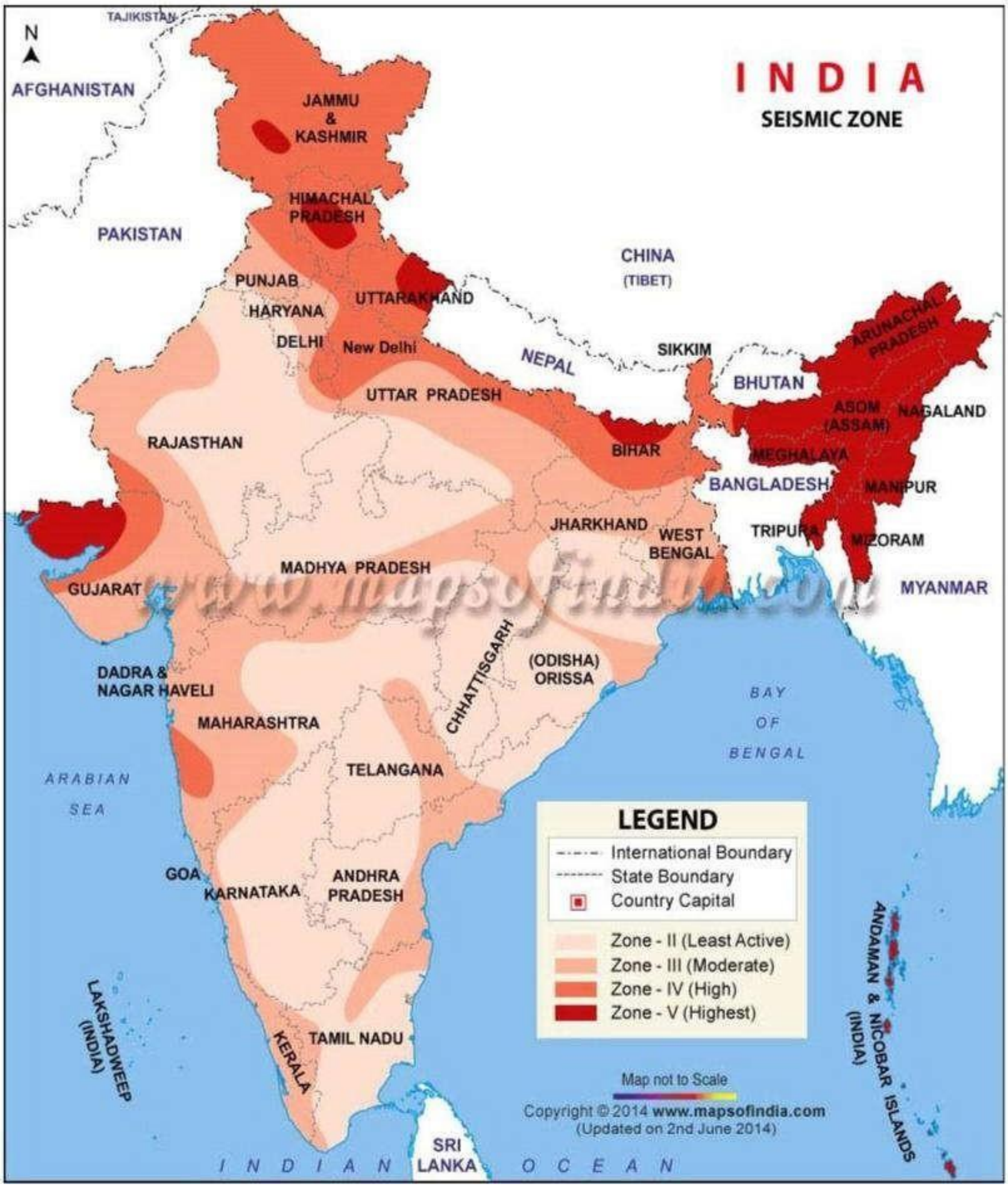


Fig:2: Seismic mapping zone of India

This map helps them in planning for a natural disaster like earthquake. An Indian seismic zoning map assists one in identifying the lowest, moderate as well as highest hazardous or earthquake prone areas in India. Even such maps are looked into before constructing any high rise building so as to check the level of seismology in any particular area. This in turn results in saving life in the long run.

1.1.2 Terminologies

Focus:

The focus or hypocenter of an earthquake is where the earthquake originated from, usually underground on the fault zone.

Epicenter:

The epicenter of an earthquake is the point on the surface of Earth directly above the epicenter.

Fault Plane:

A fault is a weak point within a tectonic plate where pressure from beneath the surface can break through and causing shaking in an earthquake.

Magnitude:

Magnitude is used to describe the size of the Earthquake. There are a number of different ways to calculate the magnitude of an earthquake, including the Richter Scale. Scientists also use the moment magnitude scale, which calculates the magnitude of an earthquake based on physical properties such as the area of movement (slip) along the fault plane.

Waves:

Earthquake waves travel through and on top of the surface of Earth causing the shaking and vibrations on the ground. Earthquake waves can travel hundreds of kilometers causing earthquakes to be felt a long way away from the origin.

Tectonic Plates:

The outer layer (crust) of Earth is divided into sections called tectonic plates.

1.1.3 Irregularities

Nowadays, most buildings are marked by irregularity in both plan and vertical configurations. Irregularity in structures means lack of symmetry which implies vital eccentricity between the building mass and stiffness centres, give rise to damaging coupled lateral response. Moreover, to design and analyse an irregular building effectively, high levels of engineering and designer efforts are needed, whereas a poor designer will design and analyze a structure by leaving many parameters not under consideration resulting in unsafe design. , to design and analyze an irregular building effectively, high levels of engineering and designer efforts are needed Therefore, irregular structures would require an additional, careful structural analysis so as to improve their dynamic response in case of an earthquake.

irregularities are one of the major reasons of failures of structures during earthquakes. For example, structures with soft storeys were the most notable structures which collapsed. So, the effect of vertically irregularities in the seismic performance of structures becomes really important. Height-wise changes in stiffness and mass render the dynamic characteristics of these buildings different from the regular building. IS 1893 definition of vertically irregular structures states that the irregularity in the building structures is due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design become more complicated.

During an earthquake, failure of structure starts off-evolved at factors of weak spot. This weak point arises due to discontinuity in mass, stiffness and geometry of structure. The systems having this discontinuity are termed as irregular systems. Irregular structures contribute a massive portion of city infrastructure. Irregularities are one of the essential motives of failures of systems during earthquakes. The effect of irregularities within the seismic overall performance of systems will become definitely vital. Peak-wise changes in stiffness and mass render the dynamic traits of those buildings exceptional from the ordinary building. The irregularity within the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building. Whilst such buildings are built in high seismic zones, the analysis and design turns into more complexes.

Vertical irregularities are one of the major reasons of failures of structures during earthquakes. For example, structures with soft storeys were the most notable structures which collapsed. So, the effect of vertically irregularities in the seismic performance of structures becomes really important. Height-wise changes in stiffness and mass render the dynamic characteristics of these buildings different from the regular building. IS 1893 definition of vertically irregular structures states that the irregularity in the building structures is due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design becomes more complicated. There are two types of irregularities-

1.Vertical Irregularities

2.Plane Irregularities

1.1.4 Vertical irregularities are mainly of five types

i(a) Stiffness Irregularity — Soft Storey-A soft storey is one in which the lateral stiffness isless than 70 percent of the storey above or less than 80 percent of the average lateral stiffness of the three storeys above.

i(b) Stiffness Irregularity — Extreme Soft Storey-An extreme soft storey is one in which the lateral stiffness is less than 60 percent of that in the storey above or less than 70 percent of the average stiffness of the three storeys above.

(ii) Mass Irregularity-Mass irregularity shall be considered to exist where the seismic weight of any storey is more than 200 percent of that of its adjacent storeys. In case of roofs irregularity need not be considered.

(iii) Vertical Geometric Irregularity- A structure is considered to be Vertical geometric irregular when the horizontal dimension of the lateral force resisting system in any storey is more than 150 percent of that in its adjacent storey.

(iv) In-Plane Discontinuity in Vertical Elements Resisting Lateral Force-An in-plane offset of the lateral force resisting elements greater than the length of those elements.

(v) Discontinuity in Capacity — Weak Storey-A weak storey is one in which the storey lateral strength is less than 80 percent of that in the storey above.

As per IS 1893, Part 1 Linear static analysis of structures can be used for regular structures of limited height as in this process lateral forces are calculated as per code based fundamental time period of the structure. Linear dynamic analysis is an improvement over linear static analysis, as this analysis produces the effect of the higher modes of vibration and the actual distribution of forces in the elastic range in a better way.

Buildings are designed as per Design based earthquake, but the actual forces acting on the structure is far more than that of DBE. So, in higher seismic zones Ductility based design approach is preferred as ductility of the structure narrows the gap. The primary objective in designing an earthquake resistant structure is to ensure that the building has enough ductility to withstand the earthquake forces, which it will be subjected to during an earthquake.

In essence all the loads are dynamic including the self-weight of the structure because at some point in time these loads were not there. The distinction is made between the dynamic and the static analysis on the basis of whether the applied action has enough acceleration in comparison to the structure's natural frequency. Structural dynamics, therefore, is a type of structural analysis which covers the behavior of structures subjected to dynamic (actions having high acceleration) loading. Dynamic loads include people, wind, waves, traffic, earthquakes, and blasts. Any structure can be subjected to dynamic loading. Dynamic analysis can be used to find dynamic displacements, time history, and modal analysis by using the software's like STAAD PRO & ETABS.

1.2 OBJECTIVES OF THE STUDY

- To understand the dynamic behavior of structural frames.
- To understand the behavior of irregular structures under dynamic loading conditions.
- To analyze the dynamic behavior of irregular structure using response spectrum method.
- To analyze the behavior of irregular structure on sloping terrain conditions.
- To analyze the vertically irregular structure under sloping terrain conditions.

To recommend a proper awareness for the construction of structures under sloping terrain conditions.

1.3 SCOPE OF THE STUDY

This project is to perform the dynamic analysis i.e., Response Spectrum Analysis of an irregular RC (Reinforced Concrete) structure under seismic loading in the seismic zone IV.

SCOPE STATEMENT

The building undergoes seismic loading and it is analyzed through response spectrum method by taking various parameters like storey displacement, storey shear, storey drift, storey overturning moment, etc.

1.4 STATEMENT OF THE PROBLEM

The problem has been identified through the review of literature. the identified problem and suitability of proper methodology for the solution was found out through software simul action and analysis. In this research analysis of irregular structure has done through ETABS software. For the proper working of software validation was done for one of the journal article. Parametric study includes analysis of regular structure, structure on sloping ground and vertical irregular structure under sloping ground has been done through response spectrum analysis. Comparison of result like base shear, overturning moment, storey displacement, storey shear, centre of stiffness, centre of load, centre of gravity has been done for the above mentioned structure.

1.5 ORGANIZATION OF CHAPTERS

CHAPTER-1:

In this chapter of Introduction, the information is about the preface of our project which gives the details related to overview and objectives of project.

CHAPTER-2:

The chapter of Literature Survey gives the matter related to some existing articles in detail, which are related to our project research and we also conclude the survey about related references.

CHAPER-3:

In this chapter of Project Design, the overview of design, analysis requirements and design functions are carried out.

CHAPTER-4:

In this chapter, the implementation of stages were carried out by performing response spectrum analysis in Etabs software.

CHAPTER-5:

This chapter shows the results of the project after performing the response spectrum analysis.

CHAPTER 2

LITERATURE REVIEW

2.1 A Study on design of vertically irregular RC building frames by Ankesh and Biswobhanu, NIT Odisha.

Seismic analysis and design of vertically irregular RC building frames proposed by Ankesh Sharma and Biswobhanu Bhadra of National Institute of Technology Rourkela Odisha, India According to results of RSA, the storey shear force was found to be maximum for the first storey and it decreased to a minimum in the top storey in all cases and mass irregular building frames experience larger base shear than similar regular building frames and the stiffness irregular building experienced lesser base shear and has larger inter storey drifts

2.2 A Study on Dynamic analysis of multi-storey building for different shapes by Rizwan and Peera, P.G student, JNTUA, Anantapura.

Dynamic analysis of multi-storey building for different shapes proposed by Mohammed Rizwan Sultan*and D. GousePeera Department of civil engineering P.G student, JNTUA, Anantapura . The aim of this study is to grasp the behaviour of the structure in high seismic zone and also to evaluate Storey overturning moment, Storey Drift, Displacement in a 15 storey-high building on four totally different shapes like Rectangular, L-shape, H-shape, and C-shape. Result has been proved that Irregular shapes are severely affected during earthquakes especially in high seismic zones and C shaped building is more vulnerable compare to all other different shapes.

2.3 A Study on Response of multi-storey regular and irregular buildings by ‘Md.Mashfiqulislam’ a senior lecture, AUST, Dhaka, Bangladesh.

‘Response of multi-storey regular and irregular buildings weight under static and dynamic loading in context of Bangladesh’ proposed by ‘Md. Mashfiqulislam’ a senior lecturer, department in civil engineering, ahsanullah university technology (AUST), Dhaka, Bangladesh. The aim of this paper is to assess the seismic vulnerability and response of regular and irregular shaped multi-storey building of identical weight in context of Bangladesh (zone-2) which is seismically active region including north eastern part of India by using response spectrum analysis method.

2.4 A Study on dynamic effect on unsymmetrical building (RCC & Steel) by 'PralobhS.Gaikwad', 'Prof.Kamhaiya K. Talani.

'Study of dynamic effect on unsymmetrical building (RCC & Steel) by 'Pralobh S. Gaikwad', 'Prof.Kamhaiya K. Talani' there main objective of earthquake engineer is to design and build a structure in such a way that damage to the structure during the earthquake is minimize. The analysis carried by using ETABS software. Permissible limit of storey drift 12 mm as per IS1893 By analysis of G+9 storey structure it is found that maximum storey drift of RCC structure is 0.679.

2.5 A Study on dynamic equations for system of irregularly shaped plane bodies by Oleg Vinogradov.

Study on Dynamic equations for system of irregularly shaped plane bodies by Oleg there mainobjective is the computer simulation of dynamic behavior of irregularly shaped granular-type materials by the system of differential and algebraic equations. Also use of Lagrange's equations for the simplicity. As a result, an explicit form of the governing equations and analytical cancellation of the terms in Lagrange's equations, lead to more efficient and accurate (in term of accumulated error) computer simulations.

2.6 A study on seismic response of an RCC building with soft storey by Dr.SwatiSeti and Vineet Sharma,NIT,Kurukshethra.

Study on Seismic Response of R.C.C Building with Soft Storey by Dr.SaraswatiSetiaandVineet Sharma, Associate Professor, NIT Kurukshetra, India and lecturer, Civil Engineering Department. G.P. Nilokheri Haryana, India. Their main aim to study behavior of R.C.C Building under seismic loading in +x direction, +z direction, -x direction, -z direction. Result are Lateral displacement is largest in bare frame with soft storey defect both for earthquake force in X-direction as well as in z-direction for corner columns as well as for intermediate columns. Displacement of intermediate column is more by 0.02% and 0.04% in X and Z-direction respectively w.r.t. corner column. Minimum displacement for corner column is observed in the building in which a shear wall is introduced in X-direction as well as in Z-direction. Building having masonry infill in upper floors and with increased column stiffness of bottom story and building with shear wall in core has a small first storey displacement of about 18% and 16% respectively of that of building having masonry in fill in upper floors only

2.7 A study on Earthquake Analysis of High Rise Building with and Without Infilled Walls ByWakchaure M.R, Ped S. P Amrutvahini College of Engineering,Sangamner.

A study on Earthquake Analysis of High-Rise Building with and Without In filled WallsByWakchaure M.R, Ped S. P H.O.D of Civil Engineering Department at Amrutvahini College of Engineering, Sangamner, and Maharashtra. The result of the present study show that structural infill wall have very important effect on structural behaviour under earthquake effect. On structural capacity under earthquake effect displacement and relative story displacement are affected by the structural irregularities. Regarding with the result, infill walls are very important effect on structural behaviour. 1) Base Shear: From the results it is shown that due to infill walls in building the base shear is increased from 2.49 to 7.81%. and the difference is 4.86%. 2) Displacement: The displacements at top story of the building with infill's wall for single strut reduce 0.77% to 0.39%. 3. Storey Drift: Storey drift for infilled wall model is within permissible limit. Storey drift is reduced 0.0034% to 0.018%. Due to infill walls in the High Rise Building top storey displacement is reduces. Base shear is increased.

2.8 Comparative Static and Dynamic Study on Seismic Analysis of Uniform and Non Uniform Column Sections in a Building Adhikari1 , Dr K. Rajasekhar Andhra University Visakhapatnam.

This study is related to column analysis of uniform and non-uniform multi-storey building under earthquake loading and to determine the critical behavior of column using ETABS software with the response spectrum method. The result of analysis are ETABS gives less value for dynamic shearby response spectrum method. Those values should be scaled appropriately according to IS code 1893 - 2000 clause 7.8.2. Static approach gives higher values of forces and moments which makes building uneconomical hence consideration of dynamic approach is also needed. Lateral force at floor level due to static shear is almost same for both building but due to dynamic shear it is less in storey 4 & 5 in case 1 and more in storey 8.

2.9 A Study on review paper on seismic responses of multi-stored RCC building with mass irregularity by Sagar R Padol, Rajashekhar S. Talikoti.

In this project work seismic analysis of RCC buildings with mass irregularity at different floor level are carried out. Here for analysis different time histories have been used. This paper highlights the effect of mass irregularity on different floor in RCC buildings with time history and analysis is done by using ETABS software many of the studies have shown seismic analysis of the RCC structures with different irregularities such as mass irregularity, stiffness and vertical geometry irregularity. Whenever a structure having different irregularity, it is necessary to analyze the building in various earthquake zones. From many past studies it is clear that effect of earthquake on structure can be minimize by providing shear wall, base isolation etc.

2.10A study on Review Paper on Dynamic Analysis of Building by Pralobh S. and Kanhaiya K.

A study on Review Paper on Dynamic Analysis of Building by Pralobh S. Gaikwad and Kanhaiya K. Tolani, Late G. N. Sapkal College of Engineering, Nasik, Maharashtra, the dynamic effect on the building with symmetrical configuration for the analysis purpose basic parameter taken are lateral force, base shear, storey drift, storey shear and results are interpreted on the bases of this parameter. Lack of research have observed on the building with unsymmetrical configuration thus in the further work will compared the building with unsymmetrical configuration. Due to the unsymmetrical the important factor to be considered is torsion.

Summary of the literature review

From all the above literature paper we come to know that the review on the irregular structures has less papers comparatively to other topics. From the above papers the problem was learnt, analysed and solved. The topic which we are doing has very less journal papers published.

CHAPTER 3

Project Design

3.0 Overview

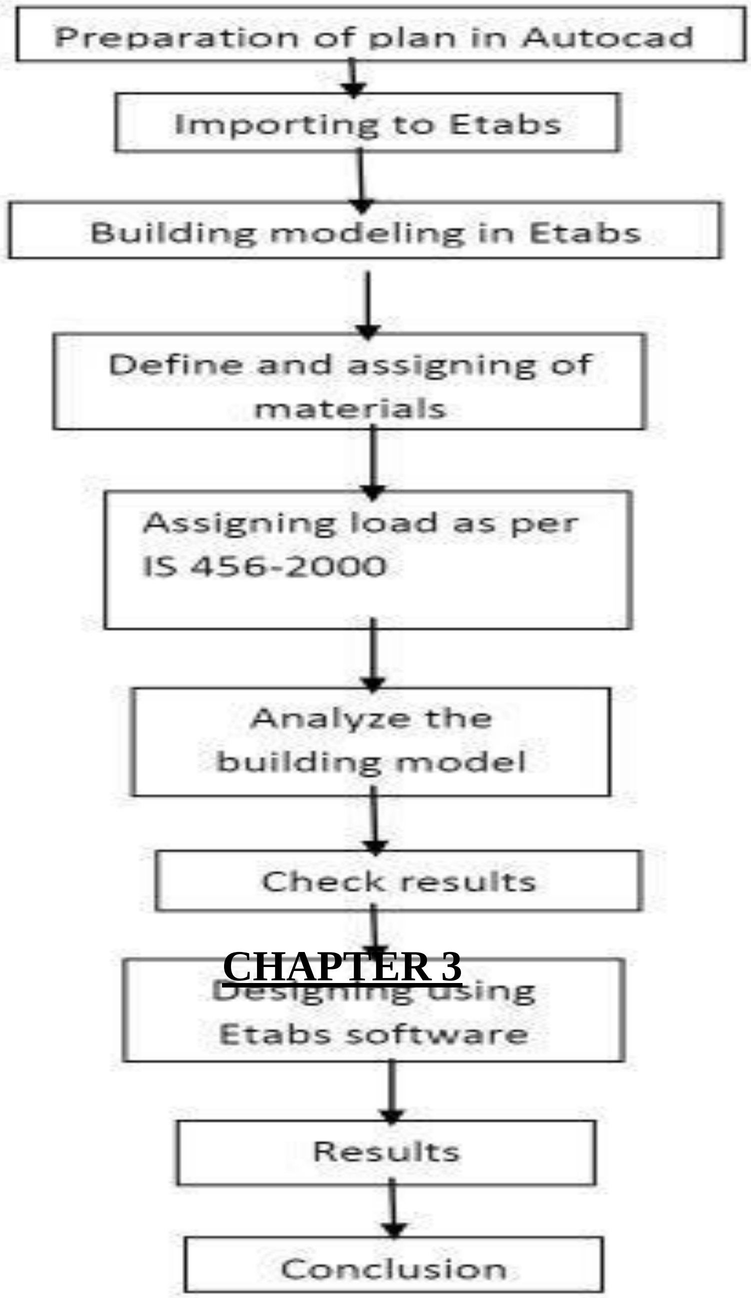
The innovative and revolutionary new ETABS is the ultimate integrated software package for the structural analysis and design of buildings. Incorporating 40 years of continuous research and development, this latest ETABS offers unmatched 3D object based modeling and visualization tools, blazingly fast linear and nonlinear analytical power, sophisticated and comprehensive design capabilities for a wide-range of materials, and insightful graphic displays, reports, and schematic drawings that allow users to quickly and easily decipher and understand analysis and design results.

From the start of design conception through the production of schematic drawings, ETABS integrates every aspect of the engineering design process. Creation of models has never been easier - intuitive drawing commands allow for the rapid generation of floor and elevation framing. CAD drawings can be converted directly into ETABS models or used as templates onto which ETABS objects may be overlaid. The state-of-the-art SAP Fire 64-bit solver allows extremely large and complex models to be rapidly analyzed, and supports nonlinear modeling techniques such as construction sequencing and time effects (e.g., creep and shrinkage).

Design of steel and concrete frames (with automated optimization), composite beams, composite columns, steel joists, and concrete and masonry shear walls is included, as is the capacity check for steel connections and base plates. Models may be realistically rendered, and all results can be shown directly on the structure. Comprehensive and customizable reports are available for all analysis and design output, and schematic construction drawings of framing plans, schedules, details, and cross-sections may be generated for concrete and steel structures

ETABS provides an unequaled suite of tools for structural engineers designing buildings, whether they are working on one-story industrial structures or the tallest commercial high-rises. Immensely capable, yet easy-to-use, has been the hallmark of ETABS since its introduction decades ago, and this latest release continues that tradition by providing engineers with the technologically-advanced, yet intuitive, software they require to be their most productive.

3.0.1 RESEARCH METHODOLOGY



CHAPTER 3

Fig.3: Flowchart for Methodology

The procedure carried out for modeling and analyzing the structure involves the following steps:

Step-1: Create a plan in AUTOCAD. Select new model and a window appears then we had to select blank page and import plan from AUTOCAD to ETABS.

Step-2: Defining of material properties. we had first defined the material property by selecting define menu, new material for our structural components by giving the specified details in defining. After that we define section size by selecting frame section for beams, columns etc.

Step-3: After defining the property we draw beams and create columns in region for columns by which property assigning is completed for beams and columns.

Step-4: By keeping the selection at the base of the structure and selecting all the columns we assigned fixed supports.

Step-5: In ETABS all the load considerations are first defined and then assigned. The loads in ETABS are defined as using static load cases command in define menu.

Step-6: After defining all the loads, dead loads are assigned including floor finishing.

Step-7: Live loads are assigned for the entire structure.

Step-8: Seismic loads are assigned as per IS 1893:2002 by giving zone, soil type and response reduction factor in X and Y directions.

Step-9: After completion of all the above steps we have performed the analysis and checked for errors.

3.1 Equipment Analysis

The effects of the finite dimensions of the beams and columns on the stiffness of a frame system are included using end offsets that can be automatically calculated. The floors and walls can be modeled as membrane elements within plane stiffness only, plate bending elements with out-of-plane stiffness only or full shell-type elements, which combine both in-plane and out-of plane stiffness. Floor and wall members may have uniform load patterns in-plane or out-of-plane, and they may have temperature loads. The column, beam, brace, floor and wall members are all compatible with one another.

Static analysis for user specified vertical and lateral floor or story loads are possible. If floors with plate bending capability are modeled, vertical uniform loads on the floor are transferred to the beams and columns through bending of the floor elements. Otherwise, vertical uniform loads on the floor are automatically converted to span loads on adjoining beams, or point loads on adjacent columns, thereby automating the tedious task of transferring floor tributary loads to the floor beams without explicit modeling of the secondary framing. The program can automatically generate lateral wind and seismic load patterns to meet the requirements of various building codes. Three dimensional mode shapes and frequencies, modal participation factors, direction factors and participating mass percentages are evaluated using eigenvector or ritz-vector analysis. P-Delta effects may be included with static or dynamic analysis.
Response spectrum analysis, linear time history analysis, nonlinear time history analysis, and static nonlinear (pushover) analysis are all possible. The static nonlinear capabilities also allow you to perform incremental construction analysis so that forces that arise as a result of the construction sequence are included.
Results from the various static load cases may be combined with each other or with the results from the dynamic response spectrum or time history analyses.

3.2 MODULES

- ETABS software
- Response Spectrum Analysis Method

3.3 Module Functionalities

3.3.0 ETABS software

ETABS is an engineering software product that caters to multi-story building analysis and design. Modelling tools and templates, code-based load prescriptions, analysis methods and solution techniques, all coordinate with the grid-like geometry unique to this class of structure. Basic or advanced systems under static or dynamic conditions may be evaluated using ETABS. For a sophisticated assessment of seismic performance, modal and direct- integration time-history analyses may couple with P-Delta and Large Displacement effects. Nonlinear links and concentrated PMM or fiber hinges may capture material nonlinearity under monotonic or hysteretic behavior. Intuitive and integrated features make applications of any complexity practical to implement. Interoperability with a series of design and documentation platforms makes ETABS a coordinated and productive tool for designs which range from simple 2D frames to elaborate modern high-rises.

3.3.0.1 History and Advantages of ETABS

Dating back more than 40 years to the original development of TABS, the predecessor of ETABS, it was clearly recognized that buildings constituted a very special class of structures. Early releases of ETABS provided input, output and numerical solution techniques that took into consideration the characteristics unique to building type structures, providing a tool that offered significant savings in time and increased accuracy over general purpose programs.

As computers and computer interfaces evolved, ETABS added computationally complex analytical options such as dynamic nonlinear behavior, and powerful CAD-like drawing tools in a graphical and object-based interface. Although ETABS 2016 looks radically different from its predecessors of 40 years ago, its mission remains the same: to provide the profession with the most efficient and comprehensive software for the analysis and design of buildings. To that end, the current release follows the same philosophical approach put forward by the original programs, namely:

- Most buildings are of straightforward geometry with horizontal beams and vertical columns. Although any building configuration is possible with ETABS, in most cases, a simple grid system defined by horizontal floors and vertical column lines can establish building geometry with minimal effort.
- Many of the floor levels in buildings are similar. This commonality can be used to dramatically reduce modelling and design time.
- The input and output conventions used correspond to common building terminology. With ETABS, the models are defined logically floor-by-floor, column-by-column, bay-by-bay and wall-by-wall and not as a stream of non-descript nodes and elements as in general purpose programs. Thus the structural definition is simple, concise and meaningful.

- In most buildings, the dimensions of the members are large in relation to the bay widths and story heights. Those dimensions have a significant effect on the stiffness of the frame. ETABS corrects for such effects in the formulation of the member stiffness, unlike most general-purpose programs that work on centreline-to-centreline dimensions.
- The results produced by the programs should be in a form directly usable by the engineer. General-purpose computer programs produce results in a general form that may need additional processing before they are usable in structural design.

3.3.0.2 What ETABS Can Do!

ETABS offers the widest assortment of analysis and design tools available for the structural engineer working on building structures. The following list represents just a portion of the types of systems and analyses
that ETABS can handle easily:

- Multi-story commercial, government and health care facilities
- Parking garages with circular and linear ramps
- Buildings with curved beams, walls and floor edges
- Buildings with steel, concrete, composite or joist floor framing
- Projects with multiple towers
- Complex shear walls and cores with arbitrary openings
- Buildings based on multiple rectangular and/or cylindrical grid systems
- Flat and waffle slab concrete buildings
- Buildings subjected to any number of vertical and lateral load cases and combinations, including automated wind and seismic loads
- Multiple response spectrum load cases, with built-in input curves
- Automated transfer of vertical loads on floors to beams and walls
- Capacity check of beam-to-column and beam-to-beam steel connections
- P-Delta analysis with static or dynamic analysis
- Explicit panel-zone deformations
- Construction sequence loading analysis
- Multiple linear and nonlinear time history load cases in any direction

3.3.0.3 An Integrated Approach

- Foundation/support settlement
- Large displacement analyses
- Nonlinear static pushover
- Buildings with base isolators and dampers
- Design optimization for steel and concrete frames
- Design capacity check of steel column base plates
- Floor modelling with rigid or semi-rigid diaphragms
- Automated vertical live load reductions and much more

ETABS is a completely integrated system. Embedded beneath the simple, intuitive user interface are very powerful numerical methods, design procedures and international design codes, all working from a single comprehensive database. This integration means that you create only one model of the floor systems and the vertical and lateral framing systems to analyze, design, and detail the entire building. Everything you need is integrated into one versatile analysis and design package with one Windows-based graphical user interface. No external modules are required. The effects on one part of the structure from changes in another part are instantaneous and automatic. The integrated components include:

- Drafting for model generation
- Seismic and wind load generation
- Gravity load distribution for the distribution of vertical loads to columns and beams when plate bending floor elements are not provided as a part of the floor system
- Finite element-based linear static and dynamic analysis
- Finite element-based nonlinear static and dynamic analysis (available in ETABS Nonlinear & Ultimate versions only)
- Output display and report generation
- Steel frame design (column, beam and brace)
- Concrete frame design (column and beam)
- Composite beam design
- Composite column design
- Steel joist design

- Shear wall design
- Steel connection design including column base plates
- Detail schematic drawing generation

3.3.0.4 Load Patterns

Loads represent actions upon the structure, such as force, pressure, support displacement, thermal effects, and others. A spatial distribution of loads upon the structure is called a load pattern. As many named load patterns as needed can be defined. Typically, separate load patterns would be defined for dead load, live load, static earthquake load, wind load, snow load, thermal load, and so on. Loads that need to vary independently, for design purposes or because of how they are applied to the building, should be defined as separate load patterns. After defining a load pattern name, you must assign specific load values to the objects as part of that load pattern, or define an automated lateral load if the case is for seismic or wind. The load values you assign to an object specify the type of load (e.g., force, displacement, temperature), its magnitude, and direction (if applicable). Different loads can be assigned to different objects as part of a single load pattern, along with the automated lateral load, if so desired. Each object can be subjected to multiple load patterns.

Vertical Loads

Vertical loads may be applied to joint, frame and shell objects. Vertical loads are typically input in the gravity, or -Z direction. Joint objects can accept concentrated forces or moments. Frame objects may have any number of point loads (forces or moments) or distributed loads (uniform or trapezoidal) applied. Uniform loads can be applied to Shell objects.
Vertical load cases may also include element self-weight. Some typical vertical load cases used for building structures might include:

- Dead load
- Superimposed dead load
- Live load
- Reduced live load
- Snow load

If the vertical loads applied are assigned to a reducible live load pattern, ETABS provides you with an option to reduce the live loads used in the design phase. Many different types of code-dependent load reduction formulations are available.

3.3.0.5 Load Combinations

ETABS allows for the named combination of the results from one or more load cases and/or other combinations. When a combination is defined, it applies to the results for every object in the model.

The five types of combinations are as follows:

- **Linear Add:** Results from the included load cases and combinations are added.
- **Envelope:** Results from the included load cases and combinations are enveloped to find the maximum and minimum values.
- **Absolute Add:** The absolute values of the results from the included load cases and combinations are added.
- **SRSS:** The square root of the sum of the squares of the results from the included load cases and combinations is computed.

Range Add: Positive values are added to the maximum and negative values are added to the minimum for the included load cases and combos. Except for the Envelope type, combinations should usually be applied only to linear load cases, because nonlinear results are not generally super possible.

3.3.1 Response spectrum analysis

Response-spectrum analysis is the linear dynamic method which estimates the contribution from each natural mode of vibration to demonstrate the possible maximum response of essentially elastic structure. This method gives the knowledge into dynamic behavior by estimating pseudo spectral acceleration, displacement or velocity as a function of structural period for a given time period and level of damping. The software takes care of the Eigen value issue of the model and estimate the fundamental natural period values. Thus, the total seismic loads are created and its dispersion along the height of the building corresponding to the mass and stiffness distribution. The modeling and analysis are performed by ETABS 2016. For each mode shape, from design spectrum responses are studied, with the assistance of parameters, for example modal frequency and modal participation mass ratio and after that they are combined to give an assessment of the total response of the structure.

3.2 Design Features

Design is the process of determining the size and the arrangement of structural members to withstand the various load combinations. According to (ACI-318-99) and UBC-97, the load combinations are taken.

Output may be viewed graphically, displayed in tabular output, compiled in a report, exported to a database file, or saved in an ASCII file. Types of output include reactions and member forces, mode shapes and participation factors, static and dynamic story displacements and story shears, inter-story drifts and joint displacements, time history traces, and more.

Import and export of data may occur between third-party applications such as Revit and Auto CAD from Autodesk, or with other programs that support the CIS/2 or IFC data models.

ETABS uses the SAP Fire analysis engine, the state-of-the-art equation solver that powers all of CSI's software. This proprietary solver exploits the latest in numerical technology to provide incredibly rapid solution times and virtually limitless model capacity.

3.2.1 Design Process

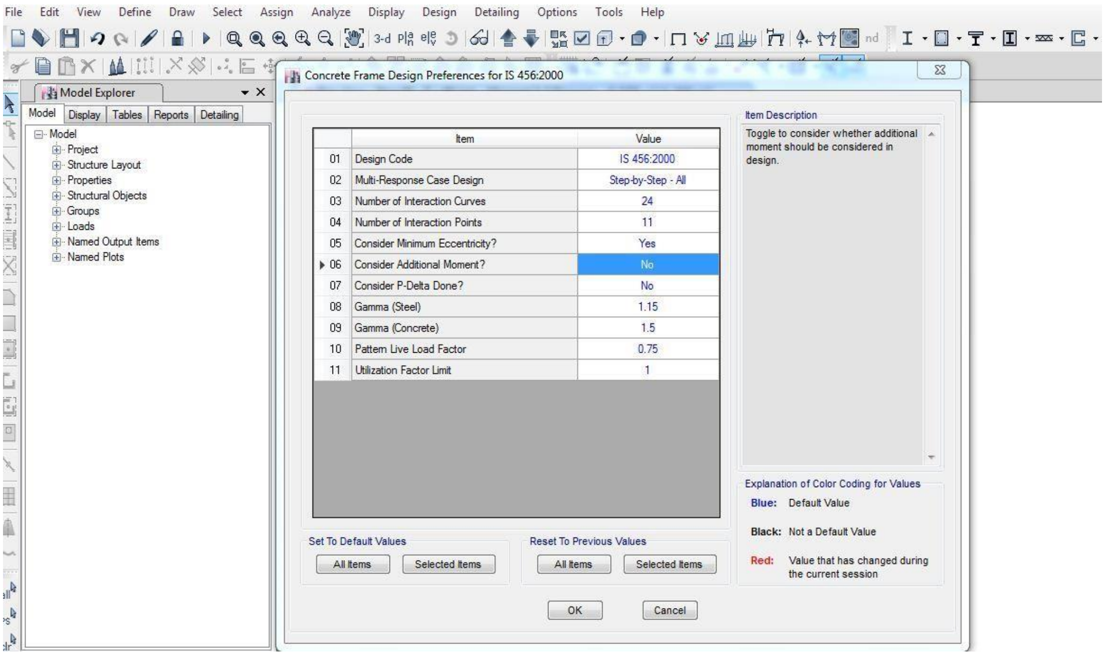


Fig 4: Design preferences in Etabs

3.2.2 Design Settings

Design is always based on combinations, not directly on load cases. A combination can be created that contains only a single load case. Each design algorithm creates its own default combinations; supplement them with your own design combinations if needed.

ETABS offers the following integrated design postprocessors:

- Steel Frame Design
- Concrete Frame Design
- Composite Beam Design
- Composite Column Design
- Steel Joist Design
- Shear Wall Design
- Steel Connection Design

The first five design procedures are applicable to frame objects, and the program determines the appropriate design procedure for a frame object when the analysis is run. The design procedure selected is based on the line object's orientation, section property, material type and connectivity. Shear wall design is available for objects that have previously been identified as piers or spandrels, and both piers and spandrels may consist of both shell and frame objects. Steel connection design will identify which beam-to-beam and beam-to-column locations have adequate load transfer capacity using the standard connections specified in the connection preferences. Steel connection design also includes sizing and design capacity checks for column base plates. For each of the first five design postprocessors, several settings can be adjusted to affect the design of the model:

Design of steel frames, concrete frames, concrete shear walls, composite beams, composite columns, and steel joists can be performed based on a variety of US and International design codes. Flexural, shear and deflection checks may all be performed depending upon the material and member type. Steel and concrete frame members may be optimized from auto select lists, and concrete sections are designed using reinforcing bar sizes chosen from US or International standards. Steel connection design automates the review of beam-beam and beam-column connections based on user specified bolt and shear plate preferences. Steel base plate design verifies the size, thickness, and anchorage of the connection.

3.2.3 Detailing Features

Schematic construction drawings showing floor framing, column schedules, beam elevations and sections, steel connection schedules, and concrete shear wall reinforcing may be produced. Concrete reinforcement of beams, columns, and walls may be selected based on user-defined rules. Any number of drawings may be created, containing general notes, plan views, sections, elevations, tables, and schedules. Drawings may be printed directly from ETABS or exported to DXF or DWG files for further

3.2.4 Output and Display Options

- General Notes
- Beam & Column Sections
- Floor Framing Plans
- Column Schedules
- Beam Schedules
- Connection Schedules
- Column Layout
- Wall Layout
- Wall Reinforcement Plans & Elevations

The ETABS model and the results of the analysis and design can be viewed and saved in many different ways, including:

- Two- and three-dimensional views of the model
- Customizable user defined reports
- Input/output data values in plain text, spreadsheet, or database format
- Function plots of analysis results
- Design sheets
- Story data for import into SAFE
- Export to other drafting and design programs

Named definitions of display views and function plots can be saved as part of a model. Combined with the use of groups, this can significantly speed up the process of getting results as the modeling is being developed.

CHAPTER 4

4.0 IMPLEMENTATION STAGES

4.0.1 Plan Details

The structure is 40m in X-direction and 30m in Y-direction with columns spaced at 4m from centre to centre. The storey height is kept as 3m. The storey height between two floors is 3m with beam of size 0.45x0.45m and column sizes of 0.65x0.65m for 1 to 7 stories and 0.50x0.50m for 8 to 15 stories and also the slab thickness is taken as 0.125m.

4.0.2 Codes

- Is-456:2000: code for RCC structures.
- Sp-16: code for columns
- Is-875(part 1): code for dead loads
- Is-875(part 2): code for imposed loads
- Is-875(part 3): code for wind loads
- Is-1893:20(part-2): earthquake loads

4.0.3 Site location and Structural system

- Type of building = G+14 R.C building
- Type of occupancy = Hotel
- Shape of the building = Irregular shaped
- Ground floor height = 4.2m
- Storey height = 3m
- Overall height = 49.2m
- Maximum length = 30m
- Maximum width = 30m
- Beam size = 0.45mx0.45m

- Column size = 0.65m x 0.65m from 1 to 7 stories
- Beam size = 0.50m x 0.50m from 8 to 15 stories
- Location = Seismic zone - IV

4.0.4 Material properties used for the proposed building are as follows

- Modulus of elasticity = 2.15 KN/m^2
- Unit weight of concrete = 7.18 KN/m^2
- Poisson’s ratio = 0.2
- Strength of concrete (fc') = $2.6\times^{KN}/m^2$
- Yield strength of main reinforcement (fy) = 3.4×10^3 KN/m^2
- Yield strength of shear reinforcement (fys)=$3.4\times10^5 KN/m^2$

4.1 Defining the material properties in ETABS

4.1.1 Concrete material

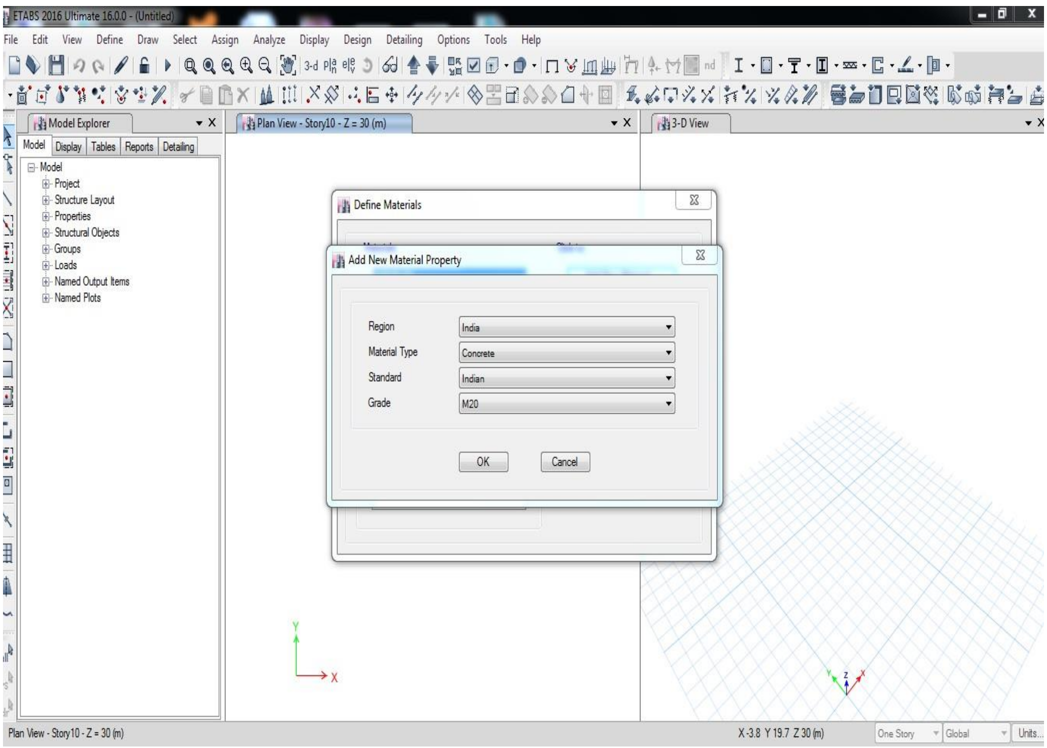


Fig 5: Concrete details in ETABS software

4.1.2 HYSD Steel bars of grade 415

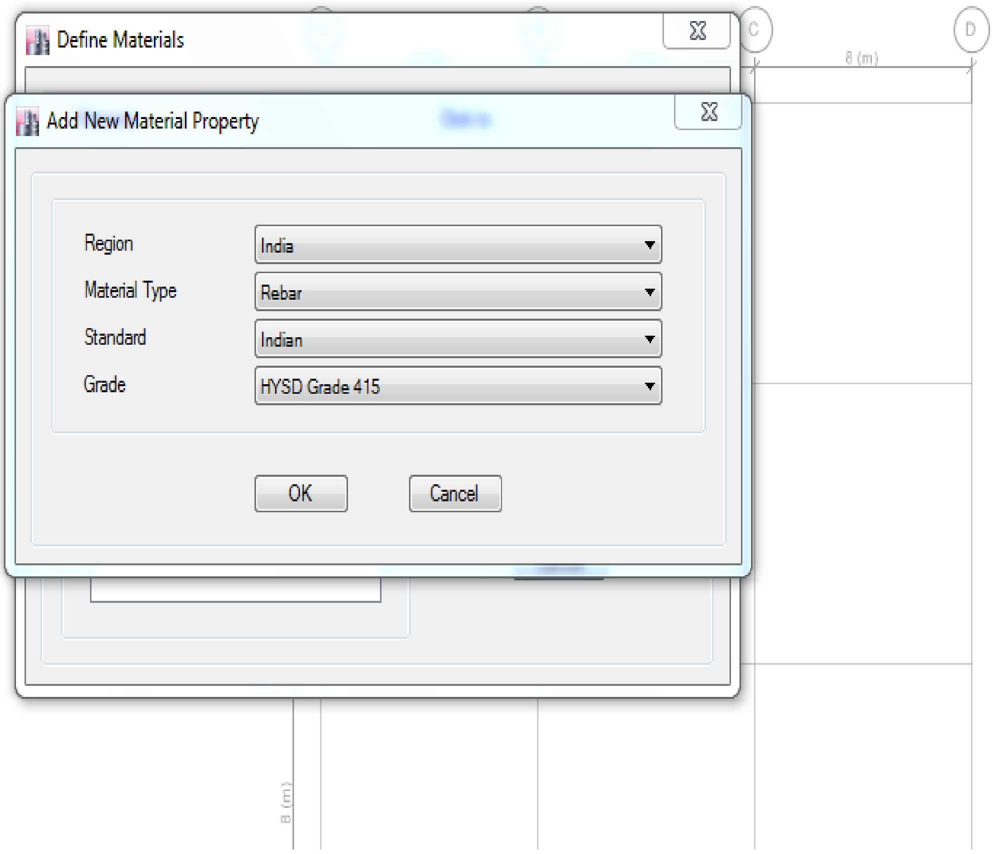


Fig 6 : HYSD steel bar details in ETABS software

4.1.3 Mild Steel of grade 250

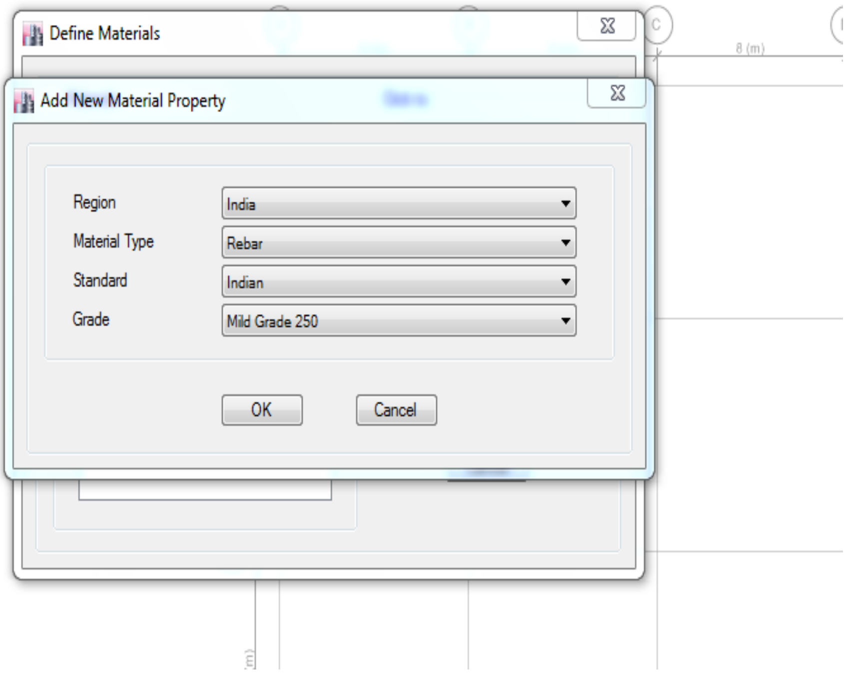


Fig 7 : Mild steel of grade 250 details in ETABS

4.2 Load Details

4.2.1 DEAD LOADS(DL):

All permanent constructions of the structure form the dead loads. The dead load comprises of the self-weight, weight of walls, partitions floor finishes and the other permanent constructions in the buildings. The loads considered in this project are as per IS 456 2000.

- Weight of concrete = 7.18 KN/m^2
- 4½ inches thick wall weight = 2.39 KN/m^2
- 9 inches thick wall weight = 4.78 KN/m^2
- Weight of glass area = 0.478 KN/m^2
- Weight of elevator = 2 tons
- Weight of ceiling and finishing = 1.197KN/m^2

4.2.2 LIVE LOAD(LL):

Live load or imposed load is defined as the load on the structure due to moving weight. Imposed load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. Imposed loads do not include loads due to wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo.

- Live load on lobbing = 4.78 KN/m^2
- Live load on corridors = 4.78 KN/m^2
- Live load on stairs = 4.78 KN/m^2
- Live load on restaurants = 4.78 KN/m^2
- Live load on assembly hall = 4.78 KN/m^2
- Live load on bed room = 1.915 KN/m^2

- Live load on roof = 0.95 KN/m^2

4.2.3 SEISMIC LOAD CALCULATION (Based on code IS 1893-2002)

During an earthquake, ground motions develop in a random manner both horizontally and vertically in all directions radiating from the epicenter. The ground motions develop vibrations in the structure inducing inertial forces on them. Hence structures located in seismic zones should be suitably designed and detailed to ensure strength, serviceability and stability with acceptable levels of safety under seismic forces.

The satisfactory performance of a large number of reinforced concrete structures subject to severe earthquake in various parts of the world has demonstrated that it is possible to design structures to successfully withstand the destructive effects of major earthquakes.

The Indian standard codes IS: 1893-1984 and IS: 13920-1993 have specified the minimum design requirements of earthquake resistant design probability of occurrence of earthquakes, the characteristics of the structure and the foundation and the acceptable magnitude of damage. Determination of design earthquake forces is computed by the following methods,

1) Equivalent static lateral loading.
2) Dynamic Analysis.

In the first method, different partial safety factors are applied to dead, live, wind earthquake forces to arrive at the design ultimate load. In the IS: 456-2000 code, while considering earthquake effects, wind loads assuming that both severe wind and earthquake do not act simultaneously. The American and Australian code recommendations are similar but with different partial safety factors.

The dynamic analysis involves the rigorous analysis of the structural system by studying the dynamic response of the structure by considering the total response in terms of component modal responses.

Zone factor (z):

The values of peak ground acceleration given in units 'g' for the maximum considered earthquake.

- The value of (Z/2) corresponds to design basis earthquake damage control in limit state.
- Based on history of seismic activities seism tectonic understanding the entire country has been divided in to four zones. The zone factor from table 2(IS 1893:2016)

Zone factor values- **Table 1**

Seismic zone	II	III	IV	V
Seismic Intensity	Low	Moderate	Severe	Very severe
Z	0.10	0.16	0.24	0.36

Response reduction factor (r):

- R is the response reduction factor and controls the permitted damage in design basis earthquake.
- The minimum value of R is 3 and maximum is 5 however to use higher values of R special ductile detailing requirements are must and the designer is accepting more damages but in the controlled manner. The Response reduction factor from table 7(IS 1893:2016)

4.2.4 IMPORTANCE FACTOR (I):

- I is the importance factor and permitted damage could be reduced by setting the value of I more than ‘1’.

- For the buildings like hospitals, communication and community buildings the value is 1.5 from table 6 (IS 1893:2002).

4.2.5 SEISMIC WEIGHT (W):

Seismic weight of the building is measured in Newton. Seismic weight includes the dead loads (that of floor, slabs, finishes, columns, beams, water tanks, permanent machines etc. Seismic weight includes only a part of Imposed loads, for example 25% to 50% of imposed loads for buildings from table 8 (IS1893:2002)

4.2.6 SOIL CLASSIFICATION:

Sa/g is the lateral acceleration to be established in m/s^2. For 5 present of damping three different types of curves are recommended in IS 1893:2002 for different stiffness of supporting media-Rock, Medium soil and Soft soil. The classification of soil is based on the average shear velocity for 30m of rock or soil layers or based on average Standard Penetration Test (SPT) values for top 30m.

- Seismic zone = IV
- Structural system = dual system with SMRF
- Seismic zone factor = 0.4
- Response modification factor, r = 8.5
- Seismic importance factor, i = 1.0
- Seismic response coefficient, ca = 0.44 na
- Seismic response coefficient, cv = 0.64 nv
- Seismic source type = A

- Near source factor, na = 1.0
- Near source factor, nv = 1.0

4.2.7 BUILDING BYE LAWS:

Building bye laws set standards for building work. There aim is to ensure the health and safety of people around the building by setting requirements for building design and construction. The bye laws also promote energy efficiency and aim to improve access for disable people.

- Line of building frontage and minimum plot sizes.
- Open spaces around residential buildings.
- Minimum standard dimensions of building elements.
- Provisions of lighting and ventilation.
- Provisions for means of access.
- Provisions of safety from fire and explosion.
- Provisions for drainage and sanitation.
- Provisions for safety of works against hazard or accidents.
- Requirements for off street parking spaces.
- Requirements for green belt and landscaping.

CHAPTER 5

5.1 RESULTS

TABLE 2 : Data from dynamic analysis performed

Modes	Time period	frequency	modal mass participation ratios	
			X trans	Y trans
1	1.57	0.637	0	75.5
2	1.524	0.656	75.82	0
3	1.372	0.729	0	0
sum of 12 modes			93.32	93.28

5.1.1 STOREY DISPLACEMENT:

Story displacement is defined as the total displacement of any storey with respect to ground.

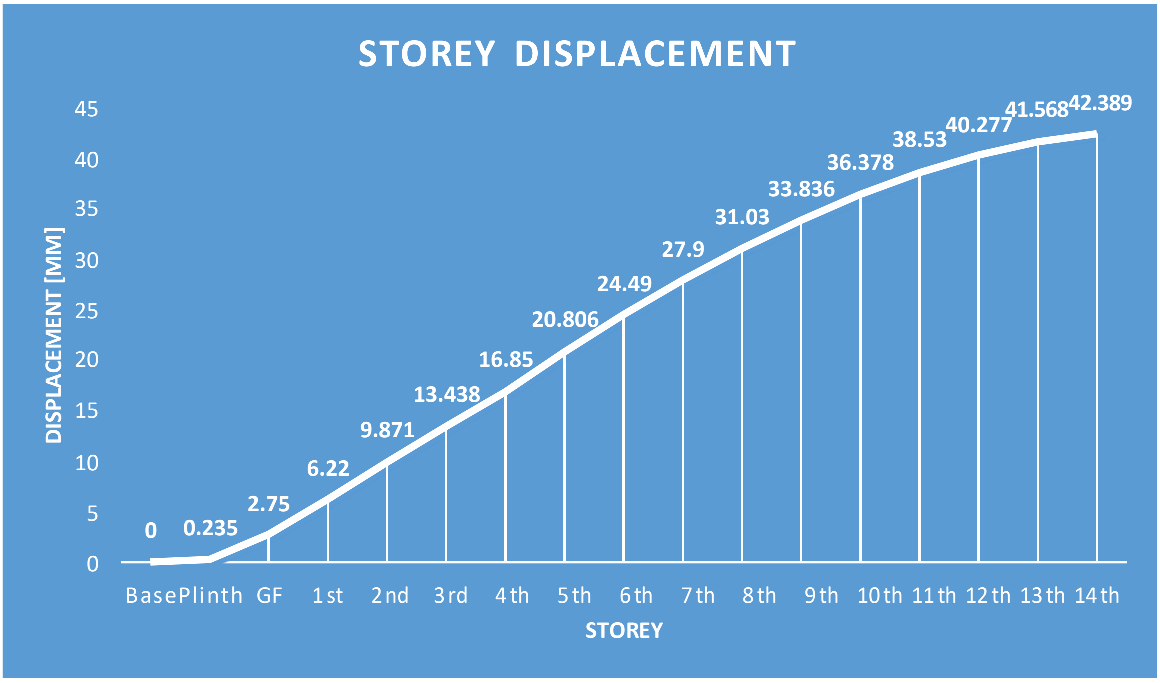


Fig 8: In the above graph the X-axis represents the storey of the building and Y-axis represents the displacement in mm. It is minimum at the base level and gradually increases with respect to storey. The maximum displacement is at the top storey.

5.1.2 STOREY SHEAR:

Storey shear is defined as the sum of design lateral forces at all levels above the storey under consideration.

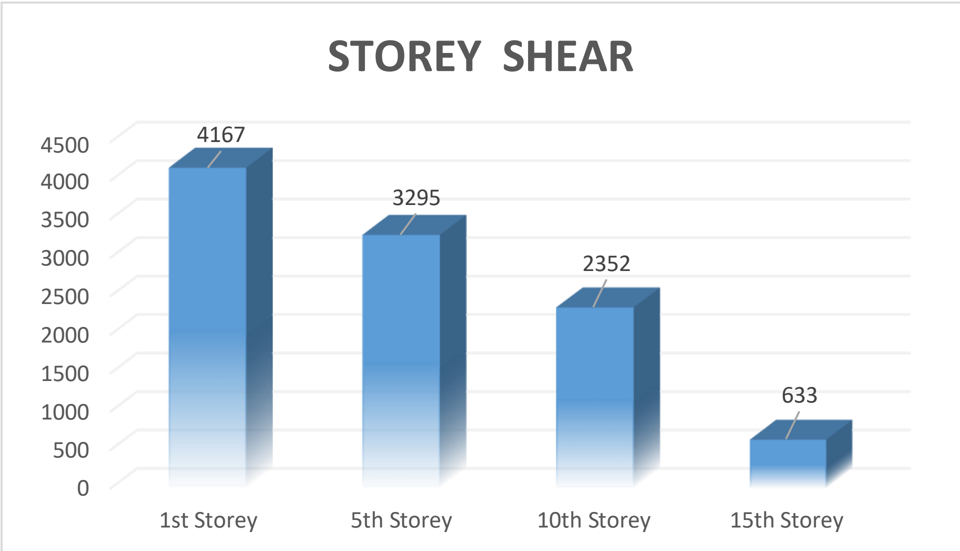


Fig 9: In the above graph the X-axis represents the storey of the building and Y- axis represents the shear force. The shear force is maximum at the first storey and it decreases with respect to the storey height.

5.1.3 STOREY DRIFT:

Storey drift is defined as ratio of displacement of two consecutive floors to height of that floor.

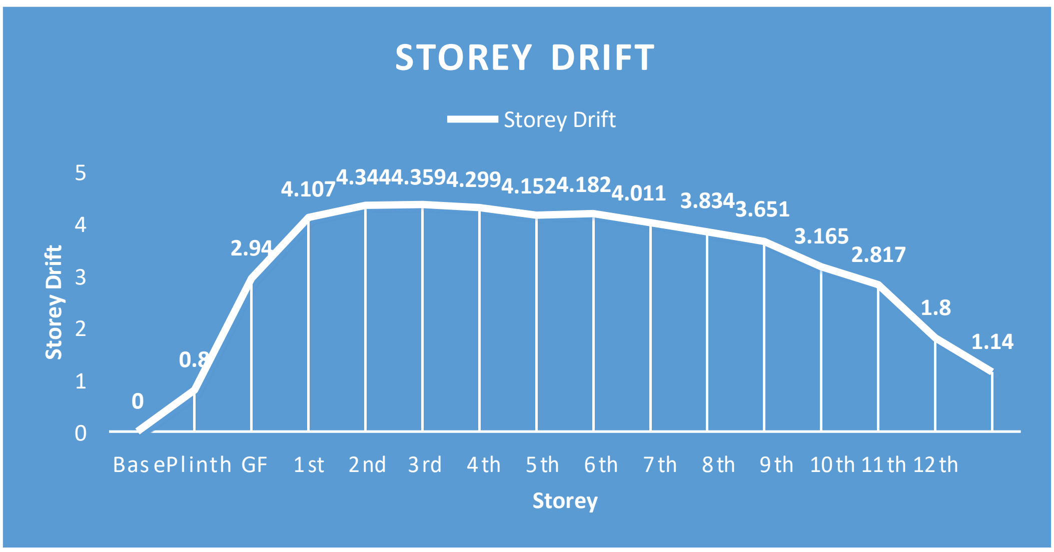


Fig 10: In the above graph the storey drift is maximum at the fifth storey and it is minimum at base plinth level.

5.1.4 STOREY OVERTURNING MOMENT:

It is taken as the sum of the moments on the column and any shear on the column multiplied by the distance from the base of the column to the base of the footing.

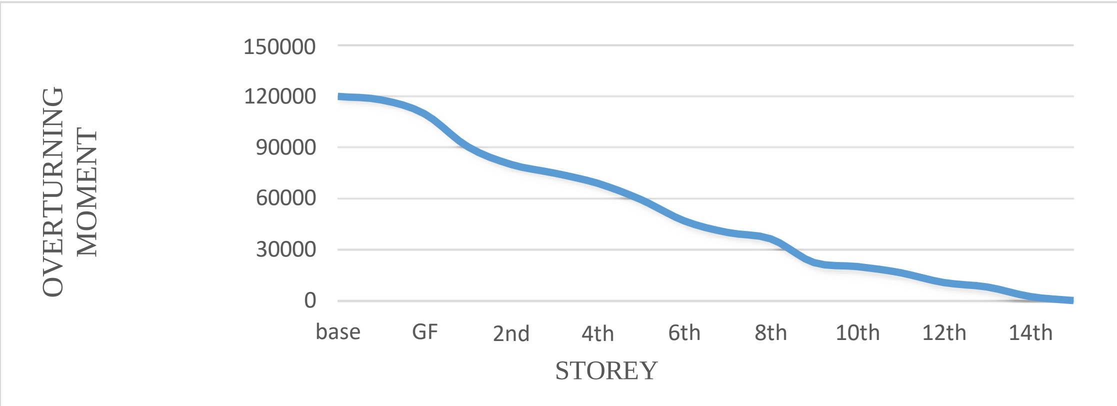


Fig 11: In the above graph the X- direction represents the storey of the building and y-direction represents the over turning moment in KN. The over turning moment is maximum at the base level and gradually decreases with respect to height of the storey.

5.2 MODEL OF THE STRUCTURE

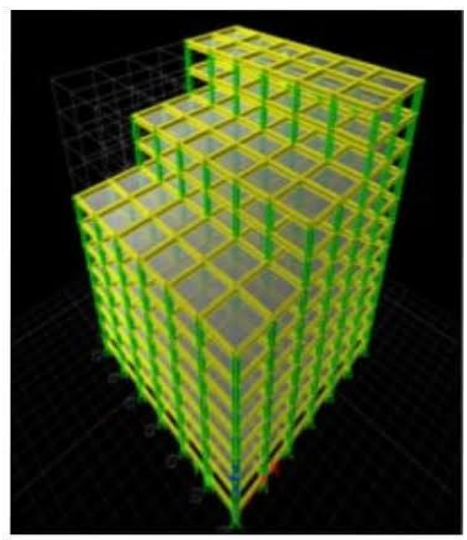


Fig. ETABS model of the structure

Fig 12: Model of the structure

5.3 FINAL RESULTS

Table 3:

S.NO.	DESIGN PARAMETER	RESULTS
1.	Storey Displacement	43mm
2.	Storey Shear	1^{st} storey - 4166.3KN 5^{th} storey - 3294.6KN 10^{th} storey - 2351.6KN 15^{th} storey - 633.19KN
3.	Storey Drift	4.3mm
4.	Storey overturning moment	119000KN

CHAPTER 6

CONCLUSION

6.1 CONCLUSION

- From the analysis of vertically irregular structure, the behaviour of the structure has been studied under dynamic loading.
- The behavior of the vertically irregular structure under plane ground conditions has been analyzed through the Response Spectrum Method.
- Developed 3D-model for the building using ETABS software and the design was performed based on IS:1893(part 1) 2016.
- It is recommended that irregular buildings are safer than regular buildings under seismic conditions and should be preferred for regular buildings.

6.2 FUTURE ENHANCEMENT

- Response spectrum analysis can be performed on any type of the structure.
- Present study can be carried to further level by applying nonlinear method of structural analysis.
- The structures strength can be increased by adopting multiple stiffness systems like shear wall with bracings.
- Time history analysis also can be performed by the above structures with different method of structural analysis.
- The analysis can be carried out for vertical irregularity by adopting soil structure interaction.
- The pushover analysis in vertically irregular structures by using different types of isolators.

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[12] Some concepts in earthquake behaviour of buildings by C.V.R Murty, Rupengoswami, A.R.Vijaya Narayana and Vipul.V.Mehta.

APPENDICES

Examination and plan of structures for static powers is a standard undertaking these days in view of accessibility of moderate PCs and particular projects which can be utilized for the investigation. Then again, dynamic examination is a tedious interaction and requires extra info identified with mass of the construction, and a comprehension of primary elements for translation of scientific outcomes. Supported cement (RC) outline structures are most normal sort of developments in metropolitan India, which are exposed to a few kinds of powers during their lifetime, like static powers because of dead and live loads and dynamic powers because of the breeze and quake.

During a tremor, disappointment of construction gets going developed at elements of flimsy point. This flimsy part emerges because of irregularity in mass, solidness and math of construction. The frameworks having this intermittence are named as unpredictable frameworks. Sporadic constructions contribute a gigantic part of city foundation. Vertical inconsistencies are one of the fundamental thought processes of disappointments of frameworks during seismic tremors. The impact of upward abnormalities inside the seismic generally speaking execution of frameworks will turn out to be certainly crucial. Pinnacle shrewd changes in firmness and mass render the unique qualities of those structures uncommon from the customary structure. The abnormality inside the structure constructions might be because of unpredictable dispersions in their mass, strength and solidness along the tallness of building.

The investigation should be possible in Staad Pro programming, ETABS programming SAP 2000 programming and Tekla programming. As ETABS is known generally all through the country, it is perhaps the best programming for underlying investigation. Approval of the ETABS programming has been finished regarding a reference paper and examination of Story toppling second, story float, Story relocations and story shear has been finished.

A

PROJECT REPORT

On

Static Analysis and Design of G+20 RCC Framed Structure by using ETABS Software

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

By

1)Mr.B.Sai Chakravarthi - (17k81A0110)
2)Mr.B.Vamshi Krishna - (17k81A0113)
3)Mr.E.Umesh - (17k81A0124)
4)Mr.T.Sairam Reddy - (17k81A0156)

Under The Guidance of
Mr.K.Prabhakar
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DEPARTMENT OF CIVIL ENGINEERING
ST. MARTIN'S ENGINEERING COLLEGE
(An Autonomous Institute)
Dhulapally , Secunderabad – 500 100

JUNE 2021

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Dhulapally, Secunderabad, Telangana (India)-500100

BONAFIDE CERTIFICATE

This is to certify that the project entitled is Static Analysis and Design of G+20 RC Framed Structure by using ETABS Software being submitted by1.**Mr.B.Sai chakravarthi (17K81A0110), 2.Mr.B.vamshi Krishna (17K81A0113), 3.Mr.E.Umesh (17K81A0124) , 4.Mr.T.Sairam Reddy (17K81A0156)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN CIVIL ENGINEERING** is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

Signature of Guide

Mr.K.Prabhakar

Assistant Professor

Department of Civil Engineering

Signature of HOD

Prof. SANDHYA KIRAN J.K.

Head of the Department

Department of Civil Engineering

Internal Examiner

External Examiner

Place:

Date:

DECLARATION

We, the student of Bachelor of Technology in Department of 'Civil Engineering', session: 2017 – 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled Static Analysis and Design of G+20 RCC Framed Structure by using ETABS Software is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

Mr.B.Sai Chakravarthi - (17k81A0110)
Mr.B.Vamshi Krishna - (17k81A0113)
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Mr.T.Sairam Reddy - (17k81A0156)

ACKNOWLEDGEMENTS

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First and foremost, we would like to express our deep sense of gratitude and in debtednes sto **our College Management** for their kind support and permission to use the facilities available in the Institute.

We especially would like to express our deep sense of gratitude and in debtedness to **Dr.P.Santosh Kumar Patra**, **our beloved Principal, St.Martin's Engineering College** for his in valuable encouragement, suggestions and support from an early stage of this research and providing me extraordinary experiences throughout the work. Above all, his priceless and meticulous supervision at each and every phase of work inspired me In innumerable ways.

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1. Bandaru Sai Chakrawarthi
2. Boya Vamshi Krishna
3. Erragani Umesh
4. Tirumala Sairam Reddy

ABSTRACT

Structural design is the primary aspect of Civil Engineers and its analysis is backbone of Civil Engineering. The improper analysis and design leads to failure of structure resulting loss of life. To perform accurate analysis, the structural engineer is able to analyze the structure considering different constraints like to satisfy the serviceability and deformability etc., by following IS codes. Though conventional method is still practicing, our technology is upgrading equally or even more based on latest softwares due to time parameter. ETABS is the present day leading software in market which is to be updated by Civil Engineers along with conventional method.

The objective of our project is to carry out analysis and design of the main structural elements of super structure such as Slabs, Beams and Columns. The building was designed by considering dead load and live load according to standards and by considering seismic and wind force to ensure the safety and keeping careful balance between economy and safety. Finally the analysis parameters like shear force, bending moment and displacements are comparatively presented.

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CHAPTER 1

Introduction

ETABS is a sophisticated, yet easy to use, special purpose analysis and design program developed specifically for building systems. ETABS 2013 features an intuitive and powerful graphical interface coupled with unmatched modeling, analytical, design, and detailing procedures, all integrated using a common database. Although quick and easy for simple structures, ETABS can also handle the largest and most complex building models, including a wide range of nonlinear behaviors, making it the tool of choice for structural engineers in the building industry.

1.1 History and Advantages of ETABS

Dating back more than 40 years to the original development of TABS, the predecessor of ETABS, it was clearly recognized that buildings constituted a very special class of structures. Early releases of ETABS provided input, output and numerical solution techniques that took into consideration the characteristics unique to building type structures, providing a tool that offered significant savings in time and increased accuracy over general purpose programs.

As computers and computer interfaces evolved, ETABS added computationally complex analytical options such as dynamic nonlinear behavior, and powerful CAD-like drawing tools in a graphical and object-based interface. Although ETABS 2016 looks radically different from its predecessors of 40 years ago, its mission remains the same: to provide the profession with the most efficient and comprehensive software for the analysis and design of buildings. To that end, the current release follows the same philosophical approach put forward by the original programs, namely:

- Most buildings are of straightforward geometry with horizontal beams and vertical columns. Although any building configuration is possible with ETABS, in most cases, a simple grid system defined by horizontal floors and vertical column lines can establish building geometry with minimal effort.
- Many of the floor levels in buildings are similar. This commonality can be used to dramatically reduce modelling and design time.
- The input and output conventions used correspond to common building terminology. With ETABS, the models are defined logically floor-by-floor, column-by-column, bay-by-bay and wall-by-wall and not as a stream of non-descript nodes and elements as in general purpose programs. Thus the structural definition is simple, concise and meaningful.
- In most buildings, the dimensions of the members are large in relation to the bay widths and story heights. Those dimensions have a significant effect on the stiffness of the frame. ETABS corrects for such effects in the formulation of the member stiffness, unlike most general-purpose programs that work on centreline- to-centreline dimensions.
- The results produced by the programs should be in a form directly usable by the engineer. General-purpose computer programs produce results in a general form that may need additional processing before they are usable in structural design.

1.2 What ETABS Can Do!

What ETABS Can Do!

ETABS offers the widest assortment of analysis and design tools available for the structural engineer working on building structures. The following list represents just a portion of the types of systems and analyses
that ETABS can handle easily:

- Multi-story commercial, government and health care facilities
- Parking garages with circular and linear ramps
- Buildings with curved beams, walls and floor edges
- Buildings with steel, concrete, composite or joist floor framing
- Projects with multiple towers
- Complex shear walls and cores with arbitrary openings
- Buildings based on multiple rectangular and/or cylindrical grid systems
- Flat and waffle slab concrete buildings
- Buildings subjected to any number of vertical and lateral load cases and combinations, including automated wind and seismic loads
- Multiple response spectrum load cases, with built-in input curves
- Automated transfer of vertical loads on floors to beams and walls
- Capacity check of beam-to-column and beam-to-beam steel connections
- P-Delta analysis with static or dynamic analysis
- Explicit panel-zone deformations
- Construction sequence loading analysis
- Multiple linear and nonlinear time history load cases in any direction

1. 3 An Integrated Approach

- Foundation/support settlement
- Large displacement analyses

Nonlinear static pushover

- Buildings with base isolators and dampers
- Design optimization for steel and concrete frames
- Design capacity check of steel column base plates
- Floor modelling with rigid or semi-rigid diaphragms
- Automated vertical live load reductions And much, much more

ETABS is a completely integrated system. Embedded beneath the simple, intuitive user interface are very powerful numerical methods, design procedures and international design codes, all working from a single comprehensive database. This integration means that you create only one model of the floor systems and the vertical and lateral framing systems to analyze, design, and detail the entire building. Everything you need is integrated into one versatile analysis and design package with one Windows-based graphical user interface. No external modules are required. The effects on one part of the structure from changes in another part are instantaneous and automatic. The integrated components include:

- Drafting for model generation
- Seismic and wind load generation
- Gravity load distribution for the distribution of vertical loads to

columns and beams when plate bending floor elements are not provided as a part of the floor system

- Finite element-based linear static and dynamic analysis
- Finite element-based nonlinear static and dynamic analysis(available in ETABS Nonlinear & Ultimate versions only)
- Output display and report generation
- Steel frame design (column, beam and brace)
- Concrete frame design (column and beam)
- Composite beam design
- Composite column design
- Steel joist design
- Shear wall design
- Steel connection design including column base plates
- Detail schematic drawing generation

ETABS 2016 is available in three different levels that all share the same graphical user interface:

ETABS 2016 Plus. Includes all available capabilities except for certain nonlinear and dynamic analyses (p-delta and tension/ compression only frame members are provided in all versions). Features include unmatched solution capacity with 64-bit optimized solvers, shear wall modeling, multiple response spectrum analyses, linear modal time histories, numerous import and export options, and comprehensive report generation. The steel frame design, concrete frame design, composite beam design, composite column design, steel joist design, shear wall design, steel connection design and steel base plate design components are all present.

ETABS 2016 Nonlinear.

Includes all of the features of ETABS 2016 Plus, with additional nonlinear static and dynamic capabilities such as pushover, base isolation, dampers, Fast Nonlinear.

1. 4 Modeling Features

Analysis (FNA), Staged Construction, and multi-linear P-y springs.

ETABS 2016 Ultimate.
Includes all of the features of ETABS 2016 Nonlinear with additional features such as nonlinear layered shell elements, linear and nonlinear direct integration time history analysis, buckling, and the modeling of creep and shrinkage behavior.

The ETABS building is idealized as an assemblage of shell, frame, link and joint objects. Those objects are used to represent wall, floor, column, beam, brace and link/spring physical members. The basic frame geometry is defined with reference to a simple three-dimensional grid system.
With relatively simple modeling techniques, very complex framing situations may be considered.
The buildings may be unsymmetrical and non-rectangular in plan. Torsional behavior of the floors and inter story compatibility of the floors are accurately reflected in the results. The solution enforces complete three dimensional displacement compatibility, making it possible to capture tubular effects associated with the behavior of tall structures having relatively closely spaced columns. Semi-rigid floor diaphragms may be modeled to capture the effects of in plane floor deformations. Floor objects may span between adjacent levels to create sloped floors (ramps), which can be useful for modeling parking garage structures.
Modeling of partial diaphragms, such as in mezzanines, setbacks, atriums and floor openings, is possible without the use of artificial ("dummy") floors and column lines. It is also possible to model situations with multiple independent diaphragms at each level, allowing the modeling of buildings consisting of several towers rising from a common base. The column, beam and brace elements may be non-prismatic, and they may have partial fixity at their end connections. They also may have uniform, partial uniform and trapezoidal load patterns, and they may have

1. 5 Load Patterns

Loads represent actions upon the structure, such as force, pressure, support displacement, thermal effects, and others. A spatial distribution of loads upon the structure is called a load pattern. As many named load patterns as needed can be defined. Typically, separate load patterns would be defined for dead load, live load, static earthquake load, wind load, snow load, thermal load, and so on. Loads that need to vary independently, for design purposes or because of how they are applied to the building, should be defined as separate load patterns. After defining a load pattern name, you must assign specific load values to the objects as part of that load pattern, or define an automated lateral load if the case is for seismic or wind. The load values you assign to an object specify the type of load (e.g., force, displacement, temperature), its magnitude, and direction (if applicable). Different loads can be assigned to different objects as part of a single load pattern, along with the automated lateral load, if so desired. Each object can be subjected to multiple load patterns.

Vertical Loads

Vertical loads may be applied to joint, frame and shell objects. Vertical loads are typically input in the gravity, or -Z direction. Joint objects can accept concentrated forces or moments.

Frame objects may have any number of point loads (forces or moments) or distributed loads (uniform or trapezoidal) applied. Uniform loads can be applied to Shell objects.
Vertical load cases may also include element self-weight. Some typical vertical load cases used for building structures might include:

- Dead load
- Superimposed dead load
- Live load
- Reduced live load
- Snow load

If the vertical loads applied are assigned to a reducible live load pattern, ETABS provides you with an option to reduce the live loads used in the design phase. Many different types of code-dependent load reduction formulations are available.

1.6 Load Combinations

ETABS allows for the named combination of the results from one or more load cases and/or other combinations. When a combination is defined, it applies to the results for every object in the model.
The five types of combinations are as follows:

- **Linear Add:** Results from the included load cases and combinations are added.
- **Envelope:** Results from the included load cases and combinations are enveloped to find the maximum and minimum values.
- **Absolute Add:** The absolute values of the results from the included load cases and combinations are added.
- **SRSS:** The square root of the sum of the squares of the results from the included load cases and combinations is computed.
- **Range Add:** Positive values are added to the maximum and negative values are added to the minimum for the included load cases and combos. Except for the Envelope type, combinations should usually be applied only to linear load cases, because nonlinear results are not generally super possible.

1.7 Analysis Features

The effects of the finite dimensions of the beams and columns on the stiffness of a frame system are included using end offsets that can be automatically calculated. The floors and walls can be modeled as membrane elements within plane stiffness only, plate bending elements with out-of-plane stiffness only or full shell-type elements, which combine both in-plane and out-of plane stiffness. Floor and wall members may have uniform load patterns in-plane or out-of-plane, and they may have temperature loads. The column, beam, brace, floor and wall members are all compatible with one another.

Static analysis for user specified vertical and lateral floor or story loads are possible. If floors with plate bending capability are modeled, vertical uniform loads on the floor are transferred to the beams and columns through bending of the floor elements. Otherwise, vertical uniform loads on the floor are automatically converted to span loads on adjoining beams, or point loads on adjacent columns, thereby automating the tedious task of transferring floor tributary loads to the floor beams without explicit modeling of the secondary framing. The program can automatically generate lateral wind and seismic load patterns to meet the requirements of

various building codes. Three dimensional mode shapes and frequencies, modal participation factors, direction factors and participating mass percentages are evaluated using eigenvector or ritz-vector analysis. P-Delta effects may be included with static or dynamic analysis.
Response spectrum analysis, linear time history analysis, nonlinear time history analysis, and static nonlinear (pushover) analysis are all possible. The static nonlinear capabilities also allow you to perform incremental construction analysis so that forces that arise as a result of the construction sequence are included.
Results from the various static load cases may be combined with each other or with the results from the dynamic response spectrum or time history analyses.

1.8 Design Features

Output may be viewed graphically, displayed in tabular output, compiled in a report, exported to a database file, or saved in an ASCII file. Types of output include reactions and member forces, mode shapes and participation factors, static and dynamic story displacements and story shears, inter-story drifts and joint displacements, time history traces, and more.
Import and export of data may occur between third-party applications such as Revit and AutoCAD from Autodesk, or with other programs that support the CIS/2 or IFC data models.
ETABS uses the SAPFire™ analysis engine, the state-of-the-art equation solver that powers all of CSI's software. This proprietary solver exploits the latest in numerical technology to provide incredibly rapid solution times and virtually limitless model capacity.

Design Settings
Design is always based on combinations, not directly on load cases. A combination can be created that contains only a single load case. Each design algorithm creates its own default combinations; supplement them with your own design combinations if needed.

ETABS offers the following integrated design postprocessors:

- Steel Frame Design
- Concrete Frame Design
- Composite Beam Design
- Composite Column Design
- Steel Joist Design
- Shear Wall Design
- Steel Connection Design

The first five design procedures are applicable to frame objects, and the program determines the appropriate design procedure for a frame object when the analysis is run. The design procedure selected is based on the line object's orientation, section property, material type and connectivity. Shear wall design is available for objects that have previously been identified as piers or spandrels, and both piers and spandrels may consist of both shell and frame objects. Steel connection design will identify which beam-to-beam and beam-to-column locations have adequate load transfer capacity using the standard connections specified in the connection preferences. Steel connection design also includes sizing and design capacity checks for column base plates. For each of the first five design postprocessors, several settings can be adjusted to affect the design of the model:

Design of steel frames, concrete frames, concrete shear walls, composite beams, composite columns, and steel joists can be performed based on a variety of US and International design codes. Flexural, shear and deflection checks may all be performed depending upon the material and member type. Steel and concrete frame members may be optimized from auto select lists, and concrete sections are designed using reinforcing bar sizes chosen from US or International standards. Steel connection design automates the review of beam-beam and beam-column connections based on user specified bolt and shear plate preferences. Steel base plate design verifies the size, thickness, and anchorage of the connection.

1.9 Detailing Features

Schematic construction drawings showing floor framing, column schedules, beam elevations and sections, steel connection schedules, and concrete shear wall reinforcing may be produced. Concrete reinforcement of beams, columns, and walls may be selected based on user-defined rules. Any number of drawings may be created, containing general notes, plan views, sections, elevations, tables, and schedules. Drawings may be printed directly from ETABS or exported to DXF or DWG files for further

1.10 Output and Display Options

- General Notes
- Beam & Column Sections
- Floor Framing Plans
- Column Schedules
- Beam Schedules
- Connection Schedules
- Column Layout
- Wall Layout
- Wall Reinforcement Plans & Elevations

The ETABS model and the results of the analysis and design can be viewed and saved in many different ways, including:

- Two- and three-dimensional views of the model
- Customizable user defined reports
- Input/output data values in plain text, spreadsheet, or database format
- Function plots of analysis results
- Design sheets
- Story data for import into SAFE®
- Export to other drafting and design programs

Named definitions of display views and function plots can be saved as part of a model. Combined with the use of groups, this can significantly speed up the process of getting results as the modeling is being developed.

1.11 Overview

The innovative and revolutionary new ETABS is the ultimate integrated software package for the structural analysis and design of buildings. Incorporating 40 years of continuous research and development, this latest ETABS offers unmatched 3D object based modeling and visualization tools, blazingly fast linear and nonlinear analytical power, sophisticated and comprehensive design capabilities for a wide-range of materials, and insightful graphic displays, reports, and schematic drawings that allow users to quickly and easily decipher and understand analysis and design results.

From the start of design conception through the production of schematic drawings, ETABS integrates every aspect of the engineering design process. Creation of models has never been easier - intuitive drawing commands allow for the rapid generation of floor and elevation framing. CAD drawings can be converted directly into ETABS models or used as templates onto which ETABS objects may be overlaid. The state-of-the-art SAP Fire 64-bit solver allows extremely large and complex models to be rapidly analyzed, and supports nonlinear modeling techniques such as construction sequencing and time effects (e.g., creep and shrinkage).

Design of steel and concrete frames (with automated optimization), composite beams, composite columns, steel joists, and concrete and masonry shear walls is included, as is the capacity check for steel connections and base plates. Models may be realistically rendered, and all results can be shown directly on the structure. Comprehensive and customizable reports are available for all analysis and design output, and schematic construction drawings of framing plans, schedules, details, and cross-sections may be generated for concrete and steel structures

ETABS provides an unequaled suite of tools for structural engineers designing buildings, whether they are working on one-story industrial structures or the tallest commercial high-rises. Immensely capable, yet easy-to-use, has been the hallmark of ETABS since its introduction decades ago, and this latest release continues that tradition by providing engineers with the technologically-advanced, yet intuitive, software they require to be their most productive.

CHAPTER-2

LITERATURE REVIEW

U.P.B.C.Sekhar April (2017)

ETABS stands for Extended Three Dimensional Analysis of building systems. The main purpose of this software is to design multi-storeyed building in a systematic process. The effective design and construction of an earthquake resistant structures have great importance all over the world. This project presents multi-storeyed residential building analysed and designed with lateral loading effect of earthquake using ETABS. This project is designed as per INDIAN CODES-IS1893-part2:2002,IS 456:2000.This analysis is carried out by considering severe seismic zones and behaviour is assessed by talking type-II Soil condition.

k.Naga Sai Gopal and N.Lingeshwaran(2017)

We are living in the 21st century number of complex and irregular structure designed to resists the Earthquake, Wind needs to analyze, design the structure by the various software like ETABS, STAAD.Pro, TEKLA and to design the structure in the project we used the ETABS software due to company suggestion and to final stress analysis in slab ,shear force for the beam and area reinforcement for the column and design the foundation depends upon the reaction and height of the foundation level depends upon site and safe bearing capacity of the soil stability purpose designed the retaining wall in this project.

Puneet Mittal; Nishant Kad

All structures are analyzed & designed according codal requirements using manual calculations or by the use of many different analysis and design software like STAAD PRO, ETABS etc. But it has been found that it is difficult to perform manually, so to overcome this problem analyzing and designing is done by using software meant for this work.

International Research Journal of Engineering and Technology (IRJET) Volume: 04 Issue: 06 June-2017

Studied Analysis And Design Of Commercial Building Using ETABS Our project "Analysis and Design of residential building using ETABS software" is an attempt to analyze and design a residential building using ETABS. A G+20 storey building is considered for this study. Drawing and detailing are done using Auto CAD .

Seismic Analysis & Design of Multistory Building Using ETABS(International Journal of Engineering Development and Research(IJEDR), Volume 5, Issue 2 ,2017)

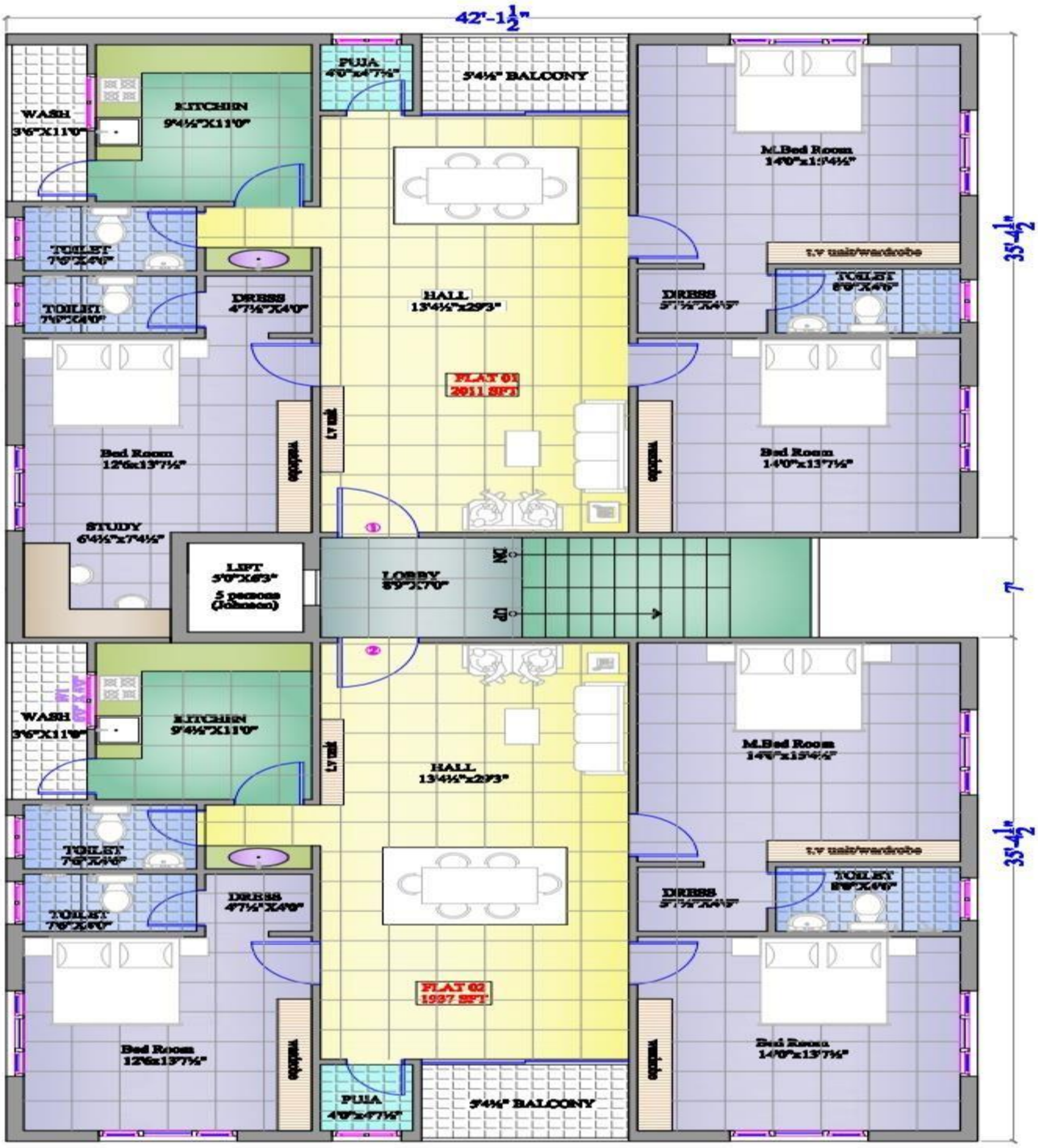
E-tabs are mostly used to analyze concrete& steel structure, low& high rise buildings, skyscrapers& portal frames structure. In this project we had studied structural behavior of multi-story building (G+20) on ETABS.

Seismic Analysis of Multistoried Building(International Journal of Engineering and Innovative Technology (IJEIT), Volume 4, Issue 9, March 2015)

In this paper, the earthquake response of symmetric multistoried building is studied by manual calculation and with the help of ETABS 9.7.1 software. The method includes seismic coefficient method as recommended by IS 1893:2002.

CHAPTER-3

plan



STILT FLOOR ------ PARKING

TOTAL BUA AREA IN 5 FLOORS 19740.0 SFT

FLOORS	FLAT -1	FLAT -2
FIRST FLOOR	2011 sft	1937 sft
SECOND FLOOR	2011 sft	1937 sft
THIRD FLOOR	2011 sft	1937 sft
FOURTH FLOOR	2011 sft	1937 sft
FIFTH FLOOR	2011 sft	1937 sft

PROJECT:
PROPOSED RESIDENCE
FOR Dr.DHANRAJ SONI
AT SRINAGAR COLONY

NO:	DATE:	REVISIONS:

TITLE: FLOOR PLAN FURNITURE LAYOUT

SCALE: | DEALT | DATE:

NORTH:

RAGA
ARCHITECTS
602, Swapnalok,
S.D.Road, Secunderabad
Tel: 27840295; 27845559
E-mail: raga_architects@yahoo.co.in

3.0 PLAN IN ETABS

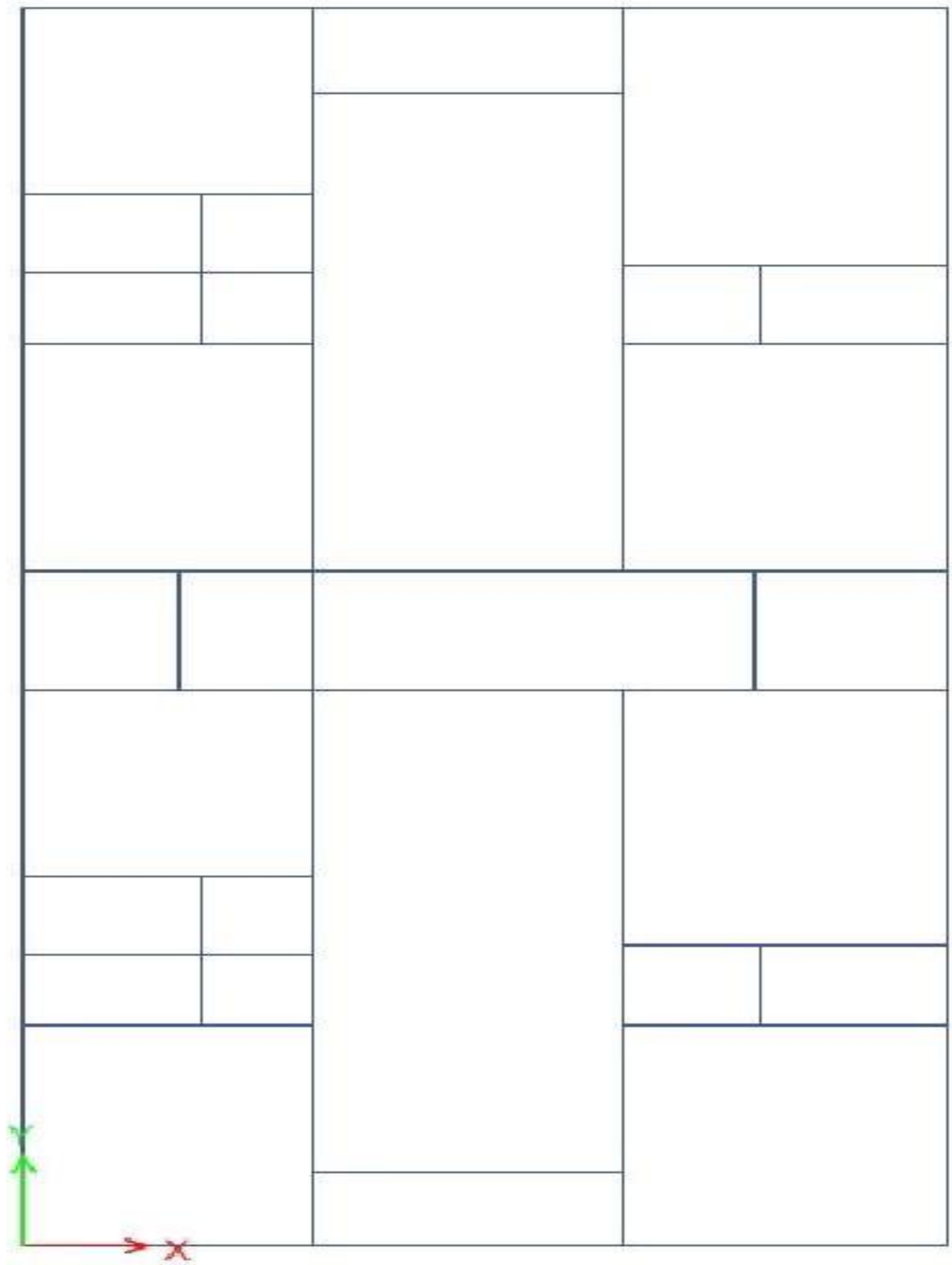


FIG -3.0
line diagram of a structure (building)

3.1 CENTERLINE DIAGRAM

Center line diagram of a structure (building)

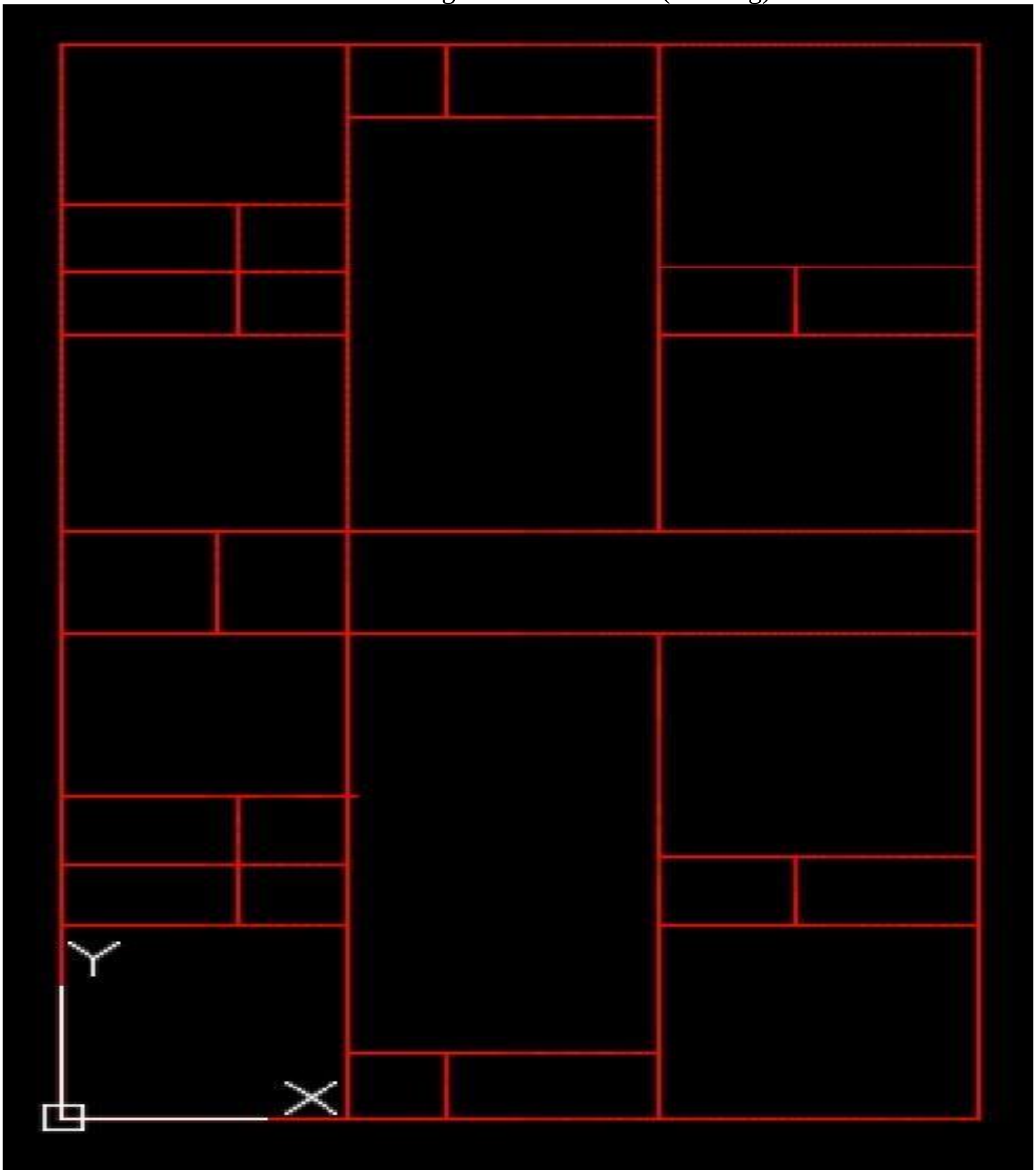
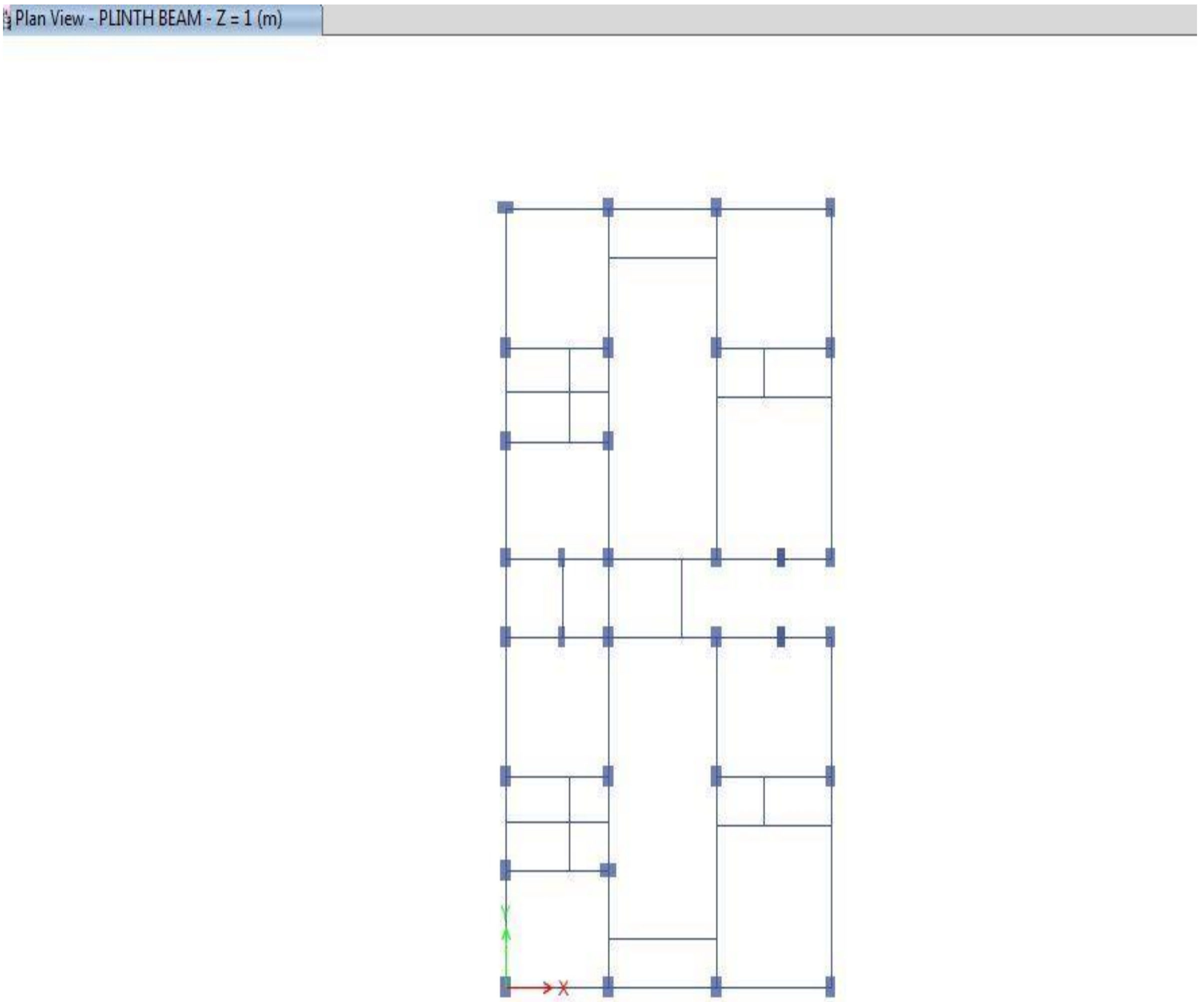


FIG – 3.1
Center line diagram of a structure (building)

3.2 PLINTH BEAM



3.3 CONCRETE MATERIAL

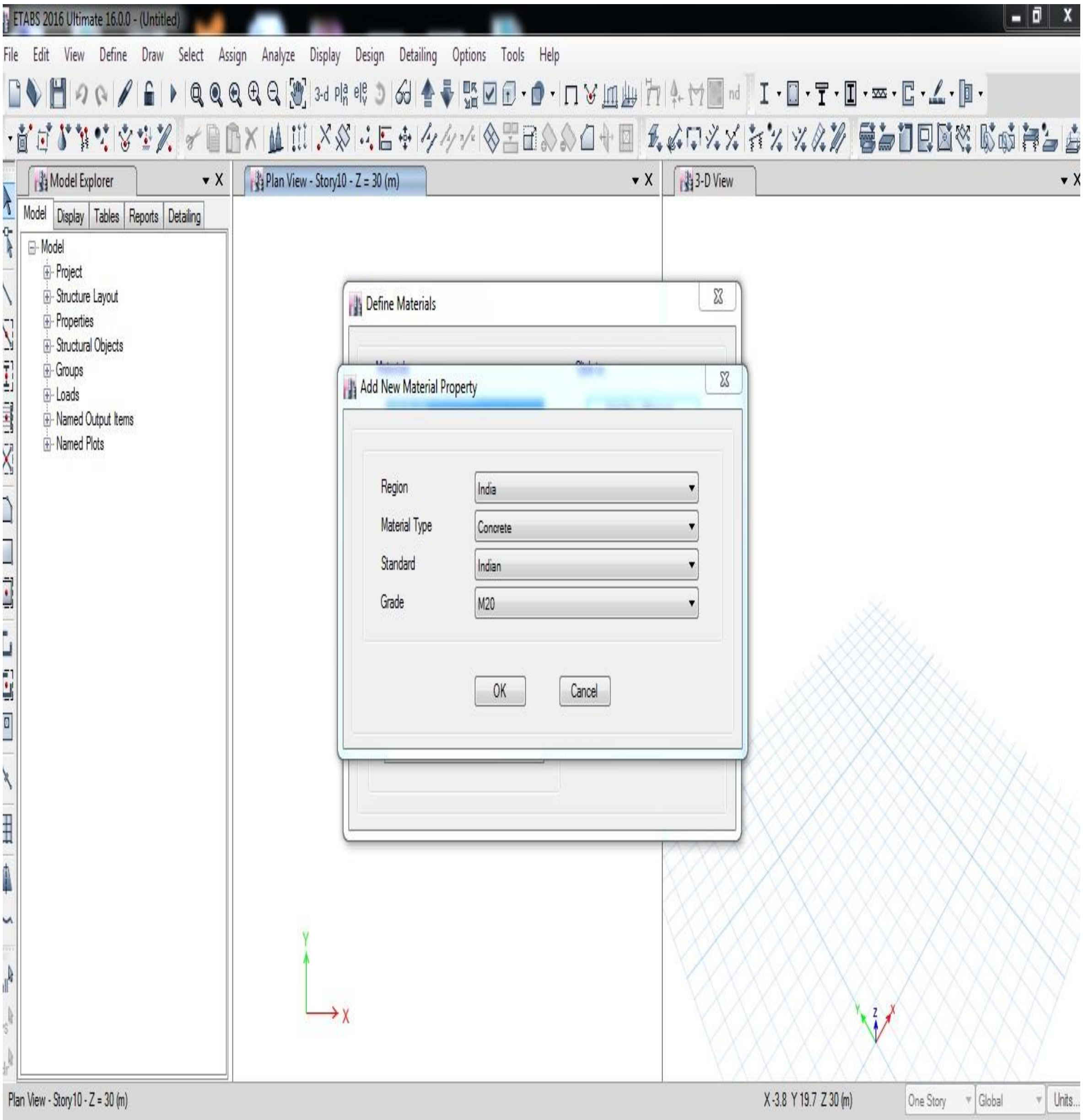


FIG -3.2
Defining the material properties in Etabs.

3.4 TOR STEEL HYSD 415

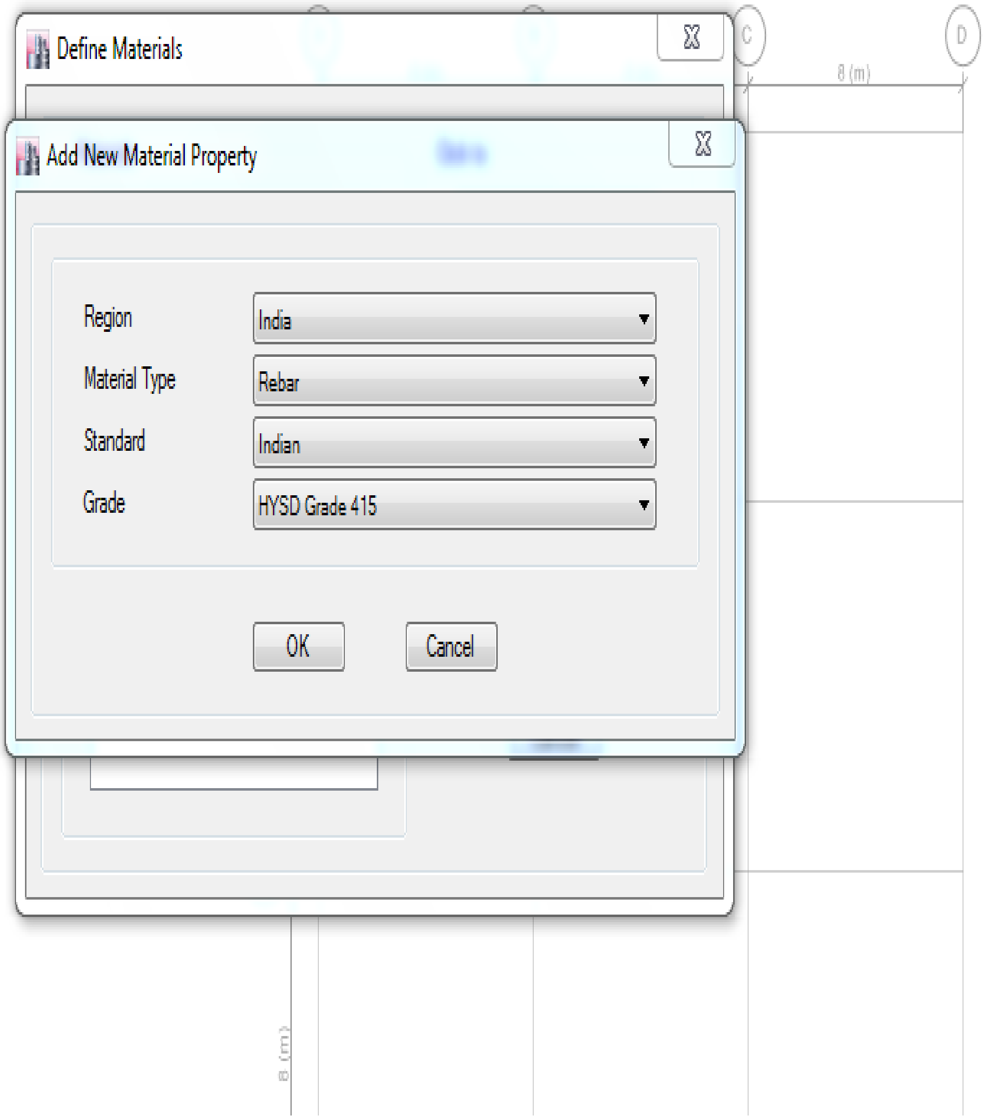


Fig: 3.3
Defining the main reinforcement material properties as per IS codes

3.5 MILD STEEL MILD GRADE 250

Defining the mid steel bars for the lateral reinforcement tie bars as per IS codes

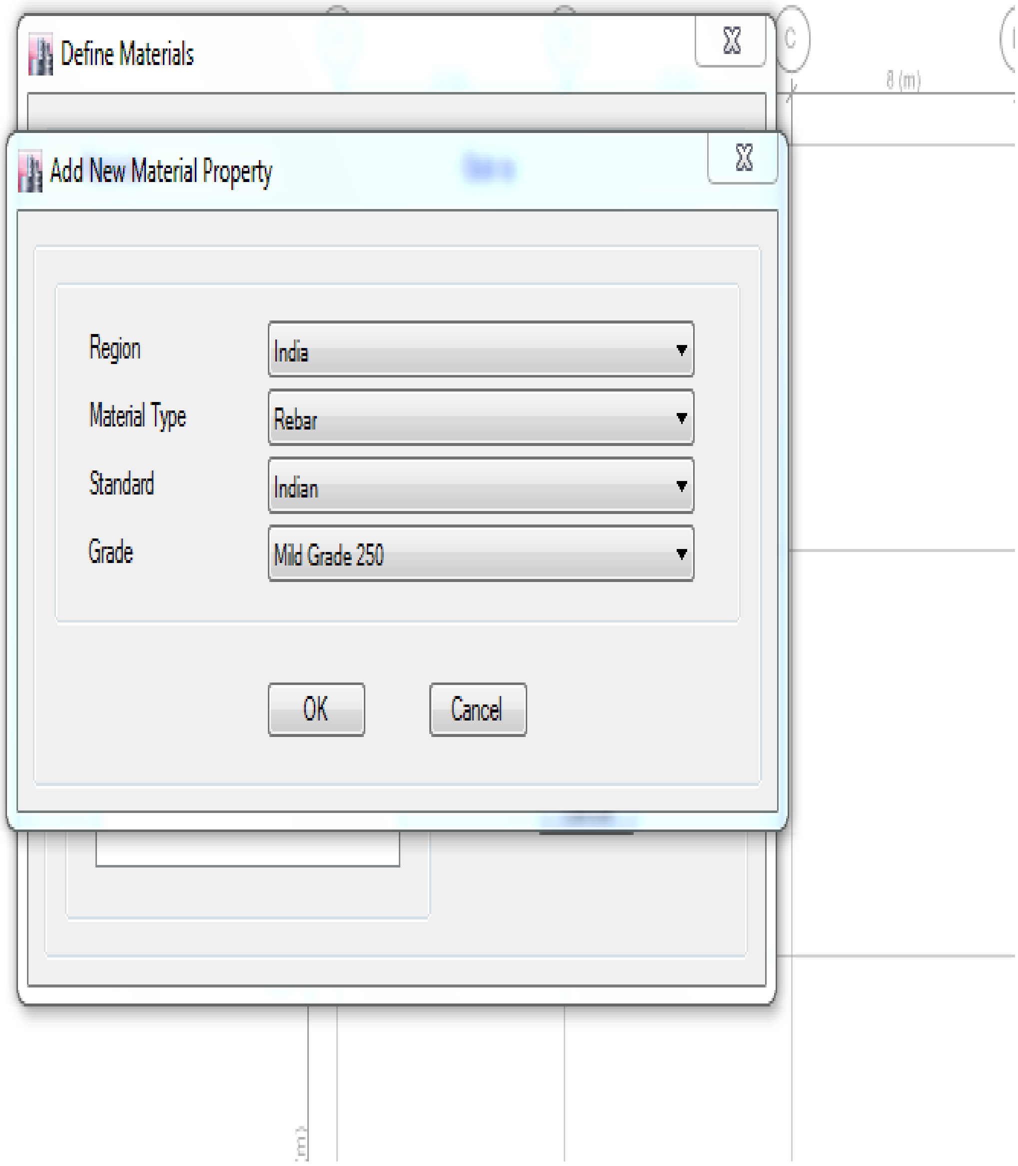


Fig: 3.4

Defining the mid steel bars for the lateral reinforcement tie bars as per IS codes

3.6 BEAMS, COLUMNS AND SLABS

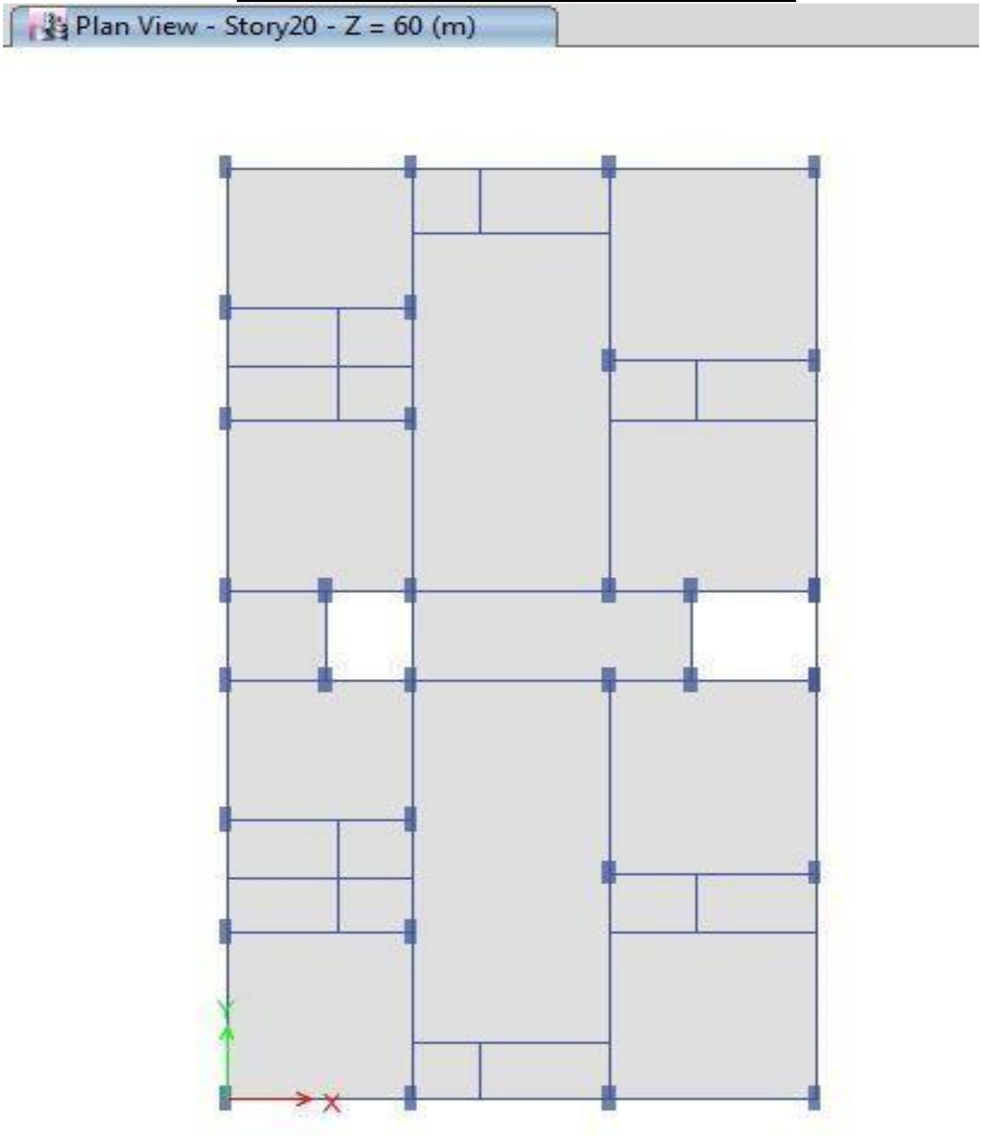


FIG -3.5
Assigning the beams, columns & slabs to the plan of the structure

3.7 3D VIEW

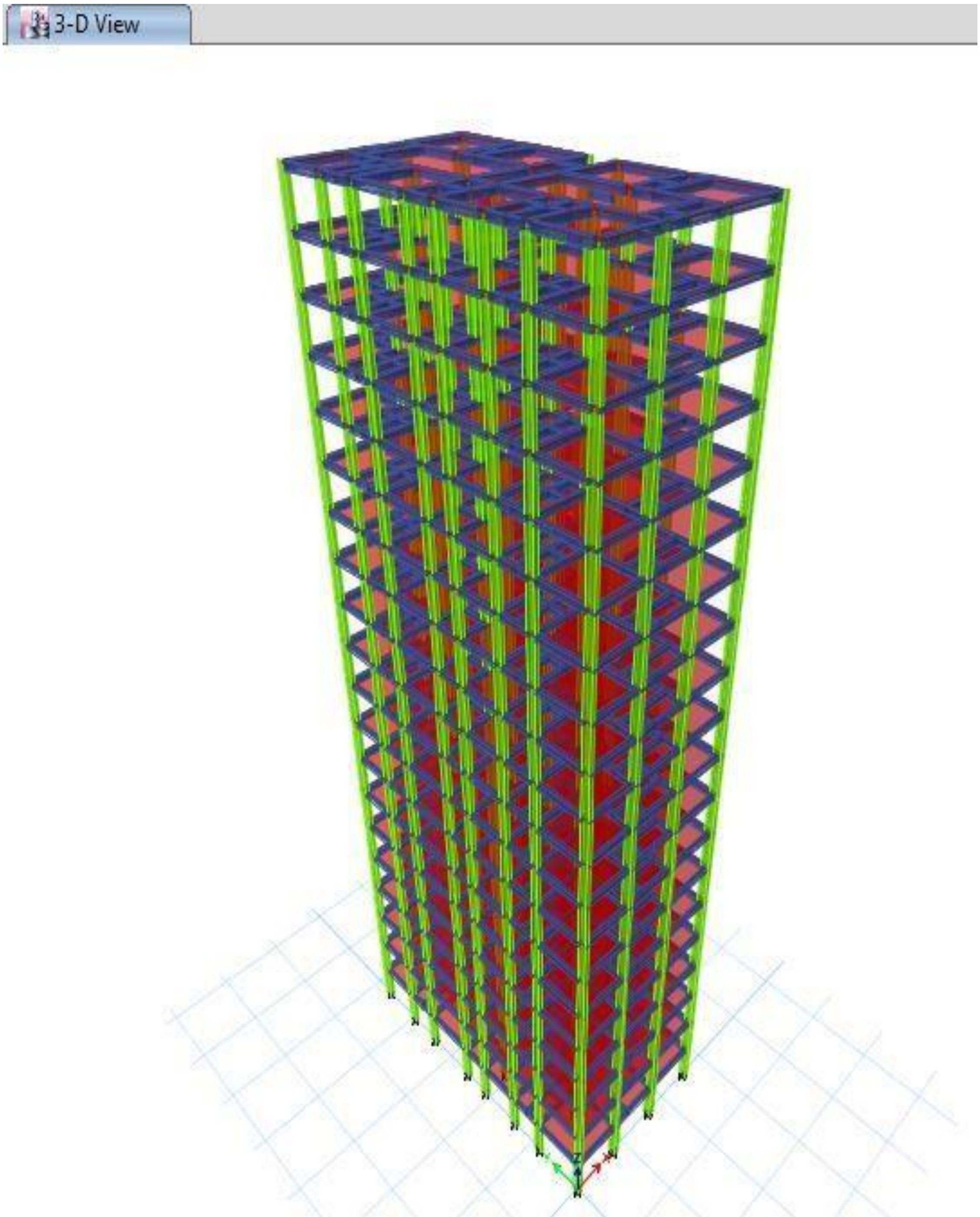


FIG -3.6

Detailing the structural components of a building

3.8 SUPPORTS

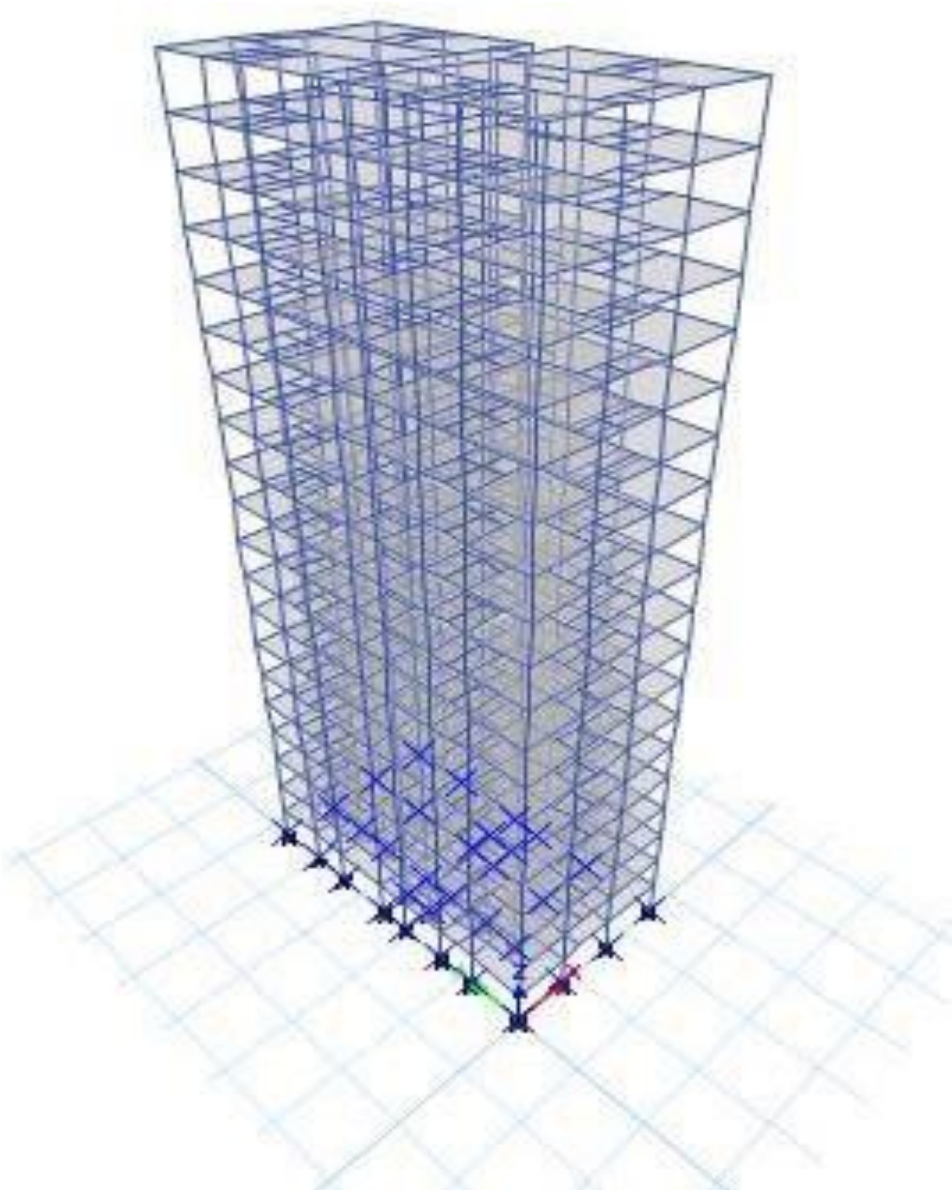


FIG-3.7
Fixed supports at base of the structure

3.9 LOADS

Application of loads

This combination of loads include beam load, column load and slab load

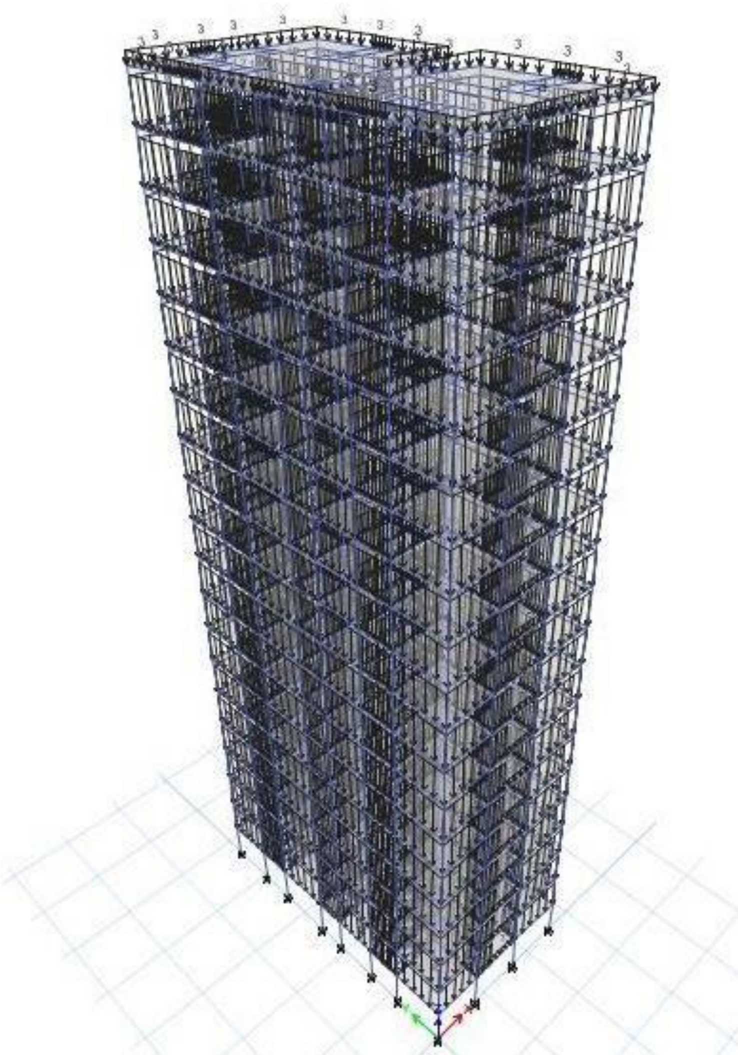


FIG-3.8

CHAPTER 4

LOADS CONSIDERED

4.1 DEAD LOADS(DL):

All permanent constructions of the structure form the dead loads. The dead load comprises of the self-weight, weight of walls, partitions floor finishes and the other permanent constructions in the buildings. The loads considered in this project are as per IS 456 2000.

4.2 LIVE LOAD(LL):

Live load or imposed load is defined as the load on the structure due to moving weight. Imposed load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. Imposed loads do not include loads due to wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo.

4.3 WIND LOAD CALCULATION

Wind is air in motion relative to the surface of the earth. The primary cause of wind is traced to earth's rotation and differences in terrestrial radiation. The radiation effects are primarily responsible for convection either upwards or downwards. The wind generally blows horizontal to the ground at high wind speeds. Since vertical components of atmospheric motion are relatively small, the term 'wind' denotes almost exclusively the horizontal wind, vertical winds are always identified as such. The wind speed is assessed with the aid of anemometers or anemographs.

BASIC WIND SPEED:

Basic wind speed is based on peak gust velocity averaged over a short time interval of about three seconds and corresponds to mean heights above ground level in an open terrain.
Basic wind speed given in figure1 in IS 875(part):1987.

DESIGN WIND SPEED:

The basic wind speed for any site is obtained from figure and shall be modified to include the following effects to get design wind velocity at any height shall be modified to include the following effects to get design wind velocity at any height(Vz) for the chosen structure:

$$V_z = V_b \times k_1 \times k_2 \times k_3$$

The suggested life period to be assumed in design and the corresponding k_1 factors for different structures for different class of structures given in table 1, IS 875(part):1987. k_2 is the terrain, Height and structure size factor given in table 2, IS 875(part):1987. k_3 is the topography factor given in table 3, IS 875(part):1987.

DESIGN WIND PRESSURE:

The design wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind velocity

$$P_z = 0.6 \times V_z^2$$

WIND FORCES:

The value of force coefficient apply to the building or structure as a whole and multiplied by effective frontal area of the building by design wind pressure, P_z gives the total wind load on that particular building or structure. The force coefficients are given in two mutually perpendicular directions relative to reference axis of the structural member. They are designed as C_{pn} and C_{pt}, give the normal and transverse, respectively to the reference plane

4.4 SEISMIC LOAD CALCULATION (Based on code IS 1893-2002)

During an earthquake, ground motions develop in a random manner both horizontally and vertically in all directions radiating from the epicenter. The ground motions develop vibrations in the structure inducing inertial forces on them. Hence structures located in seismic zones should be suitably designed and detailed to ensure strength, serviceability and stability with acceptable levels of safety under seismic forces.

The satisfactory performance of a large number of reinforced concrete structures subject to severe earthquake in various parts of the world has demonstrated that it is possible to design structures to successfully withstand the destructive effects of major earthquakes.

The Indian standard codes IS: 1893-1984 and IS: 13920-1993 have specified the minimum design requirements of earthquake resistant design probability of occurrence of earthquakes, the characteristics of the structure and the foundation and the acceptable magnitude of damage.

Determination of design earthquake forces is computed by the following methods,

1) Equivalent static lateral loading.

2) Dynamic Analysis.

In the first method, different partial safety factors are applied to dead, live, wind earthquake forces to arrive at the design ultimate load. In the IS: 456-2000 code, while considering earthquake effects, wind loads assuming that both severe wind and earthquake do not act simultaneously. The American and Australian code recommendations are similar but with different partial safety factors.

The dynamic analysis involves the rigorous analysis of the structural system by studying the dynamic response of the structure by considering the total response in terms of component modal responses.

4.4.1 ZONE FACTOR (Z):

The values of peak ground acceleration given in units 'g' for the maximum considered earthquake.

- The value of (Z/2) corresponds to design basis earthquake damage control in limit state.
- Based on history of seismic activities seism tectonic understanding the entire country has been divided in to four zones. The zone factor from table 2(IS 1893:2002)

Zone factor values- **Table 4.4.1**

Seismic zone	II	III	IV	V
Seismic Intensity	Low	Moderate	Severe	Very severe
Z	0.10	0.16	0.24	0.36

4.4.2 RESPONSE REDUCTION FACTOR (R):

- R is the response reduction factor and controls the permitted damage in design basis earthquake.
- The minimum value of R is 3 and maximum is 5 however to use higher values of R special ductile detailing requirements are must and the designer is accepting more damages but in the controlled manner. The Response reduction factor from table 7(IS 1893:2002)

4.5 IMPORTANCE FACTOR (I):

- I is the importance factor and permitted damage could be reduced by setting the value of I more than '1'.

- For the buildings like **'HOSPITALS'**, communication and community buildings the value is 1.5 from table 6 (IS 1893:2002).

4.6 SEISMIC WEIGHT (W):

- Seismic weight of the building is measured in Newton. Seismic weight includes the dead loads (that of floor, slabs, finishes, columns, beams, water tanks, permanent machines etc.

Seismic weight includes only a part of Imposed loads, for example 25% to 50% of imposed loads for buildings from table 8 (IS1893:2002)

4.7 SOIL CLASSIFICATION:

- Sa/g is the lateral acceleration to be established in m/s^2. For 5 present of damping three different types of curves are recommended in IS 1893:2002 for different stiffness of supporting media-Rock, Medium soil and Soft soil.

- The classification of soil is based on the average shear velocity for 30m of rock or soil layers or based on average Standard Penetration Test (SPT) values for top 30m.

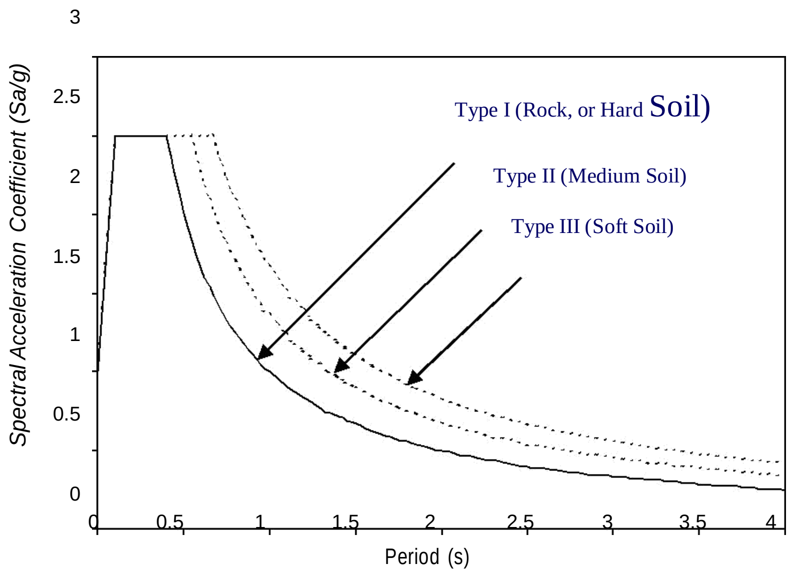


FIG-3.7 soil classification graph

4.8 BUILDING BYE LAWS:

Building bye laws set standards for building work. There aim is to ensure the health and safety of people around the building by setting requirements for building design and construction. The bye laws also promote energy efficiency and aim to improve access for disable people.

- Line of building frontage and minimum plot sizes.
- Open spaces around residential buildings.
- Minimum standard dimensions of building elements.
- Provisions of lighting and ventilation.
- Provisions for means of access.
- Provisions of safety from fire and explosion.
- Provisions for drainage and sanitation.
- Provisions for safety of works against hazard or accidents.
- Requirements for off street parking spaces.
- Requirements for green belt and landscaping.
- Minimum width provision for passage way or corridors for

    - Individual residential buildings -1.00m.
    - Other residential buildings, e.g. Hotels, Group housing etc., -2.00m.
    - Maximum size of plot of a residential building is 6000sq.m.

4.9 Analysis Using ETABS:

The procedure carried out for modeling and analyzing the structure involves the following steps:

Step-1: Create a plan in AUTOCAD. Select new model and a window appears then we had to select blank page and import plan from AUTOCAD to ETABS.

Step-2:Defining of material properties . we had first defined the material property by selecting define menu, new material for our structural components by giving the specified details in defining. After that we define section size by selecting frame section for beams, columns etc.

Step-3:After defining the property we draw beams and create columns in region for columns by which property assigning is completed for beams and columns.

Step-4: By keeping the selection at the base of the structure and selecting all the columns we assigned fixed supports.

Step-5:In ETABS all the load considerations are first defined and then assigned. The loads in ETABS are defined as using static load cases command in define menu.

Step-6:After defining all the loads, dead loads are assigned including floor finishing.

Step-7:Live loads are assigned for the entire structure.

Step-8: Seismic loads are assigned as per IS 1893:2002 by giving zone, soil type and response reduction factor in X and Y directions.

Step-9:After completion of all the above steps we have performed the analysis and checked for errors.

CHAPTER 5

ANALYSIS AND RESULTS

5.0 BENDING MOMENT OF STRUCTURE

bending moment of structure.

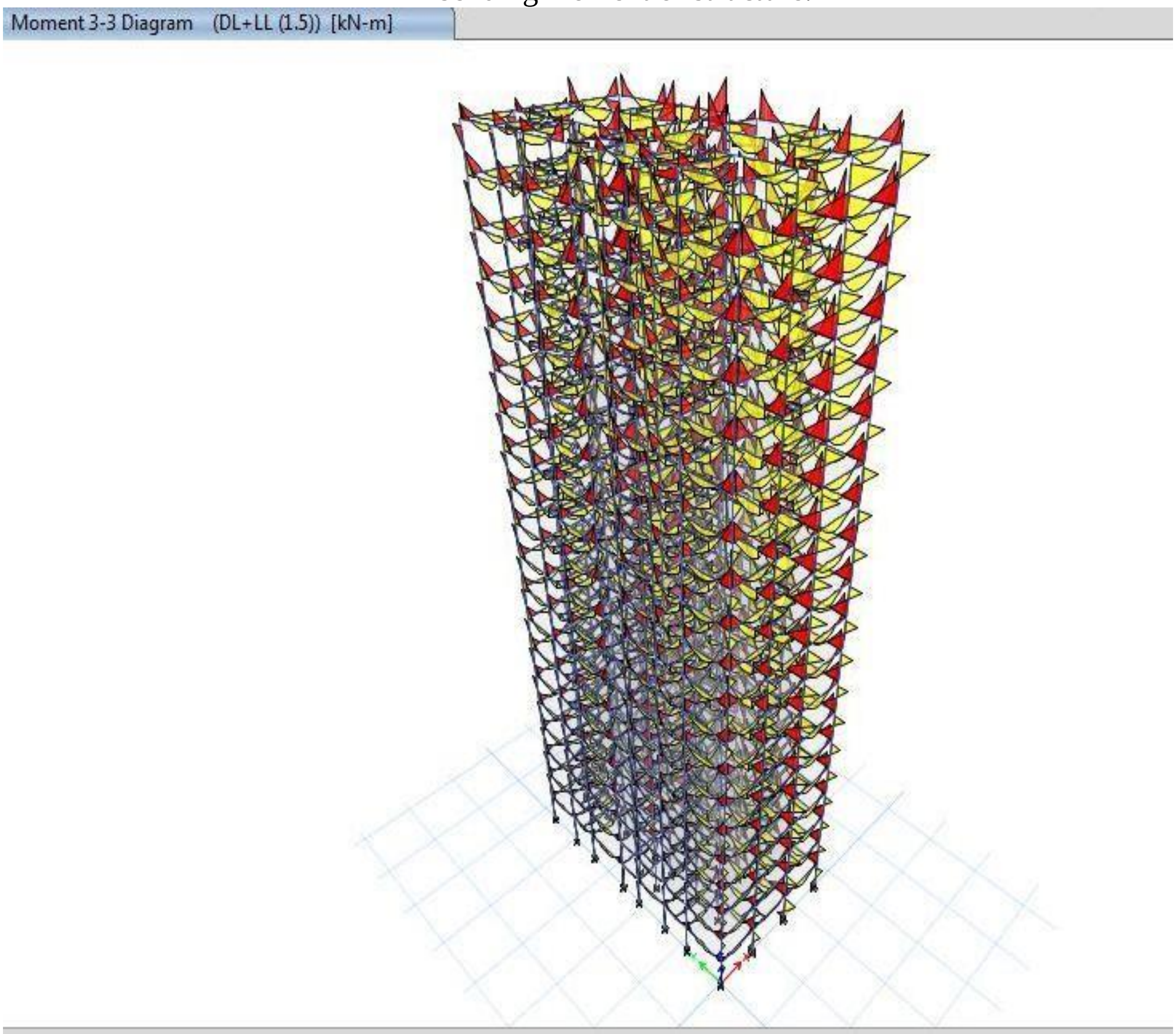


FIG-5.0
Bending moment of structure

5.1 SHEAR FORCE OF STRUCTURE

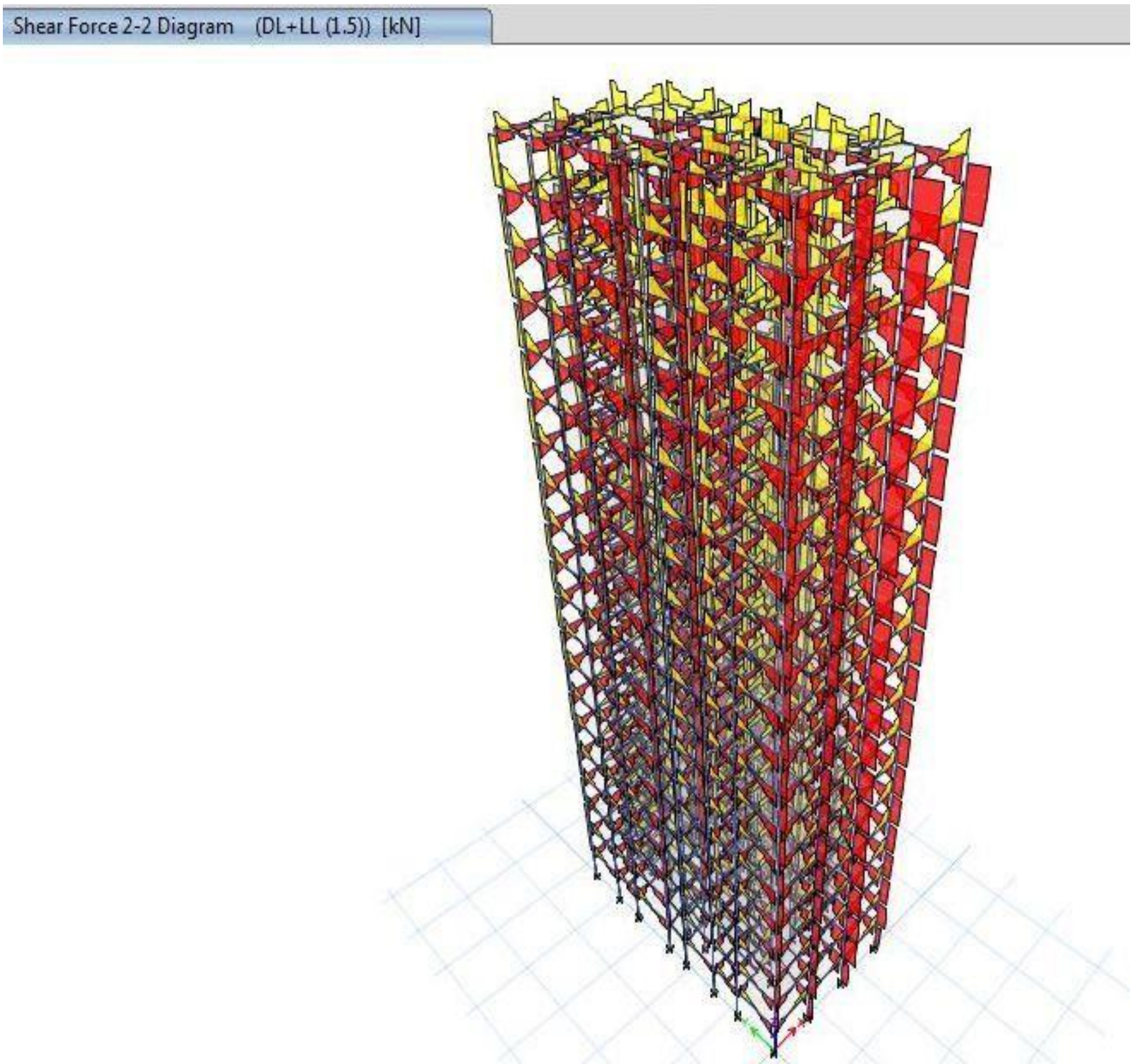


FIG-5.1
Shear force of the structure.

5.2 SHEAR OF THE STRUCTURE

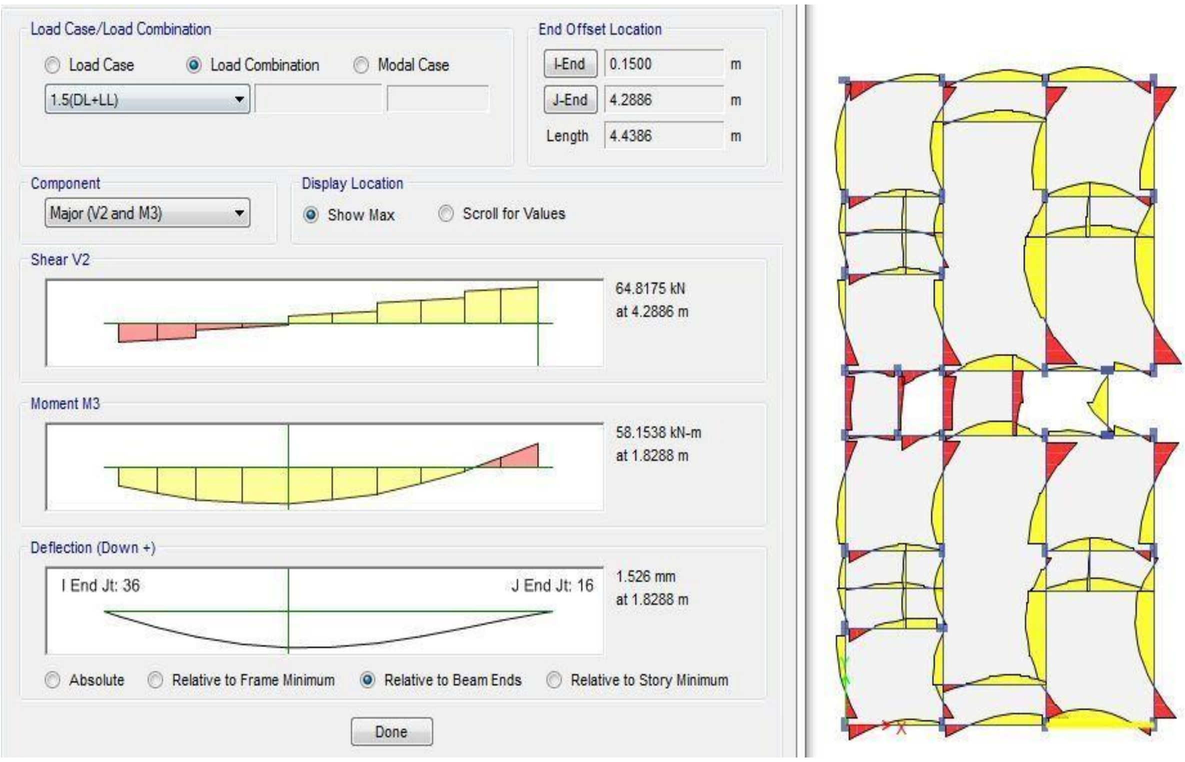


FIG-5.2

.

5.3 Structure Data

This chapter provides model geometry information, including items such as story levels, point coordinates, and element connectivity.

5.3.1 Story Data

Table 5.3.1 - Story Data

Name	Height mm	Elevation mm	Master Story	Similar To	Splice Story
Story20	3000	60000	Yes	None	No
Story19	3000	57000	Yes	None	No
Story18	3000	54000	Yes	None	No
Story17	3000	51000	Yes	None	No
Story16	3000	48000	Yes	None	No
Story15	3000	45000	Yes	None	No
Story14	3000	42000	Yes	None	No
Story13	3000	39000	Yes	None	No
Story12	3000	36000	Yes	None	No
Story11	3000	33000	Yes	None	No
Story10	3000	30000	Yes	None	No
Story9	3000	27000	No	Story10	No
Story8	3000	24000	No	Story10	No
Story7	3000	21000	No	Story10	No
Story6	3000	18000	No	Story10	No
Story5	3000	15000	No	Story10	No
Story4	3000	12000	No	Story10	No
Story3	3000	9000	No	Story10	No
Story2	3000	6000	No	Story10	No
Story1	3000	3000	No	Story10	No
Base	0	0	No	None	No

5.4 Loads

This chapter provides loading information as applied to the model.

5.4.1 Load Patterns

Table 5.4.1 - Load Patterns

Name	Type	Self Weight Multiplier	Auto Load
Dead	Dead	1	
Live	Live	0	
wl x	Wind	0	Indian IS875:1987
wl y	Wind	0	Indian IS875:1987
EQ X	Seismic	0	IS1893 2002
EQ Y	Seismic	0	IS1893 2002

5.4.2 Load Cases

Table 5.4.2 - Load Cases

Name	Type
Dead	Linear Static
Live	Linear Static
wl x	Linear Static
wl y	Linear Static
EQ X	Linear Static
EQ Y	Linear Static

5.4.3 Auto Wind Loading

Indian IS875:1987 Auto Wind Load Calculation

This calculation presents the automatically generated lateral wind loads for load pattern wl x according to Indian IS875:1987, as calculated by ETABS.

Exposure Parameters

Exposure From = Diaphragms

Structure Class = Class B

Terrain Category = Category 3

Wind Direction = 0 degrees

Basic Wind Speed, V_b [IS Fig. 1] $V_b = 44 \frac{meter}{sec}$

Windward Coefficient, $C_{p,wind}$ $C_{p,wind} = 0.8$

Leeward Coefficient, $C_{p,lee}$ $C_{p,lee} = 0.5$

Top Story = Story20

Bottom Story = Base

Include Parapet = No

Factors and Coefficients

Risk Coefficient, k_1 [IS 5.3.1] $k_1 = 1$

Topography Factor, k_3 [IS 5.3.3] $k_3 = 1$

Lateral Loading

Design Wind Speed, V_z [IS 5.3] $V_z = V_b k_1 k_2 k_3$ $V_z = 48.65872$

Design Wind Pressure, p_z [IS 5.4] $p_z = 0.6 V_z^2$

APPLIED STORY FORCES

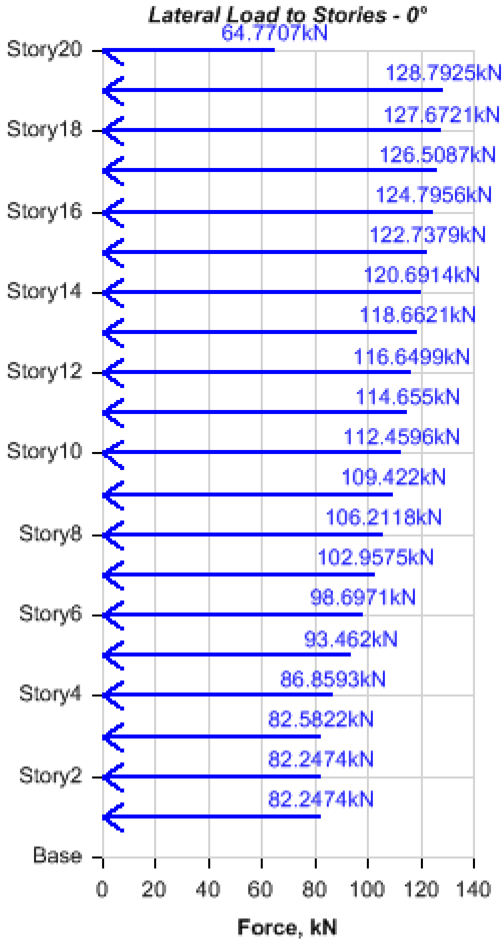


FIG-5.4.3

APPLICATION OF WIND LOADS:

Table 5.4.4 wind load

Story	Elevation m	X-Dir kN	Y-Dir kN
Story20	60	64.7707	0
Story19	57	128.7925	0
Story18	54	127.6721	0
Story17	51	126.5087	0
Story16	48	124.7956	0
Story15	45	122.7379	0
Story14	42	120.6914	0
Story13	39	118.6621	0
Story12	36	116.6499	0
Story11	33	114.655	0
Story10	30	112.4596	0
Story9	27	109.422	0
Story8	24	106.2118	0
Story7	21	102.9575	0
Story6	18	98.6971	0
Story5	15	93.462	0
Story4	12	86.8593	0
Story3	9	82.5822	0
Story2	6	82.2474	0
Story1	3	82.2474	0
Base	0	0	0

5.4.4 Wind loads :

Indian IS875:1987 Auto Wind Load Calculation

This calculation presents the automatically generated lateral wind loads for load pattern wl y according to Indian IS875:1987, as calculated by ETABS.

Exposure Parameters

Exposure From = Diaphragms

Structure Class = Class B

Terrain Category = Category 3

Wind Direction = 90 degrees

Basic Wind Speed, V_b [IS Fig. 1] $V_b = 44 \frac{\text{meter}}{\text{sec}}$

Windward Coefficient, $C_{p,wind}$ $C_{p,wind} = 0.8$

Leeward Coefficient, $C_{p,lee}$ $C_{p,lee} = 0.5$

Top Story = Story20

Bottom Story = Base

Include Parapet = No

Factors and Coefficients

Risk Coefficient, k_1 [IS 5.3.1] $k_1 = 1$

Topography Factor, k_3 [IS 5.3.3] $k_3 = 1$

Lateral Loading

Design Wind Speed, V_z [IS 5.3] $V_z = V_b k_1 k_2 k_3$ $V_z = 48.65872$

Design Wind Pressure, p_z [IS 5.4] $p_z = 0.6 V_z^2$

APPLIED STORY FORCES

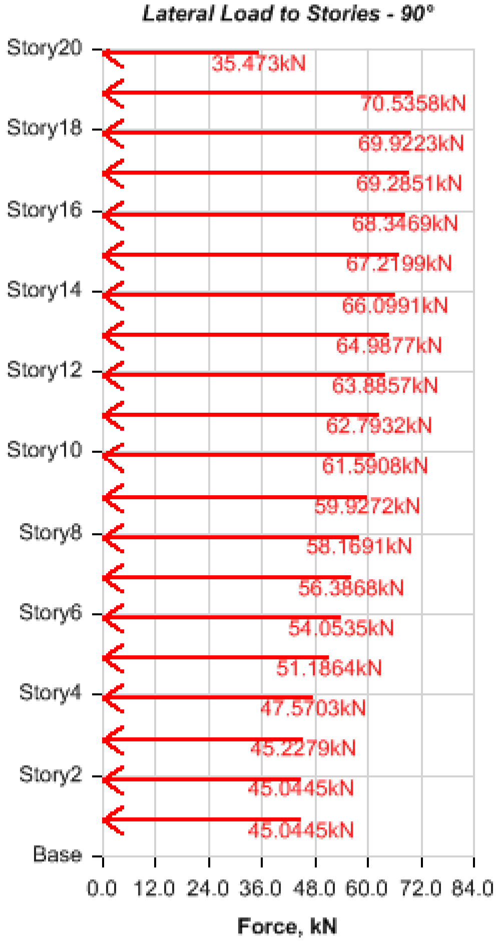


FIG-5.4.4

APPLICATION OF WIND LOADS

Table 5.4.5

Story	Elevation m	X-Dir kN	Y-Dir kN
Story20	60	0	35.473
Story19	57	0	70.5358
Story18	54	0	69.9223
Story17	51	0	69.2851
Story16	48	0	68.3469
Story15	45	0	67.2199
Story14	42	0	66.0991
Story13	39	0	64.9877
Story12	36	0	63.8857
Story11	33	0	62.7932
Story10	30	0	61.5908
Story9	27	0	59.9272
Story8	24	0	58.1691
Story7	21	0	56.3868
Story6	18	0	54.0535
Story5	15	0	51.1864
Story4	12	0	47.5703
Story3	9	0	45.2279
Story2	6	0	45.0445
Story1	3	0	45.0445
Base	0	0	0

5.5 Seismic loads

IS1893 2002 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern EQ X according to IS1893 2002, as calculated by ETABS.

Direction and Eccentricity

Direction = Multiple

Eccentricity Ratio = 5% for all diaphragms

Structural Period

Period Calculation Method = Program Calculated

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 2] $Z = 0.1$

Response Reduction Factor, R [IS Table 7] $R = 3$

Importance Factor, I [IS Table 6] $I = 1$

Site Type [IS Table 1] = II

Seismic Response

Spectral Acceleration Coefficient, S_a /g [IS 6.4.5] $\frac{S_a}{g} = \frac{1.36}{T}$ $\frac{S_a}{g} = 0.50022$

Equivalent Lateral Forces

Seismic Coefficient, A_h [IS 6.4.2] $A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
X	2.719	35388.2708	295.0322
X + Ecc. Y	2.719	35388.2708	295.0322
X - Ecc. Y	2.719	35388.2708	295.0322

Applied story forces

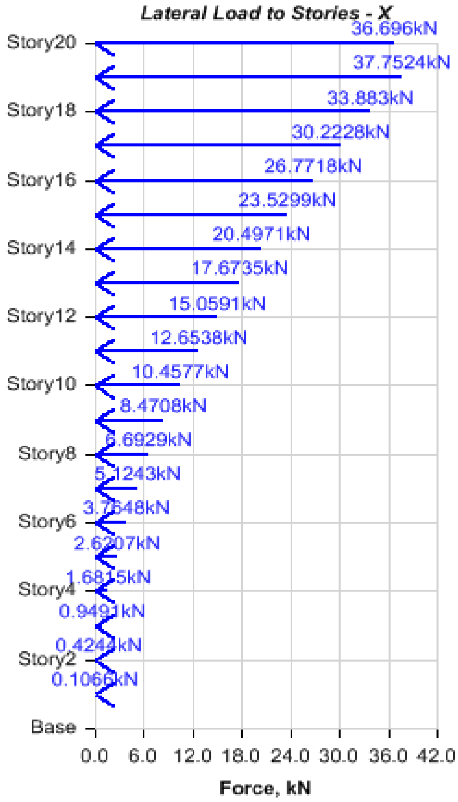


FIG-5.5

APPLICATION OF LOADS

Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story20	60	36.696	0
Story19	57	37.7524	0
Story18	54	33.883	0
Story17	51	30.2228	0
Story16	48	26.7718	0
Story15	45	23.5299	0
Story14	42	20.4971	0
Story13	39	17.6735	0
Story12	36	15.0591	0
Story11	33	12.6538	0
Story10	30	10.4577	0
Story9	27	8.4708	0
Story8	24	6.6929	0
Story7	21	5.1243	0
Story6	18	3.7648	0
Story5	15	2.6207	0
Story4	12	1.6815	0
Story3	9	0.9491	0
Story2	6	0.4244	0
Story1	3	0.1066	0
Base	0	0	0

The above table 5.5

IS1893 2002 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern EQ Y according to IS1893 2002, as calculated by ETABS.

Direction and Eccentricity

Direction = Multiple

Eccentricity Ratio = 5% for all diaphragms

Structural Period

Period Calculation Method = Program Calculated

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 2] $Z = 0.1$
Response Reduction Factor, R [IS Table 7] $R = 3$
Importance Factor, I [IS Table 6] $I = 1$
Site Type [IS Table 1] = II

Seismic Response

Spectral Acceleration Coefficient, S_a /g [IS 6.4.5] $\frac{S_a}{g} = \frac{1.36}{T}$ $\frac{S_a}{g} = 0.50022$

Equivalent Lateral Forces

Seismic Coefficient, A_h [IS 6.4.2] $A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
Y	2.048	35388.2708	391.612
Y + Ecc. X	2.048	35388.2708	391.612
Y - Ecc. X	2.048	35388.2708	391.612

Applied Story Forces

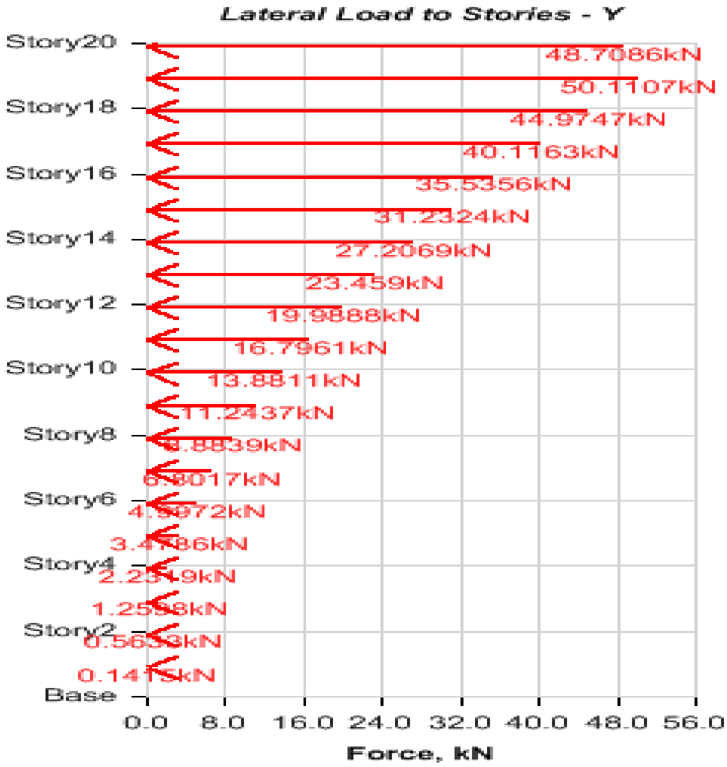

Lateral Load to Stories - Y
Story20
Story18
Story16
Story14
Story12
Story10
Story8
Story6
Story4
Story2
Base
48.7086kN
50.1107kN
44.9747kN
40.1163kN
35.5356kN
31.2324kN
27.2069kN
23.459kN
19.9888kN
16.7961kN
13.8811kN
11.2437kN
0.0
8.0
16.0
24.0
32.0
40.0
48.0
56.0
Force, kN

FIG-5.5.1

Table 5.5.2 Application of loads

Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story20	60	0	48.7086
Story19	57	0	50.1107
Story18	54	0	44.9747
Story17	51	0	40.1163
Story16	48	0	35.5356
Story15	45	0	31.2324
Story14	42	0	27.2069
Story13	39	0	23.459
Story12	36	0	19.9888
Story11	33	0	16.7961
Story10	30	0	13.8811
Story9	27	0	11.2437
Story8	24	0	8.8839
Story7	21	0	6.8017
Story6	18	0	4.9972
Story5	15	0	3.4786
Story4	12	0	2.2319
Story3	9	0	1.2598
Story2	6	0	0.5633
Story1	3	0	0.1415
Base	0	0	0

5.6 Structure Data

This chapter provides model geometry information, including items such as story levels, point coordinates, and element connectivity.

5.6.1 Story Data

Table 5.6.1 - Story Data

Name	Height mm	Elevation mm	Master Story	Similar To	Splice Story
Story20	3000	60000	Yes	None	No
Story19	3000	57000	Yes	None	No
Story18	3000	54000	Yes	None	No
Story17	3000	51000	Yes	None	No
Story16	3000	48000	Yes	None	No
Story15	3000	45000	Yes	None	No
Story14	3000	42000	Yes	None	No
Story13	3000	39000	Yes	None	No
Story12	3000	36000	Yes	None	No
Story11	3000	33000	Yes	None	No
Story10	3000	30000	Yes	None	No
Story9	3000	27000	No	Story10	No
Story8	3000	24000	No	Story10	No
Story7	3000	21000	No	Story10	No
Story6	3000	18000	No	Story10	No
Story5	3000	15000	No	Story10	No
Story4	3000	12000	No	Story10	No
Story3	3000	9000	No	Story10	No
Story2	3000	6000	No	Story10	No
Story1	3000	3000	No	Story10	No
Base	0	0	No	None	No

5.7 Loads

This chapter provides loading information as applied to the model.

5.7.1 Load Patterns

Table5.7.1 - Load Patterns

Name	Type	Self Weight Multiplier	Auto Load
Dead	Dead	1	
Live	Live	0	
wl x	Wind	0	Indian IS875:1987
wl y	Wind	0	Indian IS875:1987
EQ X	Seismic	0	IS1893 2002
EQ Y	Seismic	0	IS1893 2002

5.7.2 Load Cases

Table 5.7.2 - Load Cases - Summary

Name	Type
Dead	Linear Static
Live	Linear Static
wl x	Linear Static
wl y	Linear Static
EQ X	Linear Static
EQ Y	Linear Static

5.8 Analysis Results

This chapter provides analysis results.

5.8.1 Story Results

Table 5.8.1- Story Max/Avg Displacements

Story	Load Case/Combo	Direction	Maximum mm	Average mm	Ratio
Story20	Dead	X	11.209	9.895	1.133
Story20	Dead	Y	5.061	4.341	1.166
Story19	Dead	X	10.353	9.124	1.135
Story19	Dead	Y	4.68	4.006	1.168
Story18	Dead	X	9.501	8.36	1.136
Story18	Dead	Y	4.292	3.667	1.17
Story17	Dead	X	8.658	7.606	1.138
Story17	Dead	Y	3.906	3.33	1.173
Story16	Dead	X	7.83	6.865	1.14
Story16	Dead	Y	3.526	2.998	1.176
Story15	Dead	X	7.02	6.141	1.143
Story15	Dead	Y	3.154	2.673	1.18
Story14	Dead	X	6.233	5.439	1.146
Story14	Dead	Y	2.794	2.359	1.184
Story13	Dead	X	5.474	4.761	1.15
Story13	Dead	Y	2.446	2.056	1.19
Story12	Dead	X	4.746	4.111	1.154
Story12	Dead	Y	2.114	1.767	1.197
Story11	Dead	X	4.054	3.495	1.16
Story11	Dead	Y	1.8	1.494	1.205
Story10	Dead	X	3.404	2.917	1.167
Story10	Dead	Y	1.506	1.24	1.215
Story9	Dead	X	2.798	2.379	1.176
Story9	Dead	Y	1.235	1.005	1.229
Story8	Dead	X	2.238	1.882	1.189
Story8	Dead	Y	0.987	0.792	1.246
Story7	Dead	X	1.73	1.433	1.207
Story7	Dead	Y	0.766	0.604	1.269
Story6	Dead	X	1.278	1.035	1.234
Story6	Dead	Y	0.574	0.441	1.301
Story5	Dead	X	0.886	0.693	1.279
Story5	Dead	Y	0.412	0.306	1.346
Story4	Dead	X	0.539	0.396	1.364
Story4	Dead	Y	0.274	0.195	1.404
Story3	Dead	X	0.277	0.179	1.547
Story3	Dead	Y	0.165	0.111	1.485
Story2	Dead	X	0.131	0.074	1.766
Story2	Dead	Y	0.083	0.052	1.604
Story1	Dead	X	0.025	0.014	1.738
Story1	Dead	Y	0.016	0.01	1.562

Story	Load Case/Combo	Direction	Maximum mm	Average mm	Ratio
Story20	Live	X	2.842	2.67	1.064
Story20	Live	Y	1.007	0.912	1.103
Story19	Live	X	2.623	2.465	1.064
Story19	Live	Y	0.927	0.841	1.103
Story18	Live	X	2.406	2.262	1.064
Story18	Live	Y	0.847	0.768	1.103
Story17	Live	X	2.191	2.06	1.063
Story17	Live	Y	0.768	0.696	1.103
Story16	Live	X	1.98	1.863	1.063
Story16	Live	Y	0.69	0.626	1.103
Story15	Live	X	1.774	1.67	1.063
Story15	Live	Y	0.614	0.557	1.103
Story14	Live	X	1.574	1.482	1.062
Story14	Live	Y	0.541	0.49	1.103
Story13	Live	X	1.381	1.301	1.062
Story13	Live	Y	0.47	0.426	1.104
Story12	Live	X	1.196	1.127	1.061
Story12	Live	Y	0.403	0.365	1.104
Story11	Live	X	1.02	0.962	1.061
Story11	Live	Y	0.339	0.307	1.105
Story10	Live	X	0.854	0.805	1.061
Story9	Live	X	0.7	0.66	1.061
Story8	Live	Y	0.225	0.203	1.108
Story7	Live	X	0.557	0.525	1.061
Story5	Live	Y	0.176	0.159	1.111
Story4	Live	X	0.427	0.402	1.063
Story3	Live	Y	0.133	0.119	1.116
Story2	Live	X	0.312	0.292	1.066
Story1	Live	Y	0.095	0.085	1.124

Table 5.8.2 - Story Stiffness

Story	Load Case	Shear X kN	Drift X mm	Stiffness X kN/m	Shear Y kN	Drift Y mm	Stiffness Y kN/m
Story20	EQ X 1	36.696	0.773	47455.226	7.212E-07	0.004	0
Story19	EQ X 1	74.4484	0.96	77557.482	0	0.005	0
Story18	EQ X 1	108.3314	1.13	95838.338	0	0.005	0
Story17	EQ X 1	138.5542	1.283	108011.968	8.342E-07	0.005	0
Story16	EQ X 1	165.3259	1.416	116730.08	1.242E-06	0.006	0
Story15	EQ X 1	188.8558	1.531	123329.373	1.616E-06	0.006	0
Story14	EQ X 1	209.3529	1.628	128580.995	1.947E-06	0.006	0
Story13	EQ X 1	227.0265	1.707	132965.508	2.254E-06	0.006	0
Story12	EQ X 1	242.0856	1.77	136805.154	2.51E-06	0.006	0
Story11	EQ X 1	254.7394	1.815	140330.969	2.719E-06	0.006	0
Story10	EQ X 1	265.1971	1.849	143420.053	2.904E-06	0.006	0
Story9	EQ X 1	273.6679	1.868	146538.5	3.033E-06	0.006	0
Story8	EQ X 1	280.3608	1.871	149818.448	3.131E-06	0.006	0
Story7	EQ X 1	285.4851	1.861	153383.357	3.185E-06	0.006	0
Story6	EQ X 1	289.2499	1.832	157906.018	3.203E-06	0.006	0
Story5	EQ X 1	291.8706	1.773	164659.755	3.211E-06	0.006	0
Story4	EQ X 1	293.552	1.713	171367.797	3.18E-06	0.004	0
Story3	EQ X 1	294.5012	1.599	184232.379	2.935E-06	0.003	0
Story2	EQ X 1	294.9256	1.392	211826.795	3.074E-06	0.005	0
Story1	EQ X 1	295.0322	0.942	313296.407	3.109E-06	0.009	0
Story20	EQ X 2	36.696	0.758	48421.48	1.258E-05	0.021	0
Story19	EQ X 2	74.4484	0.932	79907.043	5.515E-06	0.032	0
Story18	EQ X 2	108.3314	1.095	98922.563	5.016E-07	0.043	0
Story17	EQ X 2	138.5542	1.253	110616.906	6.948E-06	0.051	0
Story16	EQ X 2	165.3259	1.391	118841.902	1.251E-05	0.058	0
Story15	EQ X 2	188.8558	1.511	124984.577	1.785E-05	0.065	0
Story14	EQ X 2	209.3529	1.613	129821.341	2.297E-05	0.071	0
Story13	EQ X 2	227.0265	1.696	133829.288	2.802E-05	0.075	0
Story12	EQ X 2	242.0856	1.763	137324.196	3.261E-05	0.079	0
Story11	EQ X 2	254.7394	1.813	140530.986	3.67E-05	0.083	0
Story10	EQ X 2	265.1971	1.846	143622.692	4.087E-05	0.085	0
Story9	EQ X 2	273.6679	1.865	146743.585	4.427E-05	0.087	0
Story8	EQ X 2	280.3608	1.869	150025.856	4.76E-05	0.088	0
Story7	EQ X 2	285.4851	1.859	153593.014	0.0001	0.089	0
Story6	EQ X 2	289.2499	1.836	157506.794	0.0001	0.089	0
Story5	EQ X 2	291.8706	1.772	164734.896	4.993E-05	0.088	0
Story4	EQ X 2	293.552	1.728	169857.6	0.0001	0.089	0
Story3	EQ X 2	294.5012	1.626	181133.52	0.0001	0.088	0
Story2	EQ X 2	294.9256	1.48	199338.951	0.0001	0.076	0
Story1	EQ X 2	295.0322	0.944	312553.475	0.0001	0.058	0
Story20	EQ X 3	36.696	0.75	48930.172	1.402E-05	0.029	0
Story19	EQ X 3	74.4484	0.923	80633.989	5.8E-06	0.039	0
Story18	EQ X 3	108.3314	1.099	98609.777	1.194E-06	0.05	0

Story	Load Case	Shear X kN	Drift X mm	Stiffness X kN/m	Shear Y kN	Drift Y mm	Stiffness Y kN/m
Story17	EQ X 3	138.5542	1.256	110277.475	8.617E-06	0.059	0
Story16	EQ X 3	165.3259	1.395	118484.895	1.5E-05	0.067	0
Story15	EQ X 3	188.8558	1.516	124614.936	2.109E-05	0.074	0
Story14	EQ X 3	209.3529	1.617	129442.033	2.687E-05	0.08	0
Story13	EQ X 3	227.0265	1.701	133442.182	3.253E-05	0.086	0
Story12	EQ X 3	242.0856	1.768	136930.508	3.763E-05	0.09	0
Story11	EQ X 3	254.7394	1.818	140131.521	4.214E-05	0.094	0
Story10	EQ X 3	265.1971	1.852	143217.985	4.668E-05	0.096	0
Story9	EQ X 3	273.6679	1.87	146333.987	0.0001	0.098	0
Story8	EQ X 3	280.3608	1.874	149611.613	0.0001	0.1	0
Story7	EQ X 3	285.4851	1.864	153174.272	0.0001	0.1	0
Story6	EQ X 3	289.2499	1.841	157084.963	0.0001	0.1	0
Story5	EQ X 3	291.8706	1.777	164285.233	0.0001	0.099	0
Story4	EQ X 3	293.552	1.733	169427.781	0.0001	0.096	0
Story3	EQ X 3	294.5012	1.624	181325.802	0.0001	0.083	0
Story2	EQ X 3	294.9256	1.48	199267.358	0.0001	0.073	0
Story1	EQ X 3	295.0322	0.939	314042.88	0.0001	0.041	0
Story20	EQ Y 1	0	0.048	0	48.7085	0.552	88233.305
Story19	EQ Y 1	0	0.067	0	98.8191	0.7	141224.828
Story17	EQ Y 1	0	0.1	0	183.9099	0.984	186911.027
Story16	EQ Y 1	0	0.114	0	219.4454	1.105	198599.263
Story15	EQ Y 1	0	0.126	0	250.6777	1.211	207052.433
Story14	EQ Y 1	0	0.137	0	277.8846	1.301	213537.951
Story13	EQ Y 1	0	0.146	0	301.3435	1.377	218796.698
Story12	EQ Y 1	0	0.154	0	321.3322	1.439	223301.095
Story11	EQ Y 1	0	0.16	0	338.1283	1.487	227378.215
Story10	EQ Y 1	0	0.165	0	352.0093	1.522	231276.166
Story9	EQ Y 1	0	0.169	0	363.2529	1.544	235195.789
Story8	EQ Y 1	0	0.171	0	372.1367	1.555	239352.16
Story7	EQ Y 1	0	0.171	0	378.9384	1.555	243621.937
Story6	EQ Y 1	0	0.17	0	383.9356	1.546	248378.793
Story5	EQ Y 1	0	0.165	0	387.4141	1.519	255086.06
Story4	EQ Y 1	0	0.161	0	389.646	1.48	263303.793
Story3	EQ Y 1	0	0.141	0	390.9058	1.399	279388.892
Story2	EQ Y 1	0	0.112	0	391.4692	1.216	322063.149
Story1	EQ Y 1	0	0.045	0	391.6107	0.66	593121.313
Story20	EQ Y 2	0	0.07	0	48.7085	0.561	86775.773
Story19	EQ Y 2	0	0.101	0	98.8191	0.711	138936.004
Story18	EQ Y 2	0	0.13	0	143.7937	0.862	166898.807
Story17	EQ Y 2	0	0.157	0	183.9099	0.999	184083.725
Story16	EQ Y 2	0	0.181	0	219.4454	1.122	195663.455
Story15	EQ Y 2	0	0.202	0	250.6778	1.229	204044.842
Story14	EQ Y 2	0	0.22	0	277.8846	1.32	210478.288
Story13	EQ Y 2	0	0.236	0	301.3436	1.397	215695.642
Story12	EQ Y 2	0	0.249	0	321.3322	1.46	220163.889
Story11	EQ Y 2	0	0.26	0	338.1283	1.508	224206.443
Story10	EQ Y 2	0	0.268	0	352.0093	1.543	228068.744

Story	Load Case	Shear X kN	Drift X mm	Stiffness X kN/m	Shear Y kN	Drift Y mm	Stiffness Y kN/m
Story9	EQ Y 2	0	0.274	0	363.2529	1.566	231949.111
Story8	EQ Y 2	0	0.278	0	372.1368	1.576	236062.25
Story7	EQ Y 2	0	0.28	0	378.9385	1.577	240315.744
Story6	EQ Y 2	0	0.28	0	383.9356	1.567	244998.708
Story5	EQ Y 2	0	0.273	0	387.4142	1.54	251639.424
Story4	EQ Y 2	0	0.268	0	389.646	1.5	259763.974
Story3	EQ Y 2	0	0.243	0	390.9059	1.417	275794.812
Story2	EQ Y 2	0	0.202	0	391.4692	1.23	318139.454
Story1	EQ Y 2	0	0.098	0	391.6107	0.667	587198.278
Story20	EQ Y 3	0	0.026	0	48.7085	0.543	89740.636
Story19	EQ Y 3	0	0.032	0	98.8191	0.688	143590.327
Story18	EQ Y 3	0	0.038	0	143.7937	0.835	172274.253
Story17	EQ Y 3	0	0.043	0	183.9099	0.969	189826.531
Story16	EQ Y 3	0	0.047	0	219.4454	1.088	201624.513
Story15	EQ Y 3	0	0.051	0	250.6777	1.193	210150.013
Story14	EQ Y 3	0	0.055	0	277.8846	1.282	216687.882
Story13	EQ Y 3	0	0.057	0	301.3435	1.357	221988.222
Story12	EQ Y 3	0	0.06	0	321.3322	1.419	226529
Story11	EQ Y 3	0	0.062	0	338.1282	1.466	230641.015
Story10	EQ Y 3	0	0.063	0	352.0092	1.501	234575.089
Story9	EQ Y 3	0	0.063	0	363.2529	1.523	238534.649
Story8	EQ Y 3	0	0.063	0	372.1367	1.533	242735.068
Story7	EQ Y 3	0	0.063	0	378.9384	1.534	247020.371
Story6	EQ Y 3	0	0.061	0	383.9355	1.524	251853.45
Story5	EQ Y 3	0	0.057	0	387.4141	1.498	258628.424
Story4	EQ Y 3	0	0.053	0	389.646	1.46	266941.42
Story3	EQ Y 3	0	0.039	0	390.9058	1.381	283077.884
Story2	EQ Y 3	0	0.022	0	391.4691	1.124	348227.343
Story1	EQ Y 3	0	0.008	0	391.6106	0.654	599165.059

Table 5.8.3 - Modal Periods and Frequencies

Case	Mode	Period sec	Frequency cyc/sec	Circular Frequency rad/sec	Eigenvalue rad^2/sec^2
Modal	1	2.719	0.368	2.311	5.3408
Modal	2	2.371	0.422	2.6496	7.0202
Modal	3	2.048	0.488	3.0675	9.4097
Modal	4	0.879	1.138	7.1484	51.0992
Modal	5	0.776	1.288	8.0942	65.5161
Modal	6	0.665	1.503	9.4445	89.1994
Modal	7	0.495	2.018	12.6813	160.8158
Modal	8	0.45	2.222	13.959	194.8528
Modal	9	0.377	2.649	16.6449	277.0541
Modal	10	0.347	2.881	18.1018	327.6749

Case	Mode	Period sec	Frequency cyc/sec	Circular Frequency rad/sec	Eigenvalue rad²/sec²
Modal	11	0.313	3.192	20.0582	402.3302
Modal	12	0.265	3.773	23.7035	561.8536

Table 5.8.4 - Modal Participating Mass Ratios (Part 1 of 2)

Case	Mode	Period sec	UX	UY	UZ	Sum UX	Sum UY	Sum UZ
Modal	1	2.719	0.7771	1.261E-05	0	0.7771	1.261E-05	0
Modal	2	2.371	0.0002	0.1942	0	0.7774	0.1942	0
Modal	3	2.048	2.615E-05	0.5862	0	0.7774	0.7804	0
Modal	4	0.879	0.1196	0	0	0.897	0.7804	0
Modal	5	0.776	2.334E-05	0.0232	0	0.897	0.8035	0
Modal	6	0.665	2.044E-06	0.0869	0	0.897	0.8905	0
Modal	7	0.495	0.0378	0	0	0.9348	0.8905	0
Modal	8	0.45	1.106E-05	0.0057	0	0.9348	0.8961	0
Modal	9	0.377	1.161E-06	0.0319	0	0.9348	0.928	0
Modal	10	0.347	0.0192	0	0	0.954	0.928	0
Modal	11	0.313	6.618E-06	0.0026	0	0.954	0.9306	0
Modal	12	0.265	0.0115	1.001E-05	0	0.9655	0.9306	0

Table 5.8.5 - Modal Participating Mass Ratios (Part 2 of 2)

Case	Mode	RX	RY	RZ	Sum RX	Sum RY	Sum RZ
Modal	1	3.693E-06	0.2297	0.0002	3.693E-06	0.2297	0.0002
Modal	2	0.0568	4.079E-05	0.5944	0.0568	0.2297	0.5946
Modal	3	0.1686	1.077E-06	0.2002	0.2254	0.2297	0.7948
Modal	4	5.241E-06	0.4956	3.174E-05	0.2254	0.7253	0.7948
Modal	5	0.0965	0.0002	0.0782	0.3219	0.7254	0.873
Modal	6	0.3936	1.757E-05	0.0205	0.7155	0.7255	0.8935
Modal	7	0	0.0733	2.169E-05	0.7155	0.7987	0.8936
Modal	8	0.0104	2.766E-05	0.0312	0.7259	0.7988	0.9247
Modal	9	0.0572	4.157E-06	0.0053	0.7831	0.7988	0.93
Modal	10	0	0.0674	1.851E-05	0.7831	0.8662	0.93
Modal	11	0.0084	3.108E-05	0.0169	0.7915	0.8662	0.9469
Modal	12	3.329E-05	0.0283	5.9E-06	0.7915	0.8946	0.9469

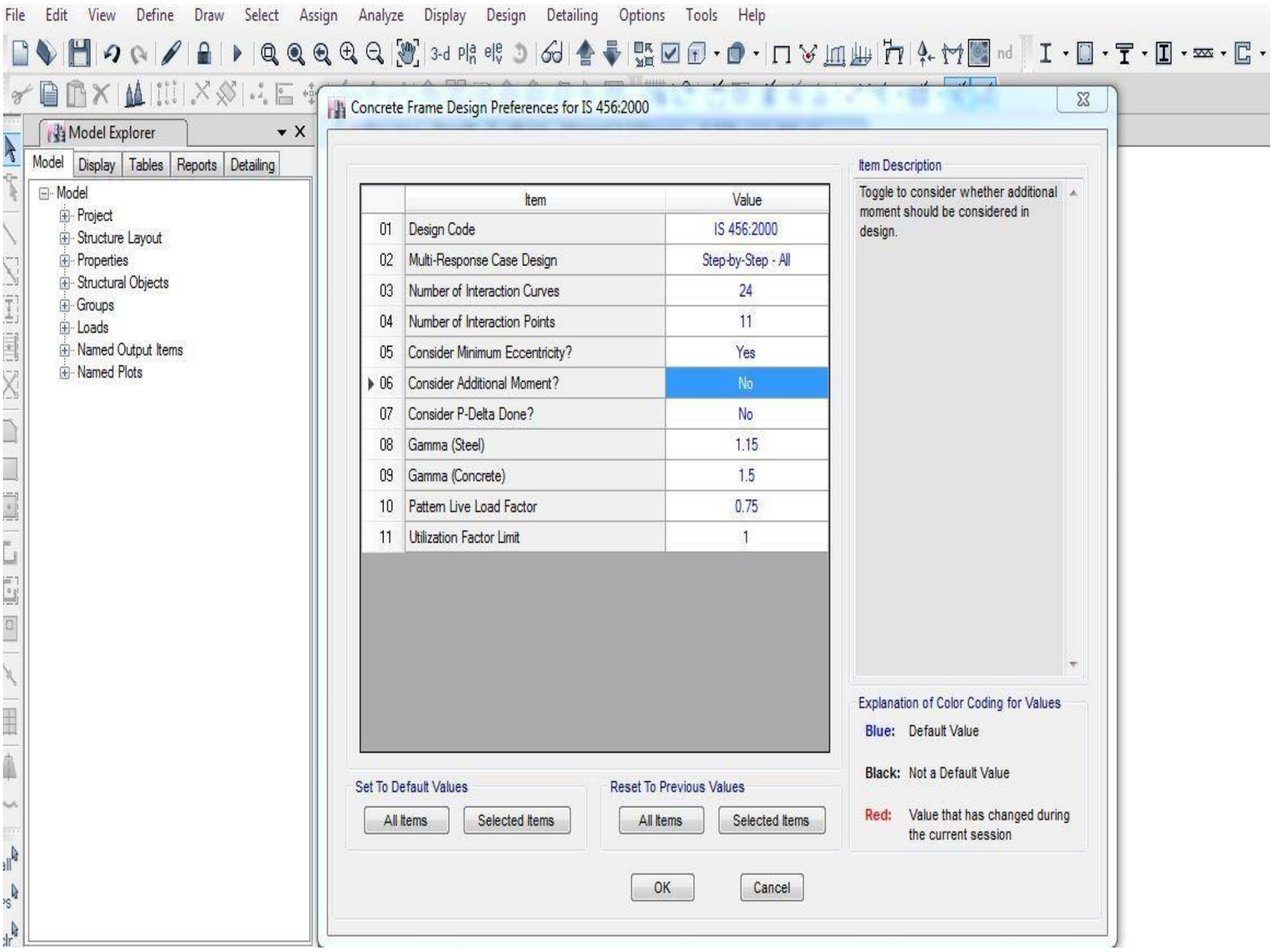
Table 5.8.6 - Modal Load Participation Ratios

Case	Item Type	Item	Static %	Dynamic %
Modal	Acceleration	UX	99.99	96.55
Modal	Acceleration	UY	99.94	93.06
Modal	Acceleration	UZ	0	0

Table 5.8.7 - Modal Direction Factors

Case	Mode	Period sec	UX	UY	UZ	RZ
Modal	1	2.719	1	0	0	0
Modal	2	2.371	0	0.25	0	0.75
Modal	3	2.048	0	0.75	0	0.25
Modal	4	0.879	1	0	0	0
Modal	5	0.776	0	0.201	0	0.798
Modal	6	0.665	0	0.799	0	0.201
Modal	7	0.495	1	0	0	0
Modal	8	0.45	0	0.136	0	0.863
Modal	9	0.377	0	0.863	0	0.137
Modal	10	0.347	1	0	0	0
Modal	11	0.313	0	0.11	0	0.889
Modal	12	0.265	0.999	0	0	0

5.9 DESIGN PROCESS



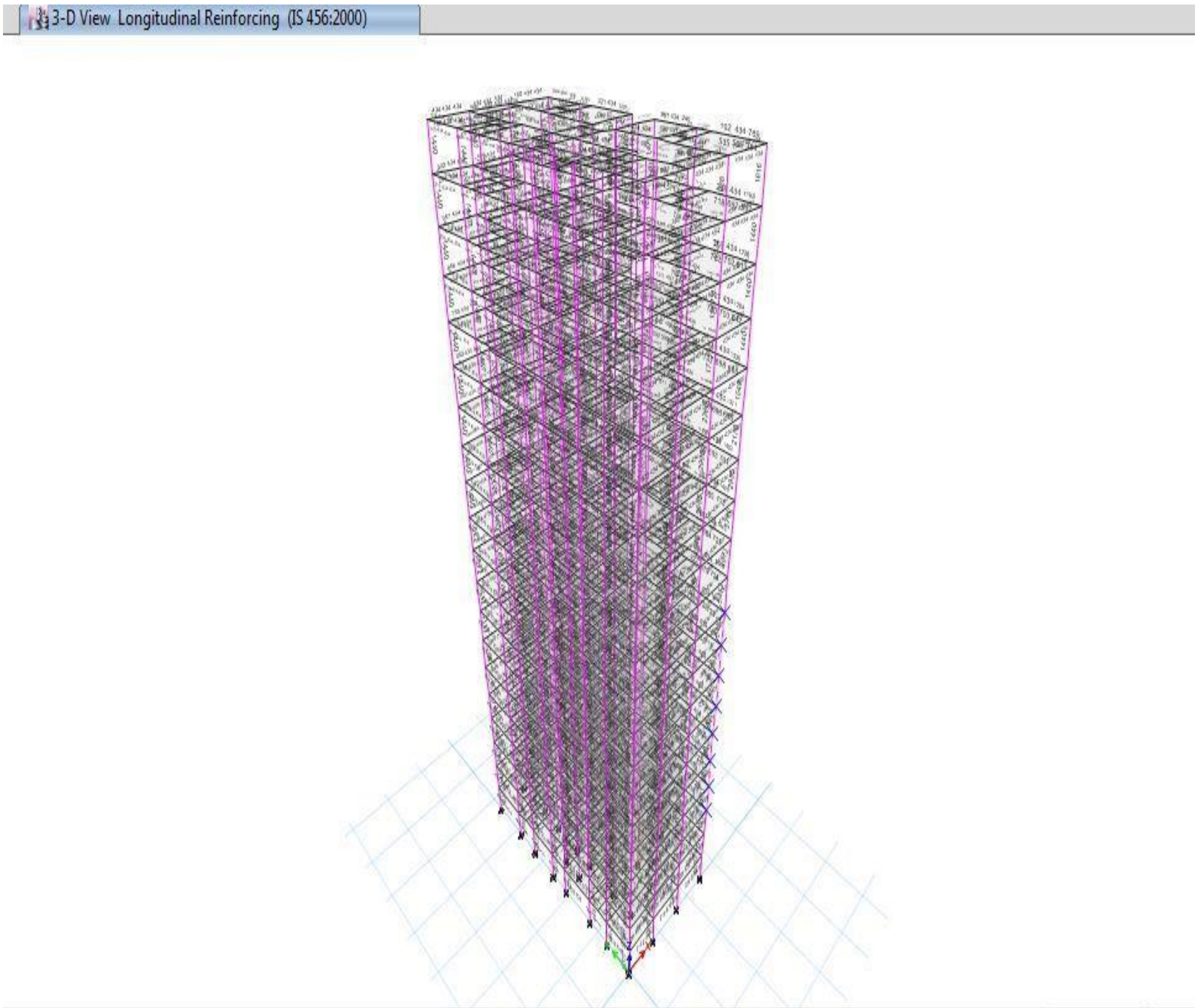
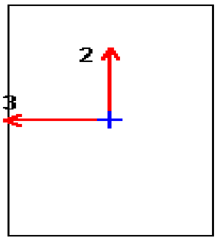


Fig: 5.9.1
3D View Longitudinal Reinforcement

ETABS 2016 Concrete Frame Design

IS 456:2000 Beam Section Design



Beam Element Details Type: Ductile Frame (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
Story20	B41	41	B 300X500	0.9DL - 1.5EQ Y	4060.1	4210.1	1

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
300	500	300	0	25	25

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	1	415	250

Design Code Parameters

γ_C	γ_S
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-13.9043	5.3301	24.226	0

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-13.9043	8.3609	0	-22.2652

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm^2	+Moment Rebar mm^2	Minimum Rebar mm^2	Required Rebar mm^2
Top (+2 Axis)	-22.2652		388	0	132	388
Bottom (-2 Axis)		0	97	0	0	97

Shear Force and Reinforcement for Shear, V_{u2} & T_u

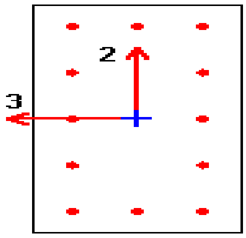
Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm^2/m
73.9695	52.8213	57	47.6277	552

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm^2/m
5.3301	24.226	270	470	0

ETABS 2016 Concrete Frame Design

IS 456:2000 Column Section Design



Column Element Details Type: Ductile Frame (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
Story20	C1	107	C 300X600	0.9DL - 1.5EQ Y	2500	3000	1

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
300	600	56	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	1	415	250

Design Code Parameters

γ_C	γ_S
1.5	1.15

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm^2	Rebar % %
56.5486	-15.2829	25.8482	1.131	1.4137	1440	0.8

Axial Force and Biaxial Moment Factors

	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	2.962753	2500	-12.4478	0	1.4137
Minor Bend(M2)	0.676669	2500	8.6746	0	1.131

Shear Design for V_{u2} , V_{u3}

	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
Major, V_{u2}	59.6942	77.2021	65.2796	59.6942	552
Minor, V_{u3}	59.6942	72.9798	58.5592	59.6942	1104

Joint Shear Check/Design

	Joint Shear Force kN	Shear V_{Top} kN	Shear $V_{u,Tot}$ kN	Shear V_c kN	Joint Area cm²	Shear Ratio Unitless
Major Shear, V_{u2}	0	0	174.9966	804.9845	1800	0.217
Minor Shear, V_{u3}	0	0	174.9966	603.7384	1350	0.29

(1.1) Beam/Column Capacity Ratio

Major Ratio	Minor Ratio
1.427	2.94

Additional Moment Reduction Factor k (IS 39.7.1.1)

A_g cm²	A_{sc} cm²	P_{uz} kN	P_b kN	P_u kN	k Unitless
1800	14.4	2068.2	809.9678	56.5486	1

Additional Moment (IS 39.7.1)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	No	0.833	600	12.345	12	Yes	0
Minor Bending (M_2)	No	0.833	300	5.639	12	No	0

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-13.9043	8.3609	0	-22.2652

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-22.2652		388	0	132	388
Bottom (-2 Axis)		0	97	0	0	97

Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
73.9695	52.8213	57	47.6277	552

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
5.3301	24.226	270	470	0

CONCRETE BEAM REBAR TABLE (2 OF 15)

BE AM	SP AN	SP AN	SECTI		LONGITUDINAL BARS							L1	L2	STIRRUPS			TYPIC AL EL
			WI	DE	A	B	C	D	F	G	H			ZONE	ZONE	ZONE	
20CB 6	1	2.924	300	500	2-14	2-14	-	-	4-14	-	-	0.731	-	4-10 @ 1	-	12-10 @	ELEVATI
	2	2.219	300	500	-	-	2-18	-	4-14	-	-	-	-	7-10 @ 7	-	17-10 @	ELEVATI
	3	3.610	300	500	-	-	2-18	-	4-14	-	-	-	-	4-10 @ 1	-	18-10 @	ELEVATI
	4	1.762	300	500	-	-	2-20	1-20	4-14	-	-	-	0.441	4-10 @ 1	-	6-10 @ 2	ELEVATI
	5	2.924	300	500	-	-	2-20	1-20	4-14	-	-	-	0.731	5-10 @ 1	-	19-10 @	ELEVATI
	6	2.219	300	500	-	-	2-18	-	4-14	-	-	-	-	7-10 @ 7	-	17-10 @	ELEVATI
	7	3.760	300	500	2-14	2-14	2-18	-	4-14	-	-	0.940	-	4-10 @ 1	-	14-10 @	ELEVATI
20CB 7	1	5.744	300	500	4-20	2-20	-	-	3-20	-	-	1.436	-	7-12 @ 7	-	63-12 @	ELEVATI
	2	3.610	300	500	3-20	2-20	2-20	1-20	2-20	-	1-20	0.903	0.903	7-10 @ 7	-	38-10 @	ELEVATI
20CB	1	4.139	300	500	2-14	2-14	2-20	1-20	2-20	-	-	1.035	1.035	7-10 @ 7	-	32-10 @	ELEVATI
20CB	1	4.439	300	500	2-14	2-14	2-18	-	2-20	-	-	1.110	-	7-10 @ 7	-	26-10 @	ELEVATI
20CB 10	1	3.074	300	500	2-20	1-20	-	-	3-20	-	-	0.769	-	7-12 @ 7	-	30-12 @	ELEVATI
	2	2.369	300	500	-	-	2-20	1-20	4-14	-	-	-	0.592	4-10 @ 1	-	9-10 @ 2	ELEVATI
	3	3.610	300	500	-	-	2-18	-	4-14	-	-	-	-	5-10 @ 1	-	24-10 @	ELEVATI
	4	1.762	300	500	-	-	2-20	1-20	4-14	-	-	-	0.441	4-10 @ 1	-	6-10 @ 2	ELEVATI
	5	2.924	300	500	-	-	2-20	1-20	4-14	-	-	-	0.731	7-10 @ 7	-	30-10 @	ELEVATI
	6	2.219	300	500	-	-	2-18	-	4-14	-	-	-	-	5-10 @ 1	-	12-10 @	ELEVATI
	7	3.610	300	500	2-20	1-20	2-20	1-20	2-20	-	-	0.903	0.903	7-12 @ 7	-	30-12 @	ELEVATI
20CB 11	1	5.744	300	500	4-20	3-20	-	-	4-20	-	-	1.436	-	7-12 @ 7	-	49-12 @	ELEVATI
	2	3.610	300	500	3-20	1-20	2-18	-	4-14	-	-	0.903	-	7-12 @ 7	-	38-12 @	ELEVATI
20CB 12	1	1.872	300	500	2-14	2-14	-	-	4-14	-	-	0.468	-	4-10 @ 1	-	6-10 @ 2	ELEVATI
	2	1.510	300	500	-	-	2-20	-	4-14	-	-	-	-	7-10 @ 7	-	10-10 @	ELEVATI
	3	3.891	300	500	-	-	2-20	1-20	2-20	-	-	-	0.973	7-10 @ 7	6-10 @ 1	15-10 @	ELEVATI
	4	2.234	300	500	-	-	2-20	1-20	3-18	-	-	-	0.558	7-12 @ 7	-	19-12 @	ELEVATI
	5	1.605	300	500	2-14	2-14	2-20	2-20	4-14	-	-	0.401	0.401	4-10 @ 1	-	7-10 @ 1	ELEVATI
20CB 13	1	3.681	300	500	2-20	-	-	-	4-14	-	-	-	-	4-10 @ 1	-	13-10 @	ELEVATI
	2	3.891	300	500	-	-	2-20	1-20	4-14	-	-	-	0.973	4-10 @ 1	-	14-10 @	ELEVATI
	3	4.139	300	500	2-20	1-20	2-18	-	4-14	-	-	1.035	-	4-10 @ 1	-	15-10 @	ELEVATI
20CB	1	3.531	300	500	2-20	-	2-18	-	4-14	-	-	-	-	4-10 @ 1	-	16-10 @	ELEVATI
20CB	1	2.324	300	500	2-14	2-14	2-18	-	4-14	-	-	0.581	-	5-10 @ 1	-	10-10 @	ELEVATI
20CB	1	3.490	300	500	2-14	2-14	2-18	-	4-14	-	-	0.872	-	4-10 @ 1	-	19-10 @	ELEVATI
20CB	1	3.681	300	500	2-14	2-14	2-18	-	4-14	-	-	0.920	-	4-10 @ 1	-	15-10 @	ELEVATI
20CB 18	1	5.744	300	500	3-20	3-20	-	-	3-20	-	-	1.436	-	7-12 @ 7	-	26-10 @	ELEVATI
	2	3.610	300	500	3-20	3-20	2-20	1-20	3-20	-	-	0.903	0.903	7-12 @ 7	-	38-12 @	ELEVATI
19CB 1	1	1.863	300	500	2-20	-	-	-	4-14	-	-	-	-	5-10 @ 1	-	8-10 @ 1	ELEVATI
	2	2.328	300	500	2-14	2-14	2-18	-	4-14	-	-	0.582	-	4-10 @ 1	-	6-10 @ 2	ELEVATI
19CB	1	1.762	300	500	2-14	2-14	2-18	-	4-14	-	-	0.441	-	4-10 @ 1	-	8-10 @ 1	ELEVATI
19CB	1	2.362	300	500	2-14	2-14	2-18	-	4-14	-	-	0.591	-	4-10 @ 1	-	6-10 @ 2	ELEVATI
19CB 5	1	3.531	300	500	2-20	-	-	-	4-14	-	-	-	-	4-10 @ 1	-	13-10 @	ELEVATI
	2	3.891	300	500	-	-	2-18	-	4-14	-	-	-	-	4-10 @ 1	-	14-10 @	ELEVATI
	3	4.139	300	500	2-20	1-20	2-18	-	4-14	-	-	1.035	-	4-10 @ 1	-	17-10 @	ELEVATI
19CB 6	1	2.924	300	500	2-14	2-14	-	-	4-14	-	-	0.731	-	4-10 @ 1	-	12-10 @	ELEVATI
	2	2.219	300	500	-	-	2-18	-	4-14	-	-	-	-	7-10 @ 7	-	17-10 @	ELEVATI
	3	3.610	300	500	-	-	2-18	-	4-14	-	-	-	-	4-10 @ 1	-	18-10 @	ELEVATI
	4	1.762	300	500	-	-	2-20	1-20	4-14	-	-	-	0.441	4-10 @ 1	-	6-10 @ 2	ELEVATI
	5	2.924	300	500	-	-	2-20	1-20	4-14	-	-	-	0.731	5-10 @ 1	-	19-10 @	ELEVATI
	6	2.219	300	500	-	-	2-18	-	4-14	-	-	-	-	7-10 @ 7	-	17-10 @	ELEVATI
	7	3.760	300	500	2-14	2-14	2-18	-	4-14	-	-	0.940	-	4-10 @ 1	-	14-10 @	ELEVATI
19CB 7	1	5.744	300	500	4-20	3-20	-	-	3-20	-	-	1.436	-	7-12 @ 7	-	63-12 @	ELEVATI
	2	3.610	300	500	3-20	2-20	2-20	1-20	2-20	-	1-20	0.903	0.903	7-10 @ 7	-	38-10 @	ELEVATI
19CB	1	4.139	300	500	2-14	2-14	2-20	1-20	2-20	-	-	1.035	1.035	7-10 @ 7	-	32-10 @	ELEVATI
19CB	1	4.439	300	500	2-14	2-14	2-18	-	2-20	-	-	1.110	-	7-10 @ 7	-	32-10 @	ELEVATI
19CB 10	1	3.074	300	500	2-20	1-20	-	-	3-20	-	-	0.769	-	7-12 @ 7	-	30-12 @	ELEVATI
	2	2.369	300	500	-	-	2-20	1-20	4-14	-	-	-	0.592	4-10 @ 1	-	9-10 @ 2	ELEVATI
	3	3.610	300	500	-	-	2-18	-	4-14	-	-	-	-	5-10 @ 1	-	24-10 @	ELEVATI
	4	1.762	300	500	-	-	2-20	1-20	4-14	-	-	-	0.441	4-10 @ 1	-	7-10 @ 2	ELEVATI
	5	2.924	300	500	-	-	2-20	1-20	4-14	-	-	-	0.731	7-10 @ 7	-	30-10 @	ELEVATI
	6	2.219	300	500	-	-	2-18	-	4-14	-	-	-	-	5-10 @ 1	-	14-10 @	ELEVATI
	7	3.610	300	500	2-20	1-20	2-20	1-20	3-20	-	-	0.903	0.903	7-12 @ 7	-	30-12 @	ELEVATI
19CB 11	1	5.744	300	500	4-20	3-20	-	-	4-20	-	-	1.436	-	7-12 @ 7	-	49-12 @	ELEVATI
	2	3.610	300	500	2-20	2-20	2-18	-	4-14	-	-	0.903	-	7-12 @ 7	-	38-12 @	ELEVATI

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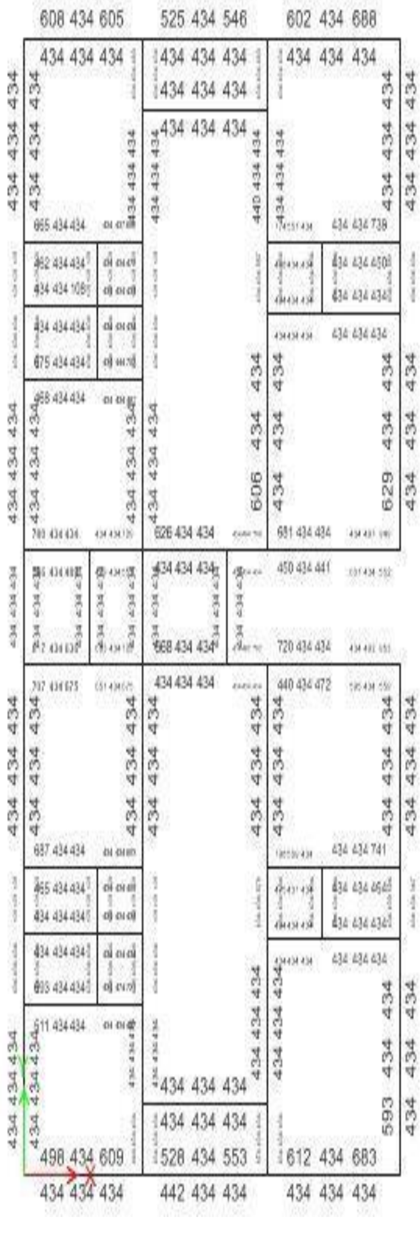
	CONSULTANT	TITLE	DATE	CHECKED	
			13-03-2019	APPROVED	IS

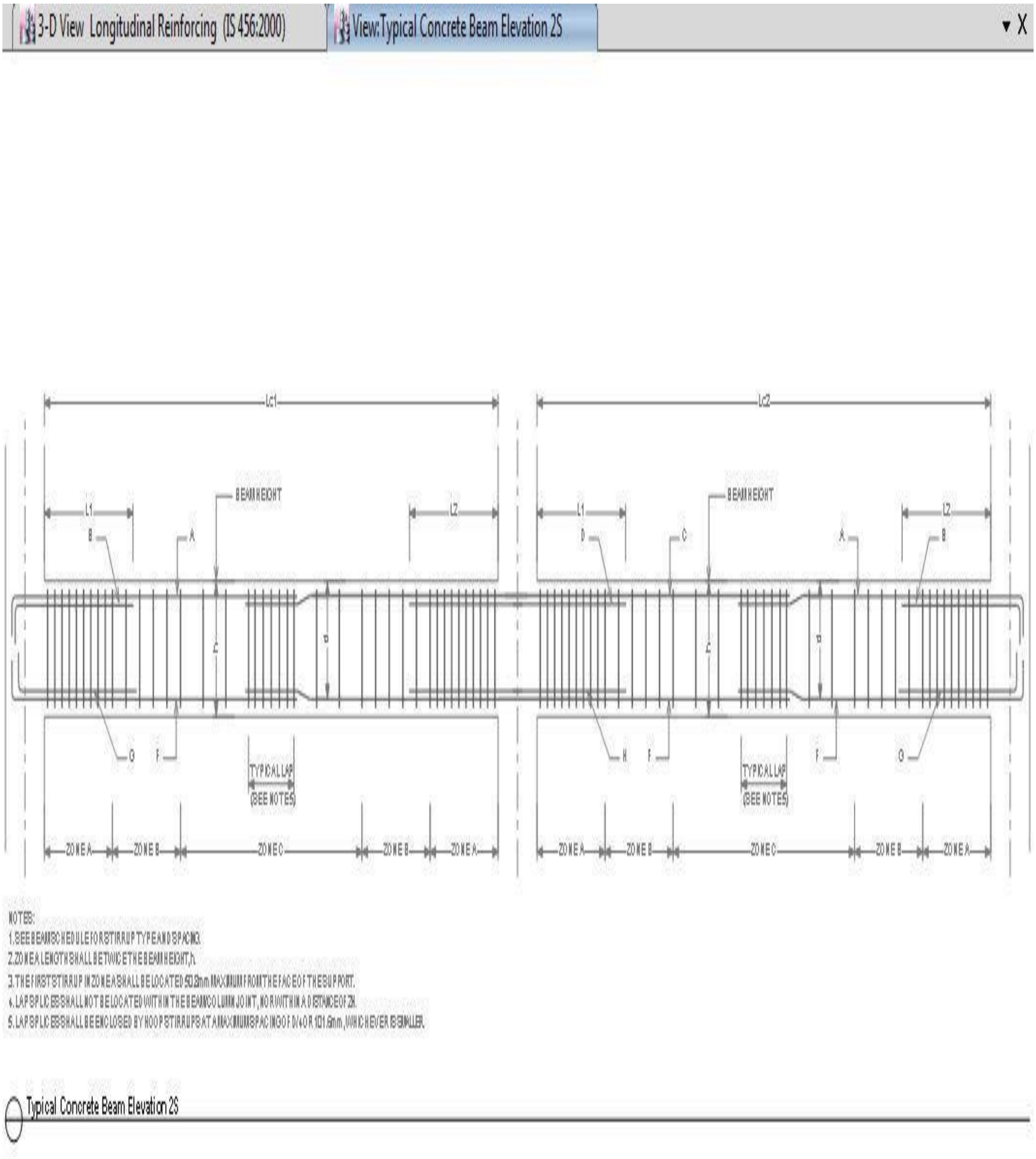
5.10 PLINTH BEAM LONGITUDINAL REINFORCEMENT

Plan View - PLINTH BEAM - Z = 1 (m) Longitudinal Reinforcing (IS 456:2000)

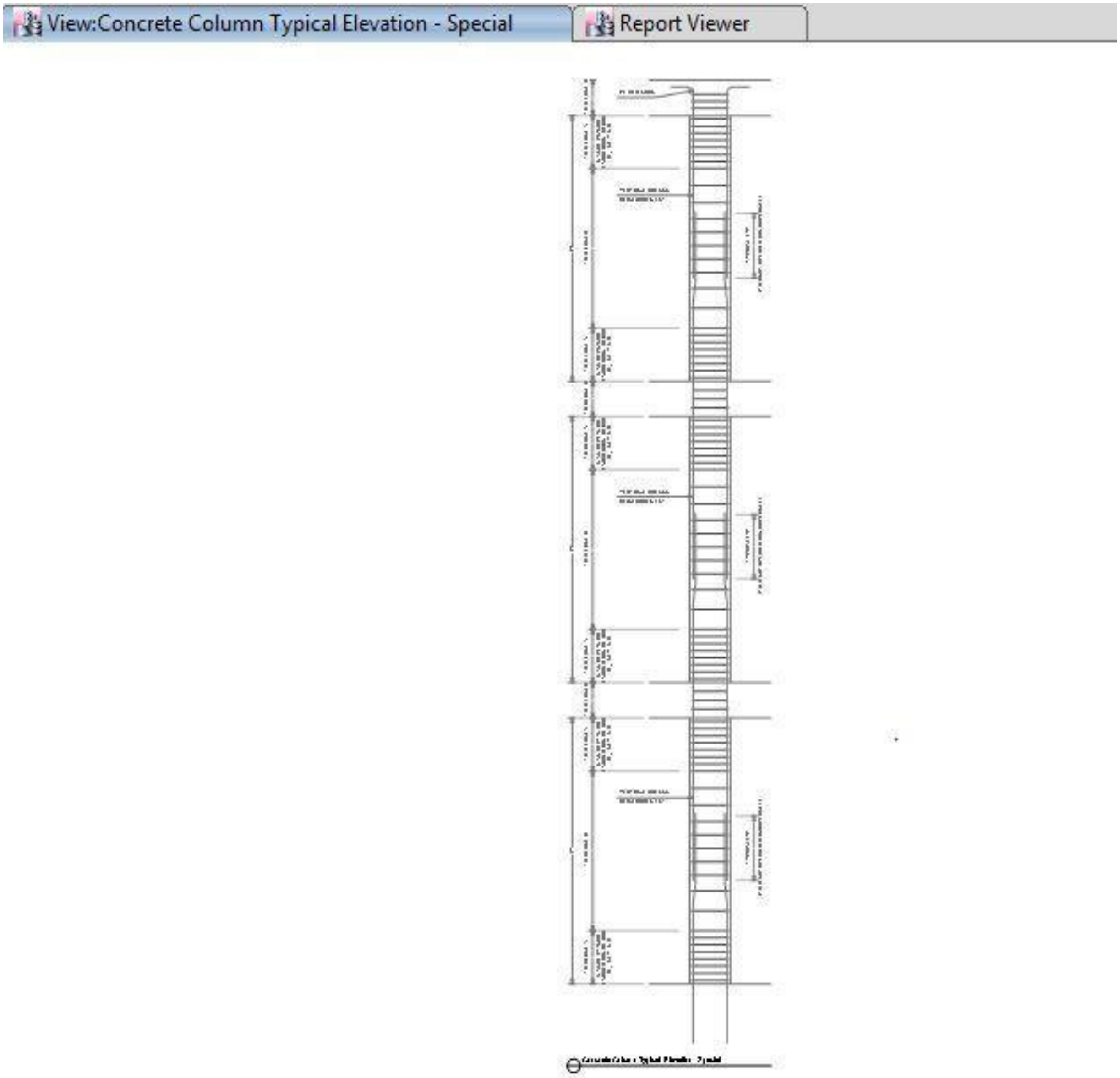


5.11 DETAILING OF STRUCTURAL MEMBERS

5.11.1 DETAILING OF BEAM



5.11.2 DETAILING OF COLUMN



CHAPTER 6
TYPICAL DESIGN OF ELEMENTS

6.1 DESIGN OF TWO WAY SLAB

Given data:

f_{ck} = 25 KN/m^2

f_y = 415KN/m^2

Live load =2KN/m^2

L_x =3.81m

L_y = 4.2 m

Aspect ratio, L_x / L_y =4.2/3.81

=1.1< 2

Design the slab as two way slab.

Step: 1. ..Depth of slab:

Assume l/d =26

d = l/26 = 3810/(26x1.6)

Effective depth d =91.58 mm

Assume clear cover = 20mm

Overall depth D = d + clear cover +Ø/2

D = 91.58+20+4 =115.8mm =120mm

Therefore, D = 120mm, d = 96mm

Step: 2. ..Effective span:

Along short span (L_x),

65. C /C of supports =3810 + 300 = 4110mm

ii. l_{clear} + D= 3810 + 120 = 3930mm

l_{eff} = 3930mm (whichever is less ,Therefore l_{eff} =3930mm)

Step: 3. ..Load Computations:

Self weight of slab = 25*0.120 = 3KN/m^2

Self weight of floor finish = 0.04*20 = 0.8 ≅ 1KN/m^2

Live load = 2KN/m^2

Total service load = 3+1+2 = 6KN/m^2

Total Design load = 1.5*6 = 9kN/m^2

Step: 4. ..Load factored moment:

Load factored moment = Mx = $\alpha w(l_x)^2$

Slab 1 is Two adjacent edges discontinuous

L_y = 4200+300 = 4500mm

l_{clear} + d = 4200+120 = 4320mm

Take whichever is less

L_y/L_x = 4320/3930 = 1.09 ≅ 1.1

From IS code 456:2000; page no 91; table 26

At continuous edge α_x =0.053

At mid span α_x = 0.040

At continuous edge α_y = 0.047

At mid span α_y = 0.035

For Shorter span:

M_x at continuous edge = α_x w $(l_x)^2$

= 0.053*9*$(3.93)^2$=7.36KN-M

M_x at span =0.040*9*$(3.93)^2$

For longer span:

Moment at support = M_y =α_y w $(l_x)^2$

=0.047*9*$(3.93)^2$=6.53KN-m

Moment at support =M_y =α_y w $(l_x)^{2-}$=0.035*9*3.93^{2-}=4.8KN-m

Step: 5. ..Check for depth:

Min depth required M_U = 0.136F_{CK}bd^2

= √(M_u /0.136fckb)

= √(7.36*10^6)/(0.136*25*1000)

d_{min} = 46mm <96mm

Depth is satisfied as per the check

Hence safe

Step: 6… Design of main reinforcement:

Along shorter span :

$M_u\ \alpha_x(-ve) = 0.87 f_y Astd(1-(f_y\ Ast/f_{ck}\ b\ d)$

$7.36*10^6 = 0.87*415*Ast*96*(1-(415Ast/25*1000*96))$

By solving equation we get $Ast(-\alpha_x) = 212.34mm^2$

Ast min = (0.12/100)*1000*96

=115.2mm

Take whichever is less, Therefore, Ast prov=$212.34mm^2$

$M_u\ \alpha_x(_+ve) = 0.87*f_y\ Ast\ d(1-(f_y Ast/f_{ck} bd)$

$5.56*10^6 = 0.87*415*Ast*96(1-(415Ast/25*1000*96))$

$Ast\ (+\alpha_x) = 160.41mm^2$

Comparing A_{st} (+ve) and A_{st} (-ve) we get A_{st} = 212.34 mm^2

8mm diameter HYSD bars are adopted

Spacing = (1000*cross area of each bar)/Ast

=(1000*50.27)/212.24 = 230mm

Provide 8mm diameter *HYSD* bars at spacing of 230 C/C as main reinforcement.

Along longer span:

$M_u\alpha_y(-ve) = 0.87\ f_y ASt\ d(1-(f_y Ast/f_{ck} bd)$

$6.53*10^6=0.87*415*Ast*88*(1-(415Ast/(25*1000*88))$

$Ast(-\alpha_y) = 205.71mm^2$

$M_u\alpha_y(+ve) = 0.87\ f_y ASt\ d(1-(f_y Ast/f_{ck} bd)$

$4.8*10^6=0.87*415*Ast*88*(1-(415Ast/(25*1000*88))$

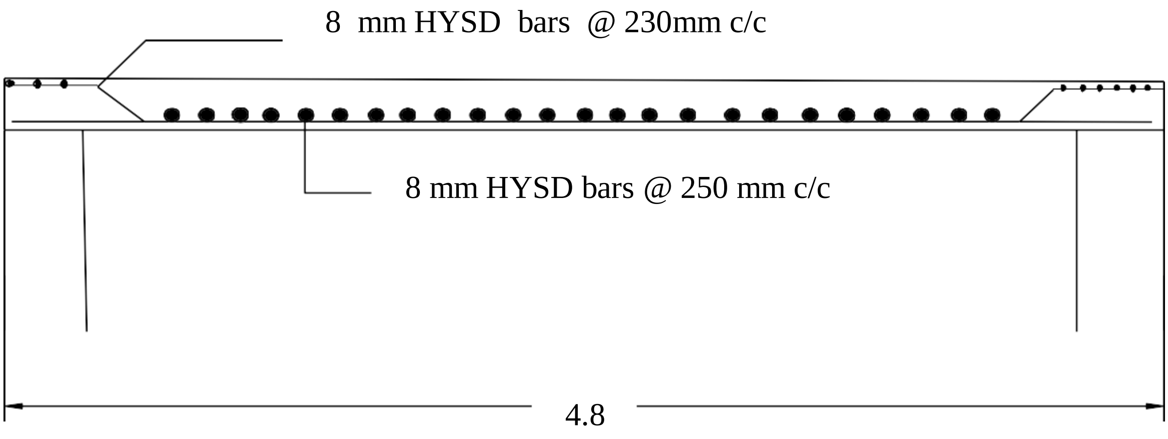
$Ast(+\alpha_y) = 151.07mm^2$

Comparing A_{st} (+ve) and A_{st} (-ve) we get A_{st} = 205.71 mm^2

8mm diameter HYSD bars are adopted

spacing = (1000*50.27)/205.71 =250

Provide 8mm diameter *HYSD* bars at spacing of 250 C/C as main reinforcement .



Slab reinforcement detailing

6.2 DESIGN OF BEAM

Given data :

Width (b) = 300mm

Depth (d) = 450mm

F_{ck} = 25KN/mm^2

F_y =415KN/mm^2

Step1….Effective depth:

L_x =3810mm

d = L_x/15 = 3810/15 = 254

Effective depth = clear cover +Ø/2

= 30+12/2

= 36mm

D = d + Effective depth

= 254 + 36

= 290mm

Minimum Depth is 450 mm

D= 450mm

d = 450-36 = 414mm

Step2….Effective span:

i. c/c of supports = 3810+414 = 4224mm
ii. l_{clear} + d = 3810 + 230 = 4040mm

l_{eff} = 4040mm

whichever is less, therefore l_{eff} = 4040mm

Step3….Load calculation:

Dead load of slab = 25*0.12*1

= 3 KN/m^2

Floor Finish = 0.06*26*1 = 1.56 KN/m^2

Tiles = 0.015*24 = 0.36 KN/m^2

Factored load = 1.5 KN/m^2

Total load (w) = 3 + 1.56 + 0.36 + 1.5 = 6.42 KN/m^2

L_y/L_x = 4200/3810 = 1.1 < 2

Two Way Slab

DL = $wL_x/ 6 (3-(L_x/l_y)^2)$

= $6.42 * 3.81/6(3-(3.81/4.2)^2)$

= 8.875 KN/m^2

DL of beam = 25 * 3 * 0.45 = 3.375 KN/m^2

DL = 8.875 + 3.375

= 12.25 KN/m^2

LL = $wL_x/ 6 (3-(L_x/l_y)^2)$

Assume w = 1.5 as per code

LL = $1.5 *3.81/6(3-(3.81/4.2)^2)$

= 2.07 KN/m^2

W = 1.5(DL + LL) = 1.5(12.25 + 2.07)

= 21.48 KN/m^2

Step4….Design of Shear force(V_u) & Bending moment(M_u) :

$M_u = WL_x^2/8$

$= 21.48 * 3.81^2/ 8 = 38.97$ KN-m

$V_u = WL_x / 2$

$= 21.48 * 3.81 / 2 = 40.91KN$

Step5….Limiting Moment Of Resistance:

$M_{ulimit} = 0.138\ f_{ck} * b*d^2$

$= 0.138 * 25 * 1000*414^2$

$= 136$ KN-m

$M_u < M_{ulimit}$

Design the section as singly reinforced beam.

Step6….Minimum Effective Depth:

$D_{min} = \sqrt{(M_u/Q*b)}$

$= \sqrt{(38.63*10^6/2.76*300)}$

$= 215.9 < 450mm$

Step7….Design Of Flexural Reinforcement:

$M_u = 0.87* f_y*A_{st}* d[1- (A_{st}* f_y/ b*d* f_{ck})]$

$38.63* 10^6 = 0.87*415* A_{st}*414[1-(A_{st*415}/300*450*25)]$

$A_{st} = 267.2\ mm^2$

Use 12 mmØ HYSD Bars

Area of 1 bar = $\frac{\pi}{4} * 12^2$

$= 113.06mm^2$

Number of bars=267.2/113.06 = 2.36= 4 no's

$A_{st,prov} = 4 *(\pi/4)*12^2 = 452.89\ mm^2$

Minimum area of steel

$A_{stmin} = 0.85\ bd / f_y$

$= 0.85 * 300 * 414/415$

$= 254.38\ mm^2$

Maximum area of steel

$A_{stmax} = 0.04* b* D$

$= 0.04*300*450$

$= 5400\ mm^2$

$A_{st,prov} < A_{stmin} < A_{stmax}$

Step7….Design Of Shear Reinforcement:

$T_v = V_u / b*d$

$= 40.91*10^3 / 300*414$

$= 0.329\ N/mm^2$

$P_t = (100\ A_{st,prov})/b*d$

$= (100*339.2)/300*414$

$= 0.273\%$

$T_c = 0.415\ N/mm^2$

$T_c > T_v$

Provide minimum shear reinforcement with 2 legged vertical stirupps of 8mmØ HYSD bars .

Spacing (S_v) = 0.87 f_y Asv/0.4b

$A_{SV} = 2 *(\pi/4 * 8^2) = 100.53\ mm^2$

$S_v = 0.87 * 415 * 100.53/0.4 * 300$

$= 302.46\ mm = 300mm$

i. Spacing = 300 mm
ii. 3d = 3 * 450 = 1350

Whichever is less, therefore spacing = 300mm

Provide minimum shear reinforcement with 2 legged vertical stirupps of 8mmØ HYSD bars@ a spacing 300mm c/c .

Step8….Check for Deflection:

$(L/d)_{prov} = 3810/414 = 9.20$

$(L/d)_{max} = (L/d)_{basic} * k_t * k_c * k_s$

$F_s = 0.58\, f_y\, (A_{st,req} / A_{st,prov})$

$= 0.58 * 415 * 1/1$

$= 240.7 N/mm^2$

$P_t = (100\, A_{st,prov})/b*d$

$= (100*339.2)/300*414$

$= 0.273\%$

According to IS 456 : 2000 graph no:

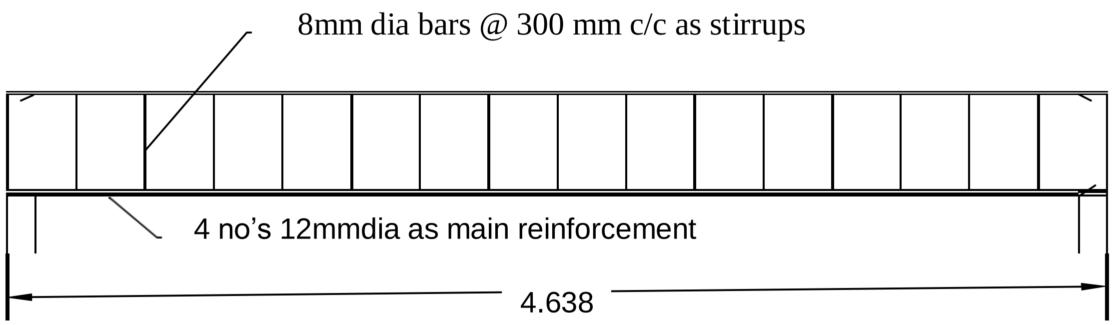
$k_t = 1.4$, $k_c = 1.1$, $k_s = 1.0$

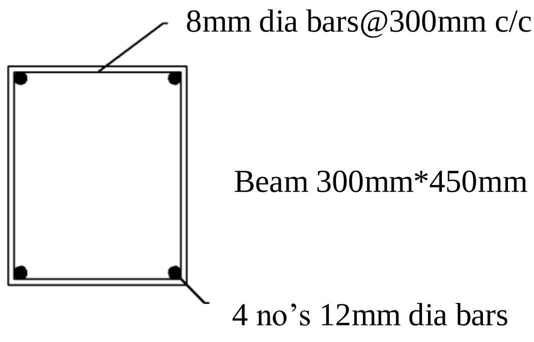
$(L/d)_{max} = 26 * 1.4*1.1*1.0$

$= 40.04$

$(L/d)_{prov} < (L/d)_{max}$

Hence The Section is safe.





Beam reinforcement detailing

6.3 DESIGN OF RECTANGULAR COLUMN:

Column dimensions = 0.30*0.5

Height of the column = 3.5m

Step: 1….

Working load = 1.5*1500 = 2250 KN

Step: 2….

Slenderness ratio $\lambda = l_{eff}/D_{eff}$

$= (0.65*3500)/300$

$=7.583<12$

Hence the column is short column

Step: 3….

$e_{xmin}= (L/500)+(D_x/30)$or 20mm

$=(3500/500)+(500/30)$ or 20mm

$=23.66$ or 20mm

$e_{xmin}= 20$mm

$e_{xmin}<0.05D_x$

$20<25$

Hence ok

$e_{ymin} = (L/500) +(D_y/30)$ or 20 mm

$=(3500/500)+(300/30)$ or 20mm

$= 17$ or 20 mm

$0.05D_x > e_{ymin}$

$15 < 17$

Hence ok .

Step: 4….Longitudinal reinforcement

$P_u = 0.4\ f_{ck}\ A_c + 0.67\ f_y A_{sc}$

$2250*10^3 = 0.4 * 25*(300*500- A_{sc}) + 0.67*415* A_{sc}$

$A_{sc} = 2108.32\ mm^2$

As per clause 26.5.3.1 of IS 456:2000

The cross sectional area of longitudinal reinforcement shall not be less than 0.8% , not more than 4% of the gross sectional area of the column.

$A_{scmin} = (0.8/100)(300*500) = 1200\ mm^2$

$A_{scmax} = (4/100)(300*500) = 6000\ mm^2$

$A_{scmin} < A_{screq} < A_{scmax}$

Assume 20 mm Ø HYSD bars

$N = 2108.32/((\pi/4)*20^2) = 8$ no's

Provide 8no's 20 mm diameter *HYSD* bars as a Longitudinal reinforcement.

LATERAL TIES

Use 8 mm Ø HYSD bars

Spacing : (As per clause 26.5. 3.2 of IS 456:2000)

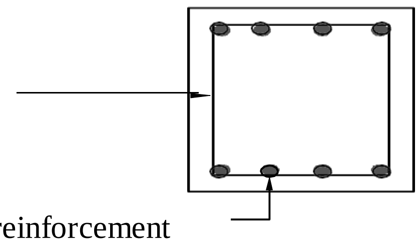
i. 300 mm c/c
ii. Least lateral dimension of the compression member = 300mm
iii. 16* diameter of longitudinal reinforcement bar = 16*20 = 320mm

Therefore, Spacing = 300 mm c/c

Provide 8mm diameter *HYSD* bars at spacing of 300 C/C as Lateral reinforcement.

Column reinforcement detailing

8mm dia lateral ties @ 300 mm c/c



8 no's 20 mmØ HYSD bars as longitudinal reinforcement


8mm dia lateral ties @ 300 mm c/c

Chapter-7

Conclusion and Future Enhancement

7.1 CONCLUSION

- This project has given an opportunity to re-collect and co-ordinate the various methods of designing and engineering principles which we have learnt in our earlier classes.
- Design was done by using ETABS software and successfully verified manually as per IS 456-2000.
- By using ETABS, the analysis and design work can be completed within the stipulated time.
- The analysis and design results obtain from software are safe when compared with manual calculations and design.
- Usage of ETABS software minimizes the time required for analysis and design.
- In ETABS steel reinforcement adapted is adequate when compared to staad pro, This benefits the economic value of steel during construction

7.2. Future Enhancement

This work is completely concentrated on analysis and design. This can be extended to comparision for design of conventional and software detailings, analysis on high rise buildings or more than G+ 20 storeys, performing seismic analysis for lower storeys and wind analysis for high rise buildings.

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A Major Project Report On

ESTIMATION OF RESILIENT MODULUS FOR STABILIZED SUBGRADE USING GENETIC ALGORITHM AND ARTIFICIAL NEUTRAL NETWORK

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Submitted by

1) Ms.CH.Harika (17K81A0117) 2) Ms.K.Sai Pranathi(17K81A0133)

3) Mr.V.Prashanth (18K85A0110) 4) Mr.A.Goutham (17K81A0104)

Under The Guidance of

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M.Tech

DEPARTMENT OF CIVIL ENGINEERING

ST.MARTIN'S ENGINEERING COLLEGE

(An Autonomous Institute)

Dhulapally, Secunderabad – 500100

JUNE 2021

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(Approved by A.I.C.T.E, New Delhi, Affiliated to JNTU Hyderabad)

Dhulapally, Secunderabad, Telangana (India)-500100

BONAFIDE CERTIFICATE

This is to certify that the project entitled **ESTIMATION OF RESILIENT MODULUS FOR STABILIZED SUBGRADE USING GENETIC ALGORITHM AND ARTIFICIAL NEUTRAL NETWORK** is being submitted .Ms.CH.harika(17K81A0117) ,2.Ms.K.Sai Pranathi (17K81A0133), **3.Mr.V.Prashanth (18K85A0110), 4.Mr.A.Goutham (17K81A01014)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OFTECHNOLOGY IN**<department name>is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

Signature of the Guide

Mr.N.Vijay Kumar

Department of Civil Engineering

Signature of the Head of the Department

Ms. Sandhya Kiran.J.K

Department of Civil Engineering

Internal Examiner

External Examiner

Place:

Date:

DECLARATION

We, the student of Bachelor of Technology in Department of Civil Engineering, session: 2017 – 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled ESTIMATION OF RESILIENT MODULUS FOR STABILIZED SUBGRADE USING GENETIC ALGORITHM AND ARTIFICIAL NEUTRAL NETWORK is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

CH.Harika (17K81A0117)
K.Sai Pranathi (17K81A0133)
V.Prashanth (18K85A0110)
A.Goutham (17K81A0104)

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Student name:

1. Ms. CH.Harika
2. Ms. K.Sai Pranathi
3. Mr.V.Prashanth
4. Mr.A.Goutham

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ABSTRACT

Soil stabilization has been a big concern in recent years because it requires the use of cement, lime, and other substances that are clearly harmful to the climate. Finding cement alternatives has been a top priority. In this respect, cement substitutes such as Fly Ash, Silica fumes, GGBS, Fibrous concrete, and others have begun to gain traction in the building industry. GGBS is used in this analysis to determine its respective contributions to reinforcing the sub grade. Various tests were performed to find the favorable amount of GGBS to be used. This paper presents the results of favorable amount of GGBS using rigorous modeling artificial neural network and genetic algorithm to examine the proper stabilization of very weak sub grade soils at high moisture contents. The scheme method displayed is a particular process of which resilient modulus for stabilized sub grade can be determined and this examines the impact of input variables on output and determines GGBS percentage, PI, LL, MC, OMC; the powerful variables on the resilient modulus of stabilized sub grade.

Key words: Soil stabilization, GGBS, Genetic Algorithm, Optimization, Artificial Neural Network, Resilient Modulus.

CHAPTER 1

INTRODUCTION

1.0 OVERVIEW OF THE PROJECT:

- This project attempts to enhance the structural integrity of pavements that have failed due to diverse loads which are upon expansive soils. Geo technical engineers have made sub grade stabilization a top priority because it can automatically improve the strength and stability of pavements. Cement and its derivatives are usually used to stabilize the sub grade; however as cement usage is environmentally dangerous, it is vital to discover alternatives.
- Across the planet, studies are being conducted to stabilize the sub grade using various admixtures such as pulverized fuel ash, silica fumes, limestone fines, GGBS, and fly ash, among many others. Black cotton soil which is an expansive soil is used in this analysis. When these expansive soils or clays come into contact with water, their volume changes. These soils are being stabilized with additives in order to be used for construction of pavements. These additives have the ability to enhance the engineering properties of soil used in base courses, sub base courses, and sub grades of pavements.
- In this study, we used GGBS as an additive to improve the stability of the sub grade. Various tests like Specific gravity, Hydrometer analysis, Atterberg limits, Standard proctor compaction test, Unconfined compressive strength (UCS) ,California bearing ratio test are performed by adding certain amounts of GGBS to the sub grade to find the favorable amount of GGBS to be used in the future to stabilize the sub grade.
- After the sub grade is stabilized, the resilient modulus of the stabilized soil samples are determined in the Triaxial test. Once all the values are obtained, ANN and GA come into existence. In this the input variables include parameters, namely GGBS percentage, PI, optimum moisture content OMC, moisture content M.C, the output variable includes resilient modulus for stabilized sub grade. The ANN has a satisfactory evaluation capability to estimate the output Mr (Resilient modulus). The most accurate value of Mr obtained either from ANN or GA is taken into consideration. Thus the resilient modulus of the stabilized sub grade is founded.

1.1 OBJECTIVES OF THE PROJECT:

- The main objective of this work is to use robot approaches to propose novel models for estimating the resilient modulus for stabilized sub grade.
- To stabilize the pavements and strengthen them to withstand any loads and sustain for longer years.

1.2 SCOPE OF THE PROJECT:

This project is to estimate the resilient modulus for sub grade stabilized with GGBS using Genetic Algorithm and Artificial Neural Network.

SCOPE STATEMENT:

The sub grade which is needed to be stabilized undergoes various tests in Geo Technical lab by adding successive amounts of GGBS to different samples of same BCS sub grade and favorable amount of GGBS is found. Then for this stabilized sun grade resilient modulus is found and the values are optimized using GA and ANN.

1.3 MATERIALS REQUIRED:

- **COLLECTION OF SOIL**

Black cotton soil (BCS) is majorly found in southern India. It is one of the penurious types of soil with micro fine clayey particles of more than 60% under 75 microns sieve. Typically, they are black in color due tofusion of iron and aluminum mixture. They are slender in nitrogen, phosphoric acid and organic matter but rich in calcium potash and magnesium. Usually BCS confirm the elements and clay minerals. BCS in this research has been collected from Bejjikal village, Thripuraram mandal, Nalgonda district (at 16.811, 79.488) of Telangana state. This is a residual distributed soil and it is excavated at 40cm depth below the natural ground surface in order to avoid grabbing of roots and vegetation or any organic matter. The soil is then placed in air tight sacks and transported to the laboratory. It consists of dark grayish heavy clay loam particles and it is oven dried before lumps are processed by pulverizing with the help of a wooden mallet. The processed samples are subjected to various geotechnical investigations to establish their index, mechanical and engineering characteristics.

Figure 1 - Collection of Soil

- **COLLECTION OF GGBS:**

GGBS (Ground Granulated Blast-furnace Slag) is a cementitious material whose main use is in concrete and is a by-product from the blast-furnaces used to make iron.
Blast-furnaces operate at temperatures of about 1,500°C and are fed with a carefully controlled mixture of iron ore, coke and limestone. The iron ore is reduced to iron and the remaining materials form a slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching optimizes the cementitious properties and produces granules similar to coarse sand. This ‘granulated’ slag is then dried and ground to a fine powder.
The GGBS was collected from Veera RMC India Pvt.Ltd at Hyderabad, Telangana state. The sample is collected in a bag and is transported to the laboratory.

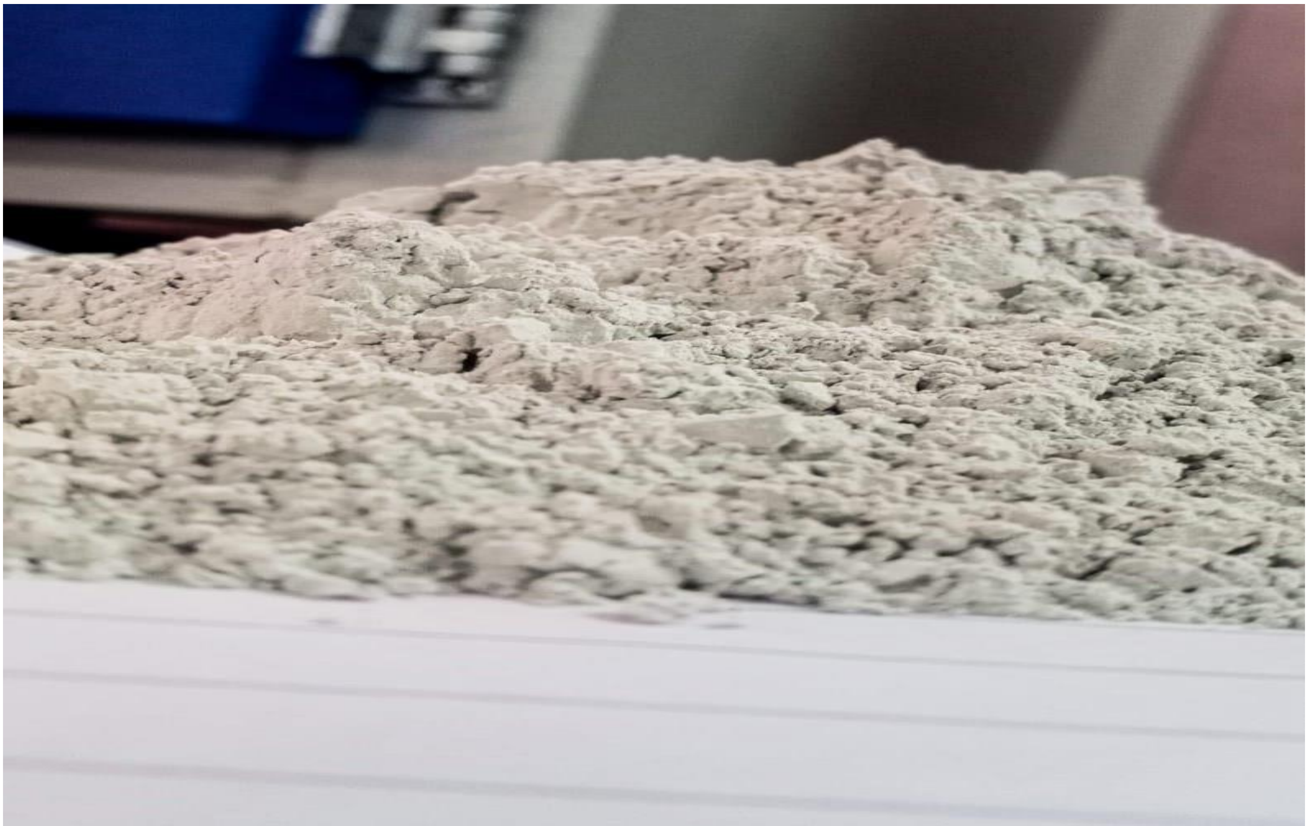


Figure 2-Collection of GGBS

1.5 ORGANIZATION OF CHAPTERS

The document has been alienated into five chapters.

- Chapter 1 consists of general introduction, overview of the project, objectives and scope of project and required materials for the project.
- Chapter 2 consists of literature reviews of various authors and journals helped in the study of the project.
- Chapter 3 discusses the entire project study along with all the tests.
- Chapter 4 presents a brief study and GA.
- Chapter 5 discusses about ANN.
- Chapter 6 consists of entire results of the project.

I NTRODUCTION:

GENERAL:

With the surge in numerous pavement construction operations, there is an urgent need to reduce construction costs and increase the durability. To cut costs, affordable and highly qualified materials and admixtures must be used right from the base of the construction, i.e. the sub grade. Since the sub-grade supports the road pavements and the load from moving vehicles, it is essential to boost the strength of weak sub-grade to increase its load bearing capacity. Flexible pavement is made up of many layers, including HMA, a base course layer, and a subgrade natural earth. Subgrade soil often contains a variety of regionally available soil contaminants, which are typically thin soil or soil with a high water table volume. Because of the low resilient modulus of poor soil, the native weak subgrade cannot withstand traffic loading. The shear weakness in the weak soil layer is causing the most failure in the pavement with a weak subgrade. If the natural soil is weak it needs some improvement to act as a sub-grade. It is therefore, needed to add the natural soil by stabilization with improved strength and compressibility characteristics at the same time lesser thickness of the pavement is required makes the construction economical. For soil modification we have to add certain amount of additive to the soil for improving their properties but these additions finally proves to be more expensive. Whereas in case of soil stabilization some inferior materials or some industrial or agricultural wastes can be used in place of cement or lime with the soil to improve its quality. This will result in cost effective construction. Moreover, due to rapid industrialization throughout the country the productions of huge quantity of waste materials create not only the environmental problems but also disposal hazards. Safe disposal of these materials is of prime concern and this situation can be addressed by the bulk utilization of these materials mainly in the field of civil engineering applications. In recent years the use of various waste products in civil engineering construction has gained considerable attention in view of the shortage and high costs of conventional construction materials, the increasing costs of transportation and environmental constraints. In recent times the demand for suitable sub-grade materials has increased due to increased constructional activities in the road sector and also the scarcity of nearby lands to allow excavating fill materials for making sub-grade. Moreover, soft soil deposits are problematic and needs large scale displacement to facilitate road construction works. These mass replacement methods which are highly cost and labor intensive can be avoided if the poor soil is being improved or modified in situ and reused as road construction materials. Soil stabilization is the process of improving the engineering properties of soil by mixing some binding agent to the soil particles. Stabilization, in broad sense, incorporates the various methods employed for modifying the properties of a soil to improve its engineering performance. Soil stabilization is required where the road alignment passing through poor soil sub-grade does not comply with the engineering requirements as per any given standard specification..

Emerging trend of using waste material in soil stabilizing or soil strengthening is being operational all over the world in present days. The main reason behind this trend is the excessive production of waste like fly ash, plastics, and rice husk ash materials in construction practice will reduce the problem in a great extent. The history of stabilization of soil has a long background with hundreds of research results. Several research results with waste materials such as fly ash, plastics; rice husk ash has also been published with their benefits. It has been reported that both CBR as well as unconfined compression values has increased with the addition of GGBS with natural soil. Also the OMC (Optimum Moisture Content) increase while MDD (Maximum Dry

Density) has decreased due to GGBS mixed with natural soil. This study also shows improvement in CBR values and unconfined compression strength. It is understood that many of the early structures are deteriorating or have already deteriorated away, however with the knowledge of the material properties of concrete that is available, it is hard to imagine that concrete structures is prematurely failing before their intended service life.

Construction of pavements using non economical materials has enormously increased..This is becoming particularly apparent in the developing countries, where tremendous lengths of roads need to be constructed in order to facilitate the development of agriculture, commerce and industry. The cost of any road pavement project includes initial costs and subsequent maintenance costs. The initial costs include many items such as land, accommodation works, bridges and subways, drainage, pavement construction etc. The type and the thickness of the pavement construction determine a large percentage of the initial cost of any road project. Therefore, the development and use of methods to decrease the cost of pavement construction is very beneficial. It is essential to take into consideration the conditions of the sub grade soil before designing the type and the thickness of the pavement, as the sub grade carries the traffic loads as well as the pavement load. The major function of the pavement is to reduce stresses in the sub grade so that there is little or no deformation in the sub grade. Therefore, the more the sub grade is resistant to deformation the thinner the pavement will be, thus reducing the construction cost of the pavement

Good quality sub grade soils are preferable for durable pavements but are not always available for highway construction. The highway engineer designing a road pavement may be faced by weak or unsuitable sub grade. In this case the following methods to overcome this problem can be considered. Firstly, improve the in-situ materials by normal compaction methods and design for the modified properties. Secondly, import suitable materials from the nearest convenient source and replace the site materials. Thirdly, improve the properties of the existing materials by incorporating some other materials; this process is known as "soil stabilization"

The most appropriate method will usually be determined by economic considerations, for example it may be cheaper to stabilize a soil using relatively expensive additives rather than excavate and dispose of unsuitable materials and import and place suitable fill, as well as the properties of the sub grade

Analysis of Sub-Grade Soil CBR is using Evolutionary techniques:

Pavement engineers have long recognized long term benefits of increasing the strength and durability of pavement sub gradesoil by mixing an admixture to the soil before paving. Millions of dollars can be saved by soil sub grade stabilization in comparison to cutting out and replacing the unstable sub grade soil. When included in pavement design, stabilizing the sub grade can result in reducing the thickness of other pavement layers.

Finding an alternative with the most cost effective or highest achievable performance under the given constraints, by maximizing desired factors and minimizing undesired ones. In comparison, maximization means trying to attain the highest or maximum result or outcome without regard to cost or expense. Putting together a portfolio in such a way that return is maximized for a given risk level or risk is minimized for a given expected return level. An optimization tool that allows us to generate an entire tradeoff curve in a single iteration will be more useful to the decision-making process that generates just a single point at a time.

Many human inventions were inspired by nature. Artificial neural networks are one example. Another example is Genetic Algorithms (GA). Genetic Algorithms search by simulating evolution. It starts from an initial set of solutions or hypotheses, then generating successive generations of solutions. This particular branch of Artificial Intelligence was inspired by the way living things evolved into more successful organisms in nature. Thus Identifying different factors that affect the strength of soil by the addition of fly ash in different proportion of sand and then inserting the data into Evolver will result into prediction of soil strength is the present scope of the study. Economic development of any country is controlled to a great extent by the highway and airport networks.

Studies over the past two decades show that it is very important to use neural networks to tackle civil engineering challenges and establish its usefulness for construction problems. The neural networks are an addition to, and not a substitute, classical calculations. In situations where traditional approaches – final elements, finite state machines – have failed, they have strong modeling. For example, differences require a lot of computer power or time to address difficulties.Artificial Neural Networks provide great solutions, such that nonlinear issues with more variables are directly mapped. Non-linear problems with numerous independents, a class of general engineering issues, are great solutions for artificial neural networks. It offers a broader range of solutions. It offers a better degree of accuracy and uses less modeling parameters compared to other modeling approaches. In terms of information, the structure of shape was understood. It might be a favorable trend in fixing difficulties with software like artificial intelligence. Combine several technologies, such neural networks, genetic algorithms and a system of experts.

1.4.3. SOIL STABILISATION:

Soil stabilization, in its general meaning, considers every physical, physico-chemical and chemical method employed to make a soil suitable for its required engineering purpose. In its specific meaning in road engineering, soil stabilization is a regulated process to improve the soil by using additives in order to use it as base or sub base courses and carry the expected traffic and pavement loads. There are several methods by which soils can be stabilized. The three basic techniques that have been successfully adopted in road construction are physical, physico-chemical (bituminous), and chemical stabilization.

Physical stabilization is primarily concerned with the application of external energy. In some cases it is called mechanical stabilization. Physical “stabilization” with the incorporation of another material to give a well-graded mixture may result in materials suitable for use as pavement material. Physico-chemical stabilization, which in the literature generally means the addition of bitumen, is a process whereby an additive is incorporated into the system. Bitumen acts as a cohesive agent in granular soil and in cohesive soil it acts as a waterproofing agent. Chemical stabilization involves the addition of additives to the original soil to form new cementitious materials which result in the soil having better engineering properties (less swelling, better plasticity and workability and better strength). This process is primarily employed with fine grained soils such as silt and clay.

Soil stabilization has been a challenge for geotechnical engineers to find innovative and cost-effective techniques to improve the engineering performance of expansive soils such as increasing soil strength (shearing resistance) and durability (wearing resistance), reducing swelling potential and stiffness (resistance to deformation) and other desirable characteristics. Chemical or mechanical treatments are intended to improve the shear strength, sustainability, reduce compressibility, and control the water absorbing capacity of treated soil.

GROUND GRANULATED BLAST FURNACE (GGBS):

Many chemical substances have been used to stabilize soils, e.g. lime, cement, calcium chloride, sodium chloride, various silicate compounds, and, recently, ground granulated blast furnace slag (GGBS) in South Africa and in the United Kingdom. A particular problem in many areas of the world (e. g. U. S. A, India, and Egypt), is where expansive clays form the sub grade. Expansive clays are those which suffer volume and behavior changes with changes of water content which results in the break-up of road pavements and damage to light structures. Replacement of such clays by other materials is generally expensive due to the high costs of excavation and disposal of unsuitable materials and the import and placing suitable fill.

This is a particular problem in developing countries where construction costs are critical. The typical cross section of an Egyptian road pavement is 200 to 300 mm of granular base courses made of compacted well graded natural pit-run gravel or crushed stone, covered by one or more layer of bituminous concrete courses. This pavement system is not generally suitable for sub grade of expansive clays due to the need to import granular materials this compounding the problem of construction on expansive soils. The volume change of expansive clays, due to a change in their moisture content, causes upward movement which is difficult to predict, resulting in heaving, cracking and the break up of the road pavement which are founded on such soils

Furthermore, most types of clay soils require a greater thickness of base layer compared to those built on suitable and strong sub grade (sand and gravel) that result in a very high increase in the initial and total expenditures of such projects.

To suppress swelling and reduce the volume change, to increase the strength of the expansive clay soils and thus decrease the thickness of the sub-base or base layer, stabilization of these types of soil is necessary.

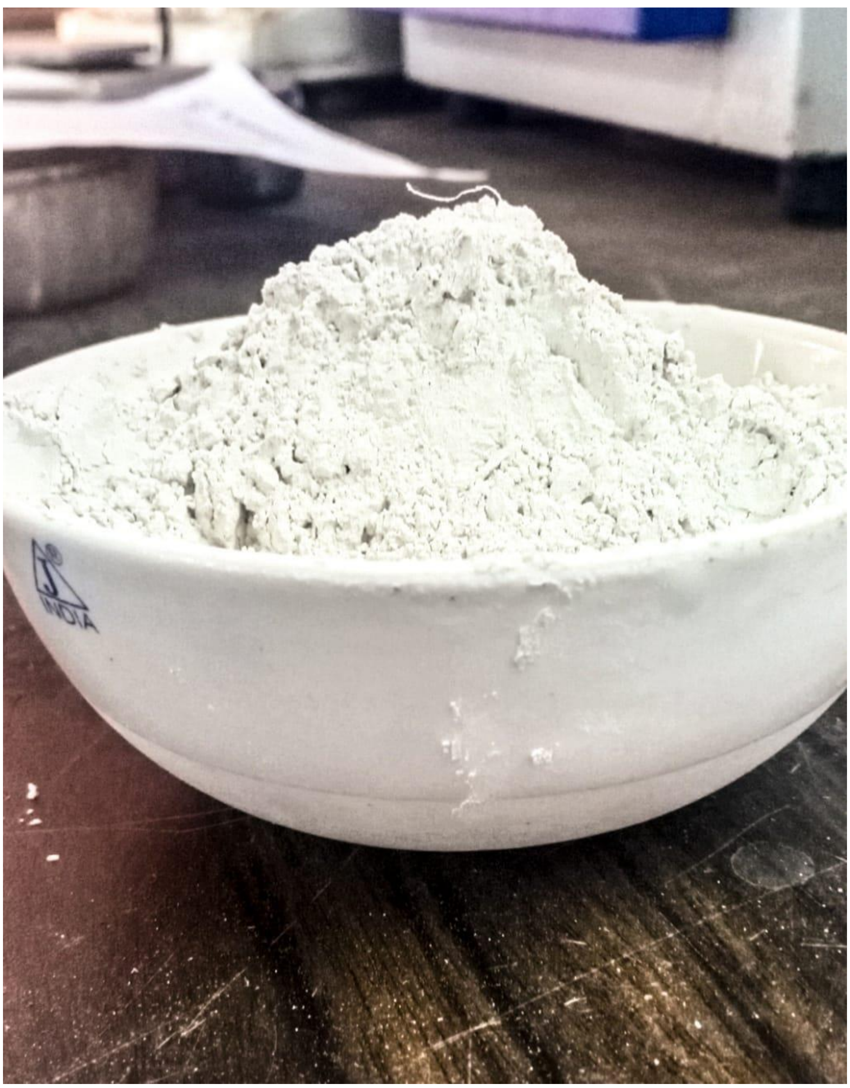
Granulated blast furnace slag (GBS), which is produced as a by-product in the manufacture of pig-iron, has been suggested as a binder. This material is produced in huge amounts by the Egyptian iron and steel company and it is comparatively cheap. It is mainly used, after being ground to fine ground granulated blast furnace slag (GGBS), to produce blended cement. However, it has not been used as a soil stabilizer agent in Egypt although it has been used in the U. K and South Africa. GGBS on its own has only mild cementitious properties and it is generally used in combination with Portland cement or hydrated lime (calcium hydroxide) which provides the necessary alkali for activation.

This dissertation describes an investigates of the effect of GGBS alone, and GGBS activated by lime as an alkali activator, on the engineering properties of a test soil which represents similar Egyptian clayey soil in order to access its suitability for use in Egypt. The predominant clay minerals in this test soil are montmorillonite, kaolinite and small amounts of illite, chlorite and mica. The selection of these materials and design of the test soil are described later in this dissertation.The starting point of the current work will be a review of the mineralogy and general properties of clay soils, the problems of expansive soils, stabilization of clay soils using lime and the effect of the addition of lime on the engineering properties of clay soils. Upto now, the utilization of RHA in sub grade soil as a soil stabilizer with conventional additive materials (Lime, Cement) has been research extensively. However, the number of researchers on the usage of it as a soil stabilizer without using any conventional additives for the stabilization of the fine grain soil is rare. So, utilization of such material for improving the engineering properties of fine grain soil needs to be investigated. that Blast furnace slag is a by-product of iron manufacturing industry. Iron ore, coke and limestone are fed into the furnace, and the resulting molten slag floats above the molten iron at a temperature of about 1500o C to 1600o C. The molten slag has a composition of 30% to 40% silicon dioxide (SiO_2) and approximately 40% CaO, which is close to the chemical composition of Portland cement. After the molten iron is tapped off, the remaining molten slag, which mainly consists of siliceous and aluminous residues, is then rapidly water-quenched, resulting in the formation of a glassy granulate. This glassy granulate is dried and ground to the required size which is known as ground granulated blast furnace slag (GGBS). The production of GGBS requires little additional energy compared with the energy required for the production of Portland cement. The replacement of Portland cement with GGBS will lead to a significant reduction of carbon dioxide gas emission. GGBS is therefore an environmentally friendly construction material. It can be used to replace as much as 80% of the Portland cement when used in concrete. GGBS concrete has better water impermeability characteristics as well as improved resistance to corrosion and sulphate attack. As a result, the service life of a structure is enhanced and the maintenance cost reduced. High volume eco-friendly replacement slag leads to the development of concrete which not only utilizes the industrial wastes but also saves significant Accepted for Publication on 16/2/2014. Sustainable Studies on S. Arivalagan-264-natural resources and energy. This in turn reduces the consumption of cementsummarize the findings and recommends the further analysis to reinforce the research outcomes.

Ground Granulated Blast furnace Slag (GGBS) is a byproduct from the blast furnaces used to make iron. These operate at a temperature of about 1500 degrees centigrade and are fed with carefully controlled mixture of iron ore, coke and limestone. The iron ore is reduced to iron and the remaining materials from a slag that floats on top of the iron. This slag is periodically tapped off as molten liquid and if it is to be utilized for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching optimizes the cementations properties and produces granules similar to coarse sand. This granulated slag is then dried and ground to a fine powder. It can also be referred to as “GGBS” or “Slag cement”.

The primary problem is the original conventional materials are consumed and we are in the search for alternate building materials which lands us here for the use of GGBS. Being a byproduct and waste using it effectively up to some extent serves as a step for a greener environment and at the same time keeping in mind that the strength of the concrete doesn’t degrade by the usage GGBS. Concrete made with GGBS cement sets more slowly than concrete made with ordinary Portland cement, depending on the amount ofGGBS in the material.

. This issue in lower heat of hydration and lower temperature rise, and makes avoiding cold joints easier, but may also affect construction schedules where the quick mount is required. So far in the literatures most of the work has done in the M30, M40 grade of concrete and very few has covered in the M20 grade of concrete using GGBS. Hence it is worth the experimenting to replace the GGBS in M25 grade of concrete and to find its optimum replacement level. The primary aim of this probe is to examine the mechanical behavior of concrete in the presence of GGBS, compared with conventional concrete. The compressive strength, split tensile strength, flexural strength of the concrete with GGBS were tested and analyzed in this study.



GENETIC ALGORITHM:

The dynamic construction site layout planning (DCSLP) problem refers to the efficient placement and relocation of temporary facilities within a construction site in time following the changing needs as the project progresses. The formulation of the DCSLP problem includes the identification of the required facilities at each project phase, the determination of their geometry and operational characteristics (size, shape, movements, etc.), the available space and topography characteristics of the construction site, and any constraints resulting from physical and operational limitations in facility placement. The optimization aims at minimizing construction, relocation, and project manufacturing costs and (ideally) enhancing safety and environmental protection in the construction site. The general construction site layout planning (CSLP) problem can be classified as either facility to location problem where a set of n facilities can be placed in n (or more) predetermined locations of the construction site or facility to site problem where existing facilities can be arranged freely to any unoccupied space within the site boundaries satisfying though all spatial constraints. The latter problem provides a wider solution space than the former and thus the opportunity for more efficient layout exploitation. However, the number of feasible solutions in this case may be enormous, especially if the number of facilities and the construction site area increase. To reduce the computational effort, most studies on this problem typically start with a preliminary "reasonable" determination of locations around which optimization is performed. In actual construction sites, the available space for facility deployment is usually limited, and therefore, one can beforehand define approximate places where the facilities can be allocated, reducing thus practically the problem to the facility to location one. Another distinction within the CSLP problem refers to the equal or unequal area assignment depending on whether all locations can sufficiently host (in terms of size, shape, terrain, operation, safety, or other constraint) every single facility or not The site layout planning problem is a complex combinatorial optimization problem involving multiple objectives and has been researched by a variety of methods and techniques from mathematical models to knowledge based systems. The problem grows significantly in size and complexity as the numbers of facilities and constraints increase and become even larger in the case of dynamic layout planning where time is involved as an additional parameter. For this reason, meta-heuristic techniques have been dominantly used in recent years because of their capability to produce acceptable (near-optimal) solutions in reasonable time for typical problem cases. Algorithms that have been applied to solve the CSLP problem fall within artificial intelligence techniques, evolutionary algorithms (EAs), and swarm intelligence (SI) algorithms. The decision for algorithm selection depends on the problem size and complexity, the solution quality sought, and the computational time requirement, especially for large-scale problems. The consideration of m project phases and corresponding layouts (DCSLP problem) increases the magnitude of the problem to the power of m compared to the single-phase one. Existing studies typically generate the optimal layout for each phase separately and accept the most efficient of the individual layouts for the whole project duration in order to avoid the burden of any relocation cost. In the present study, all project phases are jointly integrated in the optimization model to search for a globally optimal solution considering both transportation costs in each phase as well as construction and relocation costs of facilities from phase to phase. In addition, the proposed model can take into account safety and environmental considerations in the form of preferences or constraints in placing certain facilities relative to others.

A genetic algorithm (GA) has been continuously utilized as a powerful and applicable optimization tool in civil and construction management research domain to solve the resource-constrained project scheduling problem (RCPSP). The optimal solutions to the problem are of great value to project planners in resolving resource conflicts. Therefore, many researchers attempt to develop the best procedure to be used as a project management tool to allow for the complexities of real-world problems. A recent trend in solving the RCPSP using GA is to develop an integrated meta-heuristic method by combining GA with other meta-heuristic method. As an effort, the author developed an adaptive hybrid genetic algorithm search simulator (AHGASS) to find an optimal solution to the problem by providing the strategies and practical procedures (Kim and Ellis 2009). The study presented intensive computational results to demonstrate that AHGASS provides a comparable and competitive performance. However, it does not deal with the algorithm performance with regard to algorithm runtime, especially against the runtime used in generating optimal solutions. Since the major drawback of using GA is a great length of time required, in addition to the difficulty of choosing an encoding and fitness function, it is meaningful to investigate the significant difference in algorithm runtime between AHGASS and optimality. To address this issue, this paper attempts to investigate the difference in algorithm performance with regard to algorithm runtime. The following section briefly introduces genetic algorithm for construction resource scheduling problems, followed by the strategies and practical procedures of the integrated GA approach for RCPSP. Next, the computational results and analysis section describes data and variables for obtaining algorithm performance and runtime data, immediately followed by statistical results and analysis. This paper then makes concluding remarks.

ARTIFICIAL NEURAL NETWORK:

Artificial Neural Network (ANN) is a profound learning algorithm developed out of the concept of biological neural human brain networks. An attempt to imitate the functioning of the human brain culminated in ANN. ANN operates very much like neural biological networks, but does not precisely look like their functions.

Only quantitative and organized data would be allowed to form an ANN algorithm. Unstructured and non-numerical data types including Image, Text, & Speech, CNN, and RNN (Recursive Neural Networks) are accepted. We are focusing mainly on Artificial Neural Networks in this study.

Neural artificial networks are a technology based on brain and nervous system studies. These networks replicate a biological network of neurons, but employ a restricted set of biological neural systems ideas. In particular, ANN models imitate the brain and nervous system electrical activity. The processing components are linked with other processing elements (also known as neurodes or perceptons). The neurodes are often organised in a single layer or vector and one layer output is the input for the next layer and sometimes further layers.

RESILIENT MODULUS:

One of the main characteristics of design for any pavement material is resilient modulus (MR). The isotropic confining pressure and repetitive loading are used to evaluate the resilient module of any soil. Cyclic triaxial tests are performed to reproduce the stress levels generally seen in the pavement layers of base and subgrade. The resilient module determines the paving material's response to repeated loads. The measurement of the elastic property of soil is a resilient modulus that identifies specific non-linear features. MR is defined as the elastic modulus based on a repeatedly loaded recoverable strain.The resilient modulus is a material characteristic related to the elasticity modulus. That is, a stress-straining relationship is a robust module. It varies from the elasticity module, however, as it is determined by a repeated-load, triaxial compression test (sorne scientists utilize "unconfined compression") and is based on the resilient (or recoverable) component of the strain alone. Resilient modulus is defined as:

Resilient modulus = where

Stress amplitude = load/area of the specimen

Strain amplitude: recoverable deformation/original height.

A dirt or granular substance is illustrated in its general stress strain behavior. When the load is applied, the stress as the strain grows. When stress is decreased, stress also decreases, but when tension is gone, the whole strain does not return. Therefore, the total strain consists of both a permanent (or plastic) part and a regenerative (or resilient) part. In this robust module the plastic strain is not included.

CLAYEY SOILS:

Land is wealth for a nation; economic stability and human sustenance of a country depend to a large extent on conservation of land by proper use. Knowledge on physico-chemical properties of soils is prerequisite for proper land utilization. Plant growth and optimum land use for agriculture, forestry etc. are primarily governed by environmental conditions of soils which is dynamic heterogeneous polydispersed complex system of solid, liquid and gaseous components. Its components are made up of primary and secondary minerals and hydrous oxides together with organic matter and living organism in a polyphase state of system. Soil formation is a function of weathering and different soil forming factors. These processes help to develop well or relatively less well organized soil body. The clay minerals are formed either by detrital inheritance or by transformation of the original minerals of the parent and/or by neosynthesis from the products of decomposition of the original minerals. The formation of the types of layer silicate minerals and hydrous oxides depends on the ionic environment of the weathering zone yielded by parent material. The clay and hydrous oxides are the seat of all physico-chemical reactions and play a significant role in the plant nutrition. Besides these, the organic colloid constitute viz., humus is a reactive part of the soil constituent within the frame work of the skeleton composed of sand and silt fractions. The clay fraction of the soil contains the finest and the most active particles, be of crystalline and non-crystalline or amorphous part. In consequence, many of the properties of the soils are influenced by nature of such fractions even when the amount present may be meager. The crystalline clay mineral is composed of a mixture of one or more newly synthesized secondary layer hydrous aluminosilicates. Composition of a given clay mineral may vary because of isomorphous substitution of different ions in a given structural composition. The supply of exchangeable ions is continuously renewed by the weathering reactions of the minerals. The different mineral species of the soils have a controlling influence on the release of structural ions and on the 2 chemical activities of exchangeable ions. The sorption of nutrients from solution or other sources and their release for absorption by plants are the most important processes in which these minerals play a significant part. Ion exchange and ion fixation of potassium, ammonium, phosphate and some of the micro-nutrient ions are characteristic properties of crystalline clays. Thus the mineralogical composition of soil has an important bearing on soil productivity. The non-crystalline component of clays which is designated as inorganic amorphous material has been found to govern the characteristics of the associated crystalline clay minerals. When present in sufficient amounts, these play a noticeable role in regulating the properties of soils. These are responsible for high water holding capacity, low bulk density, high cation exchange capacity, specific adsorption characteristics in relation to phosphate, nitrate, borate, potassium, zinc, fluoride and arsenic. All these emphasize the importance of these materials in determining soil fertility and productivity. Further because of high reactivity and large surface area of these materials, the adsorption of inorganic fertilizers by these often make large fraction of added fertilizer unavailable to the plants and the adsorption of pollutants from streams and from atmosphere often causes considerable soil pollution. Thus the amount and nature of inorganic fractions in soil determines the physico-chemical behavior of soil. The prominent amongst the amorphous materials in soils is 'allophone' which developes on volcanic ash. A tentative definition of allophone proposed in 1969 at the international seminar on amorphous clay minerals was, "Allophones are members of a series of naturally occurring minerals which are hydrous aluminum silicates of widely varying chemical composition, characterized by short-range order by the presence of Si-O-Al bonds and by a differential thermal analysis curve displaying a low temperature endothermic and high temperature exotherm with no intermediary endotherm"

CHAPTER 2

LITERATURE REVIEW

1. Richard Ji et al (2013):

Stated that the Resilient modulus is an excellent measurement under pavement materials service condition in the pavement structure. Material properties can be used to predict the resilient modulus, its $R2$ values ranging from 0.79 to 0.97. Back calculation from in situ test device measurements and estimation using correlations with physical properties of tested soils can be employed to predict resilient modulus. Correlation equations have been developed The Scientific World Journal 13 with more commonly to estimate the resilient modulus of the unbound materials and cohesive soil.

2. Khavla H.H et al. (2020):

Stated that the lower strength soil type reviewed was silty clay located in India with CBR equal to 1%, while the higher strength soil is clay which is also located in India with CBR equal to 6.64%. The higher percent of pavement thickness reduction achieved by physical additives was adopted by adding asphalt emulsion by 12% that increase CBR from 4.6% to 20.6% Gypsum added by 25% as soil chemical additives attained highest reduction in pavement thickness when CBR increase from 1% to 22%. Geogrid when butted at 0.2% from height increase CBR from 2.14% to 12.84% represented best pavement thickness reduction.

3. Murad Abu et al. (2015) :

Has summarized that the performance-related properties (e.g., resilient modulus and permanent deformation) of cementitiously treated/stabilized very weak subgrade soils were evaluated in this study. Five different soils that represent the typical range in subgrade soils in Louisiana were studied. Three different wet of optimum moisture contents, producing a raw soil strength of 172 kPa (25 psi) or less (representing very weak soils), were chosen for treatment/stabilization. The percentage of cementitious stabilizer was determined to achieve the target 7-day strength values of 345 kPa (50 psi) (for working table applications) and 1034 kPa (150 psi) (for subbase applications).

4. S.Sasanian et al. (2014):

Stated thatthe effect of soil mineralogy and activity on the properties of cemented clays and to find important parameters governing cement-treated clay mechanical behavior, the results of laboratory shear vane, unconfined compression, undrained triaxial, and oedometer tests on many different types of clays treated with Portland cement have been examined. The results indicate that the hydration rate of ordinary Portland cement used to stabilize clay drops significantly with curing time, cemented clays continue to gain significant amount of strength long after the curing has started. This behavior, which is not typical of cement-based construction materials can be attributed to slower pozzolanic reactions that happen between clay minerals and cementation products.

5. **De Gruyter et al. (2015):**

Stated that stabilization of high-plasticity clayey subgrade of road pavements using the Isparta-Karakaya pumice waste was investigated. Once the index properties were determined, standard compaction, constant volume swelling, unconfined compression, shrinkage, and liquid and plastic limit tests were conducted to examine the effects of pumice on the compaction properties and the unconfined compressive strength of compacted clay. The Isparta-Karakaya pumice is composed of silica and aluminum. The natural unit weight of the pumice is extremely low. However, its permeability coefficient is high.

6. **6.P. Priyadharshini et al (2018) :**

Stated that dry sieving of soil removes some of the fines and clay particles, thereby improves soil-based mortar properties. Combination of sieving and stabilization of soil helps in controlling the water demand to maintain a constant workability. Dry density and compressive strength improved with slag stabilized plastic soil mortars compared to lime stabilized soil mortar. Low plastic soil mortar reached a strength value equivalent to river sand by dry sieving and stabilizing with slag.

7. **John McCall et al (2004) :**

Confirmed that the GAs are a natural evolution-inspired heuristic solution search technique. They are a dependable and adaptable tool that can be used to solve a variety of learning and optimization problems. They're especially well-suited to problems where conventional optimization techniques fail, either because of the search space's irregular structure (for example, the lack of gradient information) or because the search becomes computationally intractable. We have defined the major components and properties of a GA in this paper, along with examples of implementations on specific problems. This acts as a starting point for immunology researchers interested in applying GAs to their own problems.

8. **Sourabh Katoch et al (2020) :**

Said that the purpose of his paper is to present a structured and explained view of genetic algorithms. With regard to application, GA and its variants have been discussed. There are application-specific genetic operators. talked about Some genetic operators are intended to be represented. They are, however, not relevant to research domains The function of genetic operators such as crossover, mutation, and recombination. The role of selection in preventing premature convergence is extensively researched. The usefulness of GA and its variants have been discussed in a variety of research domains. Wireless and multimedia The focus of this paper was on network applications. The difficulties and problems. The information provided in this paper will assist practitioners in their work.

9. **Muhammad Kamal Amjad et al. (2018) :**

Firstly, it addresses the application of GA specifically to the FJSSP and provides a startup for researchers who want to excel in this area by providing recent research trends. Secondly, the parameters that have been used the most are also identified which can be mapped with references for advanced studies. Furthermore, the special cases of FJSSP have also been identified. The study has surveyed the implementation of GA for FJSSP in detail and the trends for use of GA parameters have also been presented, along with the benchmark studies conducted with each approach.It is obvious that GA is the most popular technique for the solution of FJSSP. The study has pointed out the mostly used parameters of GA in the literature.

10 Amr Mossalam et al.(2013):

Said considering that the manual selection process of projects usually has a certain amount of forced in/out projects, and not strictly following a pure formulated criterion, the level of error in the three methods is acceptable where the results of the three configuration methods showed a level of error in the predication ranging from 6.8% in case of Best Net to 14% in case of PN, while MLFN showed 8% of error in the predication. Based on these results, the best net trained network can be used to predict future projects sponsorship involvement, with a level of error of 6.8% and trend will be recorded when new projects are added.

11. Samreen bano et al.(2019):

Stated that it is obvious that ANNs have been successfully applied to many civil engineering areas such as prediction, decision-making, and risk assessment. Analysis, optimization of resources, classification, and selections and so forth According to the findings, ANNs outperform humans. other traditional methods Many people work in civil engineering. The issues are extremely complex and poorly understood. the majority of The mathematical models are unable to solve such complex problems. the way you act ANNs are only based on input and output data.which model is simple to train ANNs are always available. updated to produce better results by displaying new training As new data becomes available, examples will be provided.Thus, ANNs have produced a number of significant results, making them a powerful and practical tool for solving many problems in the field of civil engineering, and they are expected to be applicable in the future.

12. P.S. Kulakarni et al (2013):

Presented an extensive review of previous works dealing with recent applications of ANN in Cost, Productivity, Risk Analysis, Safety, Duration, Dispute, Unit Rate, and HybridModels is performed. ANNs are based on input-output data, which allows the model to be trained and updated to achieve better results by presenting new training examples. As a result, ANN has significant advantages that make it a powerful tool for solving a wide range of problems in the field of CM. However, there is still a lot of room for experimentation with different network architectures, training algorithms, and hybrid methods, which could lead to a higher level of model performance.

13. Baba Shehu et al (2007):

Stated that in cases of complex qualitative and quantitative reasoning, ANNs have been shown to be more powerful than traditional mathematical and statistical methods. They have been used successfully in the construction engineering and management fields to solve a wide range of complex nonlinear problems such as prediction, estimating, decision making, optimization, classification, and selection. They have been identified as having the potential to deal with noisy data while achieving high accuracy and reliability in prediction and forecasting.

14. Hamed Memarian fard et al. (2014) :

In this artificial neural network method the output parameter sensitivity to any of input parameters can be investigated. This capability is a rational way to investigate the relation between any of two dependent/independent parameters in certain loading process. There are also several areas in which the feasibility of artificial neural network method has yet to be tested. In many situations in geotechnical engineering, it is possible to encounter some types of problems that are very complex and not well understood that can be solved by neural network method.For most mathematical models that attempt to solve such problems, the lack of physical understanding is usually supplemented by either simplifying the problem or incorporating several assumptions into the models. Consequently, many mathematical models fail to simulate the complex behavior of most geotechnical engineering problems. In contrast, artificial neural network method is based on the data alone in which the model can be trained on input-output data pairs to determine the structure and parameters of the model.

15. Pooja Dudhe et al (2017):

Stated that a neural network is developed for predicting construction project management effectiveness for a construction firm.To predict effectiveness, twelve variables were identified. The network is a valuable practical tool that can provide management of a construction firm that specialises in institutional and commercial construction with a pre-project view of their performance. Significant variables are identified through statistical analysis to improve network performance, and these variables are then used in the ANN's input and hidden layers. This has resulted in the development of a simple and computationally efficient network capable of predicting the organisational effectiveness of a construction firm.The established neural network model can be used during the competitive bidding process to evaluate construction project management risk and predict construction budget performance. The model enables construction project managers to focus on key success factors while lowering construction risk. The model can be used to develop the construction management decision support system further.

16. Ali Akbar Firoozi et al. (2017) :

Said based on the short review of this study, desiccation, swelling, shrinkage, and cracks in clayey soil are common natural phenomena, and it significantly impacts the soil's mechanical and hydraulic behavior. Treatment of the soil with cement reduces the volume changes in soils but this type of treatment becomes unsuitable for soils with high plasticity index. Soil treated with lime and exposed to wetting and drying cycles results in loss of cohesion between the grains of soil and lime, which leads to increase in soil volume. Thus, the method of treatment with lime is only good for places that are not exposed to the wetting and drying cycles.

17. Michael Darter et al. (2009) :

Stated that cheaper, lower-quality materials can be used in greater quantities in the lower layer, where they will contribute structurally without detracting from the quality and performance of the overall pavement.

18. Anita Thengade et al. (2012) :

Stated if the conception of a computer algorithms being based on the evolutionary of organism is surprising, the extensiveness with which this algorithms is applied in so many areas is no less than astonishing. These applications, be they commercial, educational and scientific, are increasingly dependent on this algorithms, the Genetic Algorithms. In this paper we placed more emphasis on describing the basic of the Genetic Algorithm, its functionality. The various issues that are faced by Genetic Algorithm are also included in this paper.

19. Y. Cengiz Toklu et al(2014):

Stated GAs that are easily extended for use in unconstrained problems can also be easily extended for use in constrained problems by performing a few extra calculations related to fitness values. This study also shows that GAs can be applied to more general problems with relative ease. These problems may involve real cost values, undetermined durations, more uniform resource use (resource leveling), nonlinearities in any sense, and so on.

20. Devikamalam et al (2014):

Implementing the GA-developed model for resource-constrained project scheduling resulted in improved performance at a lower cost. A real-life example this optimization software was used to complete a project that the best converging result is obtained.

21. Ahmed Faez Abdulameer et al. (2017) :

Said that if the GA built model for resource-constrained project scheduling was implemented, the efficiency is improved while the cost is reduced. A real-time project solved with this optimization programme illustrates that the best converging outcome can be achieved, with a total cost reduction of 6.4 percent and a one-month reduction in project length.

22. Sofia Kaiafa et al.(2015) :

Presented the resource-constrained scheduling problem is one of the most challenging ones in the area of project management. This is a combinatorial optimization problem with multiple and conflicting objectives and constraints, i. , confine the daily resource usage within resource availability, finish the project as soon as possible, and make the daily resource histogram as smooth as possible. The problem gains significant size as the number of project activities, resource types, and alternative activity execution modes increase.
The optimization aims at minimizing the total cost that is associated with resource overallocation, project deadline exceedance, and day-by-day resource fluctuations. All three sub-objectives are represented by cost functions and the whole optimization parameter is a pure cost variable avoiding thus the need for

subjectively setting importance weights among dissimilar parameters. Due to the large number of activity execution alternatives, a genetic algorithm has been employed for the optimization.

23. Tarek Hegazy et al. (1999) :

Stated that using a widely used project management software, a macro program was written to automate the GA procedure and a case study was used to demonstrate its benefits and future improvements and extensions. In recent years, project management software systems have been improving continuously and recent versions have exhibited better interfaces, integrated planning and control features, and Internet capabilities. Yet, basic project management functions such as resource allocation, resource leveling, and timecost trade-off analysis have been the least improved.

24. Khan Md. Ariful Haque et al. (2012):

Estimated the customized GA based project time-cost optimization algorithm in a fuzzy environment. It provides an efficient computational technique for time-cost optimization project scheduling problem incorporating uncertainty in network analysis. Due to NP-hard nature of the problem, a computer code of GA based solver was used to find the optimum solution within project completion time constraint at different values of a-cut level. The problem was resolved under different combinations of GA parameters. After analysis of results, optimum values of those parameters were found. The performance of the presented GA based algorithm can be further analyzed in terms of CPU time by comparing it with other best known algorithms for project time-cost optimization. Different selection mechanisms can change the algorithm efficiency. In this problem Roulette wheel selection method is suggested.

25. Alexandrina-Elena C. Pandelea et al. (2014) :

Presented that the Neural networks are a supplement to traditional computation approaches, not a replacement.They have strong modeling in areas where conventional methods (finite elements, finite state machines) have failed. Differences, for example, necessitate a lot of computational power or time to solve problems. Artificial neural networks. Networks have excellent solutions, allowing for direct mapping of nonlinear problems with more variables.Artificial neural networks provide excellent solutions to nonlinear problems with multiple independent variables, which is a class of general engineering problems. It offers more comprehensive solutions compared to other modelling methods, it has a higher level of accuracy and needs less modeling parameters.

26. Kasthurirangan Gopalakrishnan et al. (2008) :

Stated that the Heavy Weight Deflectometer test is one of the most widely used tests for assessing the structural integrity of airport pavements in a non-destructive manner. Back calculation is the accepted term used to identify a process whereby the elastic moduli of individual pavement layers are estimated based upon measured HWD surface deflections. They are also necessary inputs to mechanistic-based analysis and design of pavements.

27. Magdi M. E. Zumrawi et al. (2007):

Carried an experimental work to estimate the resilient modulus of subgrade soils from easy measured soil index properties. Several laboratory tests to measure the MR and index properties were conducted on soil samples compacted at different moisture contents and dry densities•. Analysis of tests results and data reported by previous researchers demonstrate very clearly that a direct linear relationship exists between MR and the consistency factor•. On basis of this linear relationship•, reliable strong equations have been established between MR and soil index properties.

28. Thillai Nayagee Arumugam et al. (2019):

Stated that the usage of 4% of liquid SiO2 stabilizer had shown a better performance with 95% density and WOpt. The application of SiO2 liquid stabilizer as a subgrade stabilizer improved the resilient modulus or stiffness of the subgrade soil. The prediction of the pavement performance using AI methods showed that the specimen with 95% density and WOpt-3 gives a higher number of cycles to failure that lead to failure which indicated that when the soil is compacted with 95% density with lesser water content than optimum the resilient modulus will increases. From these two methods it showed that the specimen which was compacted at 95%density with WOpt-3% with 4% SiO2 was the best concentration for subgrade stabilization through this study.

29. Hani H. Titi et al. (2006):

Recommends when designing low-volume roads, AASHTO recommends using the resilient modulus test database in the absence of any basic soil testing. Estimating the robust modulus using basic soil properties of subgrade soils On average, there are three distinct types. For each soil type, there are models to estimate each ki (fine-grained, non-plastic coarsegrained, and plastic coarse-grained). These equations can be applied to a variety of situations.basic soil test results are available.

30. Daehyeon Kim et al. (2006) :

Presented that the highway authorities are being urged to adopt advanced designs based on the latest M-E Design Guide's philosophies. The current study examined the features included in the M-E Design Guide as part of its implementation. Unbound materials, especially subgrades, have a design guide.The M-E Design Guide assumes that the subgrade has been compacted to the ideal moisture content, resulting in an inefficient design. The use of average values is essential to ensure a conservative design for subgrades.To be more cautious, use of the Mr at wet of optimum may be recommended. In the absence of laboratory research for evaluating thawed Mr, the use of Mr optimum for wet would be reasonable; Use caution when using the suggested conservative frozen Mr value.M-E Design Guide (M-E Design Guide) (M-E Design Guide) Mr testing software for both architecture and characterizing subgrade in Indiana. It is preferable to use Level 2 and Level 1 inputs.

31. .S.Arivalagan et al. (2014): It is observed that GGBS-based concretes have achieved an increase in strength for 20% replacement of cement at the age of 28 days. Increasing strength is due to filler effect of GGBS. 2. The degree of workability of concrete was normal with the addition of GGBS up to 40% replacement level for M35 grade concrete. 3. From the above experimental results, it is proved that GGBS can be used as an alternative material for cement, reducing cement consumption and reducing the cost of construction. Use of industrial waste products saves the environment and conserves natural resources.

32. M.Rajaram et all (2017) The Following conclusions were drawn based on the experimental investigations carried out in this study.The workability of the concrete increases with the increase in the GGBS content forM25 grade concrete and the workability reaches its maximum at 50% replacement of GGBS. The present study shows that the replacement of GGBS in concrete can produce high strength than the conventional concrete mix.The early age compressive strength and split tensile strength at 7 days and 14 days has reached its maximum strength at 20%replacement of cement with GGBS forM25 grade of concrete. The early age flexural strength at 7 days and 14 days has reached its maximum strength at 35% replacement of cement with GGBS for M25 grade of concrete. It is observed that the strength level increases at 20% for compressive strength and split tensile strength replacement of GGBSand falls at 35% replacement

33. A Swami. et.al. (1983)Presented extensive investigations have been carried out by Swami on the properties in the fresh and hardened state of Fly ash concrete containing normal weight and light weight aggregate suitable for structural application. The mixes were proportioned to have one-day strength comparable with concrete without Fly ash, possessing adequate cohesiveness and workability to enable them to be compacted into place easily in structural members. The authors have after conducting extensive tests on reinforced concrete structural members with Fly ash and without Fly ash concluded that reinforced Fly ash concrete in beams and slabs exhibit structural performance similar to that of conventional concrete with adequate safety factor and predicted by existing codes. The authors have concluded on the basis of the data presented with Fly ash of controlled quality, structural concrete constructions can be designed to incorporate Fly ash up to 30 percent by weight of cement and that Fly ash concrete characteristic were in no way different from these of comparable normal concrete.

34. B. Anand Kumar B .G. et al. (2012)the best way to dispose any waste material (fly ash) is to use it as one or the other forms like construction material. In developed countries electrostatic precipitators collects fly ash, which leads to greater fineness. Hence it shows goodpozzolonic activity. So it can be used as part replacement of cement. The effective utilization of fly ash in any field is possible only when a study of physical, chemical and mineralogical properties of the particular fly ash available is done. The properties will vary from plant to plant and within a plant the source of collection. It was decided to use the fly ash of Raichur thermal power station in Karnataka in thepresent work. With the study on the strength development on various high volume fly ash concrete (with at least 50 %fly ash as binder) mixes, the following conclusions can be drawn..

35. Kishan lal Jain et al. (2016)have experimental program to effect on strength properties of concrete by usingGGBS by partial replacing cement and addition of GGBS without replacing cement. In this study partial replacement of cement OPC (43-grade) by Ground-granulated blast furnace slag which varies from 5% to 25%at interval of 5% by total weight of OPC. This study calibrates the performance of concrete mixtures in terms of slump, compressive strength, flexural strength and splitting tensile strength test for 7 days and 28 days respectively.

36. Raj.p.singh kushwah et al. (2015) Have experimental study on utilization of marble slurry in cement concrete replacing of fine aggregate. Utilization of marble slurry in cement concrete replacing sand is 30%.Which is showing equal strength as of control i.e. 1:2:4 cement concrete 0% marble slurry. As per results of practical examination this material marble slurry shows a good and acceptable strength when added in cement mortar and cement concrete both (replacing sand). It can be used as a filer material (up to 30% replacing sand) showing same strength as of control.

37. YallanagoudaParasappa Goudar et.al (2018) In their Study research was to produce an eco-friendly concrete. This paper recommends the effective use GGBS and waste foundry sand as a partial replacement for cement and fine aggregates respectively and waste ceramic tiles as a partial replacement for coarse aggregate in concrete. Concrete containing GGBSin the range of0%,10%,20%,30% and 40%, waste foundry sand (WFS) in the range of 0%,10%,20%,30%and 40% and waste ceramic tiles (WCT) in the range of0%,10%,20%,30%and 40% by weight for M-25 grade concrete. Concrete produced was tested for workability, compressed strength, split tensile strength and flexural strength. The strength properties of the specimen containing 30% GGBS, 30% waste foundry sand and30% waste ceramic Tiles a replacement for cement, fine aggregate and coarse aggregate shown higher strength as compared to Conventional Concrete and workability of concrete increases with increasing amount of GGBS.

38. Varun Jain et.al (2017) In their Study investigates the strength of unconventional concrete (UC) when coarse aggregate is partially replaced with ceramic tile aggregate (CTA). Concrete was partially replaced with ceramic tile aggregate by 10%, 20% and 30%. The results concluded that replacement of ceramic tile aggregates up to 30% improves strength properties of concrete.

39. Neelesh Kumar Singh et.al (2018) In their Study deals with the evaluation of the properties of concrete on partial replacement of its contents using Ground Granulated Blast Furnace Slag (GGBS) and Ceramic Waste. The investigation work has been done for thecompressive strength of M25 grade of concrete by the partial replacement of cement using GGBS and using ceramic waste as partial replacement for coarse aggregate. The percentage replacement of cement is from 10% to 30% by mass and coarse aggregate at a constant proportion of 15% by mass. The results concluded that using slag upto30% and ceramic wastesupto 15% in concrete can be effectivelyused without compromising its basic properties

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40. Ravi Raithatha et.al (2017) In their study, the behavior of GGBS and Ceramic Waste in concrete is examined by the replacement of Cement with the GGBS and Ceramic Waste for the determination of structural property. The replacement percentage of Cement with GGBS is up to15% with the interval of 5% and Ceramic Waste is fixed for 10% By Weight. The water cement ratio of 0.50 was used. Results showed that optimum percentage ofGGBS and Ceramic Waste replacement for highest compressive strength is 15% and 10% respectively at 28days compare to the standard solid concrete blocks.

41. Er. Kimmi Garg et.al (2016) In their Study presents an experimental investigation to know the use of GGBS in concrete as a replacing agent of cement. To accomplish this 43 grade Ordinary Portland cement were used in preparing concrete mix with a w/c ratio of 0.50 with suitable super plasticizers. In order to confirm the use ofGGBS as a replacing agent tests were conducted. Cement was replaced with 0% to 40% with GGBSrespectively. Concrete control specimens without replacement were also cast for comparison. After casting the cube moulds specimens were tested for various tests like compressive strength test, tensile strength test, flexure strength test. From the study, based on the findings the replacement of cement with GGBS is found to have least strengths with that of control mix.

42. N.Naveen Prasad et al. (2016) In their Study investigates the use of waste crushed tiles that were replaced in place of coarse aggregates by 10%, 20%,30% and 40% and Granite powder were replaced in place of fine aggregate by 10%, 20%, 30%and 40%. M25 grade of concrete was designed to prepare the conventional mix. Experimental investigation like Compressive strength test, Split tensile strength test, Flexural strength test, and Water absorption test for different concrete mixes were performed. Results concluded that workability of mix increases with increasing percentage of crushed tiles and granite powder. Further, it was concluded that for 10% of granite powder and 30% crushed tiles in concrete gives better strength than conventional concrete.

43. Krishnaveni et al.(2007): Presented based on the experimental investigation the following conclusions are, It is observed that GGBS 40% + garbage ash based concrete have achieved an increase in strength for 10% & 20% replacement of cement at the age of 7 , 14 and 28 days. 2) The replacement of cement by GGBS not only increases the compressive strength but also reduces the cement content which decrease in emission of CO_2. The most optimized mix of GGBS 40% +garbage ash based concrete is found to be 10% & 20% from both compressive and split tensile strength of concrete. However, beyond 40% of replacement, the strength decreases. As far as cost is concerned, the cost of GGBS in the market including packaging and transporting is three times less than that of OPC. Therefore, the partial replacement of OPC in concrete by GGBS & garbage ash, is not only economical but also facilitates environmental friendly disposal of the waste slag into a useful product, which is generated in huge quantities from the iron and steel industries.

44. Arthika et al. (2012): Saidbased on the compressive strength results, the maximum compressive strength at all ages of testing was obtained at (M1)10% GGBS & 50% M-sand optimum replacement, corresponding to an increase of 10.25%, 8.84% and11.33% compared to the 14- days and 28-days compressive strength of conventional concrete. • While comparing the split tensile strength results, HPC mix containing 10% GGBS & 50% M-sand (M1) achieved greater split tensile strength when compared with conventional concrete. High performance concrete mix (M1) has achieved 0.85% higher value than conventional concrete. • The flexural strength results have shown that high performance concrete with 30 % GGBS & 50% M-sand (M3) has got highest flexural strength compared with conventional concrete. The percentage increase in flexural strength is 75.36% higher when compared with conventional concrete. • Based on the results, it is observed that there is a slight increase in deflection of the beam M1of 13.42 % than the conventional beam. From the results it is observed that there is a slight increase in deflection for the beam M1 (10% GGBS & 50% M-sand) than the conventional beam.

45. PanagiotisM.Farmakis et al. (2016): Has presented that efficient layout planning of a construction site is fundamental for successful project undertaking as it enhances both productivity and safety of operations. The site layout planning problem is a complex combinatorial optimization problem involving multiple objectives, and it grows exponentially in size as the numbers of facilities and constraints increase. In addition, as construction evolves, the site layout may need to be dynamically reorganized at various schedule intervals to accommodate the operational needs. This is known as DCSLP, which refers to the efficient placement of temporary construction facilities within a dynamically changing construction site environment, considering the facilities’ characteristics and work interrelationships; the size, shape, and topography of the construction sites; and the time-varying project needs.

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CHAPTER 3

PROJECT DESIGN

METHODOLOGY:

- **TESTS PERFORMED:**

SPECIFIC GRAVITY [IS 2720-Part III-1984]

HYDROMETER ANALYSIS [IS 2720-Part IV-1985]

FREE SWELL INDEX TEST

ATTERBERG LIMITS [IS 2720-Part V-1985]

STANDARD PROCTOR COMPACTION TEST [IS 2720-Part VII-1980]

UNCONFINED COMPRESSIVE STRENGTH (UCS) [IS 2720 – part X-1991]

CALIFORNIA BEARING RATIO TEST

RESILIENT MODULUS (TRIAXIAL TEST)

SPECIFIC GRAVITY TEST:

SCOPE

This manual describes the procedure of the Department of Transportation Geo technical Engineering Bureau to determine the apparent specific gravity of a soil. Values presented in this manual without a decimal point or a tolerance is approximate.

DEFINITION:

The ratio of the mass in air of a given volume of a material at a stated temperature to the mass in air of the same volume of gas-free water at a stated temperature.

APPARATUS

1. Pycnometer with a conical cap screwed at its top
2. Balance, sensitive to 0.2 g
3. Wash bottle with desired, distilled water
4. Glass rod, about 150 mm and 3 mm diameter
5. Thermometer with 0 - 50oC range and accurate to 1oC
6. Thermostatically controlled oven.

SAMPLEPREPARATION:

1. Dry The soilsample inanovenat230±9°F(110±5°C) for atleast12hoursor until thesampleachievesaconstantweight,whicheveroccursfirst.

2. Placethesampleinthedesiccators andallowcoolingtoroomtemperature.

3. Carefullybreakupthesoilagglomerationsusingthepulverizingapparatuswithout reducingthesizeoftheindividualgrains.

4. Separate thesampleon thedesired sievesize(¾in. (19.0mm), ¼ in.(6.3 mm), No. 10(2.00mm)orNo.40(0.425mm).Formaterialfinerthan¼in.(6.3mm),100g ofmaterial arenormallyused (200 g forminus¾in.(19.0 mm)samples). However, ifsamplematerialslimited, aslittleas50g (100gforminus¾in.(19.0mm) samples)maybeused.

PROCEDURE

1. The density bottle along with the stopper, should be dried at a temperature of 105 to 110°C, cooled in the desiccators and weighed to the nearest 0.001g (W_1).
2. The sub-sample, which had been oven-dried should be transferred to the density bottle directly from the desiccators in which it was cooled. The bottles and contents together with the stopper should be weighed to the nearest 0.001g (W_2).

3. Cover the soil with air-free distilled water from the glass wash bottle and leave for a period of 2 to 3hrs.forsoaking.Addwatertofillthebottletoabout half.
4. Entrapped air can be removed by heating the density bottle on a water bath or a sand bath.
5. Keep the bottle without the stopper in a vacuum desiccators for about 1 to 2hrs. Until there is no furtherlossofair.
6. Gently stir the soil in the density bottle with a clean glass rod, carefully wash off the adhering particles from the rod with some drops of distilled water and see that no more soil particles are lost.
7. Repeat the process till no more air bubbles are observed in the soil-water mixture.
8. Observe the constant temperature in the bottle and record.
9. Insert the stopper in the density bottle, wipe and weigh (W_3).
10. Now empty the bottle, clean thoroughly and fill the density bottle with distilled water at the same temperature. Insert the stopper in the bottle, wipe dry from the outside and weigh (W_4).
11. Take at least two such observations for the same soil.

HYDROMETER ANALYSIS

SCOPE

If a soil contains appreciable quantities of fine fractions in (less than 75 micron) wet analysis is done. One form of the analysis is hydrometer analysis. The properties of the soil are very much influenced by the amount of clay and other fractions.

DEFINATION

A hydrometer analysis is the process by which fine-grained soils, silts and clays, are graded. ...
The hydrometer also determines the specific gravity (or density) of the suspension, and this enables the percentage of particles of a certain equivalent particle diameter to be calculated.

APPARTUS

A .Dispersion cup with mechanical stirrer with complete accessories

B .Two glass jar of 1 liter capacity
C. Deflocculating agent (sodium Hexa meta-phosphate solution prepared by dissolving 33g of sodium Hexameter-phosphate and 7g of sodium carbonate in distilled water to make one litre solution)
D. Stop watch
E. Thermometer
F .Scale

PROCEDURE

1. Take about 50g in case of clayey soil and 100g in case of sandy soil and weigh it correctly to 0.1g.
2. In case the soil contains considerable amount of organic matter or calcium compounds, pre-treatment of the soil with Hydrogen Peroxide or Hydrochloric acid may be necessary. In case of soils containing less than 20 percent of the above substances pre-treatment shall be avoided.
3. To the soil thus treated, add 100 cc of sodium hexa-metaphosphate solution and warm it gently for 10 minutes and transfer the contents to the cup of the mechanical mixer using a jet of distilled water to wash all the traces of the soil.
4. Stir the soil suspension for about 15 minutes.
5. Transfer the suspension to the Hydrometer jar and make up the volume exactly to 1000 cc by adding distilled water.
6. Take another Hydrometer jar with 1000cc distilled water to store the hydrometer in between consecutive readings of the soil suspension to be recorded. Note the specific gravity readings and the temperature T0C of the water occasionally.
7. Mix the soil suspension roughly, by placing the palm of the right hand over the open end and holding the bottom of the jar with the left hand turning the jar upside down and back. When the jar is upside down be sure no soil is tuck to the base of the graduated jar.

8. Immediately after shaking, place the Hydrometer jar on the table and start the stopwatch. Insert the Hydrometer into the suspension carefully and take Hydrometer readings at the total elapsed times of ¼, ½, 1 and 2 minutes.
9. After 2 minutes reading, remove the Hydrometer and transfer it to the distilled water jar and repeat step no-8. Normally a pair of the same readings should be obtained before proceeding further.
10. Take the subsequent hydrometer readings at elapsed timings of 4, 9, 16, 25, 36, 49, 60 minutes and every one hour thereafter. Each time a reading is taken remove the hydrometer from the suspension and keep it in the jar containing distilled water. Care should be taken when the Hydrometer recorded to see that the Hydrometer is at rest without any movement. As time elapses, because of the fall of the solid particles the density of the fluid suspension decreases reading, which should be checked as a guard against possible error in readings of the Hydrometer.
11. Continue recording operation of the Hydrometer readings until the hydrometer reads 1000 approximately.

FREE SWELL INDEX TEST:

SCOPE:

To determine the free swell index of soil as per IS: 2720 (Part XL) – 1977. Free swell or differential free swell, also termed as free swell index, and is the increase in volume of soil without any external constraint when subjected to submergence in water.

DEFINATION:

Free swell is the increase in volume of a soil, without any external constraints, on submergence in water. The possibility of damage to structures due to swelling of expensive clays need be identified, at the outset, by an investigation of those soils likely to possess undesirable expansion characteristics. Inferential testing is resorted to reflect the potential of the system to swell under different simulated conditions. Actual magnitude of swelling pressures developed depends upon the dry density, initial water content, surcharge loading and several other environmental factors.

APPARATUS:

1. 425 microns IS sieve.
2. Graduated glass cylinders 100 ml capacity 2Nos (IS: 878 -1956).
3. Glass rod for stirring.
4. Balance of capacity 500grams and sensitivity 0.01 gram.

PROCEDURE:

1. Take two 10 g soil specimens of oven dry soil passing through 425 micron IS Sieve.
2. Each soil specimen shall be poured in each of the two glass graduated cylinders of 100 ml capacity.
3. One cylinder shall then be filled with kerosene oil and the other with distilled water up to the 100 ml mark. After removal of entrapped air (by gentle shaking or stirring with a glass rod), the soils in both the cylinders shall be allowed to settle. Sufficient time (not less than 24 h) shall be allowed for the soil sample to attain equilibrium state of volume without any further change in the volume of the soils.
4. The final volume of soils in each of the cylinders shall be read out.

ATTERBERG LIMITS

A) Determination of liquid limit (Casagrande method)

SCOPE:

The natural moisture content of soil is closer to liquid limit, the soil can be considered as soft if the moisture content is lesser than liquids limit, the soil can be considered as soft if the moisture content is lesser than liquid limit. The soil is brittle and stiffer.

DEFINATION:

Liquid Limit (LL) is the water content at which soil changes from a plastic to a liquid state when the soil specimen is just fluid enough for a groove to close when jarred in a specified manner.

APPARATUS:

1. Casagrande liquid limit apparatus
2. Casagrande grooving tool of standard dimensions (Type A)
3. Glass plate, 10 mm thick and about 45 cm square
4. Spatula
5. Balance, sensitive to 0.01 g
6. Thermostatically controlled hot air oven
7. Airtight and non-corrodible containers for moisture content determination.
8. Wash bottle containing distilled water.
9. 425 microns IS sieve.

PROCEDURE

1. Using the gauge on the handle of the grooving tool or a separate gauge, adjust the height through which the cup of the Casagrande apparatus is lifted and dropped so that the point on the cup which comes in content with the base falls through exactly one centimeter for one revolution of the handle. Then, tighten the adjustment screws.
2. Take about 120 g of soil sample passing through 425 microns IS sieve and mix it thoroughly with distilled water on the glass plate to form uniform paste. Allow sufficient time to ensure uniform moisture distribution throughout the soil mass.
3. Remix the soil thoroughly. Take a portion of the soil paste with the spatula and place it in the central portion of the cup and spread it into position with the spatula so that the soil surface is parallel to the rubber base with the maximum depth of the soil as 1.0 cm at the centre.
4. With the help of the grooving tool, divide the soil paste in the cup along the diameter of the cup (through the centre line of the cam follower) to get a clean, sharp groove of proper dimensions.
5. Turn the handle of the apparatus at a rate of 2 revolutions per second until the two parts of the soil paste come in contact at the bottom of the groove for a distance of about 12 mm and record the number of revolutions to achieve this.

6. Collect a representative sample of the soil by moving the spatula normal to the groove, width wise from the portion of the groove where the soil flowed together and put it in a container and determine its water content by oven drying method.
7. Transfer the remaining soil in the cup back on to the glass plate. Dry the soil by kneading the wet soil using spatula.
8. Repeat the steps 3 to 6 to get a minimum of 5 trials. The trials are conducted such that the number of blows is in the range 25 ± 10.
9. Plot a "flow curve" on a semi-log sheet with water content on y-axis (arithmetic scale) and number of blows on x-axis (log scale). Draw a well-defined straight line through the points. Record the moisture content corresponding to 25 blows and round off to the nearest whole number and report it as the liquid limit of the soil. Measure the slope of the line, which represents the flow index (If).

B) **Determination of Plastic Limit**:

SCOPE:

Plastic limit test is one of the laboratory tests used internationally to differentiate or classify soils into groups. When the water content or moisture content of soil increases beyond a limit then the soil starts to behave as liquid.

DEFINATION:

The plastic limit of a soil is the moisture content at which soil begins to behave as a plastic material. At this water content (plastic limit), the soil will crumble when rolled into threads of 3.2mm (1/8in) in diameter.

APPARATUS:

1. Flat glass plate, 10 mm thick and about 45 cm square.
2. Spatula
3. Balance, sensitive to 0.01 g
4. Thermostatically controlled oven
5. Airtight and non-corrodible containers for moisture content determination.
6. Wash bottle containing distilled water
7. 425 micron IS sieve
8. 3 mm diameter rod of about 10 cm length.

PROCEDURE

1. Take about 20 gm of thoroughly mixed portion of the material passing through 425 micron I.S.sieve obtained in accordance with I.S. 2720 (Part 1)- 1983.
2. Mix it thoroughly with distilled water in the evaporating dish till the soil mass becomes plastic enough to be easily molded with fingers.
3. Allow it to season for sufficient time (for 24 hrs) to allow water to permeate throughout the soil mass
4. Take about 8 gm of this plastic soil mass and roll it between fingers and glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length. The rate of rolling shall be between 80 and 90 strokes per minute.
5. Continue rolling till you get a thread of 3 mm diameter.
6. Kneed the soil together to a uniform mass and re-roll.
7. Continue the process until the thread crumbles when the diameter is 3 mm.
8. Collect the pieces of the crumbled thread in air tight container for moisture content determination as described in ARE: 2720 (Part 2)-1973.
9. Repeat the test to at least 3 times and take the average of the results calculated to the nearest whole

STANDARD PROCTOR TEST:

SCOPE:

Determination of the relationship between the moisture content and density of soils compacted in a mould of a given size with a 2.5 kg rammer dropped from a height of 30 cm. the results obtained from this test will be helpful in increasing the bearing capacity of foundations, Decreasing the undesirable settlement of structures, Control undesirable volume changes, Reduction in hydraulic conductivity, Increasing the stability of slopesand so on.

DEFINATION:

In geotechnical engineering, soil compactions the process in which a stress applied to a soilcauses densification as air is displaced from the pores between the soil grains. It is an instantaneous process and always takes place in partially saturated soil (three phase system). The Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density.

APPARATUS:

1. Cylindrical Metal Mold, having internal diameter 4” (10.16 cm) or 6” (15.24 cm), the internal effective height of 4.6” (11.7 cm);
and the mold should have detachable base plate & collar of 2 inches (5.08 cm).

2. Rammer, weighing 5.5 lbs (2.5 kg) & having fall of 12 inches (30.5 cm), with a flat circular face of 2” diameter.
3. Sensitive Balance, sensitivity ranging from 0.1 gram to 1 gram.
4. Thermostatically controlled oven (105°C +- 110°C)
5. Steel straight edge.
6. Moisture containers.
7. Sieve No.4.
8. Tray & scoop.
9. Graduated cylinder.
10. Mixing tools. (Spoon, trowel, spatula).

PROCEDURE:

1. Take sufficient quantity of representative soil, air dry & pulverize it with a rubber mallet.
Sieve the soil through No: 4 sieve & reject the coarser material.

2. Take about, 3 kg of soil, add water to bring its water content to about 5% below the estimated optimum moisture content.
(For coarse-grained soil 4% initial water content & for fine-grained soil 10% initial water content is preferable).
Then Mix it thoroughly.

3. Clean the mold, measure its diameter & height & weigh it without the collar.

4. Fit the collar & compact the moist soil in three equal layers by the rammer with evenly distributed blows to each layer.
Use 25 blows for 4 inches diameter & 56 blows for 6 inches diameter mold to the total height of mold with collar.

5. Remove the collar trim the compacted soil even with the top of the mold with a straight steel edge.
Clean outside of the mold & base plate & weigh it.

6. Remove the soil from the mold, split it & take about 100 grams sample for water content determination.

7. Break the soil lumps; mix it with remaining soil in the tray.
Add more water to increase the water content by 2 to 3% & repeat the compaction procedure for each increment of water until the mass of the compacted soil decreases.
8. Calculate Water content for each trail & corresponding dry density.
9. Plot the compaction curve between water-content as abscissa & dry density as ordinate.
10. Note the water content against the peak of the curve as optimum moisture content & the corresponding dry density as maximum dry density.

UNCONFINED COMPRESSIVE STRENGHT TEST:

SCOPE:

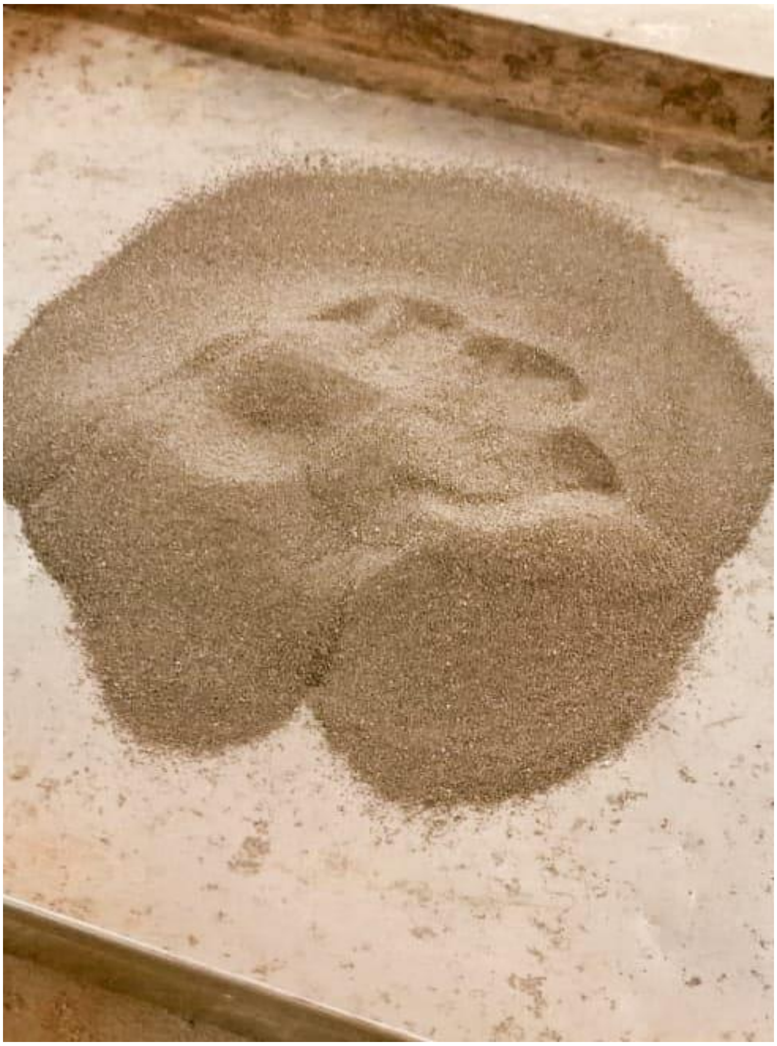
According to the ASTM standard, the unconfined compressive strength (qu) is defined as the compressive stress at which an unconfined cylindrical specimen of soil will fail in a simple compression test.

DEFINATION:

The unconfined compressive strength (UCS) is the maximum axial compressive stress that a right-cylindrical sample of material can withstand under unconfined conditions—the confining stress is zero.

APPARATUS:

1. Compression device of suitable type
2. Sample ejector
3. Deformation measuring dial gauge
4. Remolding apparatus – for specimen preparation
5. Thermostatically controlled oven
6. Balance with weights
7. Vernier calipers.
8. Air tight, non-corrodible containers for water content determination.

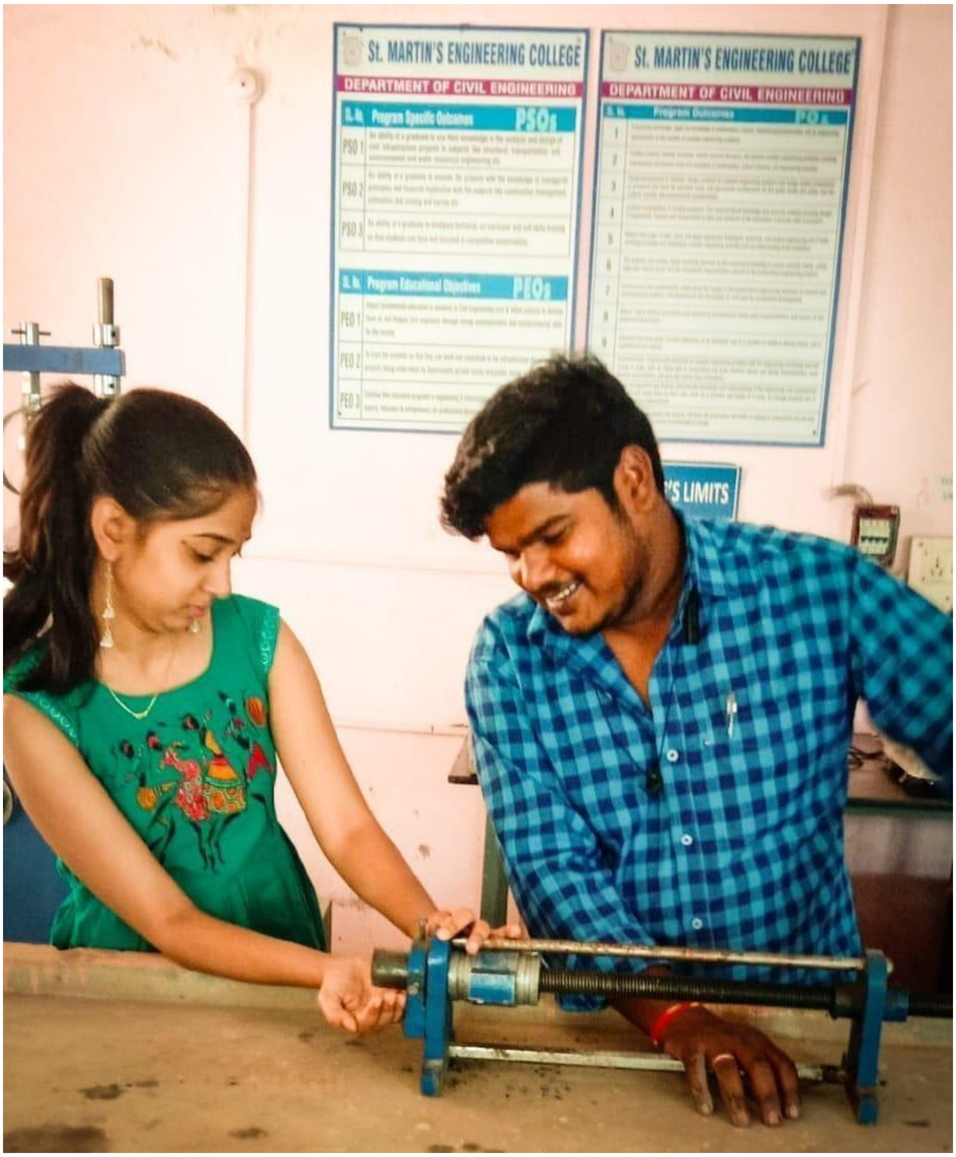


PROCEDURE:

1. Measure the initial length, diameter and mass of the specimen.

1. Measure the initial length, diameter and mass of the specimen.

2. Place the specimen on the bottom plate of the loading device. Adjust the upper plate to make contact with the specimen. Set the load dial gauge (i.e., proving ring dial) and the compression dial gauge to zero.
3. Apply axial compressive load so as to produce axial strain at a rate of 0.5 to 2 percent per minute. Take the proving ring dial readings corresponding to compression dial readings at suitable intervals.
4. Compress the specimen until failure surfaces have definitely developed or the stress- strain curve is well past its peak or until an axial strain of 20% is reached, whichever occurs first.
5. Stop loading; Remove the failed specimen; Sketch the failure pattern; Keep the soil sample taken from the failure zone for moisture content determination.



CALIFORNIA BEARING RATIO TEST(CBR):

SCOPE:

The California Bearing Ratio test is penetration test meant for the evaluation of subgrade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers.

DEFINATION:

The California Bearing Ratio test is a penetration test used to evaluate the subgrade strength of roads and pavements. The results of these tests are used with the curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement.

APPARATUS:

1. CBR mould with detachable perforated base plate
2. Spacer disc with a removable handle (to be placed inside the mould)
3. Collar of 50mm high
4. Penetration plunger of 50 mm diameter
5. One annular and a few slotted surcharge masses 2.5 kg each
6. Rammer (2.6 kg with 310mm drop for standard proctor results) and (4.89 kg with 450mm drop for modified proctor results)
7. Straight cutting edge
8. Loading machine of 50 kN capacity fitted with a calibrated proving ring to which plunger has to be attached
9. Penetration measuring dial gauge of 0.01mm accuracy
10. Soaking tank
11. Swelling gauge consisting of perforated plate with adjustable extension stem.

PROCEDURE:

1. Remolded specimen: The test material should pass 19 mm IS sieve and retained on 4.75 mm IS sieve. The dry density for a remolding shall be either the field density or the value of the maximum dry density estimated by the compaction test (Heavy Compaction Test as per IS 2720 (Part-8) - 1983, for Railway Formation). The water content used for compaction shall be the optimum water content or the field moisture as the case may be.
2. Dynamic Compaction: A representative sample of the soil weighing approximately 4.5 kg or more for fine grained soil and 5.5 kg or more for granular soil shall be taken and mixed thoroughly with water. If the soil is to be compacted to the maximum dry density at the optimum moisture content, the exact mass of the soil required shall be taken and the necessary quantity of water added so that the water content of the soil sample is equal to the determined optimum moisture content.
3. Fix the extension collar and the base plate to the mould. Insert the spacer disc over the base. Place the filter paper on the top of the spacer disc.
4. Apply Lubricating Oil to the inner side of the mould. Compact the mix soil in the mould using heavy compaction. i.e., compact the soil in 5 layers with 55 blows to each layer by the 4.89 kg rammer.
5. Remove the extension collar and trim the compacted soil carefully at the level of top of mould, by means of a straight edge. Any holes developed on the surface of the compacted soil by removal of the coarse material, shall be patched with the smaller size material. Remove the perforated base plate, Spacer disc and filter paper and record the mass of the mould and compacted soil specimen. Place a disc of coarse filter paper on the perforated base plate, invert the mould and compacted soil and clamp the perforated base plate to the mould with the compacted soil in contact with the filter paper.

6. Place a filter paper over the specimen and place perforated plate on the compacted soil specimen in the mould. Put annular weights to produce a surcharge equal to weight of base material and pavement, to the nearest 2.5 kg.
7. Immerse the mould assembly and weights in a tank of water and soak it for 96 hours. Mount the tripod for expansion measuring device on the edge of the mould and record initial dial gauge reading. Note down the readings every day against time of reading. A constant water level shall be maintained in the tank throughout the period.
8. At the end of soaking period, note down the final reading of the dial gauge and take the mould out of water tank.
9. Remove the free water collected in the mould and allow the specimen to drain for 15 minutes. Remove the perforated plate and the top filter paper. Weigh the soaked soil sample and record the weight.

Procedure for Penetration Test:

1. Place the mould assembly with test specimen on the lower plate of penetration testing machine. To prevent upheaval of soil into the hole of the surcharge weights, 2.5 kg annular weight shall be placed on the soil surface prior to seating the penetration plunger after which the remainder of the surcharge weights shall be placed.

2. Seat the penetration piston at the centre of the specimen with the smallest possible load, but in no case in excess of 4 kg so that full contact of the piston on the sample is established.
3. Set the load and deformation gauges to read zero. Apply the load on the piston so that the penetration rate is about 1.25 mm/min.
4. Record the load readings at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 4.0, 5.0, 7.5, 10 and 12.5 mm.
5. Raise the plunger and detach the mould from the loading equipment. Take about 20 to 50 g of soil from the top 30 mm layer and determine the moisture content.

RESILIENT MODULUS BY TRIAXIAL TEST:

Scope

Resilient modulus is the elasticity modulus of a material under repeated loads and is a measure of the distribution of the loads through pavement layers.The pavement materials are normally not elastic, each load repetition produce a small amount of plastic (permanent) deformation**.**

DEFINATION

Resilient Modulus - The resilient modulus is determined by repeated load compression tests on test specimens of the unbound material. Resilient modulus (Mr) is the ratio of the peak axial repeated deviator stress to the peak recoverable axial strain of the specimen.

APPARATUS REQUIRED:

a) Special:

i. A constant rate of strain compression machine of which the following is a brief description of one is in common use. A loading frame in which the load is applied by yoke acting through an elastic dynamometer, more commonly called a proving ring which used to measure the load. The frame is operated at a constant rate by a geared screw jack. It is preferable for the machine to be motor driven, by a small electric motor. A hydraulic pressure apparatus including an air compressor and water reservoir in which air under pressure acting on the water raises it to the required pressure, together with the necessary control valves and pressure dials.

ii. A triaxial cell to take 3.8 cm dia and 7.6 cm long samples, in which the sample can be subjected to an all round hydrostatic pressure, together with a vertical compression load acting through a piston. The vertical load from the piston acts on a pressure cap. The cell is usually designed with a non-ferrous metal top and base connected by tension rods and with walls formed of Perspex.

b) General:

i. 3.8 cm (1.5 inch) internal diameter 12.5 cm (5 inches) long sample tubes.

ii. Rubber ring.EXPERIMENT: 10 TRIAXIAL TEST SM-CEVL 2

iii. An open ended cylindrical section former, 3.8 cm inside dia, fitted with a small rubber tube in its side. iv. Stop clock.

v. Moisture content test apparatus.

vi. A balance of 250 gm capacity and accurate to 0.01 gm.

THEORY:

Triaxial test is more reliable because we can measure both drained and untrained shear strength.

EXPERIMENT: 10 TRIAXIAL TEST SM-CEVL 3 Generally 1.4” diameter (3” tall) or 2.8” diameter (6” tall) specimen is used. Specimen is encased by a thin rubber membrane and set into a plastic cylindrical chamber. Cell pressure is applied in the chamber (which represents σ3’) by pressurizing the cell fluid (generally water). Vertical stress is increased by loading the specimen (by raising the platen in strain controlled test and by adding loads directly in stress controlled test, but strain controlled test is more common) until shear failure occurs. Total vertical stress, which is σ1’ is equal to the sum of σ3’ and deviator stress (σd). Measurement of σd, axial deformation, pore pressure, and sample volume change are recorded. Depending on the nature of loading and drainage condition, triaxial tests are conducted in three different ways.

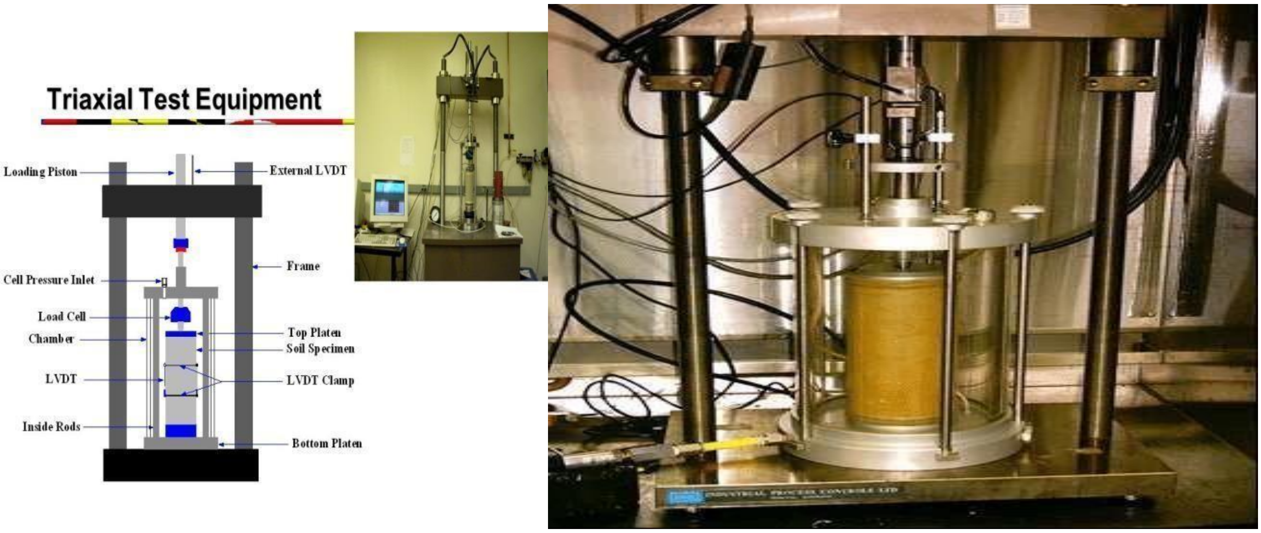
i. UU Triaxial test
ii. CU Triaxial test
iii. CD Triaxial test

APPLICATION:

UU triaxial test gives shear strength of soil at different confining stresses. Shear strength is important in all types of geotechnical designs and analyses.

PROCEDURE:

i. The sample is placed in the compression machine and a pressure plate is placed on the top. Care must be taken to prevent any part of the machine or cell from jogging the sample while it is being setup, for example, by knocking against this bottom of the loading piston. The probable strength of the sample is estimated and a suitable proving ring selected and fitted to the machine.
ii. The cell must be properly set up and uniformly clamped down to prevent leakage of pressure during the test, making sure first that the sample is properly sealed with its end caps and rings (rubber) in position and that the sealing rings for the cell are also correctly placed.EXPERIMENT: 10 TRIAXIAL TEST SM-CEVL 4
iii. When the sample is setup water is admitted and the cell is fitted under water escapes from the beed valve, at the top, which is closed. If the sample is to be tested at zero lateral pressure water is not required.
iv. The air pressure in the reservoir is then increased to raise the hydrostatic pressure in the required amount. The pressure gauge must be watched during the test and any necessary adjustments must be made to keep the pressure constant.
v. The handle wheel of the screw jack is rotated until the underside of the hemispherical seating of the proving ring, through which the loading is applied, just touches the cell piston.
vi. The piston is then removed down by handle until it is just in touch with the pressure plate on the top of the sample, and the proving ring seating is again brought into contact for the begging of the test.


Triaxial Test Equipment
Loading Piston
External LVDT
Frame
Cell Pressure Inlet
Load Cell
Chamber
Top Platen
Soil Specimen
LVDT
LVDT Clamp
Inside Rods
Bottom Platen

4. GENETIC ALGORITHM

Genetic Algorithm (GA) is a search-based optimization technique based on the principles of Genetics and Natural Selection. It is frequently used to find optimal or near-optimal solutions to difficult problems which otherwise would take a lifetime to solve. It is frequently used to solve optimization problems, in research, and in machine learning. Genetic Algorithms have the ability to deliver a "good-enough" solution "fast-enough". This makes genetic algorithms attractive for use in solving optimization problems. The reasons why GAs are needed are as follows

Introduction to Optimization

Optimization is the process of making something better. In any process, we have a set of inputs and a set of outputs as shown in the following figure.

Optimization refers to finding the values of inputs in such a way that we get the "best" output values. The definition of "best" varies from problem to problem, but in mathematical terms, it refers to maximizing or minimizing one or more objective functions, by varying the input parameters.

The set of all possible solutions or values which the inputs can take make up the search space. In this search space, lies a point or a set of points which gives the optimal solution. The aim of optimization is to find that point or set of points in the search space.

What are Genetic Algorithms?

Nature has always been a great source of inspiration to all mankind. Genetic Algorithms (GAs) are search based algorithms based on the concepts of natural selection and genetics. GAs are a subset of a much larger branch of computation known as Evolutionary Computation.

GAs were developed by John Holland and his students and colleagues at the University of Michigan, most notably David E. Goldberg and has since been tried on various optimization problems with a high degree of success.

In GAs, we have a pool or a population of possible solutions to the given problem. These solutions then undergo recombination and mutation (like in natural genetics), producing new children, and the process is repeated over various generations. Each individual (or candidate solution) is assigned a fitness value (based on its objective function value) and the fitter individuals are given a higher chance to mate and yield more "fitter" individuals. This is in line with the Darwinian Theory of "Survival of the Fittest".

In this way we keep “evolving” better individuals or solutions over generations, till we reach a stopping criterion.

Genetic Algorithms are sufficiently randomized in nature, but they perform much better than random local search (in which we just try various random solutions, keeping track of the best so far), as they exploit historical information as well.

Advantages of GAs

- GAs has various advantages which have made them immensely popular. These include
- Does not require any derivative information (which may not be available for many real-world problems).
- Is faster and more efficient as compared to the traditional methods.
- Have very good parallel capabilities.
- Optimizes both continuous and discrete functions and also multi-objective problems.
- Provides a list of “good” solutions and not just a single solution.
- Always gets an answer to the problem, which gets better over the time.
- Useful when the search space is very large and there are a large number of parameters involved.

Limitations of GAs

Like any technique, GAs also suffers from a few limitations. These include

- GAs is not suited for all problems, especially problems which are simple and for which derivative information is available.
- Fitness value is calculated repeatedly which might be computationally expensive for some problems.
- Being stochastic, there are no guarantees on the optimality or the quality of the solution.
- If not implemented properly, the GA may not converge to the optimal solution.

Getting a Good Solution Fast

Some difficult problems like the Travelling Salesperson Problem (TSP), have real-world applications like path finding and VLSI Design. Now imagine that you are using your GPS Navigation system, and it takes a few minutes (or even a few hours) to compute the “optimal” path from the source to destination. Delay in such real world applications is not acceptable and therefore a “good-enough” solution, which is delivered “fast” is what is required.

Relevance of Genetic Algorithms

Non-convex optimization problems have been researched by a number of methods such as Artificial Neural Networks, Genetic Algorithms, Simulated annealing and Particle swarm methods. There are classical algorithm based approaches in structural optimization such as in the works of Hoppe and co-workers. Genetic algorithms (GAs) are modeling techniques based on biological behavior. They rely on the speed of computers either to combine elements from two solutions (or parents) or to mutate a single solution to a complex problem to produce a third solution (or child) and along the factors ensure that the solution space is adequately covered. Since genetic algorithms are generic and flexible and need little knowledge and information about the problem domain, Mawdesley et al. (2002), they have found wide application in diverse areas. Despite classical optimization techniques such as mathematical and heuristic approaches, genetic algorithms have become sequencing, transportation, and many others. Genetic algorithms (GAs) are stochastic search techniques based upon the mechanism of natural selection and population genetics, Sriprasert and Dawood (2003), A clear advantage of using GA over other methods is potential to locate global optimum or near global optimum solution without a necessity to search for all solution spaces. Moreover, the processing time only increased as the square of the project size and not exponentially. Several studies have successfully applied GAs for optimization problems in construction scheduling, for instance, time-cost trade-off problem, resource allocation and levelling problem, and a combination of these two problems. However, none of these efforts has been able to solve and optimize the kind of multi-constraint scheduling problem. Therefore, to develop a practicable GA-based application that is particularly capable of optimizing such complex problem and to provide a background towards the formulation of the integrated problem, the problem is broken down into four main steps which include:

1. Setting the Chromosome Structure;
2. Deciding the Evaluation Criteria (Objective Function);
3. Generating an Initial Population; and
4. Generating Offspring Population (i.e., Solution).

- There are studied 87 peer-reviewed prestigious journal articles published over the past 20 years from 1995 to 2010 focusing on areas influenced by genetic algorithm application. The findings indicate that mathematical programming for cost and schedule optimization (40.23%, 35 articles) is the most widely applied area, followed by construction method and process (27.59%, 24 articles), design and layout (21.84%, 19 articles), and management (10.34%, 9 articles), Kim (2010). A recent trend in solving the resource scheduling problems using GA is to develop an integrated meta-heuristic method by combining GA with other meta-heuristic method. An integrated GA approach has been successfully applied to many engineering optimization problems such as aerodynamic design, signal analysis, water resources planning and management, and others. So, the same approach can be used in the current research study to predict the sensitivity of the CBR values of soil samples containing different proportions ofggbs

GENEXPRO (5.0)

Microsoft award winning GeneXproTools is an extremely flexible modeling tool designed for **Regression**, **Logistic Regression**, **Classification**, **Time Series Prediction**, and **Logic Synthesis**. GeneXproTools is very easy to use and and is in fact as easy as importing your data and then clicking a button (the Start button) to create a great model. GeneXproTools is available in five editions: **Home**, **Standard**, **Advanced**, **Professional**, and **Enterprise**. **Academic Versions** are also available at **half price** for education institutions and students.

GeneXproTools can process datasets with tens of thousands of variables and effortlessly extract the most significant features and their relationships. GeneXproTools is also a very user-friendly application simplifying the access to all types of data stores from raw text files to databases and Excel spreadsheets. You don't need to know any programming language to create powerful and accurate models. GeneXproTools provides all the necessary tools to clean and analyze your data, handle your datasets, generate models, analyze them and then apply them immediately to any new database using its flexible scoring engine. If you want to integrate the generated models with other applications, GeneXproTools lets you translate the code to up to 19 different programming languages (Ada, C, C++, C#, Excel VBA, Fortran, Java, JavaScript, Matlab, Octave, Pascal, Perl, PHP, Python, R, Visual Basic, VB.Net, Verilog, and VHDL).

Deployment of models and ensembles to Excel
GeneXproTools can deploy individual models or ensembles of models to Excel, with the automatic generation of the Majority Vote and Average Probability Models for Classification and Logistic Regression, and the Average and Median Models for Regression and Time Series Prediction.

High quality models
GeneXproTools generates models that are at the same time very accurate and have high generalizability. You can easily learn your way around this innovative modeling tool using the 20 sample runs that ship with GeneXproTools or by using your own data. With the 30-days Free Trial Demo you can load your own data and analyze it, create models and analyze them without restrictions, as the Demo is fully functional during the free trial period. After the trial period GeneXproTools remains fully functional for the sample runs, but blocks the opening and creation of new runs. The models created using your own data with the Free Trial Demo are unlocked as soon as you purchase a license of GeneXproTools. The application can work in demo mode indefinitely.

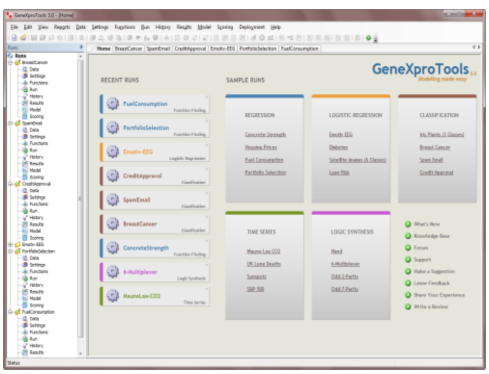
Unlimited variables and records
This new version of GeneXproTools can process any number of records and variables, limited only by the computer resources available. In practical terms a modern computer processes datasets with over one or two million cells effortlessly, processing, in this case, around five generations per second using the default settings. The new file format can load this amount of data in a few seconds and store it very efficiently.

Ease of use
GeneXproTools is the most user friendly predictive modeling tools in the market, hiding the complexity behind simple wizards and concepts familiar to anyone with basic computer knowledge. Around the world creative people with all levels of expertise are making groundbreaking discoveries and creating extraordinary new products because GeneXproTools provides a robust modeling platform across different research fields.

At first sight GeneXproTools is a surprisingly simple data modeling application. And you can use it at that level and still reap all the benefits of an innovative modeling platform. As your knowledge of the tool increases, you will find many new ways of increasing the effectiveness of your work and improve your results even further.

To Start GeneXproTools 5.0

1. In Windows, click Start, point to Programs, and point to the Gepsoft GeneXproTools 5.0 folder. The icons in the Gepsoft GeneXproTools 5.0 folder appear in a list.
2. Click the GeneXproTools 5.0 program icon. The Home Panel appears. This panel presents you with several choices, including start a new run or open an existing run.
3. To start a new run, click the File menu and then choose New. The New Run Wizard appears. This wizard helps you gather the necessary information to start evolving a model.
4. To open an existing run, in the Home Panel either choose a recent or sample run or click the File menu and then choose Open. In the Report Panel you will find relevant information concerning this run, including all the settings used in the run, the statistical evaluation of the best-of-run or active model, and a detailed account of all the models in the run History.



The GeneXproTools 5.0 modeling environment contains 10 basic panels:

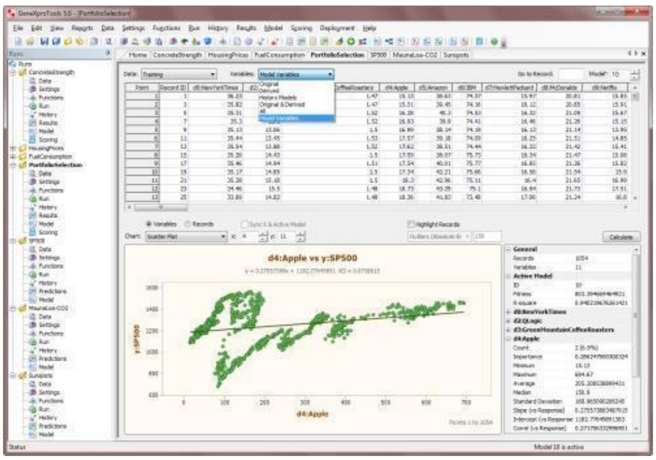
- Report Panel
- Data Panel
- Settings Panel
- Functions Panel
- Run Panel
- History Panel
- Results Panel
- Predictions Panel
- Model Panel
- Scoring Panel

Report Panel

In the **Report Panel** you can find relevant information concerning the run, including all the settings used in the run, the statistical evaluation of the best-of-run or active model (highlighted in yellow in the History heading), and a detailed account of the evolutionary history of the run.

DATA PANEL

The multifunctional **Data Panel** goes beyond a simple platform for analyzing and visualizing input data. Besides allowing the analysis and visualization of **input variables**, it also allows the visualization and analysis of all your **models** and **derived variables**, giving you access to a rich web of analyses between all these types of variables and across different datasets.



The analyses you can do in the Data Panel include **scatter plots** and **regression analysis** between all possible pairs of variables (input variables, models and derived variables); **histograms** and **summary statistics** for all variables and across different datasets; different **line charts** for **outlier detection** and **model analysis**; and evaluation of the **variable importance** and display of the **variable importance chart** for all the models.
The multifunctional Data Panel also supports extensive **record analyses**, allowing you to study different types of records using different charts and browsing tools. For example, you can compare each record with different **record prototypes** in order to gain insight into both your data and your models. By selecting just the **outliers** or the **misclassified records** to browse, you can also perform **error analysis** in the Data Panel.

Settings Panel

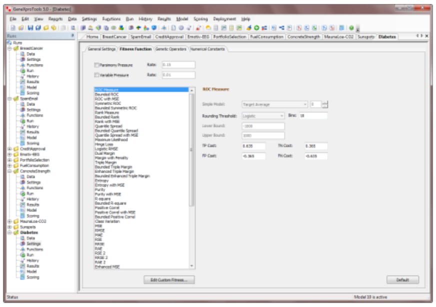
The **Settings Panel** gives you access to the most important settings of GeneXproTools, which are organized into four different tabs: General Settings, Fitness Function, Genetic Operators, and Numerical Constants

General Settings Tab

In the **General Settings Tab** you can change the number of training and validation/test records, choose different sub-sampling schemes for the training and validation/test datasets, change the chromosome architecture, the linking function, the number of chromosomes. Moreover, you can also choose the parameters for the Complexity Increase Engine of GeneXproTools and choose different modes of Model Management.

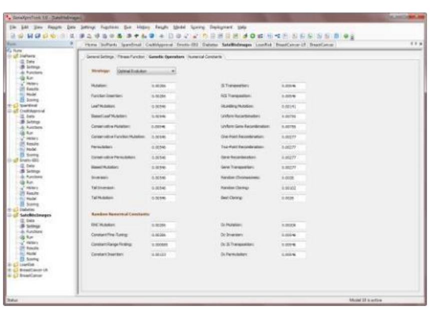
Fitness Function Tab

In the **Fitness Function Tab** you can choose one of the 100+ GeneXproTools built-in fitness functions or design and test a fitness function of your own.



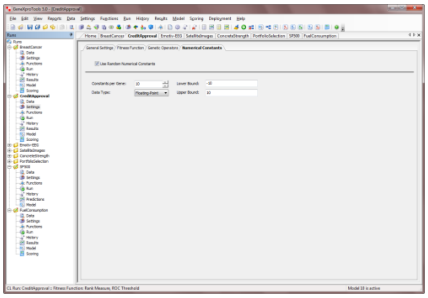
Genetic Operators Tab

In the **Genetic Operators Tab** you can change the degree of genetic modification you want to use during evolution by choosing the kind of genetic operators and their corresponding rates. Moreover, GeneXproTools provides 4 built-in **modeling strategies** that cover some of the most common modeling needs, namely a strategy for fine-tuning the numerical constants of your models (**Constant Fine-Tuning**); a strategy for model fine-tuning where the overall structure of the model remains basically unchanged making only small changes in the model's structure (**Model Fine-Tuning**); a strategy for **Sub-set Selection** which is ideal for creating good random forests, especially for datasets with many variables, as it works only with the elements that were randomly drawn for the initial population; and of course a strategy designed for **Optimal Evolution** which tries to give a good blend of diversity versus stability in order to optimize and accelerate evolution.



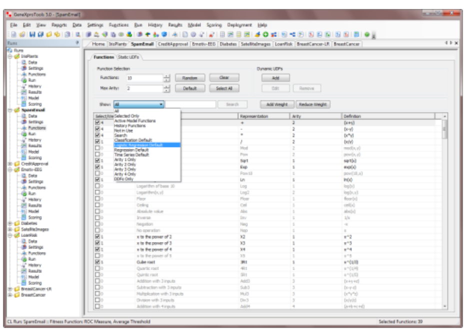
Numerical Constants Tab

In the **Numerical Constants Tab** you can activate the algorithm that enables the use of random numerical constants and customize both the type and range of your constants, and the number of constants per gene.



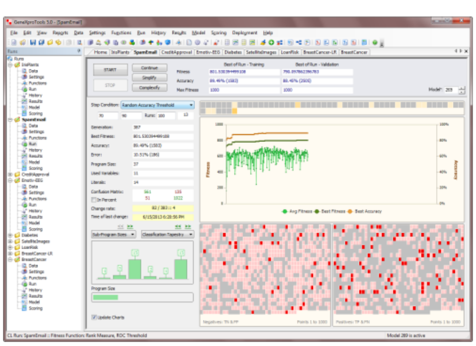
Functions Panel

In the **Functions Panel** you choose the functions GeneXproTools will use to model your data. For mathematical problems, there are a total of 279 built-in functions and comparison rules, whereas for Boolean problems there are a total of 258 built-in logical functions.



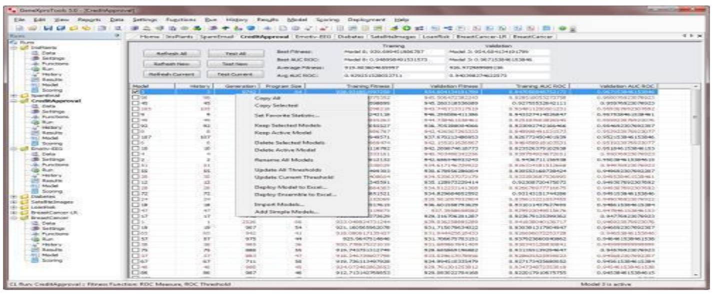
Run Panel

From the **Run Panel** you command and visualize the creation, optimization, and simplification of your models through the use of different model fitting charts, including different kinds of curve fitting charts, scatter plots, and residual charts. For Classification and Logistic Regression the model visualization tools include different binomial fitting charts, the classification scatter plot and the classification tapestry.



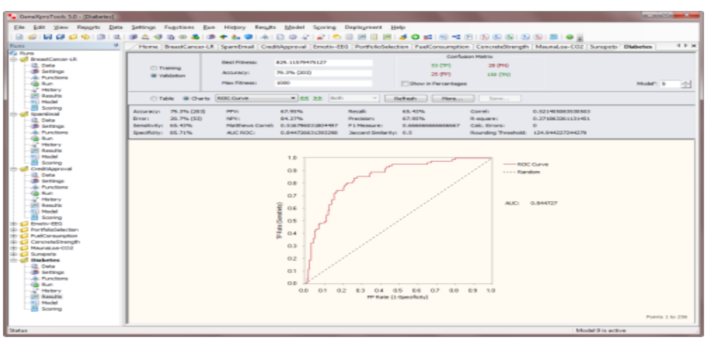
History Panel

The **History Panel** allows you to manage your models by selecting and re-ordering them using different Favorite Statistics. Moreover, you can also delete and import models from different runs and deploy models or model ensembles to Excel.



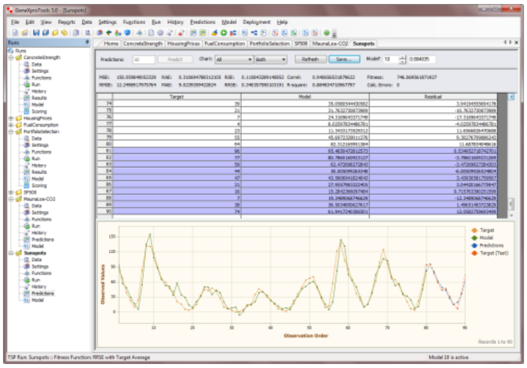
Results Panel

In the **Results Panel** a thorough statistical analysis of the evolved model is done on the fly both for the training and validation/test datasets. Furthermore, the model output and the target are compared using both a table and several charts. The number and type of available charts varies with the modeling category ofthe run.



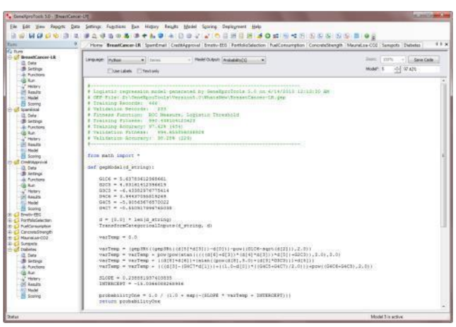
Predictions Panel

In the **Predictions Panel** is where you use your models to make predictions about future events in the **Time Series Prediction Platform**. Here is also where a thorough statistical analysis of your models takes place and, if in Testing Mode, it's also where you can test the predictive accuracy on past historical observations.



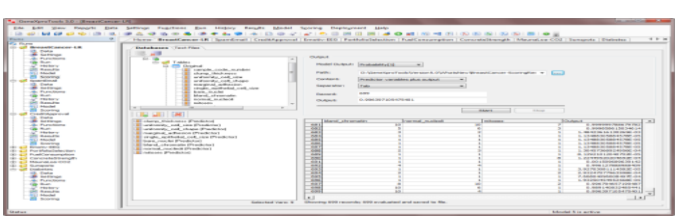
Model Panel

In the **Model Panel** you can see the mathematical/logical intricacies of the evolved models in the universal representation of Expression Trees or automatically translate the native Karva Code into several programming languages (Ada, C, C++, C#, Excel VBA, Fortran, Java, JavaScript, Matlab, Octave, Pascal, Perl, PHP, Python, R, Visual Basic, VB.Net, Verilog, and VHDL).



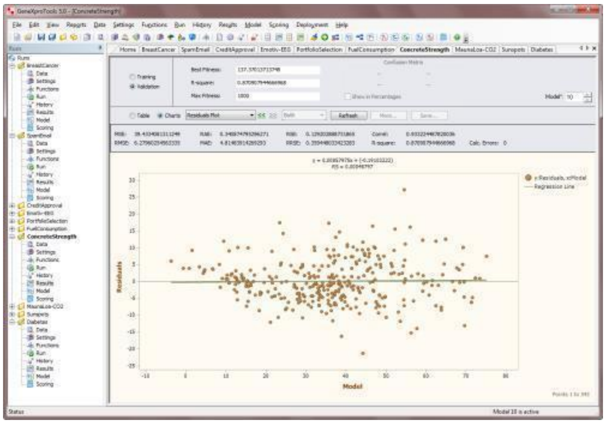
Scoring Panel

In the **Scoring Panel** you can apply your models immediately without leaving the GeneXproTools environment. The scoring engine of GeneXproTools uses the JavaScript code of your models to score your data. Both Excel/Databases and Text Files can be scored and the output saved to Excel (csv) or text files. In addition, for small datasets, the output can also be observed in its entirety in the Scoring Panel.



Residual Analysis

GeneXproTools now performs **residual analysis** for all regression models, including time series prediction models. The **Residuals Plot** is accessible both in the **Run Panel** and **Results Panel**.



- **4.5 Procedure of using genetic algorithm**

- The effect of GGBS in different proportions can be observed from liquid limit, plastic limit, plasticity index,Clay%,CBR,Compressive test and etc
- Putting the data generated from experiments with respect to these properties in GENEXPRO 5.0 will give us the predicted values of RESILIENT MODULUS for various proportions of GGBS added to the Soil Sample.
- GENEXPRO 5.0 is a true add-in to Microsoft Excel, integrating completely with your spreadsheet. Define your models, adjust your settings, run optimizations, monitor progress, and generates reports while never leaving Excel.
- It is available for a free trial version of 30days which was been used as a part of this research study.
- Standard values to maximize or minimize the outcome of a straightforward spreadsheet model given certain constraints. They find a solution which seems to be producing favorable results and continue to work on that basis, without trying new solutions.
- Where the best local solution may not -suited to finding the best overall answer by exploring the entire universe of possible answers.
- During an optimization, GENEXPRO generates a number of trial solutions approximately 50,000 in just 10 mins and uses genetic algorithms, Opt Quest, or linear programming to continually improve results of each trial. With genetic algorithms, each possible solution becomes an independent "organism" that can "breed" with other organisms.
- The spreadsheet model acts as an environment for the completely new solutions. After optimization, Evolver can display the results of the original, best, and last solution on your entire model, updating it with each scenario in a single click.
- This makes it easy to decide the best course of action. You can also generate reports directly in Excel for an optimization summary, log of all simulations, and log of progress step.
- We should collect data from the experiment and put all the values in the tabular form ,
- genes and expression trees, which express the genetic information encoded in the chromosome.
- Gene Expression Program (GeneXpro5.0) is the best solution to a save time and effort in the calculation the modulus of resilient (Mr). Furthermore, by establishing a relationship between the type of soil and its characteristics and bearing capacity and Generalization it to any site with the same characteristic.

- The program attempts several trails to obtain the optimal model when the generation has been adopted 50,000 as was a case in all trail.
- The trail was stopped and choose the optimal model based on specific criteria such as the coefficient of determination ($R2 > 0.80$) for both training and testing data.
- Observations of the predicted resilient modulus vs experimental resilient modulus are exhibited.
- Furthermore, the genetic algorithm model provides accurate assessments of the destination values.
- On the other hand, genetic algorithm model provides a good estimation and provides R2 value for training and testing as 0.95 and 0.94 respectively.
- The Gene Expression Program has provided the model in the Expression tree form where it is converted into a mathematical form using the algorithm system as shown in the equations below, d represents the inputs, variable any other constant such as "C" can be found from the visual basic language from this program.
- The predicted resilient modulus (Mr) is the summation of the three or more sub-trees (Gn).
- One of the advantages of the GP techniques is that the relationship between model inputs and the outputs can be formulated as the Expression Tree form as shown in figures and it is automatically translated into mathematical formulations which are given in Eqs. (1)–(4) that it is easy for the user to understand and use.

4.6 MULTI REGRESSION ANALYSIS

- Multiple linear regression (MLR), also known simply as multiple regression, is a statistical technique that uses several explanatory variables to predict the outcome of a response variable. The goal of multiple linear regression (MLR) is to model the linear relationship between the explanatory (independent) variables and response (dependent) variable.
- The Objective Function for applying Genetic Algorithm in this research study will be formulated as follows: Y is directly proportional to the variables X1, X2, X3 & X4. So, the equation created will be

$$Y = b0 + b1X1 + b2X2 + b3X3 + b4X4$$

Where,
Y = California Bearing Ratio (%),
b0, b1, b2, b3, b4 = constants,
X1 = GGBS Fraction (%)
X2 = Value of Liquid Limit (%),
X3 = Value of Plasticity Index (%), &
X4 = Value of Optimum Moisture Content (%).

TABLE 1: Data obtained from experiments conducted

S.No	GGBS added (%)	Specific Gravity (G_s)	GGBS Swell Index value (%)	Liquid Limit (%)	Plastic Limit (%)	Maximum Dry Density (Kg/m^3)	Optimum Moisture Content (%)	Unconfined Compressive Strength(kpa)
1	0	2.70	67.6	58.50	29.48	1.81	22	150
2	10	1.98	50.0	34.90	22.3	1.87	21.4	220
3	20	1.70	32.3	48.25	25.70	1.89	20.8	285
4	30	1.53	22.3	49.46	23.46	1.67	21.50	270
5	40	1.05	10.14	47.80	26.50	1.64	20.95	260

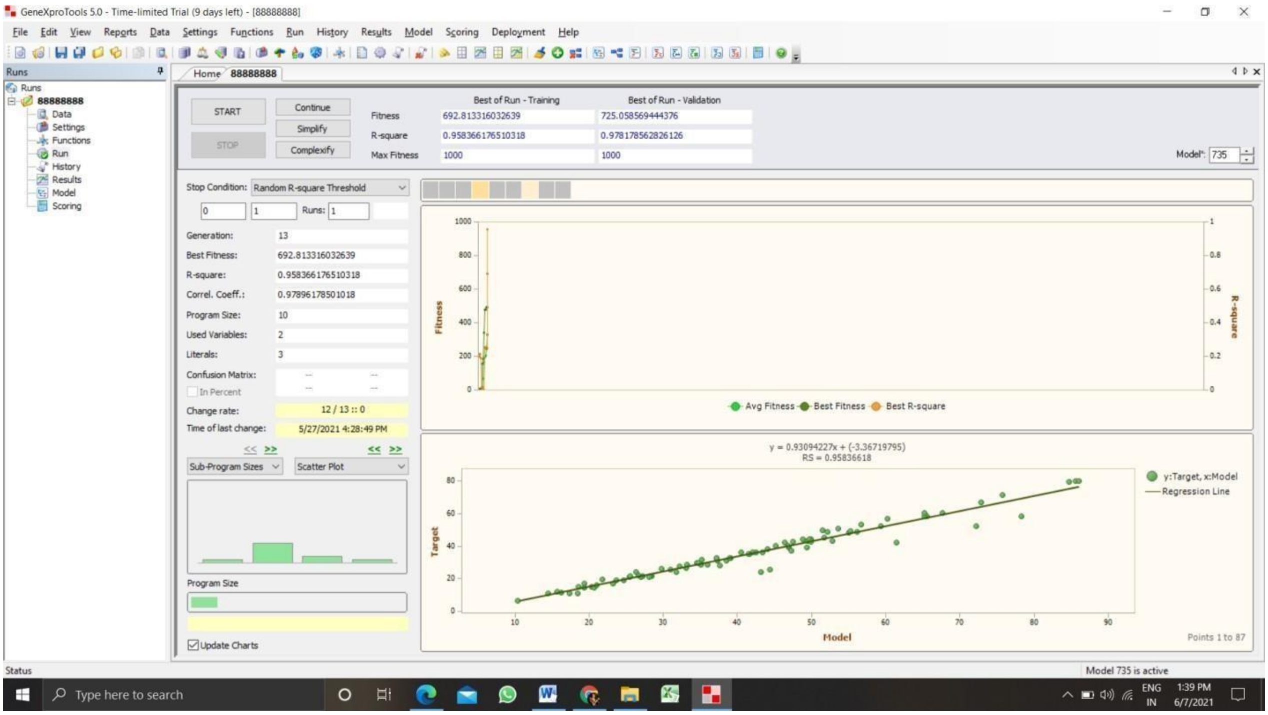
- The values of above constants will be solved using the Multi-Linear Regression Analysis in the Data Analysis Toolpak a built-in Add-In for Microsoft Excel. So by inputting the values of California Bearing Ratio, Liquid Limit, Plasticity Index, Optimum Moisture Content and GGBS Fractions we can obtain the values for the constants. Following values of the constants will be generated as shown in Table 2 below

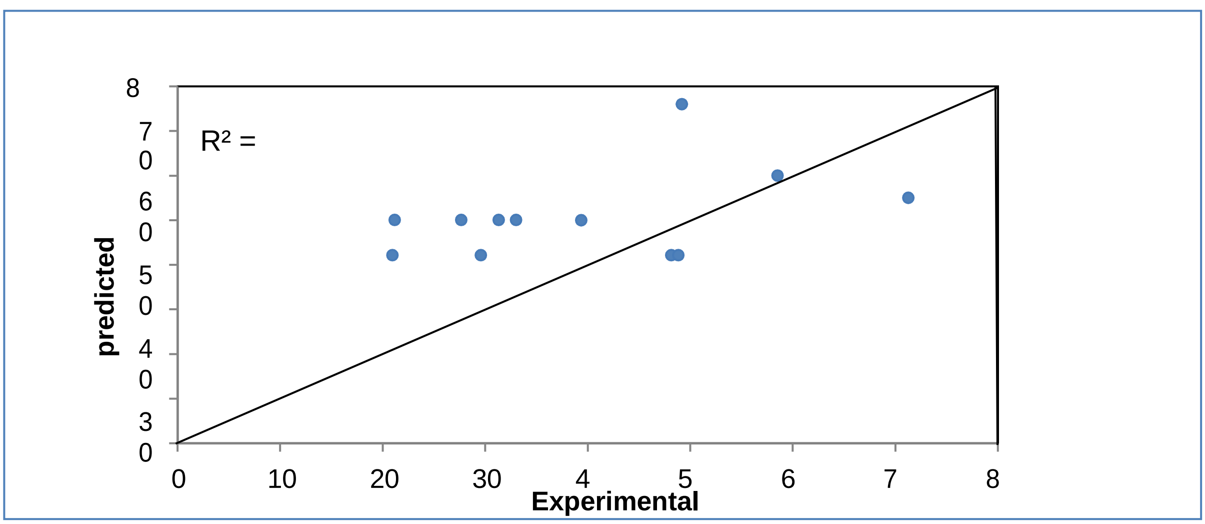
The Objective Function is

$$Y=5+0.5*X1-3.016*X2+1.6716*X3+6.831*X4$$

, the genetic algorithm model provides accurate assessments of the destination values. On the other hand, genetic algorithm model provides a good estimation and provides R2 value for training and testing as 0.95 and 0.97 respectively.

RESULTS OBTAINED FROM GENEXPRO5.0





8
70
60
50
40
30
R² =
predicted
0
10
20
30
4
5
6
7
8
Experimental

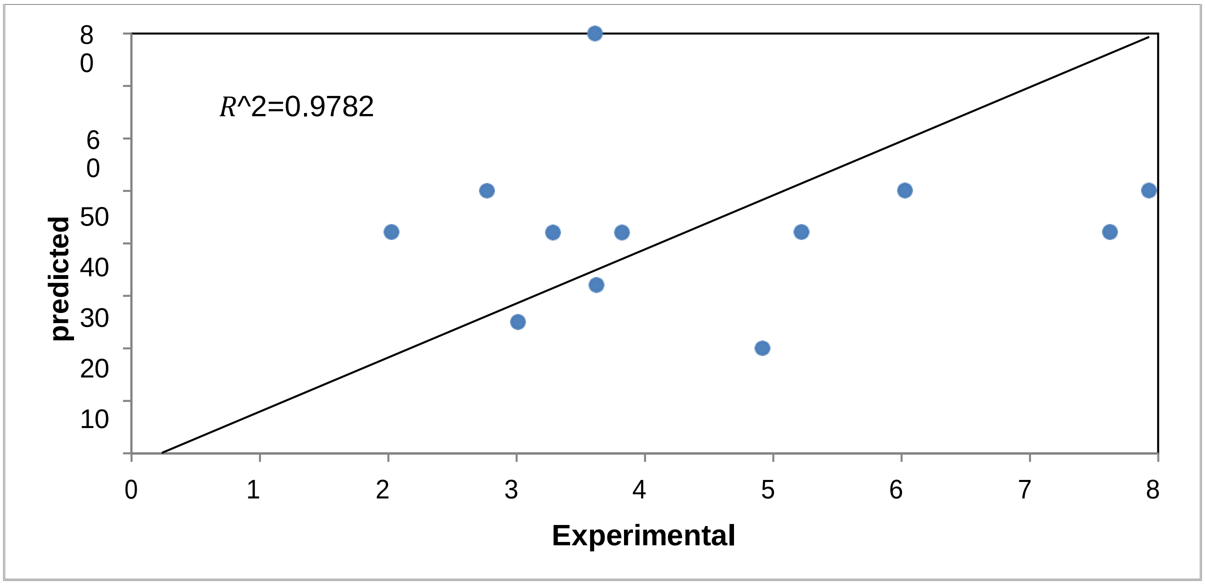


Fig. 6. Regression plot of predicted Mr against experimental Mr for training and testing data.

CONCLUSION

The value for this technique genetic algorithm was 0.97825, which is also very close to one, as more the result is closer to one more it is better and more accurate, the results obtained from the gene expression program (genexpro5.0) were satisfactory, the value of regression obtained was for training data is 0.986 and testing data is 0.97825. Because these values are quite close to one, so gene expression program (genexpro5.0) could be used to solve geotechnical problems and to predict the value of Mr. with an acceptable degree of accuracy coefficient of determination (R2)

CHAPTER 5

ARTIFICIAL NEURAL NETWORKS

A Biological Basis of Artificial Neural Networks:

Artificial neural networks are a technology based on studies of the brain and nervous system as depicted in Fig. 1. These networks emulate a biological neural network but they use a reduced set of concepts from biological neural systems. Specifically, ANN models simulate the electrical activity of the brain and nervous system. Processing elements (also known as either a neurode or perceptron) are connected to other processing elements. Typically the neurodes are arranged in a layer or vector, with the output of one layer serving as the input to the next layer and possibly other layers. A neurode may be connected to all or a subset of the neurodes in the subsequent layer, with these connections simulating the synaptic connections of the brain. Weighted data signals entering a neurode simulate the electrical excitation of a nerve cell and consequently the transference of information within the network or brain. The input values to a processing element, i_n, are multiplied by a connection weight, $w_{n,m}$, that simulates the strengthening of neural pathways in the brain. It is through the adjustment of the connection strengths or weights that learning is emulated in ANNs.

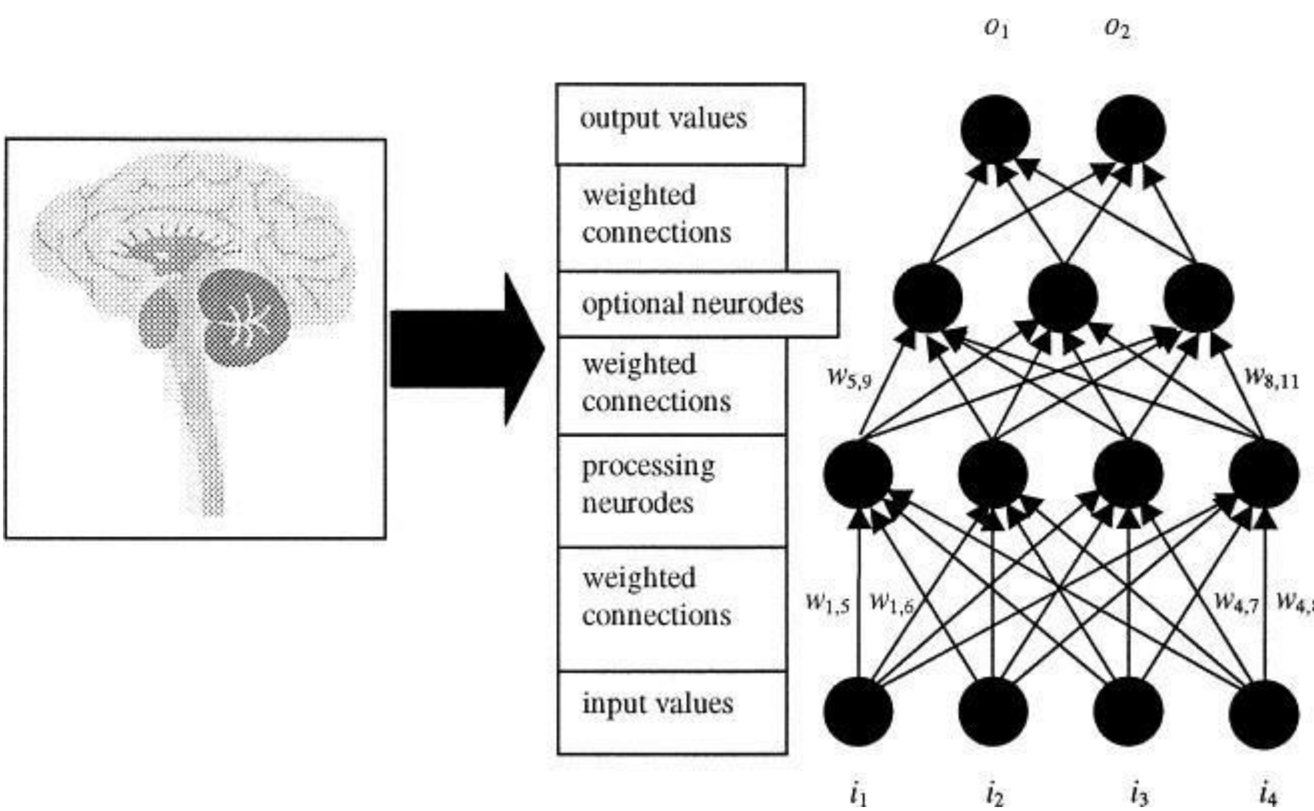


FIGURE 1. Sample artificial neural network architecture (not all weights are shown).

All of the weight-adjusted input values to a processing element are then aggregated using a vector to scalar function such as summation (i.e., $y = \Sigma w_{ij}x_i$), averaging, input maximum, or mode value to produce a single input value to the neurode. Once the input value is calculated, the processing element then uses a transfer function to produce its output (and consequently the input signals for the next processing layer). The transfer function transforms the neurode's input value. Typically this transformation involves the use of a sigmoid, hyperbolic-tangent, or other nonlinear function. The process is repeated between layers of processing elements until a final output value, o_n, or vector of values is produced by the neural network.

Theoretically, to simulate the asynchronous activity of the human nervous system, the processing elements of the artificial neural network should also be activated with the weighted input signal in an asynchronous manner. Most software and hardware implementations of artificial neural networks, however, implement a more discretized approach that guarantees that each processing element is activated once for each presentation of a vector of input values.

Introduction to Artificial Neural Networks:

Artificial Neural Network (ANN) is a deep learning algorithm that emerged and evolved from the idea of **Biological Neural Networks of human brains**. An attempt to simulate the workings of the human brain culminated in the emergence of ANN. ANN works very similar to the biological neural networks but doesn’t exactly resemble its workings.

ANN algorithm would accept only numeric and structured data as input. To accept unstructured and non-numeric data formats such as Image, Text, and Speech, **Convolutional Neural Networks (CNN),** and **Recursive Neural Networks (RNN)** are used respectively. In this post, we concentrate only on Artificial Neural Networks.

Structure of Artificial neurons and their functions:

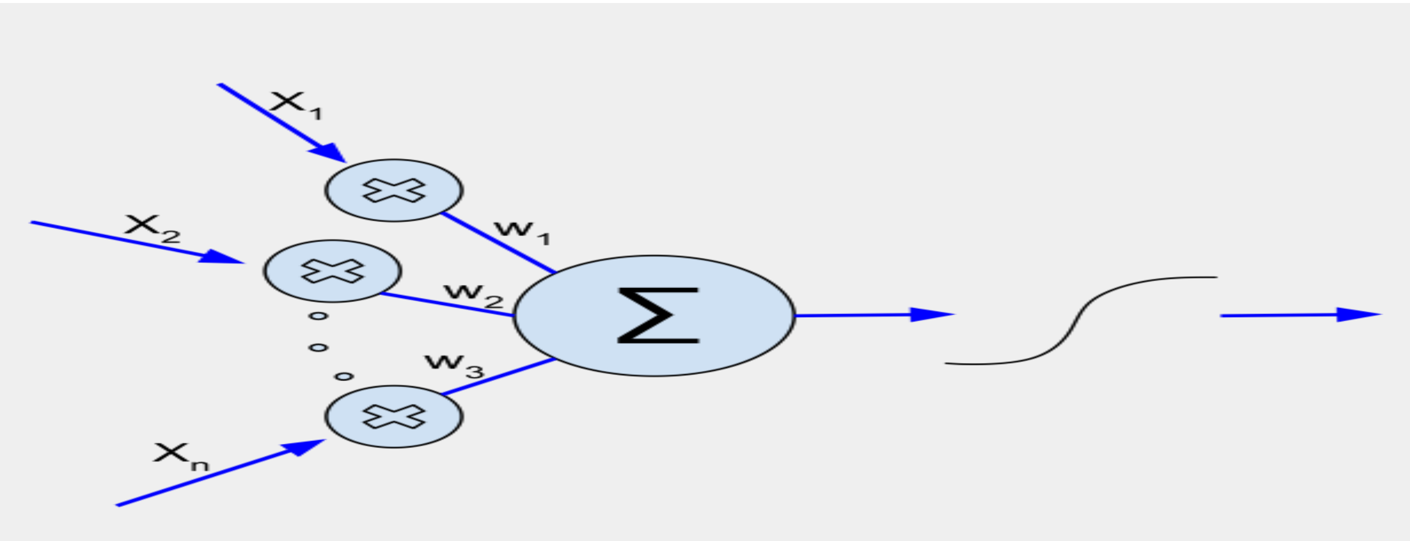
- A neural network with a single layer is called a **perceptron**. A multi-layer perceptron is called **Artificial Neural Networks.**

- A Neural network can possess any number of layers. Each layer can have one or more neurons or units. Each of the neurons is interconnected with each and every other neuron. Each layer could have different **activation functions** as well.

- ANN consists of two phases **Forward propagation and Backpropagation.** The forward propagation involves multiplying weights, adding bias, and applying activation function to the inputs and propagating it forward.

- The backpropagation step is the most important step which usually involves finding optimal parameters for the model by propagating in the backward direction of the Neural network layers. The backpropagation requires **optimization function** to find the optimal weights for the model.

- ANN can be applied to both **Regression and Classification tasks** by changing the activation functions of the output layers accordingly. (Sigmoid activation function for binary classification, Softmax activation function for multi-class classification and Linear activation function for Regression).
-



Why Neural Networks?

- Traditional Machine Learning algorithms tend to perform at the same level when the data size increases but ANN outperforms traditional Machine Learning algorithms when the data size is huge as shown in the graph below.

- **Feature Learning**. The ANN tries to learn hierarchically in an incremental manner layer by layer. Due to this reason, it is not necessary to perform feature engineering explicitly.

- Neural Networks can handle **unstructured data** like images, text, and speech. When the data contains unstructured data the neural network algorithms such as CNN (Convolution Neural Networks) and RNN (Recurrent Neural Networks) are used.

Advantages of Artificial Neural Networks (ANN):

1 **Storing information on the entire network**: Information such as in **traditional programming** is stored on the entire network, not on a database. The disappearance of a few pieces of information in one place does not prevent the network from functioning.

2 **Ability to work with** incomplete knowledge **:** After ANN training, the data may produce output even with incomplete information. The loss of performance here depends on the importance of the missing information.

3 **Having fault tolerance:** Corruption of one or more cells of ANN does not prevent it from generating output. This feature makes the networks fault tolerant.

4 **Having a distributed memory:** In order for ANN to be able to learn, it is necessary to determine the examples and to teach the network according to the desired output by showing these examples tothe

network. The network's success is directly proportional to the selected instances, and if the event can not be shown to the network in all its aspects, the network can produce false output.

5 **Gradual corruption:** A network slows over time and undergoes relative degradation. The network problem does not immediately corrode immediately.

6 **Ability to make machine learning:** Artificial neural networks learn events and make decisions by commenting on similar events.

7 **Parallel processing capability:** Artificial neural networks have numerical strength that can perform more than one job at the same time.

Disadvantages of Artificial Neural Networks (ANN):

- **Hardware dependence:** Artificial neural networks require processors with parallel processing power.
- **Determination of proper network structure:** There is no specific rule for determining the structure of artificial neural networks. Appropriate network structure is achieved through experience and trial and error.
- **Difficulty of showing the problem to the network:** ANNs can work with numerical information. Problems have to be translated into numerical values before being introduced to ANN. The display mechanism to be determined here will directly influence the **performance of the** network . This depends on the user's ability.
- **The duration of the** network is **unknown: The** network is reduced to a certain value of the error on the sample means that the training has been completed. This value does not give us optimum results.

Science: Artificial neural networks have stepped into the world in the mid-20th century are rapidly developing. In our present day, we have examined the advantages of artificial neural networks and the problems encountered in the course of their use. It should not be forgotten that the disadvantages of ANN networks, which are a developing science branch, are eliminated one by one and their advantages are increasing day by day. This means that artificial neural networks will become an indispensable part of our lives increasingly important.

Application of artificial neural networks:

ANNisacommoncomputationalmodelingnetworkthatcomprises ofinput,hiddenand output Layers,whichcanbeutilizedtomodel complicatedrelationshipsamonginputsandoutputsortoobtainpat- ternsindata.Itiscomprisedofinterconnectedadaptivesimple processingelementsnamed(artificialneuronsornodes)capableofper- forming computations for data processing and knowledge representation., Artificial Neural Networks (ANNs) exemplify the overallinterconnectionofthesystemstogetherwithnumericweighting whichistunedbasedonexperience,inputs,processingandoutputs. Duetoitshighperformanceinthemodeling,theANNmodelisoneof theattractivetoolsusedinengineeringapplications,suchaspattern.

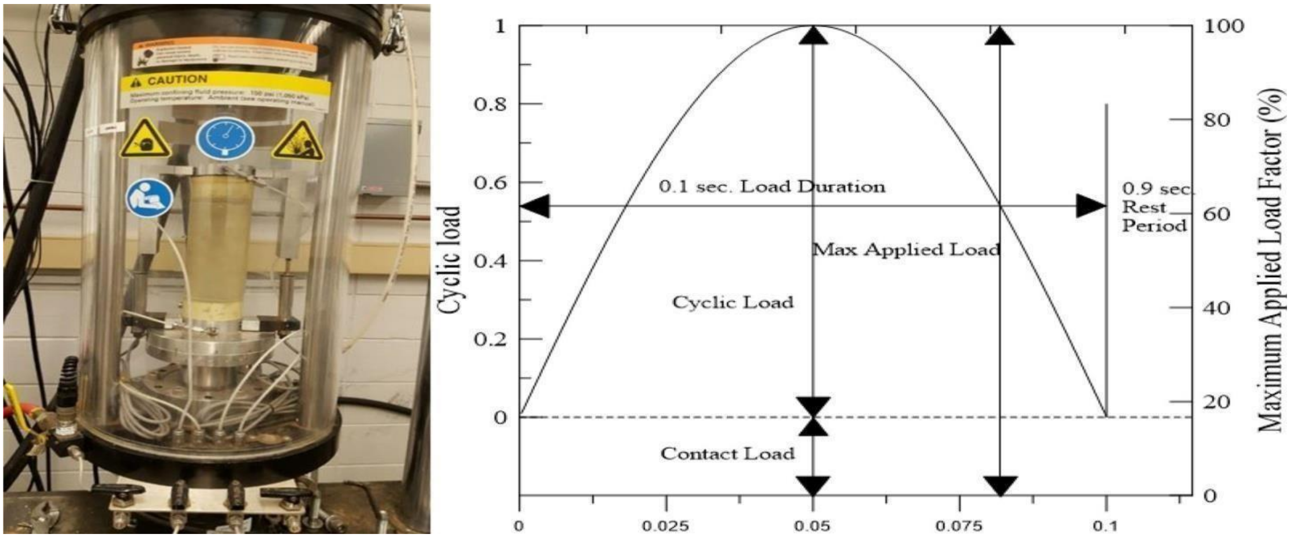


Fig. MTS machine with load pulse shape.

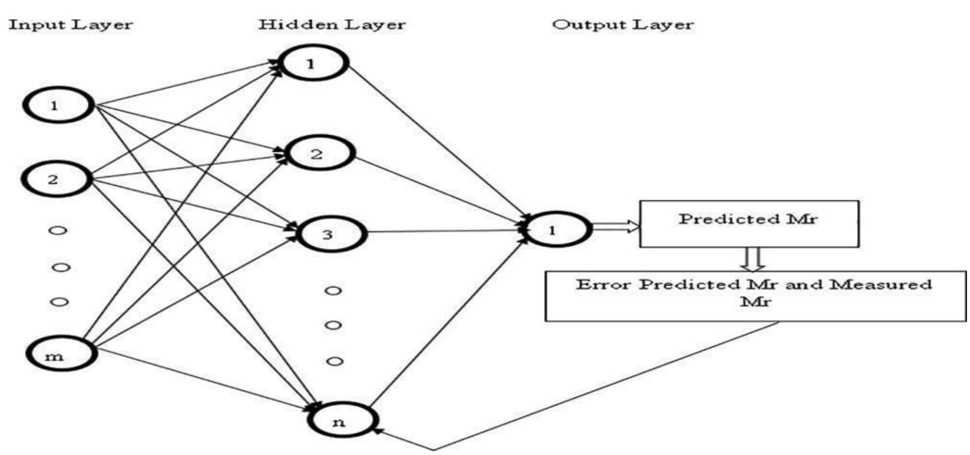


Fig. 2. Structure of backpropagation neural network

Recognition or data classification, through a learning process, which can easily solve complex system problems such as ones that are found within the transportation infrastructure systems. ANN model must integrate system-engineering techniques inorder to be maintained at acceptable levels and be sustainable for future years. ANNs, like people, learn by experience, examples and practicing, the architecture of an ANN model is a collection of nodes distributed over an input layer, hidden layer(s), and an output layer as shown in Fig. There is no specific rule to select the number of hidden layers and nodes. After several trial and error processes, the best performance was found at five hidden layers, thisjudgmentwasbaseduponthevalueofsquaredregression. Thedatabaseinthisstudywascollectedfrom previous studies which considered parameters to obtain the output which is the “M_r”, the computer program MATLAB was used. A single neuron for the output parameter representing resilient modulus. The primary caseis howtoachieveapropermodeltopredictanaccuratepredicationvalue to M_r.Consequently,an ecessity works to get a valid control in the modeling by switching the number of hidden layer and number of the node fore a hidden layer.

Computer program MATLAB was used to perform the ANN analysis.

Development of artificial neural networks models to predict resilient modulus

Backpropagation neural network algorithms were adopted in this study to develop ANN models that can accurately predict the resilient modulus. 70% of the data points were selected randomly for training, 15% were selected for cross validation, and 15% were used for testing the network. The training data points were used to train the network and compute the weights of theinputs. The test data points were used to measure the performance of the selected ANN model.The cross validation computes the error in a test set at the same time that the network is being trained with the training set.Several network structures with different number of nodes in the hidden layer were trained and tested.This strategy was chosen to find the best performing network architecture among different models.Neuro-Solutions 6.0 software was used in creating the neural network models.This software combines a modular design interface with advanced learning procedures, giving the power and flexibility needed to design the neural network that produces the best solution.Multilayer perceptron (MLP) with one hidden layer and hyperbolic tangent (tanh) as a transfer functionwas used in creating the neural networks.The hidden layer hasfour processing elements. The (tanh) transfer function was usedfor both the hidden and the output layers.Levenberg rule wasselected as the training rule.Based on running several neural

network models using Neuro-Solutions 6.0 software, the bestperforming neural network models were chosen.

Two approaches were used to develop ANN models to predictthe resilient modulus:

1. ANN models were developed using all independent variables,namely: M_r which is backcalculated from FWD using different methods, liquid limit (LL), plasticity index (PI), % passingsieve No.200, % clay, % silt, optimum moisture content, maximum dry unit weight, insitu moisture content, and in situ dryunit weight.All these variables were used as model predictors for M_r .A total of twelve ANN models were developed.These models were called all variables models (AVM)

2. ANN models were developed using the same variables thatwere used in the aforementioned regression models presentedin Tab. 2.These variables were selected in the developmentof ANN models for predicting M_r .A total of twelve ANNmodels were developed.These models were called selectedvariables models (SVM). This approach was used to comparethe regression result to the ANNs results.

The proceeding sections provide a description of results of analysis conducted using each of those approaches.

Workflow for Neural Network Design

The work flow for the neural network design process has seven primary steps. Referenced topics discuss the basic ideas behind steps 2, 3, and 5.

1. Collect data
2. Create the network — Create Neural Network Object

3. Configure the network — Configure Shallow Neural Network Inputs and Outputs
4. Initialize the weights and biases
5. Train the network — Neural Network Training Concepts
6. Validate the network
7. Use the network

Data collection in step 1 generally occurs outside the framework of Deep Learning Toolbox™ software, but it is discussed in general terms in MultilayerShallowNeuralNetworksandBackpropagationTraining. Details of the other steps and discussions of steps 4, 6, and 7, are discussed in topics specific to the type of network.

The Deep Learning Toolbox software uses the network object to store all of the information that defines a neural network. This topic describes the basic components of a neural network and shows how they are created and stored in the network object.

After a neural network has been created, it needs to be configured and then trained. Configuration involves arranging the network so that it is compatible with the problem you want to solve, as defined by sample data. After the network has been configured, the adjustable network parameters (called weights and biases) need to be tuned, so that the network performance is optimized. This tuning process is referred to as training the network. Configuration and training require that the network be provided with example data. This topic shows how toformat the data for presentation to the network. It also explains network configuration and the two forms of network training: incremental training and batch training.

- The Coefficient Of Correlation, R, the Root Mean Squared Error, RMSE, and the Mean Absolute Error, MAE, are the main criteria that are often used to evaluate the prediction performance of ANN models. The coefficient of correlation is a measure that is used to determine the relative correlation and the goodness-of-fit between the predicted and observed data.

The RMSE has been used in this paper since it is the most widespread measure of error and has the advantage that large errors receive much greater attention than small errors. RMSE and MAE are calculated, as follows:

$$\text{RMSE}=\sqrt{\frac{1}{n}\sum_{j=1}^{n}(y_j - d_j)^2}$$

$$\text{MAE}=\frac{1}{n}\sum_{j=1}^{n}\left|y_j - d_j\right|$$

where;
y_j= model (predicted) output, yj=y1,y2,y3,….,yn;
d_j=Desired (observed) output,dj=d1,d2,d3,….,dn;
n = number ofdata

In order to be acknowledged as a satisfactory prediction model, it is necessary to validate the neural network. The important features for validity of an artificial neural network systemare:

- Consistency: a system is consistent if repeated executions with the same data lead to the same output;
- Accuracy: is measured by comparing the number of correct predictions with actualdata.

Resilient Modulus Modeling Results:

The main results of the Artificial Neural Networks (ANN), kernel extreme machine learning, visualizations investigations and correlations between the analysisparameters.
MATLAB™ neural network toolbox is used to develop the model. A two-layer network with sigmoid hidden neurons and linear output neurons and tansig isselected.
The network is trained with different backpropagation algorithms with different number of neurons in the hidden layer to find out the best number of neurons and backpropagation algorithm. Mean absolute relative error (MARE) and root mean square error (RMSE) are used as the criteria for the predication accuracy of the model.

ParametricAnalysis

The ANN parameters governing the prediction of the Resilient Modulus process is shown in figures (8,9,10,11,12,13,14,15&16). In the following parametric study, the sensitivity of each parameter is measured by removing one of the parameters from the database sets. After that an ANN model is structured for prediction for each case. The prediction outcomes are presented below and the models' performance is summarized in Appendix (A). It can be seen that the divator stress and unconfined compression strength test are important parameters for Mr prediction. Similar conclusions have been made by [Redrigo et al. 2010] by employing ANN for prediction of Resilient Modulus of the Minnesota state Soil of Redrigo(2010)

Figure 1. Compression between the Actual Mr and the predicted Mr after removing the confining stress from the network

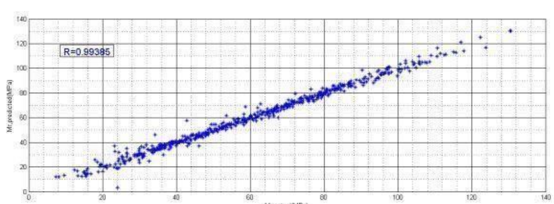


Figure 2. Compression between Mr Actual and Mr predicted after removing the Deviator Stress from the net

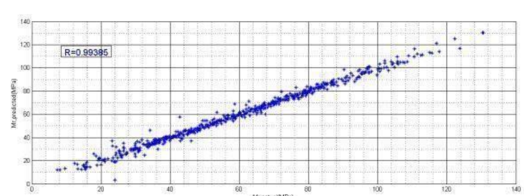


Figure 3. Compression between Mr Actual and Mr predicted after removing the Unconfined Compression strength test from the network.

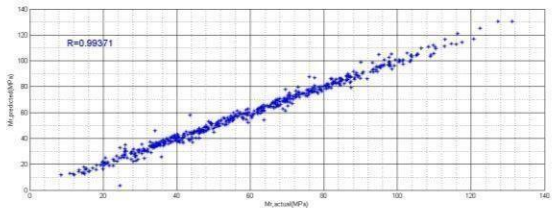


Figure 4. Compression between Mr Actual and Mr predicted after removing the Liquid Limit from the network.

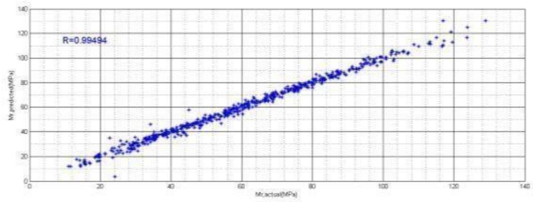


Figure 5. Compression between Mr Actual and Mr predicted after removing the Optimum Moisture Content from the network.

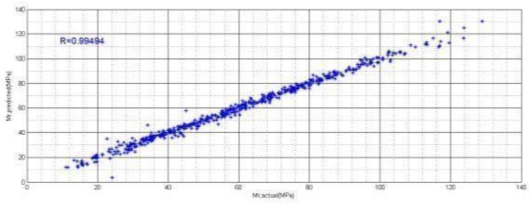


Figure 6. Compression between Mr Actual and Mr predicted after removing the Percent Passing Sieve #200 from the network.

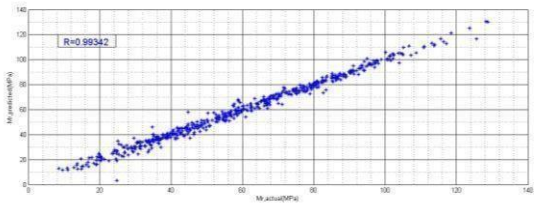


Figure 7. Compression between Mr Actual and Mr predicted after removing Plasticity Index from the network

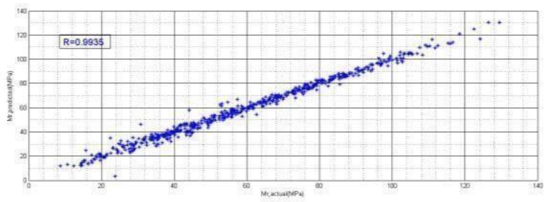


Figure 8. Compression between the Actual Mr and the predicted Mr after removing Moisture Content from the network.

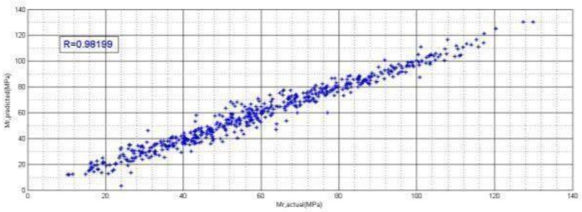


Figure 9. Compression between the Actual Mr and the predicted Mr after removing the Degree of Saturation from the network

Conclusions

1. The Artificial Neural Network (ANN) model Bayesian Regulation have the lowest Mean Square Error of 3.129e-04. Which was better in predicting the (Mr) than those estimated from using Extreme Machine Learning and from the Models proposed by previousstudies
2. From The parametric study, it is found that the confining stress (Ϭc) has a considerable effect on the accuracy of the ANN (15.24 % reduction in performance accuracy). Meanwhile, the performance of the ANN before and after removing the deviator stress (Ϭd) is nuance (3.03 % reduction in performance accuracy) compared with reduction exhibited when removing (Ϭc). The same as with the Unconfined Compressive Strength (UCS) which exhibits only 0.12% reduction in accuracy, Which means they have a lesser effect onit.
3. Other soil properties such as Liquid Limit, Optimum Moisture Content, percent passing sieve #200 , plasticity index Moisture content and the degree of saturation, all have an effect on the performance which means they improve ANN performance by (0.14%, 0.15%, 0.36, 0.17,0.15 & 1.31) and should be taken into consideration when predicting theMr.
4. Despite the good performance of the ANN in this work and in many situations in geotechnical engineering, ANN suffer from a number of shortcomings notably the lack in theory of model identification to help with their development the fact that success in finding good solution is usually achieved by trial-and-error and their limited ability to explain that way they use available information to arrive at suchSolution.

CHAPTER 6

DATA ANALYSIS AND RESULTS

INTRODUCTION

6.1. Specific Gravity (G_S)

The appropriate method for determining the specific gravity of the soil is the pycnometer test. Specific gravity of the soil particles is the ratio of weight of given volume of soil solids to the weight of an equal volume of water at 4°c. i.e. $G = \gamma_s / \gamma_w$. Specific gravity as such does not indicate the behavior of a soil mass under external load, but it is an important factor which is used in computing other soil properties. For example soil particle size determination by means of the hydrometer method .It is also used in consolidation studies of clay in calculating the degree of saturation of a soil and in other calculation. The effect of addition of GGBS in different proportions to the Soil Sample can be observed from the properties like Liquid Limit, Plastic Limit, Optimum Moisture Content and California Bearing Ratio. Putting the data generated from experiments with respect to these properties in Evolver 8.0 will give us the predicted values of CBR for various proportions of Fly Ash added to the Soil Sample.

Specific Gravity (G_S)

Results for Specific Gravity test

S.No	Details	Soil Sample
1	Weight of Pycnometer (m_1g)	500
2	Weight of Pycnometer + Dry soil (m_2g)	730
3	Weight of Pycnometer + Soil + Water (m_3g)	1536.1
4	Weight of Pycnometer + Water (m_4g)	1372.1
5	Specific gravity (G_s)	2.70

Weight of sample = 200gm

Specific gravity (G_s) = $(m_2-m_1)/ (m_2-m_1) - (m_3-m_4)$

$$G_s = \frac{(730-500)}{(730-500) - (1536.1 - 1391.1)} = 2.7$$

Results for Specific Gravity test for 10% GGBS

S.No	Details	Soil Sample
1	Weight of Pycnometer (m_1g)	500
2	Weight of Pycnometer + Dry soil (m_2g)	741.94
3	Weight of Pycnometer + Soil + Water (m_3g)	1521
4	Weight of Pycnometer + Water (m_4g)	1399.81
5	Specific gravity (G_s)	1.98

$$G_s = \frac{(741.94-500)}{(741.94-500) - (1521 - 1401.1)} = 1.98$$

Results for Specific Gravity test for 20% GGBS

S.No	Details	Soil Sample
1	Weight of Pycnometer (m_1g)	500
2	Weight of Pycnometer + Dry soil (m_2g)	750
3	Weight of Pycnometer + Soil + Water (m_3g)	1520
4	Weight of Pycnometer + Water (m_4g)	1373
5	Specific gravity (G_s)	1.70

$$G_s = \frac{(750-500)}{(750-500) - (1520 - 1417.0)} = 1.70$$

Results for Specific Gravity test for 30% GGBS

S.No	Details	Soil Sample
1	Weight of Pycnometer (m_1g)	500
2	Weight of Pycnometer + Dry soil (m_2g)	770
3	Weight of Pycnometer + Soil + Water (m_3g)	1520.75
4	Weight of Pycnometer + Water (m_4g)	1357.65
5	Specific gravity (G_s)	1.53

$$G_s = \frac{(770-500)}{(770-500) - (1520.75 - 1426.8)} = 1.53$$

The experimental results for specific gravity adding some percentage of GGBS we can see that 0% of GGBS added the specific gravity value is 2.07, when we add 10% of GGBS we get 1.98%,then for 20% we get 1.70,for 30% we get 1.53,40% for 1.05. Initial stage it has highest valueand drop down randomly.

HYDROMETER ANALYSIS :

Weight of the total sample	55	grams
Weight of the soil sample passing from no 40 sieve	48	grams
Specific Gravity of solids (Gs)	2.65	-
Meniscus Corr. (cm)	0.0005	g/cm^3
Volume of hydrometer	55	cm^3
Area of cylinder	28.274	cm^2
Dragent	0.002	g/cm^3
Tref	22	^0C
H1	16	cm
H2	6	cm
r1	1.000	g/cm^3
r2	1.040	g/cm^3

Density of fluid rf (g/cc) calculation: Fluid is water + sodium hexametaphosphate solution. In our experiment,wehaveassumedthattemperatureisconstantduringtheprocess,sodensityoffluidwill remain constant during the test. For this example, temperature is equal to 22 ^{0}C and water density is 0.99777 g/cc at thistemperature.

$$\rho f = \rho w@T + \Delta\rho agent = 0.99777 + 0.002 = 0.99977\ g/cm^3$$

Density of Suspension (g/cc): In this step, you need to calculate density of the slurry for each hydrometer reading. The reading taken from the hydrometer is specific gravity of the slurry so you needtomultiplythereadingwithdensityofthewaterwhichhydrometeriscalibrated.Hydrometeris calibrated at 19.5 ^{0}C distilled water. The density of water at 19.5 ^{0}C is 0.9983 g/cm^3. Thus, for a hydrometer reading 1.026 density of suspension should be calculated asfollows;

$$\rho suspension = (1.026 + 0.0005) * 0.9983 = 1.0248 g/cm^3$$

In the above calculation, 0.0005 is meniscus correction cm.

Height of Fall H(cm): Height of fall is the distance between slurry surface and centroid of the hydrometer. For any hydrometer reading, height of fall must be calculated in compliance with the interpolation formula written in Lab Sheet part 7.3. For Gs=1.026, height of fall can be calculated as follows:

$$H = 16 + \frac{(6-16)}{(1.040-1.000)} * (1.0248 - 1.000) - \frac{55}{2 * 28.274} = 8.83\ c$$

Particle Diameter D, (mm): The particle diameter passing from the centroid of the hydrometer at time t can be calculated with the given formula below:

$$D = \sqrt{\frac{18 \cdot \mu}{\rho_f g \cdot (G_s - 1)} \cdot \frac{H}{t}}$$

In the above formula,

m is the viscosity of the water and for our example it is equal to 0.961 MPa.s for 22 ^{0}C temperature,

rf is the density of the fluid that is calculated as 0.99977

g/cm^3, g is the gravitational acceleration and equals to **981**

cm/s^2,

Gs is the specific gravity of solids, in our example it is

2.65, H is the height of fall and for this example it is

8.83cm,

t is time in seconds. Since our reading 1.026 is taken at t = 2 minutes, t is equal to

120 sec. Putting everything together on the formula;

$$\boldsymbol{D} = \sqrt{\frac{18 * 0.961 * 8.83}{0.99977 * 981 * (2.65 - 1) * 120}} = 0.02805\ \boldsymbol{mm}$$

Percent Finer Than D (%): With this calculation, you can find the percentage finer than particle diameter calculated as 0.02805 mm

$$\% finer than\ 0.02805\ \boldsymbol{m} = \frac{2.65}{2.65 - 1} * \frac{1000}{48} * (1.0248 - 0.99977) * 100 = 83.75\%$$

Thus, %83.75 of the soil is finer than 0.02805mm.

Scalingtheresultstotheentiresoilsample: Aboveformulationwillgiveyoufractionsofsamplethat goesintohydrometertest.Sincesomeoftheparticlesremainonthenumber40sieve,ascalingmust be done to find real fractions. For this example, to find which fraction of the total sample (55 grams) is smaller than 0.02805 mm, following procedure can be done. 48 grams out of 55 grams of the soil specimenisusedinthehydrometertest.Inordertocalculateadjustedpercentagefinerthan0.02805 mm, we need to multiply 83.75 with the ratio48/55.

Adjusted percentage finer than D= 83.75* 48/55 = 73.

73.09% of the 55 grams is smaller than 0.02805 mm.

Below chart shows particle diameter limits for silt and clay. Numbers are in mm.

Clay size	less than 0.002
Silt size	0.002–0.075

FREE SWELL INDEX

It is a standard model which is specified by the Bureau of Indian standards (IS: 2720, 1977). 10gm of oven dried passing through 425µm sieve is placed in 100ml of graduated measuring jar comprising distilled water to that in kerosene. After an equilibrium period of 24hrs the swell potential of the soil is calculated utilizingFSI.

$$FSI(\%)=\frac{(Vd-Vk)}{Vd}*100$$

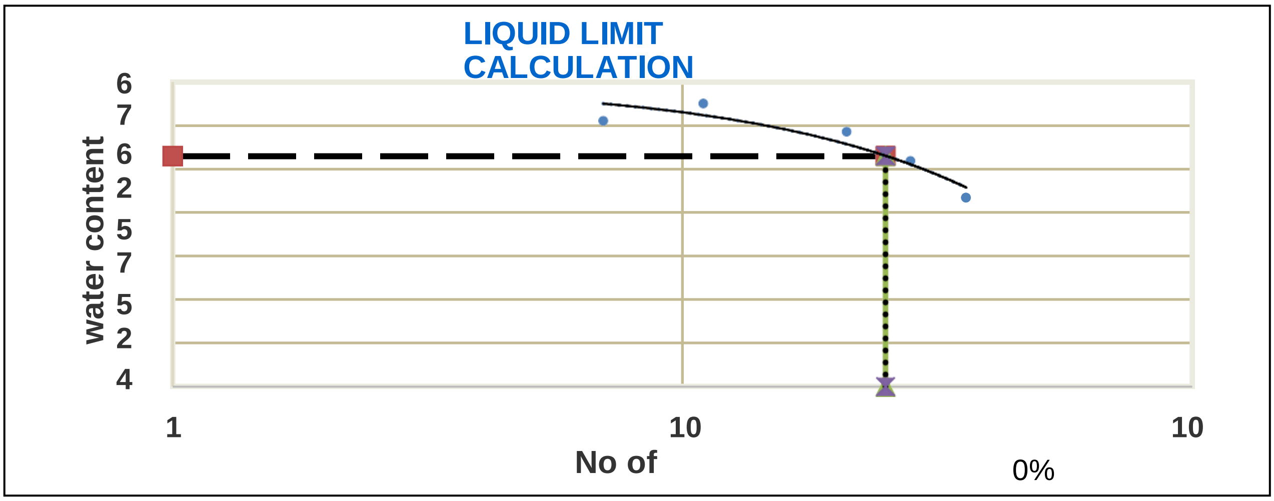
Where, V_d is the sediment volume in distilled water, $V_k$is sediment volume inkerosene

S.No	Soils	Equilibrium sediment value predicted by using Hyperbola method (ml)	Time taken for prediction of final value using Hyperbola method	Sediment volume in kerosene (V_d) (ml)	FSI (%)
1.	Soil sample 1	16.6	37 min	9	67.6
2.	Soil sample 2	14.7	4hrs. 20min	10	50
3.	Soil sample 3	12.5	6hrs	9	32.3
4	Soil sample 4	22.5	7hrs	11	22.3
4.	Soil sample 4	25	8 hrs	12	10.14

Atterberg'sLimits

Observation Table showing atterberg'slimits of BC Soil

S.No.	1	2	3	4	5
Container no.	18	43	20	27	35
Empty weight of the container	56.58	51.05	63.25	68.91	60.61
Wet weight of the soil and container	44.47	47.43	44.13	46.28	48.51
Dry weight of the soil and container	40.01	40.3	39.3	39.74	41.84
No of blows	36	28	21	11	7
Water content	53.70	57.90	61.25	64.50	62.50

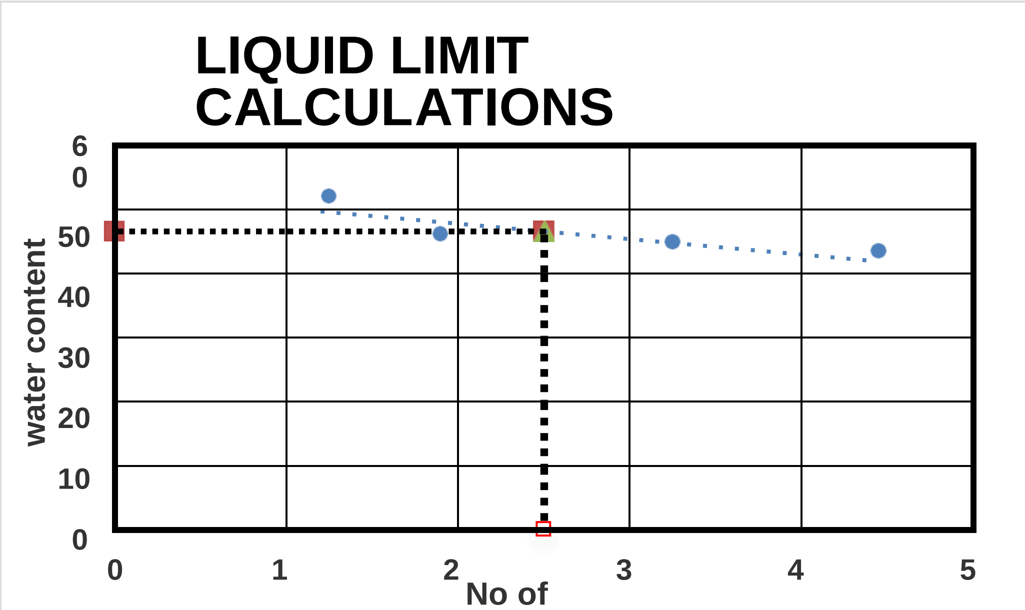


Observations of plastic limit test

Empty weight of the container	27.59	29.48
Wet weight of soil and container	36.25	37.52
Dry weight of soil and container	34.03	35.74
Plastic limit	30.87	28.10

Observations of Liquid Limit Test for GGBS (10%)

S.No.	1	2	3	4
Container no.	25	44	50	2
Empty weight of the container	29.51	22.78	23.15	27.77
Wet weight of the soil and container	49.39	45.32	46.76	50.92
Dry weight of the soil and container	43.23	38.22	39.13	42.76
No of blows	44	32	19	12
Water content	44.70	44.10	46.12	51.25

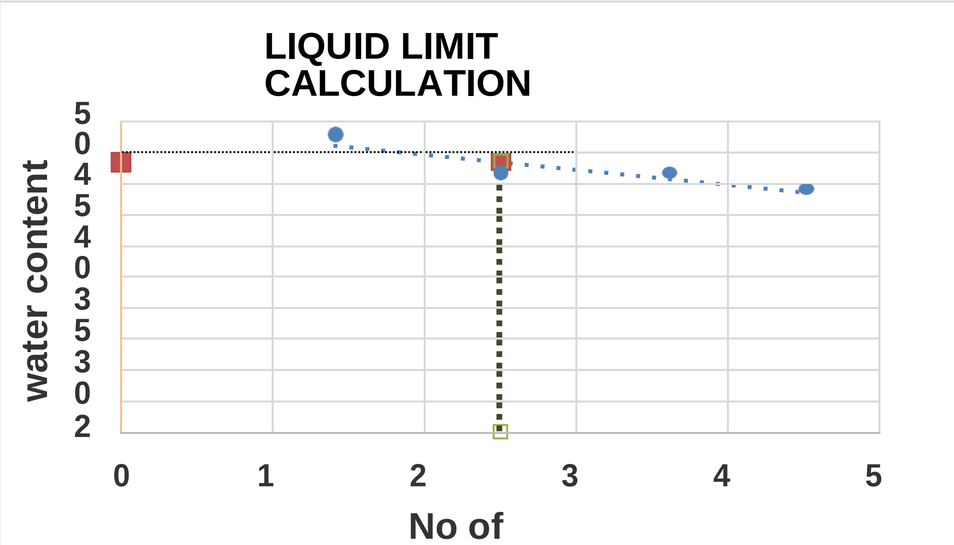


Observations of plastic limit test

Empty weight of the container	29.01	19.55
Wet weight of soil and container	34.86	24.54
Dry weight of soil and container	33.85	23.69
Plastic limit	24.87	23.53

Observations of Liquid Limit Test for GGBS (20%)

S.No.	1	2	3	4	5
Container no.	34	10	143	19	35
Empty weight of the container	29.5	30.64	30.12	29.86	30.16
Wet weight of the soil and container	50.55	51.02	51.83	50.81	50.84
Dry weight of the soil and container	44.73	45.22	45.5	44.41	43.84
No of blows	45	36	25	14	10
Water content	38.75	40.91	41.16	46.99	55.19

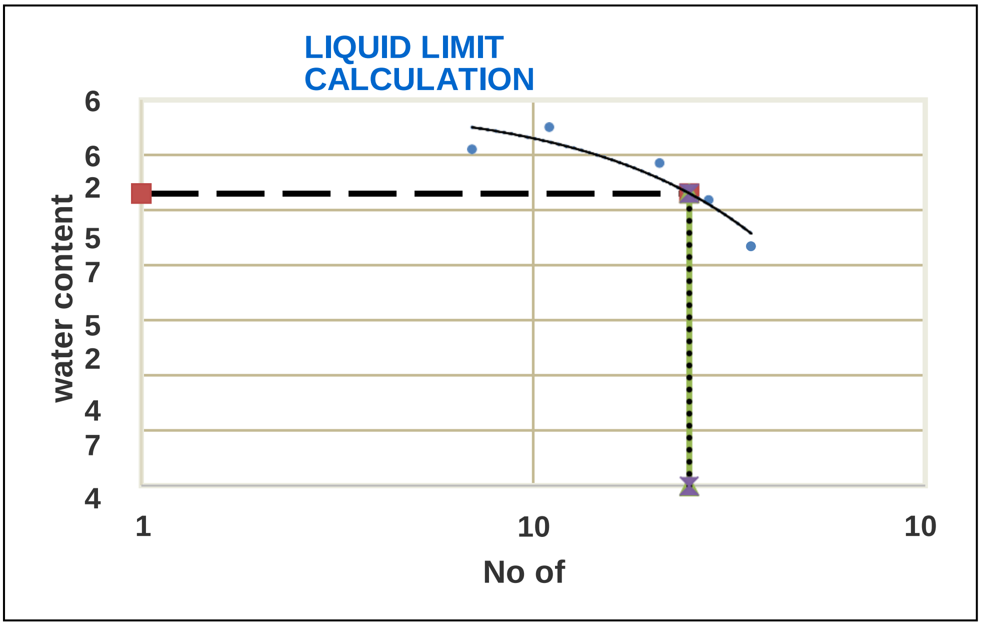


Observations of plastic limit test

Empty weight of the container	28.68	22.74
Wet weight of soil and container	42.45	41.87
Dry weight of soil and container	39.08	37.12
Plastic limit	25.40	26.50

Observations of Liquid Limit Test for GGBS (30%)

S.No.	1	2	3	4
Container no.	100	50	40	48
Empty weight of the container	29.56	23.15	32.01	19.55
Wet weight of the soil and container	49.18	44.48	56.75	43.18
Dry weight of the soil and container	44.82	39.9	50.93	37.42
No of blows	44	37	22	12
Water content	28.57	37.57	39.85	44.10



Observations of plastic limit test

Empty weight of the container	30.87	28.56
Wet weight of soil and container	38.9	35.26
Dry weight of soil and container	37.83	34.42
Plastic limit	25.80	26.50

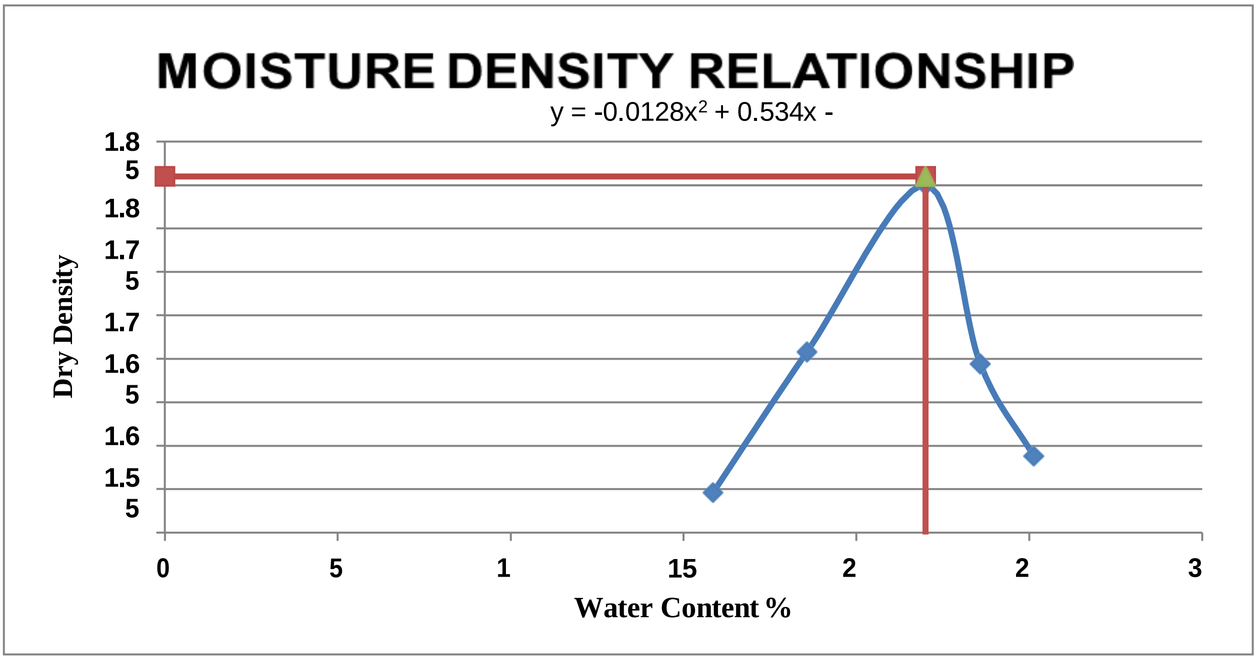


Table 6.5.2 Compaction Properties of **GGBS (10%)**

(As per IS: 2720 (Part VIII) – 1980)

Observation of Compaction test

Type of compaction: Heavy Compaction

Calculation of Moisture content

1	Container no	31	129	30	44	24
2	Empty weight of container in gm	26.7	28.81	30.75	30.19	31.98
3	Weight of wet soil and container in gm	51.12	59.52	63.17	66.38	60.61
4	Weight oven dry soil and container in gm	47.49	54.47	57.42	59.66	55.09
5	Weight of moisture (W1) in gm	3.63	5.05	5.75	6.72	5.52
6	Weight of oven dry soil (W2) in gm	20.79	25.66	26.67	29.47	23.11
7	Moisture content % (W= w1/w2*100)	17.46	19.68	21.56	22.8	23.89

Calculation of Dry Density

1	Weight of mould and compacted soil in gm	3.906	4.137	4.215	4.201	4.093
2	Bulk density γb	1.676	1.907	1.985	1.971	1.863
3	Dry density $\gamma d = \gamma b/1+w$	1.446	1.608	1.641	1.594	1.488

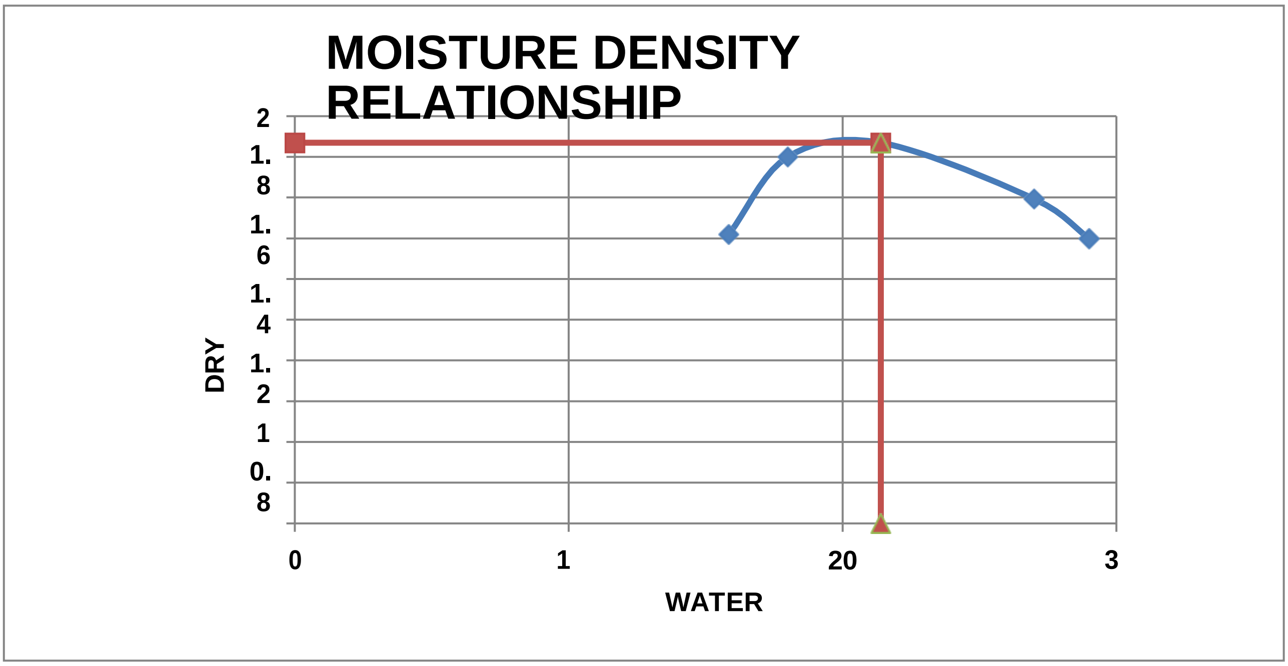


Table 6.5.3 Compaction Properties of **GGBS (20%)**

(As per IS: 2720 (Part VIII) – 1980)

Observation of Compaction test

Type of compaction: Heavy Compaction

Calculation of Moisture content

1	Container no	133	37	21	15	30
2	Empty weight of container in gm	25.64	22.32	31.82	29.4	25.44
3	Weight of wet soil and container in gm	63.05	56.90	76.30	46.50	43.50
4	Weight oven dry soil and container in gm	60.79	54.07	71.90	44.54	40.87
5	Weight of moisture (W1) in gm	2.26	2.85	4.39	2.17	2.60
6	Weight of oven dry soil (W2) in gm	35.50	31.70	40.40	15.17	15.76
7	Moisture content % (W= w1/w2*100)	6.40	9.20	10.80	14.75	17.45

Calculation of Dry Density

1	Weight of mould and compacted soil in gm	4.106	4.261	4.327	4.136	4.075
2	Bulk density γb	1.876	2.031	2.094	2.086	1.844
3	Dry density $\gamma d = \gamma b/1+w$	1.762	1.863	1.891	1.825	1.572

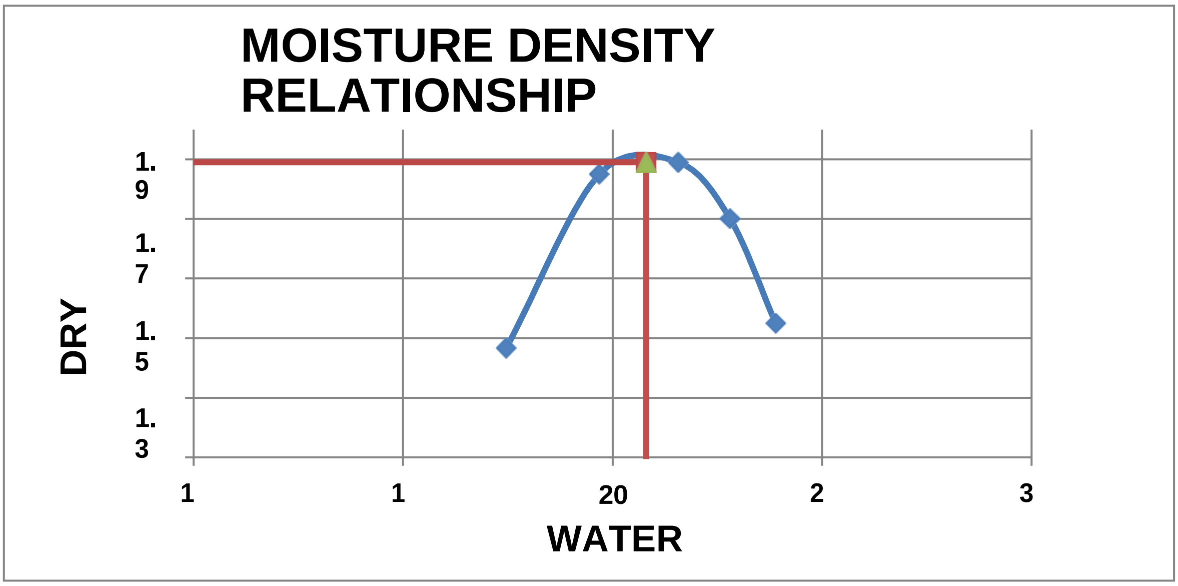


Table 6.5.4 Compaction Properties of **GGBS (30%)**

(As per IS: 2720 (Part VIII) – 1980)

Observation of Compaction test

Type of compaction: Heavy Compaction

Calculation of Moisture content

1	Container no	39	133	123	30	199
2	Empty weight of container in gm	26.7	28.81	30.75	30.19	31.98
3	Weight of wet soil and container in gm	51.12	59.52	63.17	66.38	60.61
4	Weight oven dry soil and container in gm	47.49	54.47	57.42	59.66	55.09
5	Weight of moisture (W1) in gm	3.63	5.05	5.75	6.72	5.52
6	Weight of oven dry soil (W2) in gm	20.79	25.66	26.67	29.47	23.11
7	Moisture content % (W= w1/w2*100)	17.46	19.68	21.56	22.8	23.89

Calculation of Dry Density

1	Weight of mould and compacted soil in gm	3.618	4.002	4.128	3.982	3.825
2	Bulk density γb	1.388	1.772	1.898	1.752	1.595
3	Drydensity $\gamma d = \gamma b/1+w$	1.266	1.6	1.678	1.523	1.349

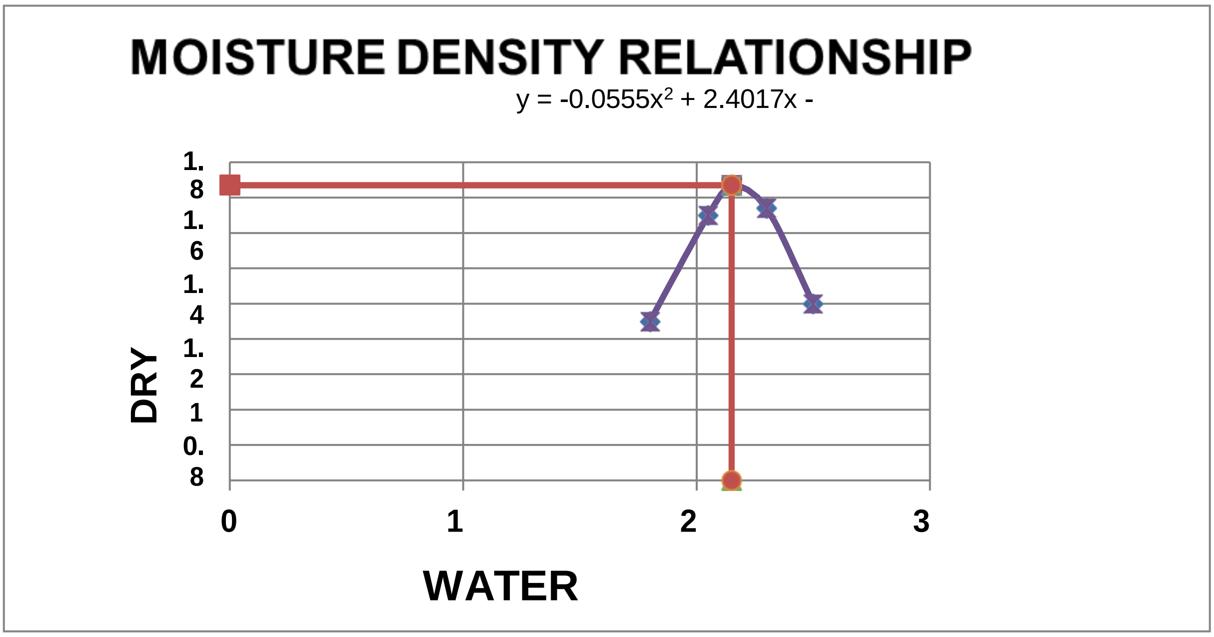


Table 6.5.5 Compaction Properties of **GGBS (40%)**

(As per IS: 2720 (Part VIII) – 1980)

Observation of Compaction test

Type of compaction: Heavy Compaction

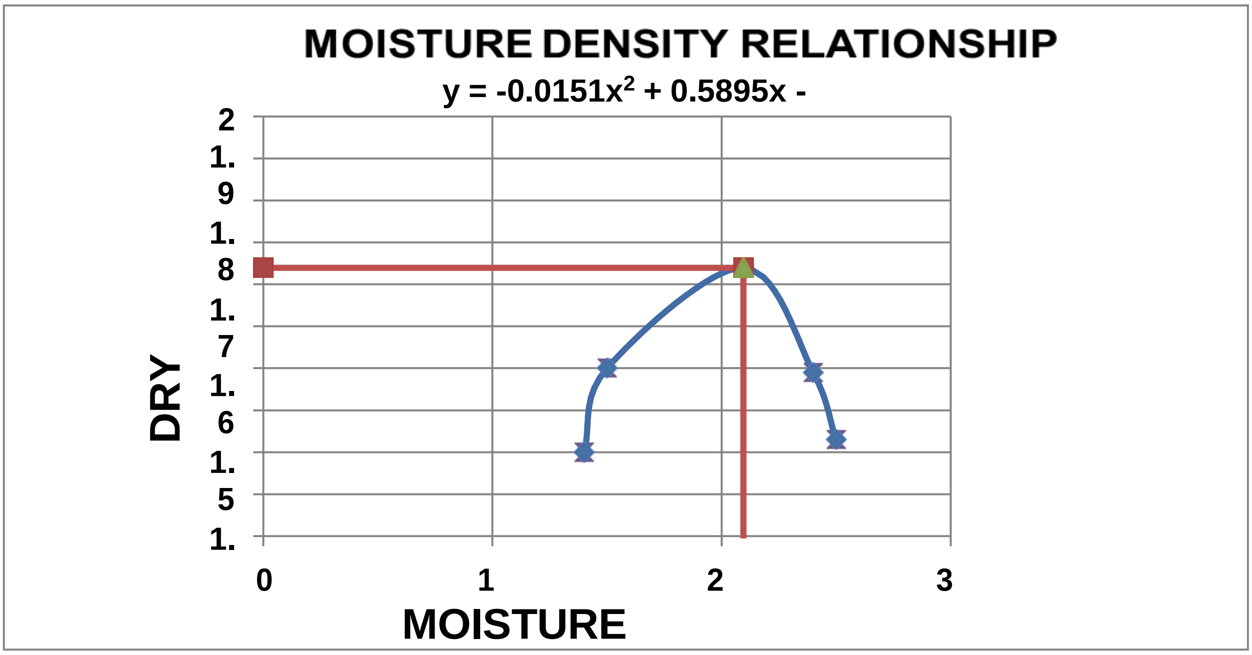
1	Container no	10	123	9	143	36
2	Empty weight of container in gm	33.84	29.40	29.32	26.61	33.84
3	Weight of wet soil and container in gm	50.29	51.54	48.89	49.98	51.02
4	Weight oven dry soil and container in gm	48.04	47.82	45.50	45.33	47.57

Calculation of Moisture content

5	Weight of moisture (W1) in gm	2.25	3.42	3.39	4.65	3.45
6	Weight of oven dry soil (W2) in gm	14.25	18.42	16.18	19.72	13.73
7	Moisture content % (W= w1/w2*100)	15.85	18.57	20.95	23.85	25.13

Calculation of Dry Density

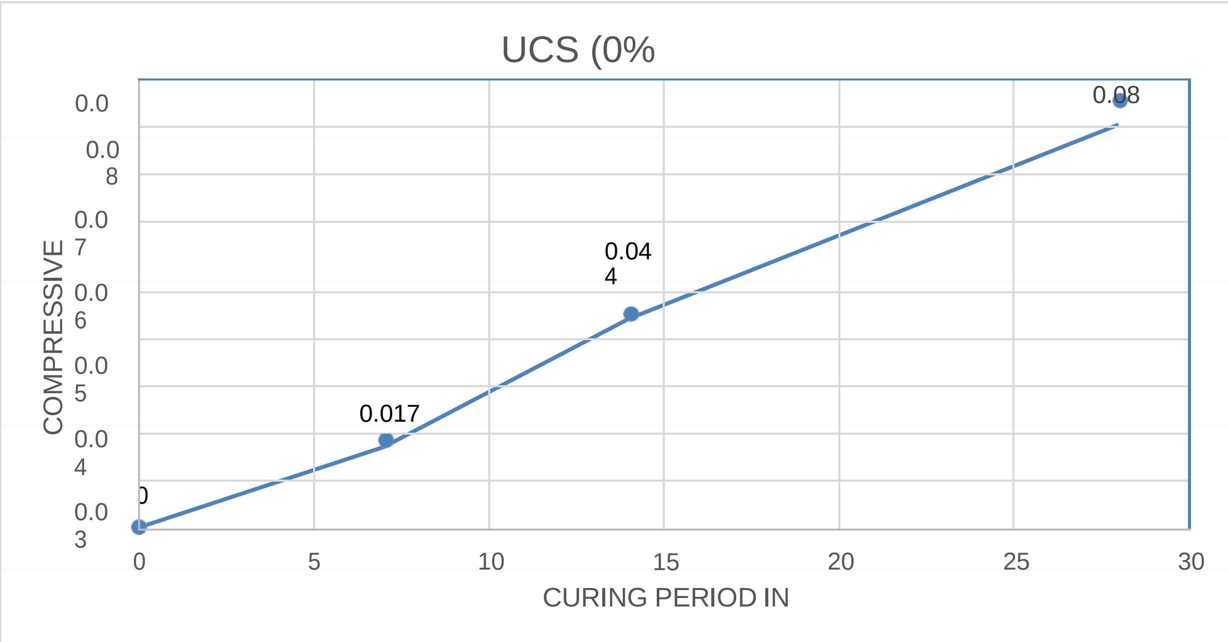
1	Weight of mould and compacted soil in gm	3.906	4.137	4.125	4.201	4.093
2	Bulk density γb	1.676	1.907	1.985	1.971	1.863
3	Dry density $\gamma d = \gamma b/1+w$	1.446	1.608	1.641	1.594	1.488



UNCONFINED COMPRESSIVE STRENGTH

UCS FOR 0% OF GGBS

S.NO	CURING PERIOD	COMPRESSIVE STRENGTH
1	0	0
2	7	0.017
3	14	0.044
4	28	0.085

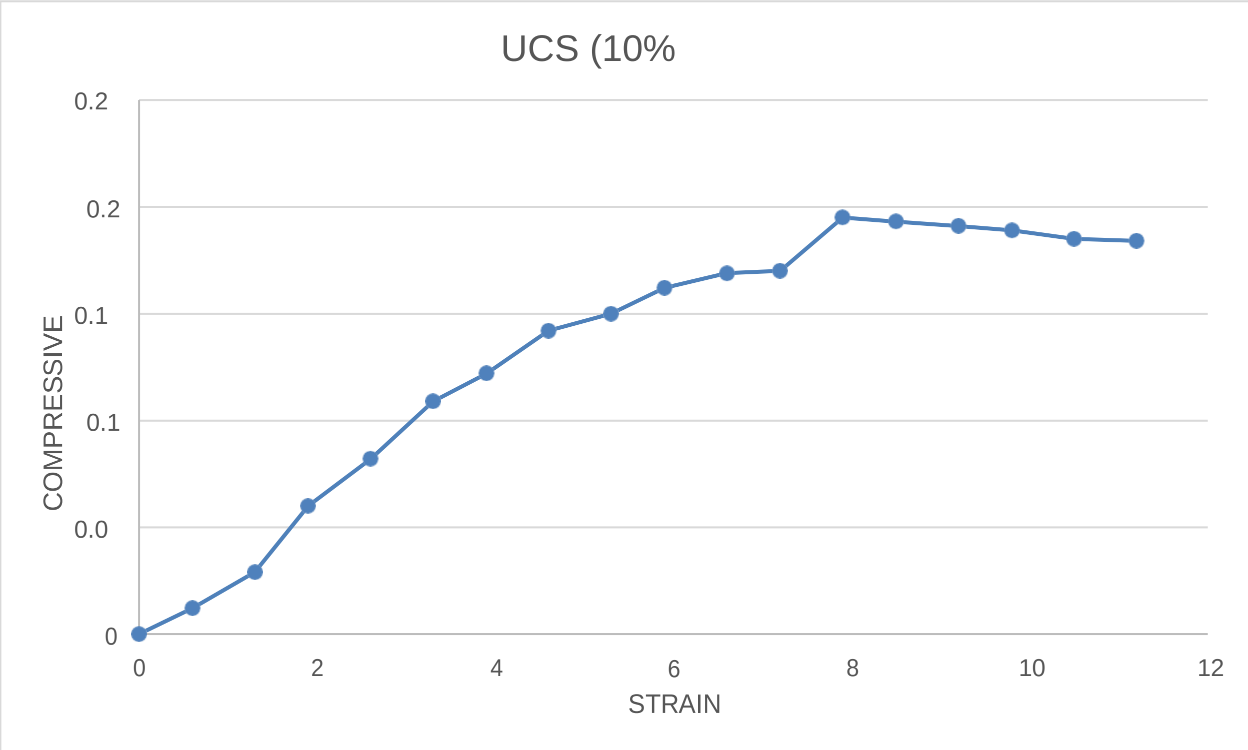


UCS FOR 10% OF GGBS

S.NO	STRAIN %	COMPRESSIVE STRENGTH
1	0	0
2	0.6	0.012
3	1.3	0.029
4	1.9	0.06
5	2.6	0.082
6	3.3	0.109
7	3.9	0.122
8	4.6	0.142

9	5.3	0.15

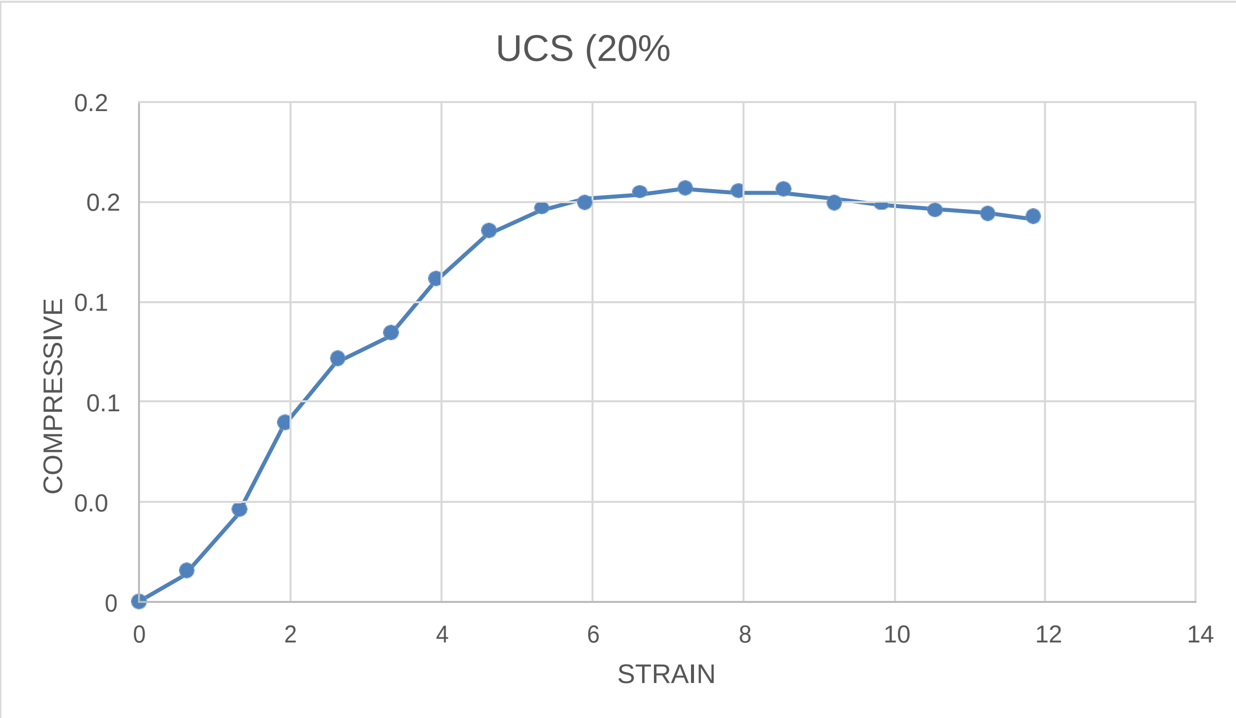
10	5.9	0.162
11	6.6	0.169
12	7.2	0.17
13	7.9	0.195
14	8.5	0.193
15	9.2	0.191
16	9.8	0.189
17	10.5	0.185
18	11.2	0.184



UCS FOR 20% OF GGBS

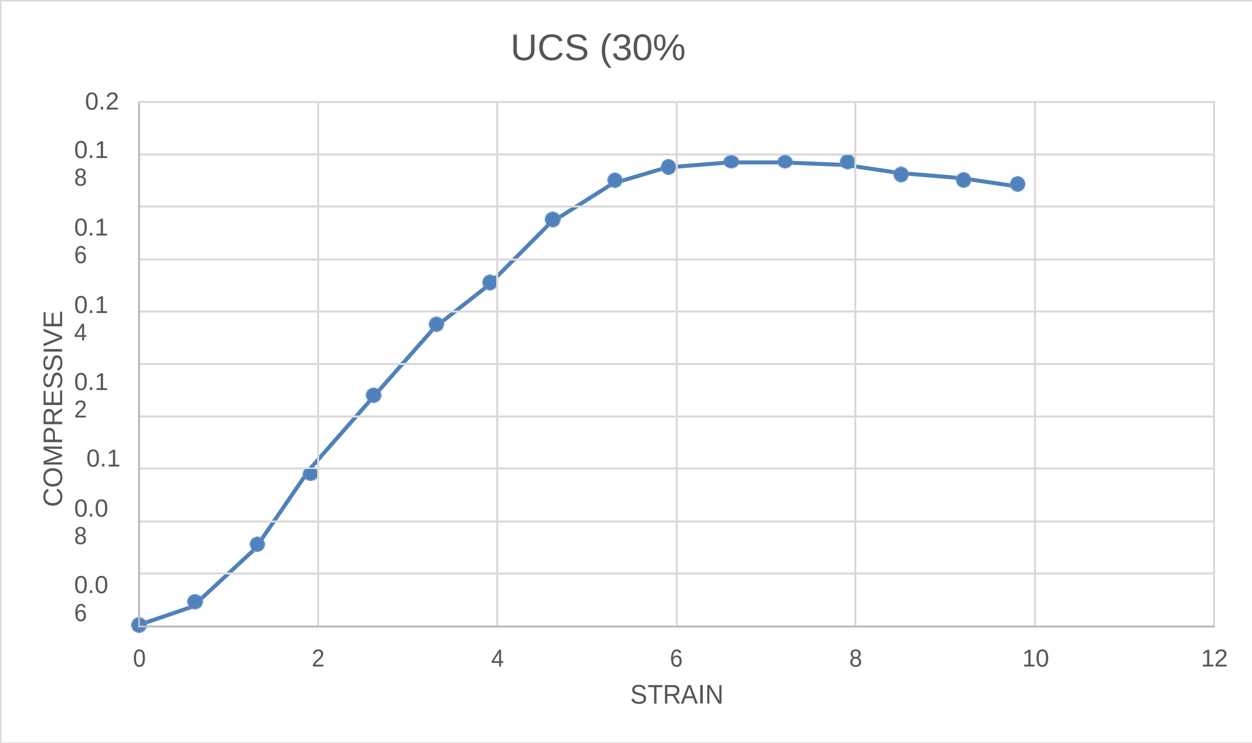
S.NO	STRAIN %	COMPRESSIVE STRENGTH
1	0	0
2	0.6	0.013
3	1.3	0.043
4	1.9	0.087
5	2.6	0.119
6	3.3	0.132
7	3.9	0.159
8	4.6	0.183
9	5.3	0.195
10	5.9	0.201
11	6.6	0.203
12	7.2	0.206
13	7.9	0.204
14	8.5	0.204
15	9.2	0.201
16	9.8	0.198
17	10.5	0.196

18	11.2	0.194
19	11.8	0.191



UCS FOR 30% OF GGBS

S.NO	STRAIN %	COMPRESSIVE STRENGTH
1	0	0
2	0.6	0.007
3	1.3	0.029
4	1.9	0.059
5	2.6	0.086
6	3.3	0.113
7	3.9	0.129
8	4.6	0.153
9	5.3	0.168
10	5.9	0.174
11	6.6	0.176
12	7.2	0.176
13	7.9	0.175
14	8.5	0.172
15	9.2	0.17
16	9.8	0.167



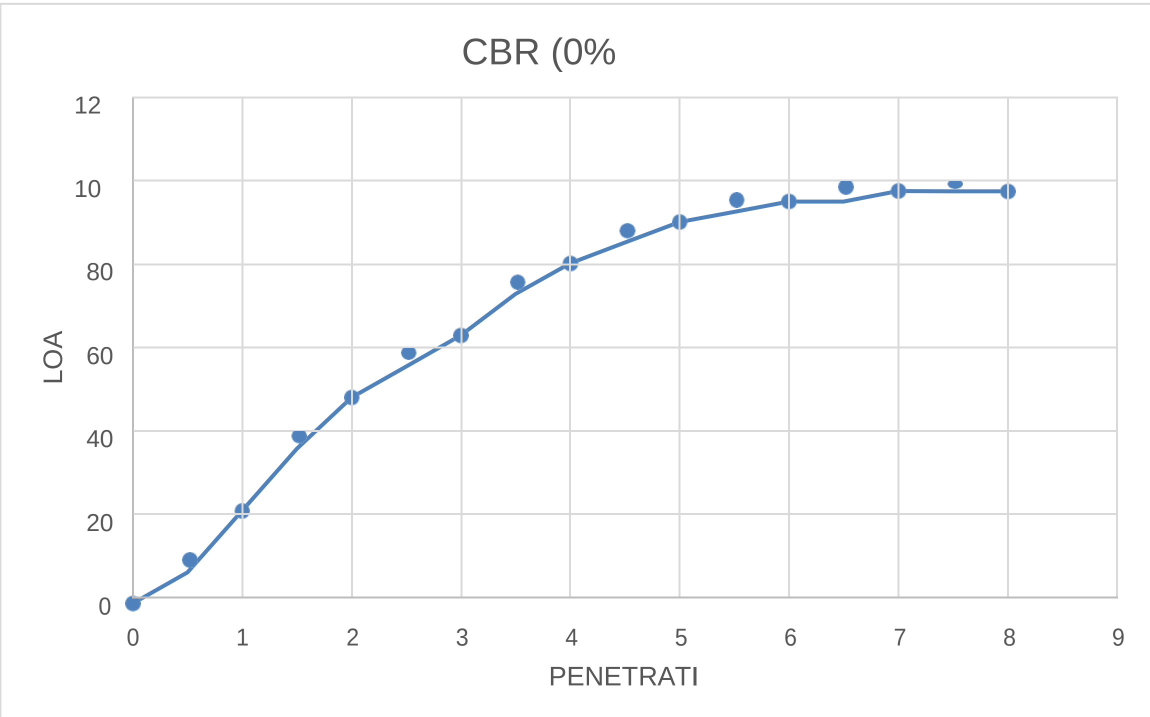
UCS FOR 40% OF GGBS

S.NO	STRAIN %	COMPRESSIVE STRENGTH
1	0	0
2	0.6	0.01
3	1.3	0.026
4	1.9	0.057
5	2.6	0.087
6	3.3	0.111
7	3.9	0.137
8	4.6	0.158
9	5.3	0.166
10	5.9	0.17
11	6.6	0.17
12	7.2	0.169
13	7.9	0.168
14	8.5	0.165
15	9.2	0.163

CALIFORNIA BEARING RATIO

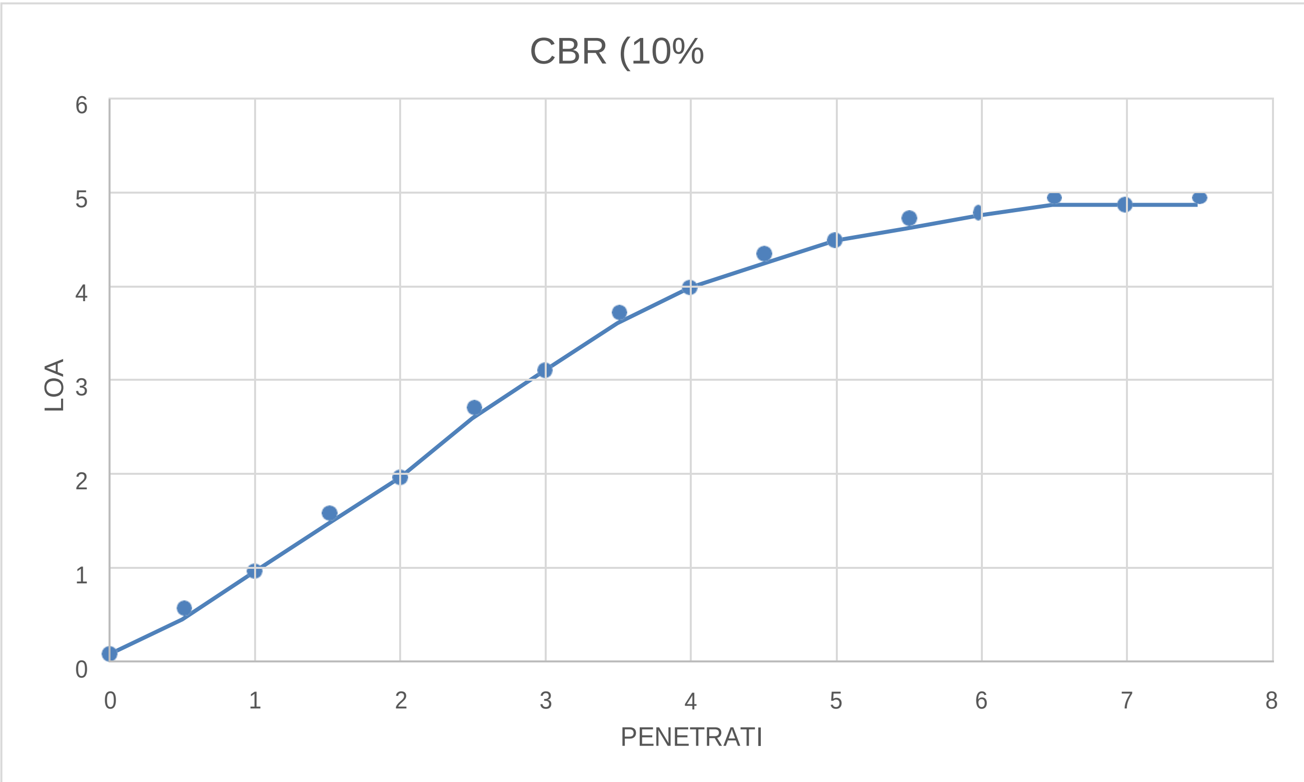
CBR FOR 0% OF GGBS

S.NO	PENETRATION	APPLIED LOAD
1	0	0
2	0.5	7.41
3	1	22.24
4	1.5	37.07
5	2	49.42
6	2.5	56.83
7	3	64.25
8	3.5	74.13
9	4	81.54
10	4.5	86.49
11	5	91.43
12	5.5	93.9
13	6	96.37
14	6.5	96.37
15	7	98.84
16	7.5	98.81
17	8	98.81



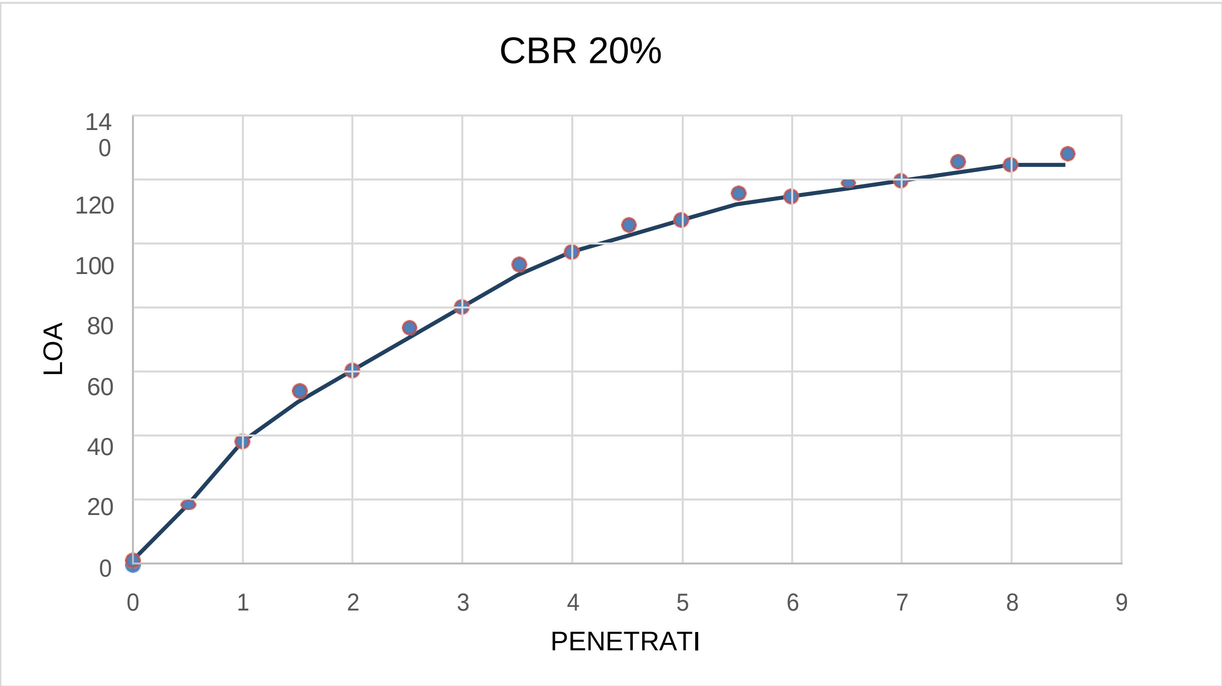
CBR FOR 10% OF GGBS

S.NO	PENETRATION	LOAD
1	0	2.47
2	0.5	19.77
3	1	39.54
4	1.5	51.89
5	2	61.78
6	2.5	71.66
7	3	81.54
8	3.5	91.43
9	4	98.84
10	4.5	100.78
11	5	102.72
12	5.5	103.67
13	6	106.14
14	6.5	108.61
15	7	110
16	7.5	110.2



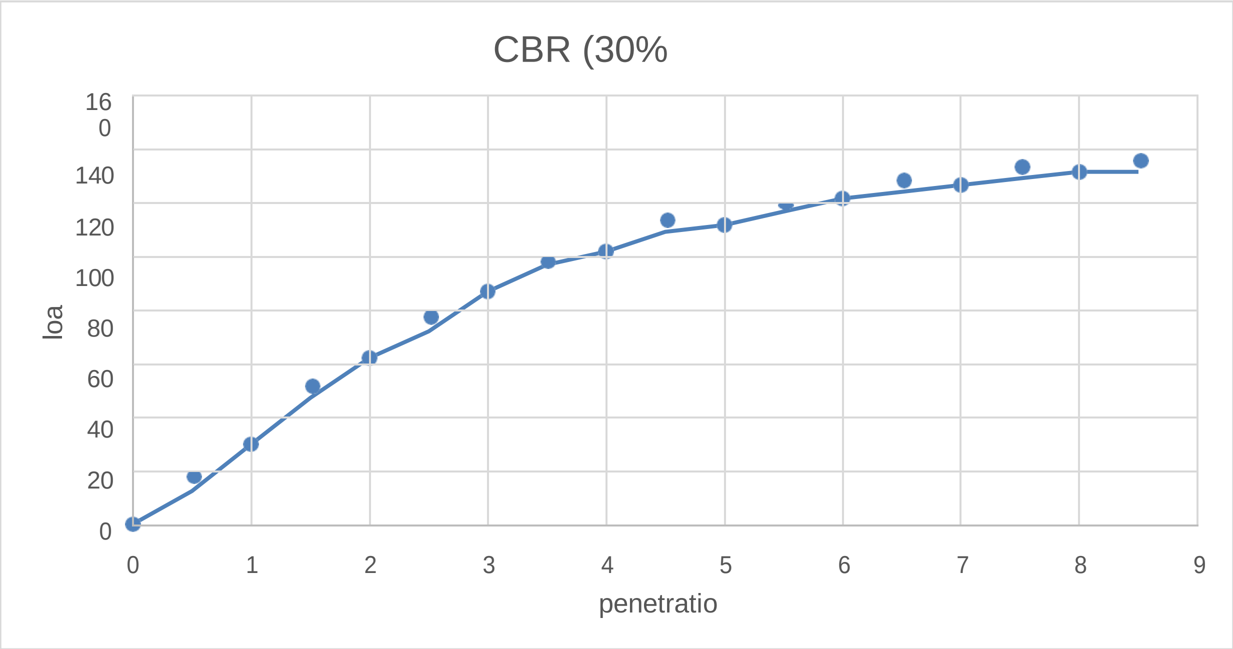
CBR FOR 20% OF GGBS

S.NO	PENETRATION	LOAD
1	0	2.47
2	0.5	19.77
3	1	39.54
4	1.5	51.89
5	2	61.78
6	2.5	71.66
7	3	81.54
8	3.5	91.43
9	4	98.84
10	4.5	103.78
11	5	108.72
12	5.5	113.67
13	6	116.14
14	6.5	118.61
15	7	121.08
16	7.5	123.55
17	8	126.02
18	8.5	126.02



CBR FOR 30% OF GGBS

s.no	penetration	load
1	0	2.47
2	0.5	14.83
3	1	32.12
4	1.5	49.42
5	2	64.25
6	2.5	74.13
7	3	88.96
8	3.5	98.84
9	4	103.78
10	4.5	111.2
11	5	113.67
12	5.5	118.61
13	6	123.55
14	6.5	126.02
15	7	128.49
16	7.5	130.96
17	8	133.43
18	8.5	133.43



RESILIENT MODULUS

DEFINATION:

Resilient modulus (MR) is considered as one of the important design parameters for any pavement material. Resilient modulus of any soil is evaluated under the application of isotropic confining pressure and repeated loading. Cyclic triaxial test is used to recreate the stress conditions that in general occur in the base and subgrade pavement layers. For the pavement design, U.S. Federal Highway Administration considers resilient modulus as the primary performance parameter. Resilient modulus defines the response of pavement material to the repeated loads. Resilient modulus is the measurement of the elastic property of soil recognizing certain nonlinear characteristics. MR is defined as the elastic modulus based on the recoverable strain under repeated loading.

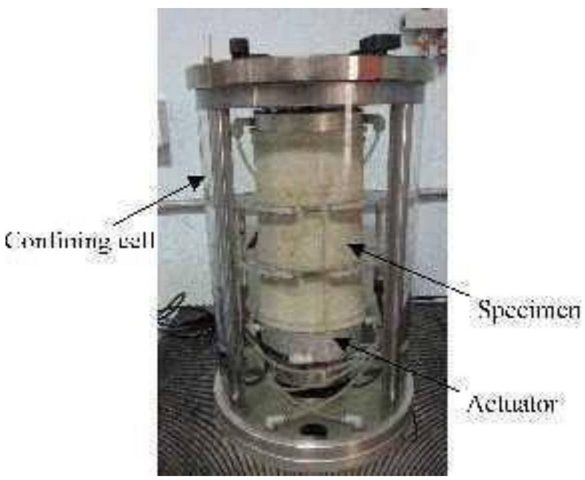
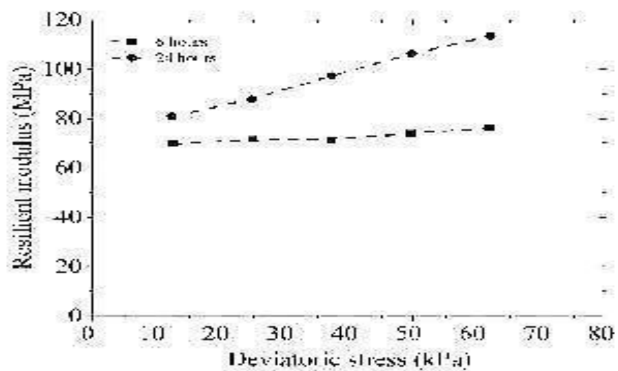


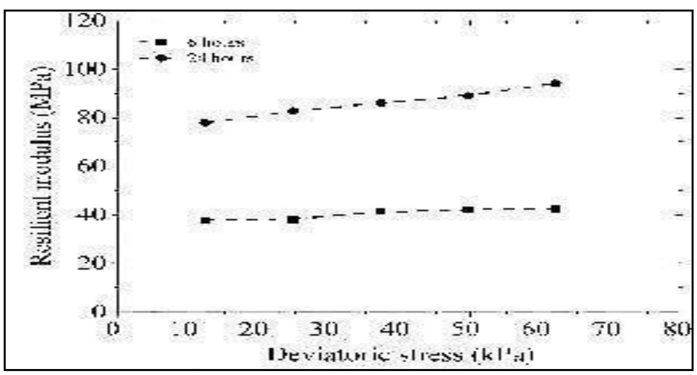
TABLE 32: Observation table of resilient modulus

CYCLES	Deviatoric stress(kPa)	(kPa)
1	12.5	41.4
2	24.9	41.4
3	37.3	41.4
4	49.6	41.4
5	61.9	41.4
6	12.2	27.6
7	24.7	27.6
8	37.2	27.6
9	49.5	27.6
10	61.7	27.6
11	12.3	13.8

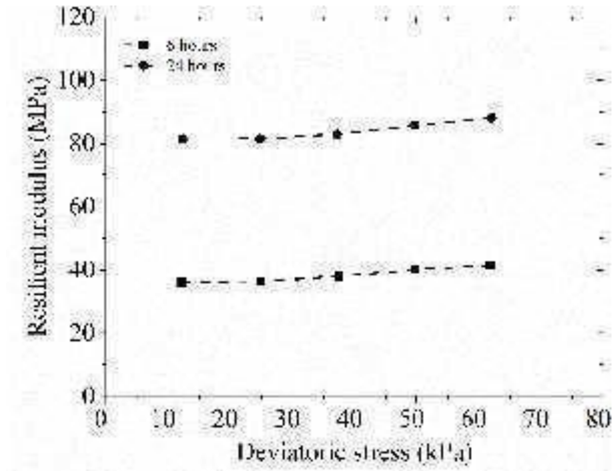
12	24.6	13.8
13	37.1	13.8



(A)



(B)

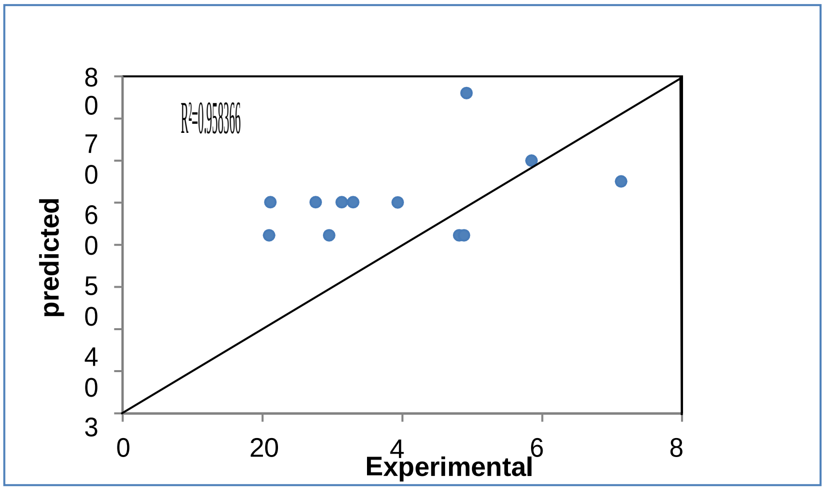


RESILIENT MODULUS OBTAINED FROM GENETIC ALGORITHM

Training Data Summary: Correlation Coefficient & R-square of the gepModel against the Target	
Correlation Coefficient:	0.978962
R-square:	0.958366

Testing Data Summary: Correlation Coefficient & R-square of the gepModel against the Target	
Correlation Coefficient:	0.959029
R-square:	0.978179

GepModel(RESILIEN MODULUS) MPA	T
150	
185	
162	
250	
220	



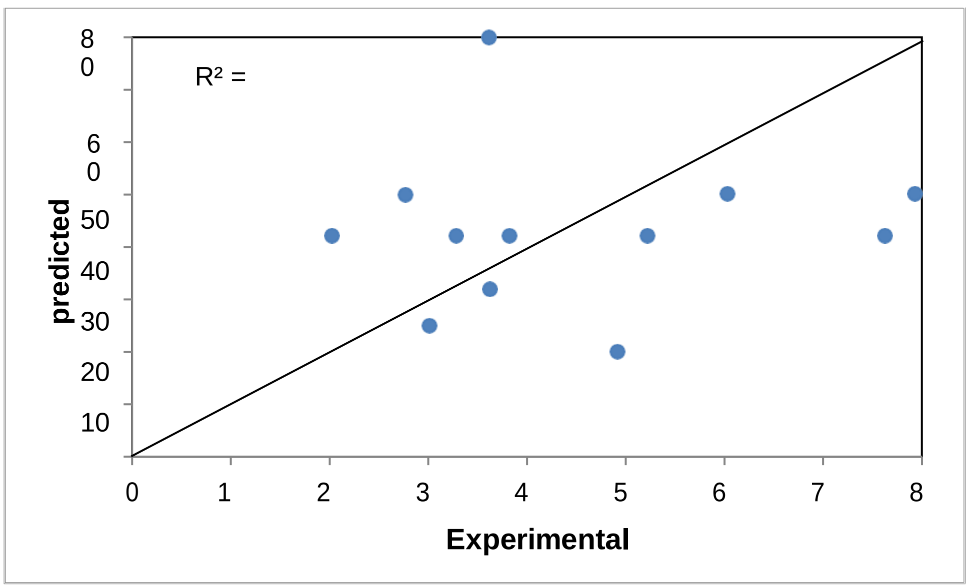
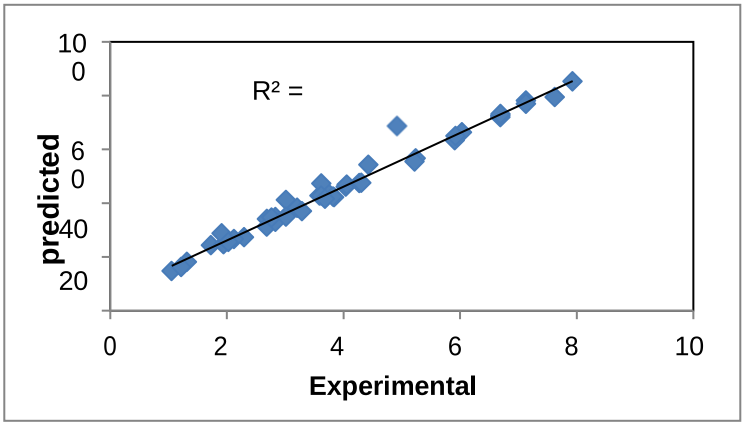


FIG : regression plot of (Predicted Mr against expreimental Mr for training and testing data)

RESILIENT MODULUS OBTAINED FROM ARTIFICIAL NEURAL NETWORK



MATLAB (RESILIENT MODULUS) MPA
180
215
250
220
196

FINAL RESULTS:

FINAL RESULTS OBTAINED FROM TESTS:

S. No	GGBS added (%)	Specific Gravity (G_s)	GGBS Swell Index value (%)	Liquid Limit (%)	Plastic Limit (%)	Maximum Dry Density (Kg/M^3)	Optimum Moisture Content (%)	California Bearing Ratio	Unconfined compressive strength (KPa)
1	**0**	**2.80**	**66.9**	**57.34**	**30.12**	**1.81**	**21**	**97.35**	**160**
2	**10**	**1.88**	**50.0**	**35.01**	**21.53**	**1.84**	**20.4**	**109.52**	**235**
3	**20**	**1.74**	**35.6**	**49.05**	**25.55**	**1.87**	**20.7**	**125.32**	**285**
4	**30**	**1.59**	**21.3**	**50.11**	**24.16**	**1.65**	**22.10**	**129.66**	**270**

FINAL RESULTS OBTAINED THROUGH GENETIC ALGORITHM and ARTIFICIAL NEURAL NETWORK:

The efficiency and strength of the genetic algorithm and neural network models were investigated using R^2 coefficients of determination. The R^2 value is greater than 0.85, implying that the predicted and experimental Mr values are in excellent accordance. The ANN, on the other hand, uses a reliable evaluation and gives an R^2 value of 0.97 for training So that we will consider the resilient modulus values obtained from the artificial neural network as shown in Tabular form:

S.No	GGBSadded (%)	Resilient modulus test (MPa)
1	0	180
2	10	215
3	20	250
4	30	220

CHAPTER -7

CONCLUSION AND FUTURE ENHANCEMENT

CONCLUSION:

The main objective of the research work was to study the effect of adding GGBS on the engineering properties of a sample of test soil similar toa clay soil and to find resilient modulus to that stabilized soil using genetic algorithm and artificial neural network. Extensive experimental work was carried out on the engineering properties of the test soil. Major changes were observed in some of the engineering properties of the test soil on the addition of GGBS and lime. Four analytical techniques were used to identify the nature of the reaction products and to understand how the engineering properties of the test soil were changed after the addition of GGBS. The analytical tests used were found to be very useful lin helping to develop an understanding of how the GGBS stabilized the test soil and also to identify the reaction products. From the study it can be concluded that the addition of GGBS alone to the test and pure clay test soils slightly decreased the liquid limit while the plastic limit increased slightly, thus significantly decreasing the plasticity index. Also the addition of GGBS has slightly increased the dry density and optimum moisture content.

- Adding GGBS has noticeably increased the unconfined compressive strength of thetest soil up to 20% and decreases after that.
- On considering all the values from the tests, Specific gravity to the UCS after optimizing with the help of Genetic Algorithm, it can be said that 20% GGBS, is the favorable amount to be used to stabilize the sub grade.
- The genetic algorithm model uses a reliable evaluation and provides a $\mathbf{R^2}$ value of 0.93 for training, whereas the ANN model provides 0.97, which is more accurate. Hence ANN can be preferred to Genetic algorithm while predicting Mr values.

FUTURE ENHANCEMENT:

- The project's future potential is huge. In the future, the project might be deployed across the Black Cotton soil zones in India. Because it is quite versatile in terms of growth, performance.
- The project may be upgraded in the near future as and when the need arises as it is flexible.
- As there will be no mere odds of GGBS extinction, the usage of GGBS can last for longer years.
- Once the value of Mr is estimated for certain sample of stabilized BCS sub grade the same value can be taken as reference for similar samples in the future.

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A Major Project Report

On

EXPERIMENTAL ANALYSIS ON SELF COMPACTING CONCRETE BY USING NANO-SILICA GEL

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

by

Mr. MD. Shahed - (17K81A0141)

Mr. G. Sandesh - (18K85A0112)

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DEPARTMENT OF CIVIL ENGINEERING

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JUNE 2021

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BONAFIDE CERTIFICATE

This is to certify that the project entitled Experimental Analysis on Self Compacting Concrete Using Nano Silica Gel: A Concrete Technology project is being submitted by **1. Mr. MD. Shahed (17K81A0141) 2. Mr. G. Sandesh (18K85A0112) 3. Mrs.B.Anusha (18K85A0114) 4. Mr.A.Dinesh (17K81A0106)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN** Civil Engineering is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

Signature of Guide

Mr.V. RAJESH
Assistant Professor
Department of Civil Engineering

Signature of HOD

Prof. SANDHYA KIRAN J.K.
Head of the Department
Department of Civil Engineering

Internal Examiner

External Examiner

Place:

Date:

DECLARATION

We, the student of **Bachelor of Technology** in Department of ‘Civil Engineering’, session: 2017 – 2021, St. Martin’s Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled Experimental Analysis on Self Compacting Concrete Using Nano Silica Gel, A Concrete Technology Project is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

Mr. MD. Shahed (17K81A0141)
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Mrs. B. Anusha (18K85A0114)
Mr. . A.Dinesh (17K81A0106)

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4. Appala Dinesh Kumar

ABSTRACT

In the present era, concrete is mixed, transported, placed, compacted, and finished. In spite of all the activities done through checking with high standard quality with tight schedule of work, there occurs marginal errors, such as honey combing, voids in concrete, and could not achieve desired values. So the traditional concerte is replaced with the new technique called SCC, that is Self Compaction Concrete. The workability properties of SCC show significant increase in strength and workability properties. Self Compacting Concrete has segregation resistance evaluated using workability tests, such as slump flow, V funnel, and L-Box tests.

The present work deals with addition of nano-silica to concrete as partial replacement to cement in dosages of 1%, 1.5%, and 2% by weight of cement. Based on early research, M25 grade concrete has been chosen for this work. The mix design was prepared using IS: 10262-2009 guidelines for concrete mix design proportioning. In the present work, 24 numbers of cube moulds and 12 numbers of cylinder moulds were casted with addition of nano-silica with different proportions, which are tested for compressive strength and split tensile strength. Addition of nano-silica to normal cement concrete show increase in compressive strength and decrease in splitting tensile strength.

The compressive strength of cement concrete can be increased considerably by the addition of nano-silica. Based on the experimental results, use of nano-Silica as partial replacement of cement in small quantities is advantageous on the performance of concrete. Nano-Silica added in small quantities can improve the compressive strength.

Keywords: Self Compacting Concrete, Flowability, Passing Ability, Nano Silica, Super Plasticizer

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LIST OF ABBREVIATIONS

<SCC	Self Compacting Concrete
<NS	Nano silica
<OPC	Ordinary Portland Cement
<NT	Nano-technology
<NC	Nominal Concrete

Chapter - 1

Introduction

1.1 General

Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete.

The elimination of vibrating equipment improves the environment on and near construction and precast sites where concrete is being placed, reducing the exposure of workers to noise and vibration.

SCC is still not widely used in India in spite of its many advantages including reduction in labour and fast track construction etc. This is because of lack of sufficient data and information on SCC made of materials available in the different parts of the country and hence insufficient confidence of engineers in producing this material. India has abundant supply of fly ash, with its sources well distributed across the country. SCC generally possesses a high powder content which keeps the concrete cohesive with high flow ability. This high powder content is required to maintain a sufficient yield value of the fresh mix and cement cannot be the only powder material in SCC. For achieving economy, a substantial part of this powder could also contain fly ash. SCC can accommodate more than 200 kg/m3 of fly ash which is regarded as a high-volume addition. Hence it is considered worthwhile to investigate the influence of fly ash in SCC.

In 2002 EFNARC published their “Specification & Guidelines for Self-Compacting concrete” which, at that time, provided state of the art information for producers and users. Since then, much additional technical information on SCC has been published but European design, product and construction standards do not yet specifically refer to SCC and for site applications this has limited its wider acceptance, especially by specifiers and purchasers. In 1994 five European organisations BIBM, CEMBUREAU, ERMCO, EFCA and EFNARC, all dedicated to the promotion of advanced materials and systems for the supply and use of concrete, created a "European Project Group" to review current best practice and produce a new document covering all aspects of SCC.

1.2 Concrete and Sustainability

Concrete is probably unique in construction, it is the only material exclusive to the business and therefore is the beneficiary of a fair proportion of the research and development money from industry. Concrete is a composite construction material composed primarily of aggregate, cement and water, which is a nanostructured, complex, multi-phase material that ages overtime. It is basically an idea for concern for the wellbeing of planet Earth with continued growth and human development. The current construction practices are based on the consumption of enormous quantities of building materials and water, resulting in the scarcity of these resources after a long term.

The sustainable development of the cement concrete would save not only the natural resources and energy but also protect the environment with the reduction of waste material. The mortar properties in fresh state such as workability are governed by the particle size distribution and the properties in hardened state, such as strength and durability, are affected by the mix grading. Rheological properties of a fresh cement paste play an important role in determining the workability of concrete.

The water requirement for flow, hydration behavior and properties of the hardened state largely depends upon the degree of dispersion of cement in water. Factors such as water content, early hydration, water reducing admixtures and mineral admixtures like Nano-silica determine the degree of flocculation in a cement paste.

The development of Self Compacting Concrete is based on the following well known relationships of concrete technology. For high strength, water cement ratio should be low. The strength w/c ratio rule holds good for concrete strength. Low water cement ratio is also required for low permeability of concrete, which is vital for high durability. Impermeability is also aided by pore filling effects of fine pozzolanic additions.

The relationship between coefficient of permeability of cement paste and water cement ratio is such that the permeability increases asymptotically for water cement ratio above 0.45 or according to the mix design.

Thus, low water cement ratio ensures high strength and low permeability, or high durability. Low water cement ratio will require high cement content to ensure the amount of water and cement paste are adequate for the workability of concrete. However, too high a cement content will cause high heat of hydration and increase cracking tendency. The use of Ns when added in different percentages will give the difference between the compressive strength of the concretes.

1.3 Self-constructing concrete definition

The British Standard describes “SCC is the concrete that is capable to flow and compact under its own weight, fill the formwork with its reinforcement, ducts, box outs etc., whilst managing homogeneity”.

1.4 Requirements for SCC

SCC exhibits following properties in its plastic state.

Filling Ability: It is the ability of SCC to flow into and fill completely all spaces in the formwork and encapsulate reinforcement while maintaining homogeneity.

Passing Ability: It is the ability of concrete mix to pass through obstacles like narrow sections in form work, closely spaced reinforcement bars without getting blocked by interlocking of aggregate particles.

Resistance to segregation: Segregation resistance of self-compacting concrete is its capability to retain homogeneity in the distribution of ingredient in fresh state during both static and moving condition i.e., during mixing, transportation and placing. It is dependent on viscosity of mix in fresh state

1.5 History and development of SCC

In the mid-1980s, exploration begun into underwater induction technology within the UK, North America and Japan led to the improvement of concrete mixes with a high degree of washout resistance. However, the creation of durable structures from such mixes enforced adequate compaction by skilled workers. At the same time in Japan, a gradual reduction in the number of skilled workers in the construction industry was leading to a reduction in the quality of construction work, with subsequent knock-on effects on concrete durability (Okamura et al., 1998). One quick fix to overcome the durability issues in concrete structures independently of the quality of construction work was to use self-compacting concrete (SCC) (Okamura and Ouchi, 2003).

Its use was early proposed by Okamura (1986) who also conducted a fundamental study on the workability of SCC. The first prototype SCC was concluded in 1988 at Tokyo University, adopting constituent materials promptly used in conventional vibrated concrete (Ozawa et al., 1989). The main reasons for the employment of SCC were to shorten the construction time, to avoid vibrating the confined zones which are a bit crucial to reach and to erase noise caused by vibration (Okamura and Ouchi, 2003).

In the far two decades, self-consolidating concrete has been advanced further, applying different materials such as pulverized-fuel ash (PFA), ground granulated blast furnace slag (GGBS) and condensed silica fume (CSF). SCC has achieved wide interest especially for structures with very complicated shapes, crucial casting process and congested reinforcement. In spite of this, the overall production is still almost small compared to conventional concrete, the global gap that has been ever present in the market for such a concrete argue that in the future there is possible to be an even greater demand for all samples of SCC.

1.6 Nano Technology in Concrete

Nanotechnology is rapidly becoming the Industrial Revolution of 21st century. It will affect almost every aspect of life. In comparison to other technologies, nanotechnology is much less well defined and well-structured. It is known that ‘Nano’ is a Greek word and means ‘dwarf’. It is a common word for everything which is smaller than 1Micron or 1 Million of a millimeter (10^{-9}) 1 Micron is 1000 Nanometer. The main approaches of applications of Nano technology in concrete. Nano Silica is mainly added to provide strength to the concrete. Until today, concrete has primarily been seen as a structural material. Nano technology is helping to make it smart functional material.

Nano Silica has been added in order to increase the strength, low permeability and reduces shrinkage. Nano-concrete is defined as a concrete made with Portland cement particles that are less than five hundred Nano-meters as the cementing agent. Currently cement particle sizes range from a few Nano-meters to a maximum of about one hundred micro meters. In the case of micro- cement the average particle size is reduced to 5 micro meters. An order of magnitude reduction is needed to produce Nano-cement. Certain unique properties of Portland cement such as: room temperature processing, low shrinkage, temperature resistance up to 600°C, compatibility with a number of fiber types including carbon fibers, reaction capability with currently available Nano-materials such as Nano-silica and nontoxic characteristics can be effectively used to create unique products. It can also be molded to complex shapes; heat cured and coated with other Nano-materials. Conventional analytical methods are unable to provide an accurate model for the rate of cement's reaction with water as a function of temperature, water/cement ratio, and grain size because the reactions occur in the Nano-scale pores of the cement.

1.7 Problem Statement

The majority of concrete cast required compaction to ensure that the development of adequate strength and durability. Generally, the purpose of compaction of concrete is to achieve the highest possible density of the concrete. Dense microstructure of concrete will results in low permeability, high strength, high resistance to chloride and sulfate attacks, low carbonation, and improved durability. Insufficient compaction will lead to the formation of voids, which results in negative impact on the physical and mechanical properties of concrete. Inclusion of voids will also influence the protection of the embedded steel reinforcement. Compaction of concrete is done manually by using vibrators in construction site. However, compaction will be difficult to be carried out at conditions as follows:

1.7.1 Large concrete casting areas.

1.7.2 Presence of congested reinforcement

1.7.3 Inaccessible areas and spaces, etc.

The concrete floor slabs in factories and commercial buildings are of large areas and often subjected to continuous static and dynamic loadings. Self-weight is considered as static loading, while vibrations and impact loadings can be categorized as dynamic loadings. The loadings are usually induced by storages, containers, machineries, and heavy vehicles that present in the factories and commercial buildings. Hence, the concrete slabs have to exhibit good fatigue and impact strength to prevent failure in fatigue.

SCC will be suitable in the construction of industrial concrete floor slabs due to its Advanced features. The elimination of compaction enables the casting of large area of concrete slab to be completed in shorter time with reduced cost and manpower required. Besides, when fibers reinforced with SCC will improve the tensile properties, flexural strength, impact strength, toughness, and post- cracking behaviour of concrete. Therefore, SCC is an ideal solution for the construction of concrete slabs to maintain the serviceability of slab throughout their service lifespan. Figure show the casting of a large area of concrete slab with congested reinforcement in commercial centre in Italy.

1.8 Objective

The objective of the present work is to find the influence of the application of Nano silica partially replacing cement. Nano silica is added in different dosages to study the variation in the compressive strength of the concrete. 2%, 2.5%, 3% of Nano silica are adopted as replacement by weight according to the mix design of M20 grade. Cube and cylinder moulds are casted for the purpose of testing. Specific objectives are:

- To find the workability aspects of M20 grade concrete using Nano silica.
- To know the influence of Nano silica on the strength characters of self-compacting concrete.
- To decrease the permeability and to reduce the shrinkage in self compacting concrete.

1.9 Scope

The scope of present work is to decrease the permeability, increase the density as well as increase the compressive strength of the self- compacting concrete by adding Nano silica. Alterations can be done to achieve more strength and durability. Effect of Nano silica on the compressive strength of the self-compacting concrete are studied and further modifications can be done. Mix design of M20 grade is chosen to increase its strength and reduce shrinkage. Compressive strength of ordinary self compacting concrete is compared with SCC of Nano silica and conclusions are made.

Chapter - 2

Literature Review

2.1 Self-Compacting Concrete

M.C. Nataraja, Anvit Gadkar and Giridhar Jogin (2018) Developed a simple procedure to produce self-compacting concrete based on the requirement of strength by slight modification to IS 10262:2009. Considered the limits prescribed by EFNARC and investigated on 25 mix proportions to obtain the relationship between compressive strength and water cementitious ratio of SCC. For this method, compressive strength ranges from 20MPa to 60MPa were considered by using poly corboxilic ether based high water reducing agent. It was observed that w/c from 0.47 to 0.37 was sufficient to obtain the strength values between 25 to 60MPa. Fresh properties and strength results occurred by this procedure were in good agreement.

Athiyamaan. V & G. Mohan Ganesh (2018) Studied about SCC mix design using nan-su method and trail mixes were carried out by using Design of Experiments method (DOE). In trail mixes central composite design was farmed with variables; cement, superplasticizer, w/c, Fine aggregate and coarse aggregate. 33 trail runs were investigated and M16 numbered mix gave optimum results. And also noted that by decreasing coarse aggregate from 750Kg/m3 to 710 kg/m3 increase the rheological properties but signs against the strength, increasing of fine aggregate will results of maximum packing factor.

M. Sri Rama Chand, P. Rathish Kumar, P.S.N.R. Giri, G. Rajesh Kumar (2018) investigated the durability, strength and microstructures of SCC by addition of self-curing chemicals. Self-curing compounds are used to overcome the improper curing and compacting issues. Hydrophilic, Super absorbent polymers and Hydrophobic chemicals can use as self-curing compounds. Hydrophilic and Hydrophobic efficiencies were tested on M70 and M50 grade concretes. Polyethylene Glycol 4000, Liquid paraffin wax (LPW) with 0%, 0.1%, 0.5% and 1.0% was used in this study, which includes water retention capacity, compressive strength, RCPT, SEM, XRD, Sorptivity and Porosity tests. Results shows that LPW at 1% doesn't influence the strength of concrete and by using self-curing compounds the strength obtained is 90% of the water curing specimen. XRD shows they will not increase the effect of freeze thaw effect and SEM confirmed that microstructure is dense in self-curing self-compacting concrete.

M. Sri Rama Chand, P. Swamy Naga Ratna, K. L. Radhika, P. Rathish Kumar and C. Yedukondalu (2017) Investigated to optimize the proportions on particle packing model to obtain the requirements of self-compacting concrete. Three models firstly Modified Toufar method, secondly J.D. Dewar method and last one Compressible Packing Method (CPM) were studied on M20, M40 and M60 grade concretes. It was discovered that particle packing methods MTM, JDDM and CPM with IS 383 grading shows that the percentage passing value of CPM coincides with upper limits of IS grading. MTM and JDDM are coarser content and not suitable for SCC, whereas CPM based optimization is suitable for designing SCC mixes.

Shaik Khaja Sameer, B. Jagadish Chakravarti and V. Ramesh (2017) Designed mix proportion using compressible packing model for M20, M40 and M60 self-compacting concrete grades and suggested a modification zone gradations similar to IS 383 for SCC to achieve optimum mix. Sample mix design was presented to get an idea about the mix calculations for SCC. It was observed that compressive strength increases from 7 days to 28 days at a ratio of 0.71, 0.7 and 0.68 for M20, M40 and M60 grade concretes respectively. The relation between compressive strength and flexural strength, split tensile strength were developed.

B. Nagendra Kumar (2017) High strength self-compacting concrete was developed by replacing natural river sand with quartz sand at a range of 20%, 40%, 60%, 80% and 100%. Specimens were casted in standard sizes and tested at periods of 7 days, 28 days, 90 days and 180 days. For every percentage of replacement, mix satisfies the fresh properties but at 100% replacement mix attains compressive strength of 100MPa for 28 days. Result shows that not only compressive strength but also split tensile and flexural strength increased with increase of quartz sand percentage.

S. Girish (2017) Studied about the importance of volume of paste and powder on hardened properties and of self-compacting concrete(SCC) with perpetual water content, ranging from 175 lit/m3 to 210 lit/m3. Paste contents (0.38, 0.41 and 0.43) chosen to test with cement from 300 kg/m3 to 450 kg/m3. Results show that compressive strength of SCC increase with increase of volume paste for same water cement ratio and water content. 30% increase was observed at 190 lit/m3 and 35% at 175 lit/m3 and maximum compressive strength is noted at volume paste 0.14. By this, increase in strength as the paste is increased but beyond the particular amount strength values decreases due to decrease of coarse aggregate, load transfer within the body gets affected and strength may reduce.

T. H. Patel, J. M. Srihaila, Prahalada. V (2016) explored the durability properties of High Performance Self-Compacting Concrete by using sodium chloride (NaCl), Magnesium Sulphate (MgSO4). Cement was substituted with Fly ash at 10%, 20%, 30% 40%, 50% and GGBS at 10%, 20%, 30%, 40%, 50% separately and experiments conducted and results were compared. Cubes casted at standard size and cured in water for 28 & 56 days but for durability study after 28 days water curing, cubes were cured in 10% concentration of NaCl & MgSO4 solution for 28 and 56 days. Cement with 10% fly ash and cement with 20% GGBS gave maximum compressive strengths. It was observed that NaCl effects more on self-compacting concrete(SCC) without fly ash and also without GGBS, by adding fly ash or GGBS acid resistance could be increased but, sulphate resistance is higher than chloride resistance.

R. Vasusmitha and Dr. P. Srinivasa Rao (2013) developed M80 grade concrete by using micro silica, quartz powder in addition to the cement, chemical admixtures are used. Water cement ratio maintained at 0.215 and as part of hardened properties; split tensile strength, compressive strength, flexural strengths were calculated. For durability characteristics tests like rapid chloride penetration test (RCPT), acid resistance by using HCl, H2SO4, Na2SO4 were conducted on designed grade of concrete. Acid attack tests are carried out based on weight loss technique, from the results it was perceived that the specimens are more resistant to 5% Na2SO4 than 5% H2SO4 and 5% HCl. Chloride ion penetrability getting decreased by the increasing of age and obtained values are at a range of very low.

N. Venkat Rao, M. Rajasekhar, Mohd Mujeeuddiahmed (2013) studied about durability properties of high strength self-compacting concrete by maintaining water cement ratio at 0.24 and all fresh properties of SCC was examined as per the guidelines given by EFNARC. To study durability properties, acid attack and sulphate attack was considered, for this study 8% HCl, 8% H2SO4, 8% Na2SO4 were used and weight loss technique was used to determine the durability properties. It showed that the designed grade was more resistant against the sodium sulphate than hydrochloric acid and sulphuric acid. Acid attack resistance also determined by conducting compressive strength test after immersing specimens in 5% HCl, 5% H2SO4, 5% Na2SO4 in alternative days and it was observed that compressive strength decreased at 16.31%, 47.07% and 19.8% while using HCl, H2SO4 and Na2SO4 respectively

2.2 Workability test on SCC

Daniel C, Joel Shelton J, Vincent Sam Jebadurai S, Arun Raj E (2016) Studied on high strength self-compacting concrete by using copper slag in place of river sand at an interval of 10% from 0% to 100% with water cement ratio at 0.4 and super plasticizer was maintained at 0.6%. Wet concrete properties like passing ability, flow ability and filling ability was tested by using L-box, U-box, V-funnel, slump flow test. Mechanical properties like flexural strength, split tensile strength, compressive strength were also known at 7 days and 28 days. By the increase of copper slag, workability improves and at 40% replacement shows the optimum values in both fresh and hardened properties.

M. Fadee, R. Mirhosseini, R. Tabatabaei & M.J. Fadaee (2015) Investigated about usage of copper slag as cementitious material in self-compacting concrete(SCC); physical and chemical analyses were performed. Cement was replaced with copper slag at 20%, 25%, 30%, 35% and 40%, and tests were conducted to know the variation of fresh and mechanical properties with and without copper slag. V-funnel and J-Ring tests on wet concrete, compressive strength at 7, 14, 28 and 42 days age on hardened concrete were conducted. In the results, it shows that copper with 40% gives better passing ability and filling ability than without copper slag. Copper slag with 20% gives 85 percentage of compressive strength without slag, by this it was recommended to use at 20%.

Karthik, Dr. G. Baskar (2015) Mainly studied about durability of self-compaction concrete with copper slag used as fine aggregate at levels of 20%, 40%, 60% and 80%. By conducting fresh concrete tests like T50, V-funnel, slump flow, L-box, J-ring to examined the fresh properties. Durability properties were studied by using weight loss technique. To conduct durability tests like acid resistance, sulphate resistance and corrosion tests, various chemicals like sulphuric acid, ferrous sulphate and sodium chloride solutions were used. From the results it was concluded that at 60% copper slag in concrete as fine aggregate gave the more durable concrete

Iman Afshoon and Yasser Sharifi (2014) Investigated about influence of Ground Copper Slag as a binding material on the fresh properties of self-compacting concrete(SCC). In this investigation water – powder ratio was maintained at 0.51 and cement replaced at a levels of 0%, 5%, 10%, 15%, 20%, 25% and 30% with ground copper slag. Tests on wet concrete like slump flow, viscosity index, J – ring, V-funnel, L-box, air content and setting times were conducted. Due to usage of ground copper slag as cementing material slump flow increases, viscosity decreases, passing ability decreases, air content also decreased but setting increased.

2.3 Admixtures in SCC

C. Sashidhar, B. Radhamma, J. Gurujawahar, C. Yedukondalu (2018) Studied about self-compacting geopolymer concrete with 50:50 proportions using class F fly ash and GGBS with artificial sand as fine aggregate. EFNARC guidelines are considered for trail mixes to get optimum proportions and 8M, 10M, 12M NaoH issued in the experiment. Various fresh properties like segregation resistance, passing ability and filling ability were examined by using test methods; L-box, T500 slump flow, v-funnel and slump flow. It was observed that by increasing the NaOH morality the fresh properties are decreased and no adverse effect has been marked when self-compacting geopolymer concrete mixes prepared with artificial sand.

K Ganesh Babu and B Chandrasekhar (2018) worked on high performance self-compacting concrete with fly ash of 25%, 35%, 50% and 70% as a cementitious content. Various water powder ratios were used ranging from 0.25-0.72. It was observed that fly ash based SCC ranging from 25-110 Mpa could be produced by replacing 70-25% of cement, charge passing through the specimen is also decreased by increasing the fly ash content. Durability tests like acid attack, corrosion tests shows better results by increasing fly ash percentage.

H. Y. Leung, J. Kim, A. Nadeem, Jayaprakash J and M. P. Anwar (2016) Studied about water absorption of self-compacting concrete with silica fume and fly ash by conducting sorptivity test. For this test two separate mix series were casted namely F-series and FS-series. In F-series ordinary Portland cement was replaced with 0%, 12.9%, 20%, 30%, 40% and 50% but in FS-series Fly ash fixed at 25% and cement replaced at 0%, 5%, 10% and 15% with silica fume. Water to powder ratio maintained at 0.38 and water content at 235.6kg/m3. From the results it can conclude that OPC with silica fume and fly ash reduces sorptivity. Combination of flyash and silica fume decreases sorptivity than only using fly ash and also witnessed that there is no relation between strength and sorptivity. Behaviour of compressive strength and surface absorption depends on proportion of mineral admixture and other environmental factors.

Gritsada Suaiam, Natt Mukal (2015) Studied about self-consolidating concrete which prepared with recycled alumina and fly ash waste as mineral admixtures. Fly ash replaced at fixed 20% and recycled alumina waste replaced at 0%, 25%, 50%, 75% and 100%. Fresh and mechanical properties were examined by using, J-ring, V-funnel, slump flow, compression strength; quality of concrete by using ultra pulse velocity test. In the results it was observed that alumina waste up to 75% as optimum and satisfied all the conditions given by the EFNARC and best results shown than the conventional concrete, achieved compressive strength up to 56MPa at 28 days age.

T. Adhavanathan, V. Vinoth (2015) M30 grade concrete was used to investigate the consumption of copper slag as fine aggregate and cement replaced with fly ash moderately. In this study copper slag used at level of 0%, 10%, 20%, 30% up to 100%. Fresh concrete properties and hardened concrete properties are studied at 7,14,28 days and by results it was concluded that 30% of copper slag obtains the optimum results and concrete replaced by 40% of fly ash increases the compressive strength, the maximum split tensile strength obtained at 40% copper slag and maximum flexural strength at 60% copper slag.

K. S. Jhansirani and A. Jagannathan (2015) Durability was studied on self-compacting concrete by considering acid resistance, sulphate resistance, alkaline, sorptivity, chloride penetration. In this study fly ash and silica fume was used as cementitious material by replacing fly ash at 10%, 20%, 30% and silica fume at 5%, 10%, 15%, and 20%. Not only observed the results by using fly ash and silica fume separately but also by combining them at different levels. From the results it was identified that silica fume shows more resistance against the acid, alkaline, chlorine penetration then the fly ash and also when combine both. It also observed that by increasing of mineral admixtures in self compacting concrete both fresh and durability properties are increased.

2.4 Concrete with Nano-silica

G.Quercia et.al(2013) A new Nano-silica (Ns) can be produced in high quantities and for low prices that allows for a mass application in concrete. It may replace cement in the mix, which is the most costly and environmentally unfriendly component in concrete. The use of Ns makes concrete financially more attractive and reduces the CO2 footprint of the produced concrete products. The nS will also increase the product properties of the concrete: the workability and the properties in hardened state, enabling the development of high performance concretes for extreme constructions. That means that a concrete with better performance, lower costs and an improved ecological footprint can be designed.

Yuvaraj Shanmugasundaram et.al(2012) Nano concrete could control the carbon dioxide emission from the earth which is shown by using fly ash concrete products instead of cement concrete. Thus the Nano particles which is in the form of silica can easily react with cement particles which are normally in Nano scale initiate the CSH reaction and hence its tend to accelerate the compressive strength of concrete. Nano-silica consumes calcium hydroxide crystals, reduces the size of the crystals at the interface zone and transmute the calciumhydroxide feeble crystals to the C-S-H crystals, and improves the interface zone and cement paste structures.

M. Nili et.al(2010) The results show that increasing in Nano silica content 1.5% to 4.5% by weight, leads to an increase of compressive strength at all stages. The results also indicate thatthe specimens which contain both nano and micro silica, due to the high pozzolanic activity, have higher compressive strength than reference ones. However, large quantities of nano silica in the mixtures, due to agglomerate effect, don't lead to increase compressive strength. As it is shown the highest compressive strength at the age of 28 days is corresponding to SF6, NS1.5 mixture.

Loland (1981) Nano-silica is typically a highly effective pozzolanic material. It normally consists of very fine vitreous particles approximately 1000 times smaller than the average cement particles. It has proven to be an excellent admixture for cement to improve strength and durability and decrease permeability (Loland, 1981; Aitcin et al., 1981). NS reduces the setting time and increases the strength (compressive, tensile) of resulting cement in relation with other silica components that were tested (Roddy et al., 2008). Nano-silica is obtained by direct synthesis of silica sol or by crystallization of nano-sized crystals of quartz.

2.5 SEM analysis

Divya chopra, rafat siddique and kunal (2015) strength, permeability and microstructure of self-compacting concrete containing rice husk", biosystems engineering

Salim barbhuiya , pengloy chow and shazimmemon(2015) microstructure , hydration and nanomechanical properties of concrete containing metakaolin", construction and building materials.

Yogesh aggarwal and rafat siddique (2014) microstructure and properties of concrete using bottom ash and waste foundry sand as partial replacement of fine aggregates" construction and building materials.

Vitoldas vaitkevicius, evaldasšerelis and harald hilbig(2014) the effect of glass powder on the microstructure of ultra high performance concrete", construction and building materis

Mahmoud khashaa mohammed, andrew robert dawson and nicholas howard thom,(2014) production, microstructure and hydration of sustainable self-compacting concrete with different

types of fillers”, construction and building materials.

R. Roychand, s. De silva, d. Law, and s. Setung(2016) micro and nano engineered high volume ultrafine fly ash cement composite with and without additives” international journal of concrete structures and materials, vol.10, no.1, pp.113–124.

Jumate .elena and manea daniela lucia (2012)application of x ray diffraction (xrd) and scanning electron microscopy (sem) method to the portland cement hydration processes” journal of applied engineering science volume 2(15),issue 1

Hui li, hui-gang xiao, jie yuan and jimping ou(2004) microstructure of cement motar with nano-particles” ’composite part b.

P. Kumar mehta and paulo.j.m. Monterio(2006) concrete microstructure, properties and materials”3rd edition.

Chapter-3

Methodology

3.1 General

The present study deals with the process of preparing of self-constricting concrete and its working. Various tests are conducted on the workability of the self-constricting concrete. The grade of concrete used is M20 which was designed in accordance with IS: 10262-2009. We have chosen mix design of M20 grade, in order to find the properties and working of self-constricting concrete.

Over the last decade, extensive research has been devoted to achieve self-compactability. Three different types of mixes can be distinguished: "Powder- type" by increasing the powder content, "VMA-type" using viscosity modifying admixture (VMA) and "Combined- type" by increasing powder content and using a viscosity agent in consideration of structural conditions, constructional conditions, available material, restrictions in concrete production plant, etc.

a) Powder-Type SCC

Okamura and Ozawa proposed a simple mix proportioning system for SC mix. Their main ideas were to fix the coarse aggregate content at 50% of solid volume and the fine aggregate content at 40% of mortar volume. Depending on the properties of mortar, the water to powder ratio is in the range of 0.9-1. This ratio should be carefully selected due to the high sensitivity of SCC to it. The self-compactability is achieved by adjusting the super-plasticizer dosage and the final water to powder ratio. This independent consideration of gravel and sand, results in a relatively high content of paste. The Japanese method has been adopted and used in many European countries as a starting point for the development of SCC. Su and Miao (2003) then developed an alternative method, henceforth referred to as 'the Chinese method' which starts with packing all coarse and fine aggregates, and then filling of the aggregate voids with paste. This easier method can result in less paste and hence saving the most expensive constituents, namely cement and filler. With this method, concrete with normal strength is obtained, while in Japanese method a higher strength than actually required can be attained.

b) VMA-Type SCC

By adding a high dosage of VMA to the mix of SCC, plastic viscosity can be controlled and increased without adding extra powder. To achieve flow-ability using this method a higher amount of super-plasticizer or higher water-powder ratio is required compared with the powder-type method.

c) Combined-Type SCC

This charter of mix was advanced to improve the robustness of powder-type SCC by adding a slight amount of VMA. In such mixes, the VMA content is less than that in the VMA-type SCC and the powder content and water to powder ratio are less than those in the powder-type SCC. The viscosity is provided by the VMA along with the powder. This type of SCC was reported to have high filling ability, high segregation resistance and improved robustness.

3.2 Materials used

3.2.1 Cement

In the present investigation Birla Shakti, Ordinary Portland Cement (PPC) of 53 Grade confirming to IS: 12269:1999 was used. The physical properties of cement as per IS: 12269:1999 when tested at the concrete lab at St. Martin's Engineering College are shown below.

Cement starts to set when mixed with water which causes a series of hydration chemical reactions. The constituents slowly hydrate and the mineral hydrates solidify; the interlocking of the hydrates gives cement its strength. Contrary to popular perceptions, hydraulic cements do not set by drying out, proper curing requires maintaining the appropriate moisture content during the curing process. If hydraulic cements dry out during curing, the resulting product can be significantly weakened.

Portland cement is by far the most common type of cement in general use around the world. This cement is made by heating limestone (calcium carbonate) with other materials (such as clay) to 1450 °C in a kiln, in a process known as calcination, whereby a molecule of carbon dioxide is liberated from the calcium carbonate to form calcium oxide, or quicklime, which then chemically combines with the other materials that have been included in the mix to form calcium silicates and other cementitious compounds.

The resulting hard substance, called 'clinker', is then ground with a small amount of gypsum into a powder to make 'ordinary Portland cement', the most commonly used type of cement (often referred to as OPC). Portland cement is a basic ingredient of concrete, mortar and most non- specialty grout. The most common use for Portland cement is in the production of concrete. Concrete is a composite material consisting of aggregate (gravel and sand), cement, and water.

As a construction material, concrete can be cast in almost any shape desired, and once hardened, can become a structural (load bearing) element. Portland cement may be grey or white.

3.2.2 Fine Aggregate

Locally available river sand confirming to IS: 383:1970 was used as the fine aggregate in the concrete preparation.

Table:3.3.2.1 Properties of Fine Aggregates

S.no	**Property**	**Result**
1	Specific Gravity	2.61
2	Fineness Modulus	2.8
3	Bulk Density (loose)	15.75 kN/m^3
4	Grading of Sand	ZONE-II

Construction aggregate, is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. Aggregates are the most mined materials in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material. Due to the relatively high hydraulic conductivity value as compared to most soils, aggregates are widely used in drainage applications such asfoundation and French drains, septic drain fields, retaining wall drains, and road side edge drains. Aggregates are also used as base material under foundations, roads, and railroads. In other words, aggregates are usedas a stable foundation or road/rail base with predictable, uniform properties (e.g. to help prevent differential settling under the road or building), or as a low-cost extender that binds with more expensive cement or asphalt to form concrete.

Fine aggregate is natural sand which has been washed and sieved to remove particles larger than 5 mm and coarse aggregate is gravel which has been crushed, washed and sieved so that the particles vary from 5 up to 50 mm in size. The fine and coarse aggregate are delivered separately. Because they have to be sieved, a prepared mixture of fine and coarse aggregate is more expensive than natural all-in aggregate.

The reason for using a mixture of fine and coarse aggregate is that by combining them in the correct proportions, a concrete with very few voids or spaces in it can be made and this reduces the quantity of comparatively expensive cement required to produce a strong concrete**.**

Sieving can be done by holding the sieving in both hands and gentle wrist motion; this will be involving the no danger of spilling of sand. This shall be kept well spread out on the screen. More or less continuous rotation of sieve can be carried out throughout the sieving. Washers, shortsand slugs shall not be used on the sieve. The underside of sieve shall be lightly brushed with a 25 or 45 mm brittle brush after even five minutes of sieving. Mechanically sieving devices may be used but the sand cannot be rejected if it meets fineness requirement.

3.2.3 Coarse Aggregate

Coarse aggregate of nominal size 12 mm and 10 mm, obtained from the local quarry confirming to IS: 383:1970 was used. The properties of coarse aggregate are shown in Table 3.3.3. The coarse aggregate used for the preparation of concrete is a mixture of 12 mm and 10 mm size aggregates in ratio 1.5: 1.0.

Table 3.2.3.1 Properties of Coarse Aggregate

S.No	**Property**	**Result**
1	Specific Gravity	2.60
2	Bulk Density	14.15 kN/m^3
3	Water Absorption	0.5%
4	Fineness Modulus	7.2

The advent of modern blasting methods enabled the development of quarries, which are now used throughout the world, wherever competent bedrock deposits of aggregate quality exist. In many places, good limestone, granite, marble or other quality stone bedrock deposits do not exist.

In these areas, natural sand and gravel are mined for use as aggregate. Where neither stone, nor sand and gravel, are available, construction demand is usually satisfied by shipping in aggregate by rail, barge or truck. Additionally, demand for aggregates can be partially satisfied through the use of slag and recycled concrete. However, the available tonnages and lesser quality of these materials prevent them from being a viable replacement for mined aggregates on a large scale. Large stone quarry and sand and gravel operations exist near virtually all population centers. These are capital-intensive operations, utilizing large earth- moving equipment, belt conveyors, and machines specifically designed for crushing and separating various sizes of aggregate, to create distinct product stockpiles. Aggregates themselves can be recycled as aggregates. Unlike deposits of sand and gravel or stone suitable for crushing into aggregate, which can be anywhere and may require overburden removal and/or blasting, "deposits" of recyclable aggregate tend to be concentrated near urban areas, and production from them cannot be raised or lowered to meet demand for aggregates. Supply of recycled aggregate depends on physical decay of structures and their demolition. The recycling plant can be fixed or mobile; the smaller capacity mobile plant works best for asphalt-aggregate recycling. The material being recycled is usually highly variable in quality and properties. Many aggregate products of various types are often recycled for other industrial purposes.

3.2.4 Nano-Silica

Silicon dioxide nanoparticles, also known as silica nanoparticles or nano silica, are the basis for a great deal of biomedical research due to their stability, low toxicity and ability to be functionalized with a range of molecules and polymers. Nano-silica is a new pozzolanic material commercially available in the form of water emulsion of colloidal silica. It is potentially better than the other pozzolanic materials because of high content of amorphous silica (>99%) and the reduced size of its spherical particles of order 5-10nm.

Nano-technology (NT) has been a recent development and is getting applied to many varieties of fields. There have been many highly successful NT based applications which could have been almost impossible without utility of nano sized particles. This is due to extra-ordinary properties of materials when their particle sizes are in nano-scale. However, for civil engineering applications, nano-silica (NS) seems to have very high potential, since, Portland cement generates free lime which can be utilized with very high efficiency by nS, as there is always a chemical affinity between Ca(OH)2 and SiO2 to form secondary calcium-silicate hydrates (C-S-H) which are both pore filling and refining compounds in a cement matrix. This was found to occur in the high volume fly ash containing cement mortar.

Table 3.3.4 Properties of Nano-Silica

S.No	Property	Actual Analysis
1	Active nano silica content	35-40%
2	pH	9.3-9.6
3	Specific Gravity	1.08-1.11
4	Texture	Milky White Liquid
5	Dispersion	Water

Nano-silica incorporation into cement concrete is the direct application approach of nanomaterial's. Researchers have worked on the mechanical and durability properties and microstructure analysis of concrete with nano-silica as discussed below.

Reduced setting times were observed by various researchers on incorporation of nano-silica in concrete which is same as observed for pastes and mortar. Use of nano-silica to reduce setting time and increase early strength of concretes with high volumes of fly ash or slag.

Concrete strength is influenced by lots of factors like concrete ingredients, age, ratio of water to cement materials, etc. Nano-silica incorporation into concrete resulted in higher compressive strength than that of normal concrete to a considerable level.

The nano-silica (Ns), a product of modern Nano-technology (NT), was chosen to examine whether it can improve the degree of impermeability of a porous cement matrix containing mineral admixtures such as FA and SF. For this, a high water- binder ratio of 0.5 was chosen to produce a porous mortar matrix wherein 25% of cement was replaced by Class F fly ash and in another mix, 5% SF was utilised. It may be noted here that the value of 25% represents the average FA content of common Portland Pozzolana Cements (PPCs) available in the market today in India and the value of 5% represents the common SF content used in most of the concrete mixes. After curing the mortar specimens, they were oven dried and then impregnated with 'nano-silica solution' (Nss) by simple soaking. The (Nss) contained 30 %(Ns) solids. The permeability of (Nss) treated specimens were evaluated by determining the COA which required water absorption measurements on oven dried specimens.

3.2.5 Water

Water used for mixing the concrete ingredients, casting and curing the test specimens is free from impurities which when present can adversely influence the strength of concrete confirming to IS:3025:1964 (part 22 and 23) and IS:456:2000.

3.2.6 Super plasticizer

As the locally available PCE based super plasticizers proved to be very effective in SCC; this study is carried out using such type of super plasticizers. CONPLAST SP430 Commercially available poly- carboxylic ether based super plasticizer it is an admixture of a new generation based on modified polycarboxylic ether. CONPLAST SP430 is a super plasticizer manufactured by DOM CONSTRUCTIVE SOLUTIONS, was used in this experimentation. Its use enhances the workability of the mix and strength aspect, helps in producing a better compaction and finishing. It also permits reduction in water content

3.3 Conplast SP430

High performance superplasticising admixture

Description

Conplast SP430 is a chloride free, superplasticising admixture based on selected sulphurated naphthalene polymers. It is supplied as a brown solution which instantly disperses in water.

Conplast SP430 disperses the fine particles in the concrete mix, enabling the water content of the concrete to perform more effectively. The very high levels of water reduction possible allow major increases in strength to be obtained.

Properties of Conplast SP430

Table 3.3.1: Properties of Conplast SP430

S.No	Properties
Appearance	Brown liquid
Specific gravity	Typically, 1.20 at 20°C
Chloride content	Nil to BS 5075
Air entrainment	Typically, less than 2% additional air is entrained at normal dosages.
Alkali content	Typically, less than 72.0 g. Na_2O equivalent/liter of admixture.
Fire resistance	Conplast SP430 is water based and non- flammable.

Additional information

Conplast SP430 was previously known as Conplast 430.

Typical dosage

The optimum dosage of Conplast SP430 to meet specific requirements should always be determined by trials using the materials and conditions that will be experienced in use. This allows the optimization of admixture dosage and mix design and provides a complete assessment of the concrete mix. Starting points for such trials, based on the primary use of the product, are to use a dosage within the normal typical ranges.

For high strength, water reduced concrete the normal dosage range is from 0.70 to 2.00 liters/100 kg of cementitious material, including PFA, GGBFS and micro silica. For high workability concrete the normal dosage range is from 0.70 to 1.30 liters/100 kg of cementitious material.

Where a combination of performance is required, such as some increase in workability combined with reduced water content, then the whole range of dosages from 0.70 to2.00 liters/100 kg of cementitious material can be considered.

Use at other dosages

Dosages outside the typical ranges quoted above may be used if necessary and suitable to meet particular mix requirements, provided that adequate supervision is available. Compliance with requirements must be accessed through trial mixes. Contact the Fosroc Customer Service Department for advice in these cases.

Instructions for use

Mix design

Where the primary intention is to improve strengths, initial trials should be made with normal concrete mix designs. The addition of the admixture will allow the removal of water from the mix whilst maintaining the workability at the levels obtained before the use of the admixture. After initial trials, minor modifications to the overall mix design may be made to optimise performance.

Where the primary intention is to provide high workability concrete, the starting mix design should be one suitable for use as a pump mix. Advice on mix design for flowing concrete is available from the Fosroc Customer Service Department.

In correctly designed flowing concrete, the improved dispersion of the cement particles and the more efficient use of mixing water will improve mix cohesion. The slight air entrainment obtained with Conplast SP430 will also help to minimise bleed and segregation. After initial trials, minor modifications to the mix design may be made to optimise performance.

Compatibility

Conplast SP430 is compatible with other Fosroc admixtures used in the same concrete mix. All admixtures should be added to the concrete separately and must not be mixed together prior to addition. The resultant proper- ties of concrete containing more than one admixture should be assessed by the trial mix procedure recommended on this data sheet to ensure that effects such as unwanted retardation do not occur.

Conplast SP430 is suitable for use with all types of ordinary Portland cements and cement replacement materials such as PFA, GGBFS and silica fume.

Uses

- To provide excellent acceleration of strength gain at early ages and major increases in strength at all ages by significantly reducing water demand in a concrete mix.
- Particularly suitable for precast concrete and other high early strength requirements.
- To significantly improve the workability of site mixed and precast concrete without increasing water demand.
- To provide improved durability by increasing ultimate strengths and reducing concrete permeability.
- In screeds it reduces the water content required to give suitable workability for placing and compaction.

Advantages

- Major increases in strength at early ages without increased cement contents are of particular benefit in precast concrete, allowing earlier stripping times.
- Makes possible major reductions in water: cement ratio which allow the production of high strength concrete without excessive cement contents.
- Use in production of flowing concrete permits easier construction with quicker placing and compaction and reduced labour costs without increasing water content.
- Increased workability levels are maintained for longer than with ordinary sulphurated melamine admixtures.
- Improved cohesion and particle dispersion minimises segregation and bleeding and

improves pumpability.

- Chloride free, safe for use in prestressed and rein- forced concrete.
- In screed material, the lower water content leads to quicker drying times

3.4 Mixture proportioning

Table 3.4.1: Mix proportions of SCC

Mixture ID	**Cement (kg/m3)**	**Sand (kg/m3)**	**C.A (kg/m3)**	**Water**	**NS (kg/m3)**	**SP 3% (kg/m3)**
SCC	550	910	590	252	0	16.5
SCC 2%NS	539	910	590	228	11	16.5
SCC 2.5%NS	537.25	910	590	233.3	13.75	16.5
SCC 3%NS	533.5	910	590	242	16.5	16.5

Where,

SCC = Self compacting concrete,

SCC2% = Compacting toward oneself Cement with 2% NS as concrete substitution.

SCC2.5% = Compacting toward oneself Cement with 2.5% NS as concrete substitution.

SCC3% = Compacting toward oneself Cement with 3% NS as concrete substitution.

NS = Nano silica.

CA = Coarse aggregate

SP = Super plasticizer

3.5 Fresh properties of self-constricting concrete

The fresh concrete is an assembly of solid particles which behaves like other granular materials. The paste is then added in quantities, which are adequate to fill the voids between the aggregate particles.

The assumption is made that fresh concrete is a homogeneous material of uniform composition. The three key properties of SCC of its fresh state are to be achieved are

1. Filling ability

2. Passing ability

3. Segregation resistance.

These properties are tested in the laboratory

1. Filling ability:

It is the potential of concrete to flow under its own weight both vertically downwards and horizontally, without honeycombing around any shape.

Filling ability refers to the ability of SCC mix to deform and undergo changes in shape with completely filling all areas and corners of the formwork horizontally and vertically while maintaining its homogeneity. The deformability of SCC is characterized by the concrete's fluidity and cohesion, and mainly assessed using the slump flow test.

2. Passing ability:

This is the potential of the concrete to flow freely without getting blocked through dense reinforcement.

Passing ability refers to the ability of SCC mix to pass through congested reinforcement without blocking, whilst maintaining good suspension of coarse particles in the matrix, thus avoiding arching near obstacles and blockage during flow. The J-ring and L-box tests are the most common methods used to assess this property. The probability of blocking

increases when the volume fraction of large aggregates and/or fibres increases. The size of aggregates, their shapes and their volume fraction influence the passing ability of SCC, moreover, the presence of fibres especially long and hooked or crimped ends make self-compacting fibre reinforced concrete (SCFRC)more difficult to pass through reinforcement.

3. Resistance to segregation: This is the potential of SCC to resist separation of aggregate from the paste to maintain a homogenous mix during and after placement.

Segregation Resistance (Homogeneity/Cohesiveness) Segregation resistance refers to the ability to retain the coarse components of the mix and the fibres in suspension in order to maintain a homogeneous material. Stability is largely dependent on the cohesiveness and the viscosity of the concrete mixture which can be increased by reducing the free water content and increasing the amount of fines.

“Since coarse aggregate is smaller a finer than that of NCC”, SCC obtains strength due to densification”, table 3.4 gives the methods of evaluating the properties of SCC.

Table 3.5.1 List of Test Methods for Workability Properties of SCC

S. No	Test	Property
1	Slump cone	Filling ability
2	Flow table	Filling ability
3	J-ring	Passing ability
4	V-funnel	Filling ability
5	L-box	Passing ability
6	U-box	Passing ability

3.6 Flow chart showing methodology to achieve self Compactability in concrete

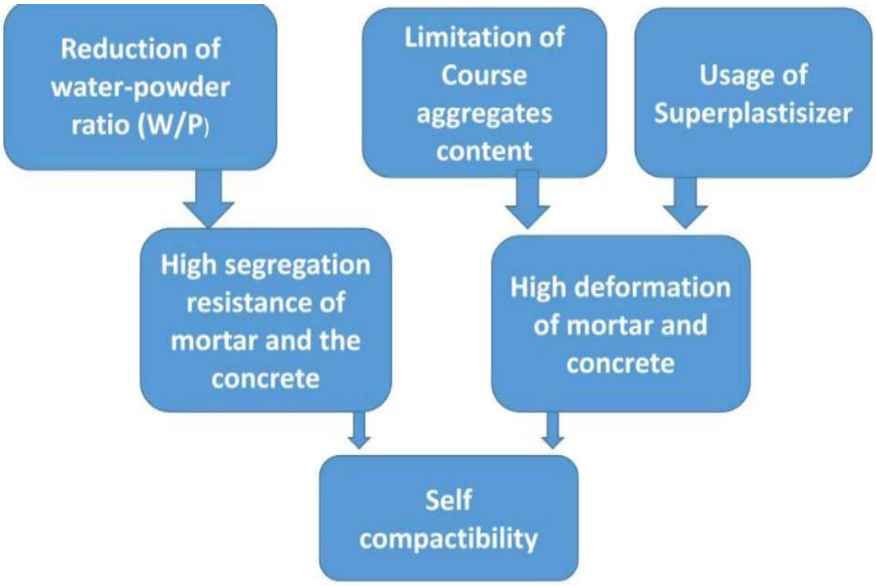


Fig.1 Met

Fig.1 Methodology to achieve self compactability in concrete

Chapter-4

Results and Discussions

4.1 Tests on Cement

Cement is an important constituent in concrete. The process of manufacture of cement consist of grinding the raw materials mixing them intimately in certain proportions and burning them in kiln at a temperature 13000C to 15000C. To determine the various properties of cement different tests are done. The tests done are:

1. Standard Consistency

2. Initial & Final Setting Time

3. Fineness of Cement

4. Specific gravity of Cement

5. Soundness of Cement

6. Marsh cone test

7. Compression strength of Cement

Standard procedure of the above test are given in detail with results in next part of document

4.1.1 Standard Consistency

The basic aim is to find out the water content required to produce a cement paste of standard consistency as specified by the IS: 4031 (Part 4) – 1988. The principle is that standard consistency of cement is that consistency at which the Vicat plunger penetrates to a point 5-7mm from the bottom of Vicat moulds. Vicat apparatus conforming to IS: 5513 – 1976.

Procedure to determine consistency of cement

- Weigh approximately 400g of cement and mix it with a weighed quantity of water. The time of gauging should be between 3 to 5 minutes.
- Fill the Vicat mould with paste and level it with a trowel.
- Lower the plunger gently till it touches the cement surface.
- Release the plunger allowing it to sink into the paste. Note the reading on the gauge.
- Repeat the above procedure taking fresh samples of cement and different quantities of water until the reading on the gauge is 5 to 7mm.

Observation and calculations

Table 4.1.1: Standard Consistency observations

Cement	% of Water added	Penetration
250gms	27*(250/100)	38
	28*(250/100)	20
	29*(250/100)	9
	30*(250/100)	7
	31*(250/100)	4

Result

The percentage of water for normal consistency for the given sample of cement is 36%

4.1.2 Initial Setting Time

Initial setting time is the time elapsed between the moment the water is added to the cement to the time that the paste starts losing its plasticity is called initial setting time.

Procedure to determine Initial setting time

- Prepare a cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency.
- Start a stop-watch, the moment water is added to the cement.
- Fill the Vicat mould completely with the cement paste gauged as above, the mould resting on a non-porous plate and smooth off the surface of the paste making it level with the top of the mould.
- The cement block thus prepared in the mould is the test block.

Observation and calculations

Table 4.1.2: Initial Setting Time observations

Cement	% of Water added	Time (sec)	Penetration (mm)
250gms	0.85*31% of weight of cement	5	0
		10	0
		15	0

	0.85/100*(31)*(250)=66.935	20	0
		25	3
		30	3
		35	4
		40	5

Results

Initial setting time of given cement sample is found to be 40 min & Final setting time as 10 hrs

4.1.3 Fineness of Cement

To determine the fineness of cement by dry sieving as per IS: 4031 (Part1) – 1996.The principle of this is that we determine the proportion of cement whose grain size is larger than 90µm IS Sieve size.

Procedure to determine fineness of cement

- Break down any air set lumps in the cement sample with fingers.
- Weigh accurately 100 g of cement and place it on standard 90 micron IS sieve
- Continuously sieve the sample giving circular and vertical motion for a period of 15 minutes.
- Weigh the residue left on the sieve. As per IS code the percentage residue should not exceed 10%.

Observation and calculations

Table 4.1.3: Fineness of Cement observations

S.No	Weight of cement (gms)	Weight of residue formed (gms)	Fineness of cement (%)
1	300	18g	6%

Result

The fineness of cement is found to be 6%, Which is less than 10%

4.1.4 Specific Gravity of Cement

Specific Gravity is just a comparison between the weight of a volume of a particular material to the weight of the same volume of water at a specified temperature.

Procedure to determine the Specific gravity of cement

- The Flask should be free from the liquid that means it should be fully dry. Weigh the empty flask (W1).
- Fill the cement on the bottle up to half of the flask (about 50gm) and weigh with its stopper (W2).
- Add Kerosene to the cement up to the top of the bottle. Mix well to remove the air bubbles in it. Weigh the flask with cement and kerosene (W3).
- Empty the flask. Fill the bottle with kerosene up to the top and weigh the flask (W4).
- Specific Gravity

Observation and calculations

Table 4.1.4: Specific Gravity of Cement observations

Description of items	Weights
Weight of empty bottle W_1g	26g
Weight of bottle + Cement W_2g	31g
Weight of bottle + Cement + Kerosene W_3g	70g
Weight of bottle + Kerosene W_4g	66g
Weight of bottle with full water W_5g	77g

$$\text{Sp.gravity of kerosene } S_K = \frac{W4-W1}{W5-W1}$$

$$S_K = \frac{66-26}{77-26} = 0.784$$

$$\text{Sp.gravity of cement Sc} = \frac{W2-W1}{(W4-W1)-(W3-W2)Sk}$$

$$\text{Sc} = \frac{(31-26)}{(66-26)-(70-31)*0.784} = 3.92$$

Result

The specific gravity of the given cement sample is 3.92

4.1.5 Soundness of Cement

The testing of soundness of cement is to ensure that the cement does not show any applicable subsequent expansion. Unsoundness in cement is due to excess of lime, magnesia or excessive proportion of sulphates. Experiment is done by Le Chatelier apparatus.

Procedure to determine soundness of cement

- Place the mould on a glass sheet and fill it with the cement paste formed by gauging cement with 0.78 times the water required to give a paste of standard consistency.
- Cover the mould with another piece of glass sheet, place a small weight on this covering glass sheet and immediately submerge the whole assembly in water at a temperature of 27 ± 2oC and keep it there for 24hrs.
- Measure the distance separating the indicator points to the nearest 0.5mm (say d1).
- Submerge the mould again in water at the temperature prescribed above. Bring the water to boiling point in 25 to 30 minutes and keep it boiling for 3hrs.
- Remove the mould from the water, allow it to cool and measure the distance between the indicator points (say d2).
- (d2 – d1) represents the expansion of cement.

Observation and calculations

Table 4.1.5 Soundness of Cement observations

Distance separating the indicator submerged in normal KMP water from 24hrs	Distance separating the indicator submerged in boiling water for 3hrs	Difference between two measurements
7mm	8mm	1mm
9mm	10mm	1mm

Result

The given cement is found to be SOUND

4.1.6 Marsh cone test

The Marsh cone test is a workability test used for specification and quality control of cement pastes. Marsh cone test standard varies from one country to another, but its principle is usually the same. The

time needed for a certain amount of material to flow out of the cone is recorded. This measured flow time is linked with the fluidity of the tested material. The longer the flow time, the lower is the fluidity.

The Marsh cone test is a simple approach to get some data about cement pastes behaviour. It is used in cement based materials mix design in order to define the saturation point, i.e. the dosage beyond which the flow time does not decrease appreciably. The cone is filled with the fluid material while the nozzle is kept closed. When the cone is filled with measured quantity of fluid, the nozzle is opened and the fluid is allowed to flow freely. The time needed for measured quantity of material to flow out is recorded as Marsh cone time.

The saturation point is defined as the chemical admixture dosage beyond which the flow time dose not decrease appreciably. The dose at which the Marsh cone time is lowest is called the saturation point. The dose is the optimum dose for that brand of cement and admixture (plasticizer or superplasticizer) for that w/c ratio.

Procedure to determine the flowability of cement by Marsh cone test

- Observations for 0 minutes, 15 minutes and 60 minutes retention period are taken.
- For first test, water cement ratio is kept as 0.55 and Conplast SP430 admixture dose of 0.2% is administered. Temperature is noted down.
- Mix the measured quantity of Jaypee Cement, water and Conplast SP430 admixture thoroughly in a mechanical mixer for two minutes.
- While mixing, first put the water in mixing bowl and then add 2 Kg of cement to this water. Stirrer for 1 minute and then add Conplast SP430 admixture dose and stirring operation is continued for next one minutes. Thus slurry is formed.
- Pour one-liter slurry into marsh cone duly closing the aperture with a finger.
- Start the stop watch and simultaneously remove the finger. Note the time taken for emptying the Marsh Cone. This time is called the “Marsh Cone Time”.
- Repeat the test for 15 minutes and 60 minutes retention period for same mix and duly noting Marsh Cone time. The mixture of cement and admixture should be kept stirred throughout the test.
- Repeat the test for different plasticizer dosage i.e. 0.2% to 2.0% (AS per IS 456: 2000).

- A typical graph of Marsh Cone Time in Seconds Vs Admixture/Cement dosage in percentage is drawn and optimum dose is ascertained. This point is known as "Saturation Point"
- For Jaypee Cement and Conplast SP430 admixture, different w/c ratio i.e. 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.55 the whole procedure is repeated and for each combination of cement, water and plasticizer, saturation point is obtained.
- Repeat step 2 to 9 for the Jaypee Cement and Conplast SP430 admixture.

Observation and calculations

Table 4.1.6 Flowability by Marsh cone test observations

S.No	Chemical dosage	Passing in sec
1	50ml	126sec
2	100ml	87sec
3	150ml	54sec
4	200ml	36sec
5	250ml	20sec
6	300ml	7sec

Result

Max passing value is found at the chemical dosage of 300ml as 7sec

4.2 Tests on Fine Aggregate

4.2.1 Sieve Analysis

The properties of fine aggregate are shown in Tables below. Weight of sand = 1000gms

Weight of pan = 814gms Weight of pan +sand = 1814gms

Table 4.2.1.1 Sieve Analysis Results

S.No	Sieve Size(mm)	Percent Retained	Cumulative % Retained	Percentage Passing
1	4.75	4.91	4.91	95.09
2	2.36	3.24	8.15	91.85
3	1.18	8.47	16.62	83.38
4	600 microns	26.00	42.60	57.38
5	300 microns	32.50	75.10	24.90
6	150 microns	21.20	96.30	3.70

Fine aggregate is allowed to pass through the 4.75mm sieve and retain on 150microns sieve.

4.2.2 Bulking of Fine Aggregate

Put sufficient quantity of sand loosely into a container until it is 2/3 rd. full. Level the top surface of the sand.

Push the steel rule vertically down through the sand at the middle to bottom and measure the height 'h'. Empty the container and to a clean metal tray without any loss of sand. Add 2% water by weight of sand and mix thoroughly with hand.

Put back the loose sand into container without tamping it. Repeat above the procedure by increasing the moisture content in the sample till the bulking is maximum starts dropping ultimately zero.

Prepare bulking chart by plotting increase volume verses percentage increase in moisture content.

Calculation:

Initial reading h=17.9cm

Table 4.2.2.1 Bulking of Fine Aggregate

S.No	% of water added to the weight of sand	Height of moist sand in cm (h^i)	Percentage of bulking of sand ($(h^i$-$h)/h$ *100
1	2	20.5	12.02
2	4	22.5	22.9
3	6	23	25.6
4	8	22	22.02
5	10	21	14.75
6	12	19.7	7.65

Result:

Bulking of fine aggregate is 25.6%.

4.3 Workability test on SCC

4.3.1 Slump flow test

Introduction

The slump flow is used to assess the horizontal free flow of SCC in the absence of obstructions. It was first developed in Japan (1) for use in assessment of underwater concrete. The test method is based on the test method for determining the slump. The diameter of the concrete circle is a measure for the filling ability of the concrete.

Assessment of test

This is a simple, rapid test procedure, though two people are needed if the T50 time is to be measured. It can be used on site, though the size of the base plate is somewhat unwieldy and level ground is essential. It is the most commonly used test, and gives a good assessment of filling ability. It gives no indication of the ability of the concrete to pass between reinforcement without blocking, but may give some indication of resistance to segregation. It can be argued that the completely free flow, unrestrained by any boundaries, is not representative of what happens in practice in concrete construction, but the test can be profitably be used to assess the consistency of supply of ready-mixed concrete to a site from load to load.

Equipment

A mould in the shape of a truncated cone with the internal dimensions 200 mm diameter at the base, 100 mm diameter at the top and a height of 300 mm, conforming to EN 12350-

2

base plate of a stiff none absorbing material, at least 700mm square, marked with a circle marking the central location for the slump cone, and a further concentric circle of 500mm diameter

- trowel
- scoop
- ruler
- stopwatch (optional)

Procedure

About 6 litres of concrete is needed to perform the test, sampled normally. Moisten the base plate and inside of slump cone, Place base plate on level stable ground and the slump cone centrally on the base plate and hold down firmly. Fill the cone with the scoop. Do not tamp, simply strike off the concrete level with the top of the cone with the trowel. Remove any surplus concrete from around the base of the cone. Raise the cone vertically and allow the concrete to flow out freely.

Simultaneously, start the stopwatch and record the time taken for the concrete to reach the 500mm spread circle. (This is the T50 time). Measure the final diameter of the concrete in two perpendicular directions. Calculate the average of the two measured diameters. (This is the slump flow in mm).

Table 4.3.1.1 Properties and Acceptance criteria for Slump flow

S No	**Method**	**Properties evaluated by the test**	**Acceptance criteria**		
			unit	**Min**	**max**
1	Slump flow	Filling ability,flowability,segregation and bleeding	mm	650	800

Observation and calculations

Table 4.3.1.2 Slump flow test observations

Water cement ratio	Slump in cm
0.4	22cm
0.5	17cm
0.6	15cm

Result

Slump value for the given SCC sample is found to be 22cm for W/C ratio of 0.4, 17cm for W/C ratio of 0.5 & 15cm for W/C ratio of 0.6

4.3.2 J Ring test

Introduction

The principle of the J-Ring test may be Japanese, but no references are known. The J-Ring test itself has been developed at the University of Paisley. The test is used to determine the passing ability of the concrete. The equipment consists of a rectangular section (30mm x 25mm) open steel ring, drilled vertically with holes to accept threaded sections of reinforcement bar. These sections of bar can be of different diameters and spaced at different intervals: in accordance with normal reinforcement considerations, 3x the maximum aggregate size might be appropriate. The diameter of the ring of vertical bars is 300mm, and the height 100 mm. The J-Ring can be used in conjunction with the Slump flow, the Orimet test, or eventually even the V- funnel. These combinations test the flowing ability and (the contribution of the J-Ring) the passing ability of the concrete. The Orimet time and/or slump flow spread are measured as usual to assess flow Characteristics. The J-Ring bars can principally be set at any spacing to impose a more or less severe test of the passing ability of the concrete. After the test, the difference in height between the concrete inside and that just outside the J-Ring is measured. This is an indication of passing ability, or the degree to which the passage of concrete through the bars is restricted.

Assessment of test

These combinations of tests are considered to have great potential, though there is no general view on exactly how results should be interpreted. There are a number of options for instance it may be instructive to compare the slump-flow/J-Ring spread with the unrestricted slump-flow: to what extent is it reduced? Like the slump-flow test,

these combinations have the disadvantage of being unconfined, and therefore do not reflect the way concrete is placed and moves in practice. The Orimet option has the advantage of being a dynamic test, also reflecting placement in practice, though it suffers from requiring two operators.

Equipment

Mould, WITHOUT foot pieces, in the shape of a truncated cone with the internal dimensions 200 mm diameter at the base, 100 mm diameter at the top and a height of 300 mm.

Base plate of a stiff non absorbing material, at least 700mm square, marked with a circle showing the central location for the slump cone, and a further concentric circle of 500mm diameter

- Trowel
- Scoop
- Ruler

J-Ring a rectangular section (30mm x 25mm) open steel ring, drilled vertically with holes. In the holes can be screwed threaded sections of reinforcement bar (length 100mm, diameter 10mm, and spacing 48 +/- 2mm)

Procedure

About 6 litres of concrete is needed to perform the test, sampled normally. Moisten the base plate and inside of slump cone, Place base-plate on level stable ground. Place the J-Ring centrally on the base-plate and the slump-cone centrally inside it and hold down firmly.

Fill the cone with the scoop. Do not tamp, simply strike off the concrete level with the top of the cone with the trowel. Remove any surplus concrete from around the base of the cone.

Raise the cone vertically and allow the concrete to flow out freely. Measure the final diameter of the concrete in two perpendicular directions. Calculate the average of the two measured diameters. (in mm). Measure the difference in height between the concrete just inside the bars and that just outside the bars. Calculate the average of the difference in height at four locations (in mm). Note any border of mortar or cement paste without coarse aggregate at the edge of the pool of concrete.

Table 4.3.2.1 Properties and Acceptance criteria for J-ring

S No	Method	Properties evaluated by the test	Acceptance criteria		
			Unit	Min	Max
1	J-ring	Passing ability, flowing ability	Mm	0	10

Observation and calculations

Table 4.3.2.2 J-ring test observations

Water cement ratio	Flowing of concrete in mm
0.4	7mm
0.5	6mm
0.6	4mm

Result

J-ring value for the given SCC sample is found to be 7mm for W/C ratio of 0.4, 6mm for W/C ratio of 0.5 & 4mm for W/C ratio of 0.6

4.3.3 V funnel test

Introduction

The test was developed in Japan and used by Ozawa et al (5). The equipment consists of a V-shaped funnel, shown in Fig. An alternative type of V-funnel, the O funnel, with a circular section is also used in Japan. The described

V-funnel test is used to determine the filling ability (flow ability) of the concrete with a maximum aggregate size of 20mm. The funnel is filled with about 12 litres of concrete and the time taken for it to flow through the apparatus measured. After this the funnel can be refilled concrete and left for 5 minutes to settle. If the concrete shows Segregation, then the flow time will increase significantly.

Assessment of test

Though the test is designed to measure flow ability, the result is affected by concrete properties other than flow. The inverted cone shape will cause any liability of the concrete to block to be reflected in the result – if, for example there is too much coarse aggregate. High flow time can also be associated with low deformability due to a high paste viscosity, and with high inter-particle friction. While the apparatus is simple, the effect of the angle of the funnel and the wall effect on the flow of concrete are not clear.

Equipment

- V-funnel
- bucket (±12 litres)
- trowel
- scoop
- stopwatch

Procedure flow time

About 12 litres of concrete is needed to perform the test, sampled normally. Set the V-funnel on firm ground. Moisten the inside surfaces of the funnel. Keep the trap door open to allow any surplus water to drain. Close the trap door and place a bucket underneath. Fill the apparatus completely with concrete without compacting or tamping; simply strike off the concrete level with the top with the trowel. Open within 10 sec after filling the trap door and allow the concrete to flow out under gravity. Start the stopwatch when the trap door is opened, and record the time for the discharge to complete (the flow time). This is taken to be when light is seen from above through the funnel. The whole test has to be performed within 5 minutes.

Table 4.3.3.1 Properties and Acceptance criteria for V- funnel test

S No	Method	Properties evaluated by the test	Acceptance criteria		
			Unit	min	max
1	V-Funnel	Filling ability,viscosity, segregation	Sec	6	12

Results

The time of the flow in V-funnel for SCC is found to be 8sec

4.3.4 L-box test

Introduction

This test, based on a Japanese design for underwater concrete, has been described by Peterson. The test assesses the flow of the concrete, and also the extent to which it is subject to blocking by reinforcement. The apparatus is shown in figure. The apparatus consists of a rectangular-section box in the shape of an ‘L’, with a vertical and horizontal section, separated by a moveable gate, in front of which vertical lengths of reinforcement bar are fitted. The vertical section is filled with concrete, and then the gate lifted to let the concrete flow into the horizontal section. When the flow has stopped, the height of the concrete at the end of the horizontal section is expressed as a proportion of that remaining in the vertical section (H2/H1in the diagram). It indicates the slope of the concrete when at rest. This is an indication passing ability, or the degree to which the passage of concrete through the bars is restricted. The horizontal section of the box can be marked at 200mm and 400mm from the gate and the times taken to reach these points measured. These are known as the T20 and T40 times and are an indication for the filling ability. The sections of bar can be of different diameters and spaced at different intervals: in accordance with normal reinforcement considerations, 3x the maximum aggregate size might be appropriate. The bars can principally be set at any spacing to impose a more or less severe test of the passing ability of the concrete.

Assessment of test

This is a widely used test, suitable for laboratory, and perhaps site use. It assesses filling and passing ability of SCC, and serious lack of stability (segregation) can be detected visually. Segregation may also be detected by subsequently sawing and inspecting sections of the concrete in the horizontal section. Unfortunately, there is no agreement on materials, dimensions, or reinforcing bar arrangement, so it is difficult to compare test results. There is no evidence of what effect the wall of the apparatus and the consequent ‘wall effect’ might have on the concrete flow, but this arrangement does, to some extent, replicate what happens to concrete on site when it is confined within formwork. Two operators are required if times are measured, and a degree of operator error is inevitable.

Equipment

- L box of a stiff non absorbing material see figure.
- trowel
- scoop
- stopwatch

Procedure

About 14 litres of concrete is needed to perform the test, sampled normally. Set the apparatus level on firm ground, ensure that the sliding gate can open freely and then close it. Moisten the inside surfaces of the apparatus, remove any surplus water Fill the vertical section of the apparatus with the concrete sample. Leave it to stand for 1 minute. Lift the sliding gate and allow the concrete to flow out into the horizontal section. Simultaneously, start the stopwatch and record the times taken for the concrete to reach the 200 and 400 mm marks. When the concrete stops flowing, the distances “H1” and “H2” are measured. Calculate H2/H1, the blocking ratio. The whole test has to be performed within 5 minutes.

Table 4.3.4.1 Properties and Acceptance criteria for L-box test

S No	Method	Properties evaluated by the test	Acceptance criteria		
			Unit	mm	Max
1	L-box	Passing ability,flowability,blocking effects	(h2-h1)	0.8	1.00

Result

The time of flow of SCC in L-box is 1.7min

4.3.5 U-box test

Introduction

The test was developed by the Technology Research Centre of the Taisei Corporation in Japan. Sometimes the apparatus is called a "box-shaped" test. The test is used to measure the filling ability of self-compacting concrete. The apparatus consists of a vessel that is divided by a middle wall into two compartments, shown by R1 and R2 in fig. An opening with a sliding gate is fitted between the two sections. Reinforcing bars with nominal diameters of 13 mm are installed at the gate with centre-to-centre spacing of 50 mm. This creates a clear spacing of 35 mm between the bars. The left hand section is filled with about 20 litres of concrete then the gate lifted and concrete flows upwards into the other section. The height of the concrete in both sections is measured.

Note: An alternative design of box to this, but built on the same principle is recommended by the Japan Society of Civil Engineers.

Assessment of test

This is a simple test to conduct, but the equipment may be difficult to construct. It provides a good direct assessment of filling ability – this is literally what the concrete has to do – modify by an unmeasured requirement for passing ability. The 35mm gap between the sections of reinforcement may be considered too close. The question remains open of what filling height less than 30 cm. is still acceptable.

Equipment

- U box of a stiff non absorbing material see figure
- trowel
- scoop
- stopwatch

Procedure

About 20 litre of concrete is needed to perform the test, sampled normally. Set the apparatus level on firm ground, ensure that the sliding gate can open freely and then close it. Moisten the inside surfaces of the apparatus, remove any surplus water Fill the one compartment of the apparatus with the concrete sample. Leave it to stand for 1 minute. Lift the sliding gate and allow the concrete to flow out into the other compartment. After the concrete has come to rest, measure the height of the concrete in the compartment that has been filled, in two places and calculate the mean (H1). Measure also the height in the other compartment (H2) Calculate H1 - H2, the filling height. The whole test has to be performed within 5 minutes.

Table 4.3.5.1 Properties and Acceptance criteria for U-box test

S No	Method	Properties evaluated by the test	Acceptance criteria		
			Unit	min	Max
1	U-box	Passing ability, filling ability, blocking effects	(h2-h1)	0	30

Result

The passing value of SCC in U-box test is found to be 26cm.

4.3.6 FLOW TABLE TEST

Introduction

This test is performed to determine the consistency of concrete where the nominal maximum size of aggregate does not exceed 38 mm using flow table apparatus.

Apparatus

- Flow table
- Trowel
- Scale

PROCEDURE

- Before commencing test, the table top and inside of the mould is to be wetted and cleaned of all gritty material and the excess water is to be removed with a rubber squeezer.
- The mould is to be firmly held on the centre of the table and filled with concrete in two layers, each approximately one-half the volume of the mould and rodded with 25 strokes with a tamping rod, in a uniform manner over the cross section of the mould.
- After the top layer has been rodded, the surface of the concrete is to be struck off with a trowel so that the mould is exactly filled.
- The mould is then removed from the concrete by a steady upward pull.
- The table is then raised and dropped from a height of 12.5 mm, 15 times in about 15 seconds.
- The diameter of the spread concrete is the average of six symmetrically distributed calliper measurements read to the nearest 5 mm.

Table 4.3.6.1 Properties and Acceptance criteria for Flow table test

S.No	Method	Properties evaluated by the test	Acceptance criteria		
			Units	Min	Max
1	Flow table	Flowability, consistency & segregation	%	0	150

Observation and calculations

Table 4.3.6.2 Flow table test observations

Chemical dosage	% flowability
100ml	52%
200ml	86%
300ml	102%

Result

The flow table value of SCC is found to be max at 300ml chemical dosage as 102%

4.4 Casting

The cube mould plates should be removed properly, cleaned, assembled and all the bolts should be fully tight. A thin layer of oil then shall be applied on all the faces of the mould. It is important that cube side faces must be parallel. After taking concrete samples and mixing them, the cubes shall be cast as soon as possible. The concrete sample shall be filled into the cube moulds in layers approximately 5 cm deep. In placing each scoopful of concrete, the scoop shall be moved around the top edge of the mould as the concrete slides from it, in order to ensure a symmetrical distribution of the concrete with in the mould. Number of specimens casted are shown below.

Table 4.4.1. Number of specimens casted

S.No	**Mix Designation**	**No. of cubes**		**No. of Cylinders**
1	NOMINALCONCRETE	3	3	3
2	SCC(without nano silica)	3	3	3
3	SCC 2%	3	3	3
4	SCC 2.5%	3	3	3
5	SCC 3%	3	3	3
Total Specimens		15	15	15

4.4.1 Procedure for Casting Concrete Cubes

Clean the cube mould properly with a cloth and apply a coat of form oil on the inner surfaces of the mould. No excess oil should be visible on the inner surfaces. Fix the nuts & bolts tightly with base plate and side plates, no gaps should be seen within the parts of cube mould. It is necessary that the cube mould should be placed on a clean, level & firm surface for filling the concrete in it.

Concrete for specimen should be collected from three or four random mixes according to the preferred mix design of M20 grade. Place the concrete mix into the mould in each layer ofmaximum 50 mm thick. Level off the top with the steel float & clean any concrete from around the mould and leave the mould undisturbed for 24 hours.

Give number & casting date of the specimens on the top surface after 90 minutes. Remove the cube from the mould after 24 hours. The specimen should be put straight into a tank of clean water. The specimen should be fully submerged under water. After 7 and 28 days, send the specimen to the testing laboratory todetermine the compressive strength of concrete.

4.4.2 Procedure for casting concrete cylinder

Clean the Cylinder mould properly with a piece of cloth and apply a coat of form oil on the inner surface of mould.No excess oil should be visible on inner surface. Fix the nuts & bolts tightly with base plate and no gaps should be within the parts of cylinder mould. It is necessary that the cylinder mould should be placed on a clean, level & firm surface. Concrete for specimen should be collected from three or four random mixes. Place concrete into the mould in each layer of maximum 50 mm thick. Level off the top with the steel float & clean any concrete from around the mould and leave the mould undisturbed for 24 hours.

Give number & casting date of the specimens on the top surface after 90 minutes. After 24 hours the specimen should be taken out from the mould and put it straight into a tank of clean water. The specimen should be fully submerged under water. After 7 and 28 days, send the specimen to the testing laboratory to determine the tensile strength of concrete. Minimum three specimens are made at a time on site. The average test result is taken to determine the tensile strength of concrete.

4.4.3 Curing

The cube shall be removed from the moulds at the end of 24 hours and immersed in clean water till the 7 or 28-days age of testing. The cubes shall be tested in the saturated and surface dry condition. For the true representation of actual strength of concrete in the structure, extra cubes shall be cast, stored and curded as per the identical conditions of that structure, and tested at required age.

4.4.4 Compressive Strength Test

The dimensions of the specimens to the nearest 0.2 mm and their weight shall be noted before testing. The bearing surfaces of the testing machine shall be wiped clean and any loose sand or other materials removed from the surface of the specimen which are to be in contact with the compression platens. The cube shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast that is not to the top and bottom.

The axis of the specimen shall be carefully aligned with the center of the thrust of the spherically seated platen. No packing shall be used between the faces of the test specimen and the steel platen of the testing machine. As the spherically seated block is brought to bear on the specimen, the movable portion shall be rotated gently by hand so that uniform seating may be obtained.

The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted. The compressive strength of concrete shall be calculated from:

$$Compressive\ strength = (Maximumload)/(Cross{-}sectional\ area)$$

The compressive strengths of the casted specimens were determined by the compressive test machine and are tabulated as follows:

Table 4.4.4.1 Compressive Strength Values

S.No	**Mix Designation**	**Characteristic Compressive Strength(N/mm^2)**	
		7 Days	**28 Days**
1	Nominal Concrete	17.52	20.8
2	SCC	19.81	22.32
3	SCC 2% NS	21.30	23.12

4	SCC 2.5% NS	22.20	24.90
5	SCC 3% NS	21.40	24.50

Graphs are plotted for the obtained results and increase in the characteristic compressive strengths can be clearly read out. It was observed that the percentage increase in compressive strength was greater for 7 days compared to 28 days. Hence from the experimental investigation results it can be inferred that Nano-silica improves early strength also.

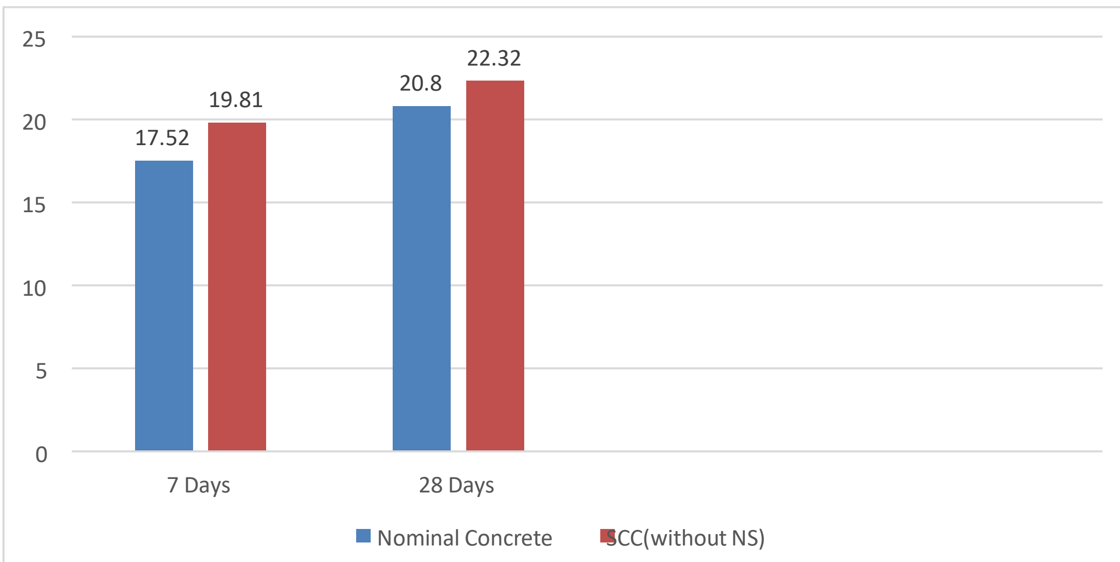


Fig 4.4.1 Compressive Strength of Nominal concrete and SCC (without NS)

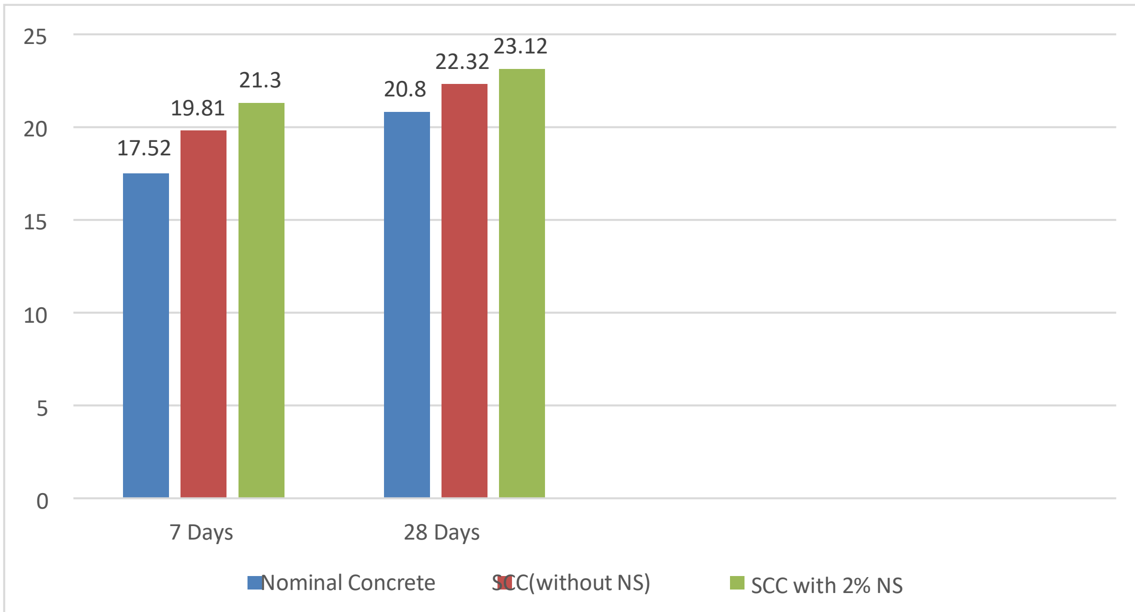


Fig 4.4.2 Compressive Strength of Nominal Concrete, SCC and SCC with 2% NS

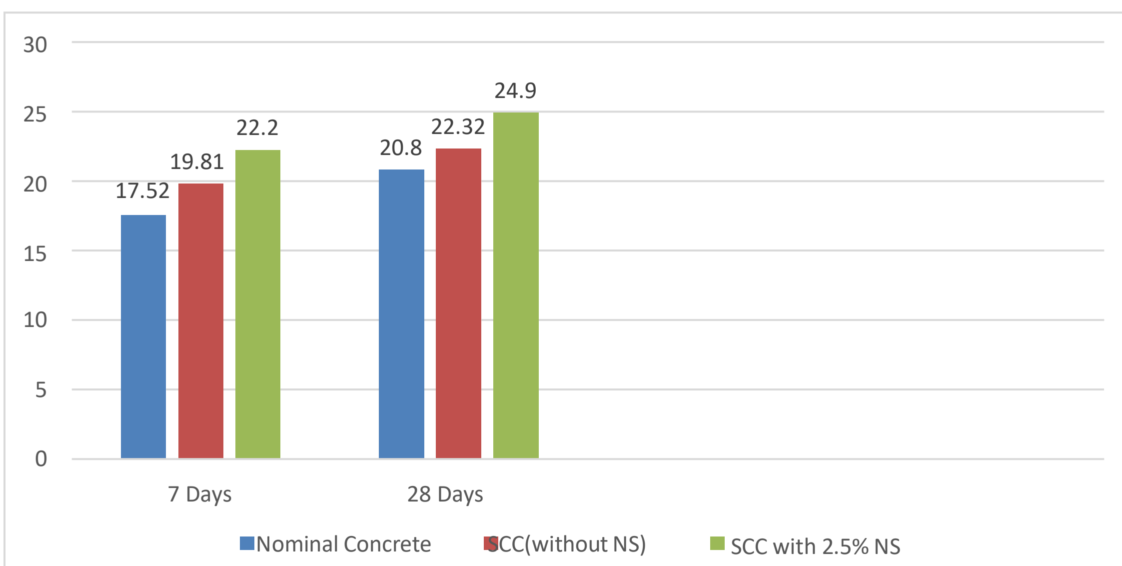


Fig 4.4.3 Compressive Strength of Nominal Concrete, SCC and SCC with NS 2.5%

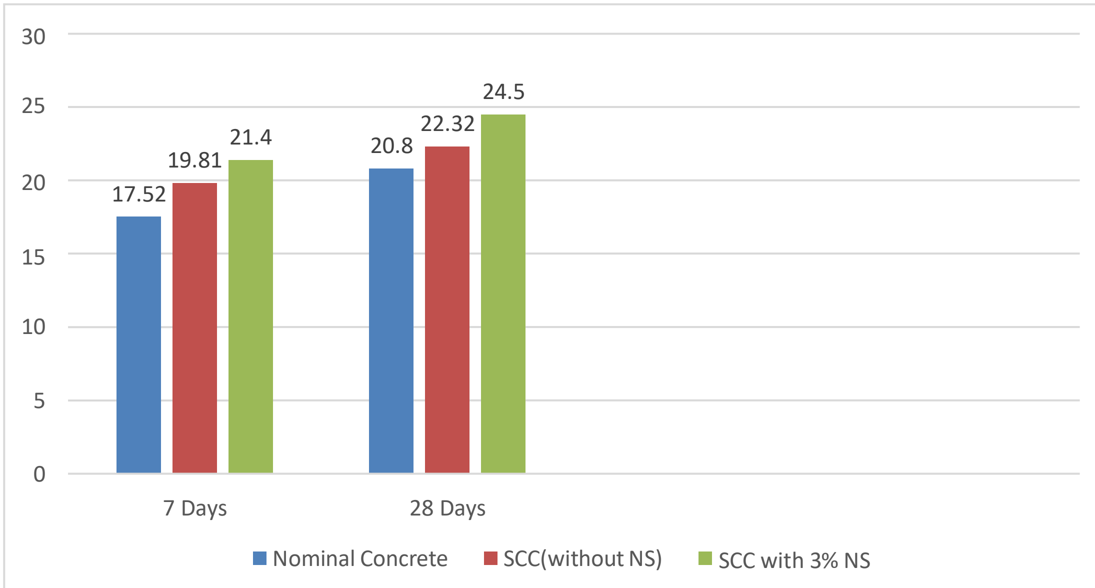


Fig 4.4.4 Compressive Strength of Nominal Concrete, SCC and SCC with NS 3%

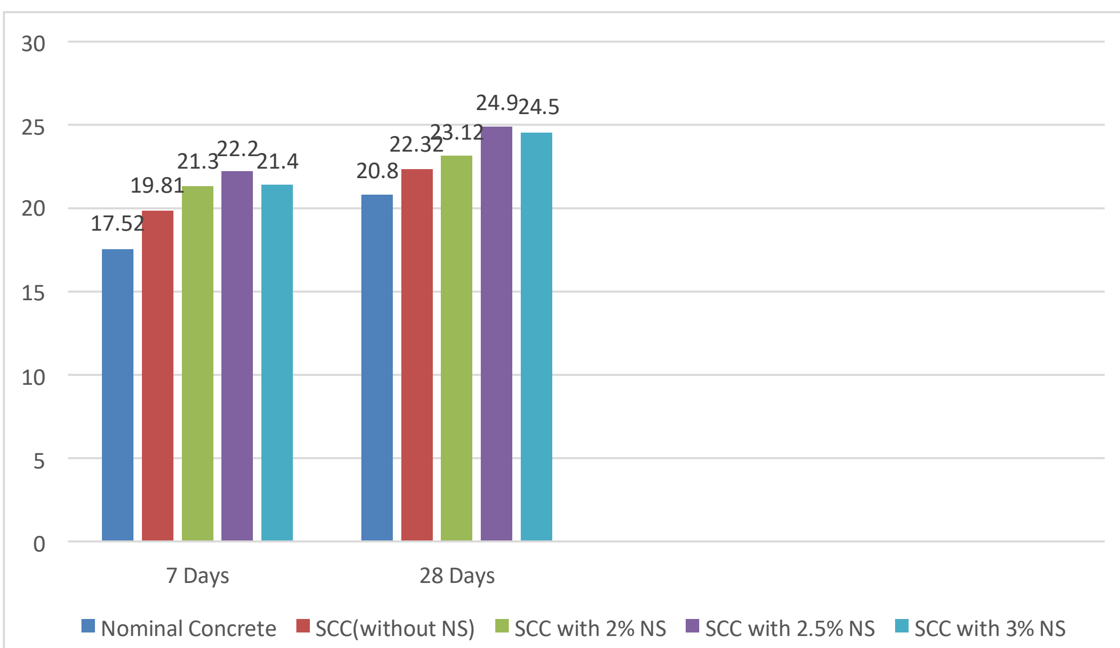


Fig 4.4.5 Compressive Strength of Nominal Concrete, SCC without NS, SCC with 2% NS, SCC with 2.5% NS and SCC with 3% NS

Nano silica reacts with calcium hydroxide ($Ca(OH)_2$) to develop more of the strength carrying structure of cement: calcium silica hydrate (C-S-H). Hence there is an increase in the compressive strength in specimens in which cement is replaced by Nano-silica.

Table 4.4.4.2 Percentage increase in Compressive Strength

S.No	**Dosage of Nano –Silica (% by weight)**	**Percentage increase in Characteristic Compressive Strength**	
		7 Days	**28 Days**
1	2%	0.25	1.28
2	2.5%	2.26	1.38
3	3%	1.25	2.9

4.4.5 Split-Cylinder Test (Tensile Strength)

It is the standard test, to determine the tensile strength of concrete in an indirect way. This test could be performed in accordance with IS: 5816-1970.

A standard test cylinder of concrete specimen (300mm x 150mm diameter) is placed horizontally between the loading surfaces of Compression Testing Machine. The compression load is applied diametrically uniformly along the vertical diameter. Concrete cylinders split into two halves along this vertical plane due to indirect tensile stress generated by poisson’s effect.

Due to this compressive loading, an element lying along the vertical diameter of the cylinder is subjected to a vertical compressive stress and a horizontal stress. The loading condition produces a high compressive stress immediately below the loading points. But the larger portion of cylinder, corresponding to its depth is subjected to uniform tensile stress acting horizontally. It is estimated that the compressive stress is acting for about 1/6 depth and the remaining 5/6 depth is subjected to tension due to poission’s effect.

Assuming concrete specimen behaves as an elastic body, a uniform lateral tensile stress of **ft** acting along the vertical plane causes the failure of specimen, which can be calculated from the formula as, **ft = $2P/\pi DL$**

P= Compressive load at failure L= Length of cylinder

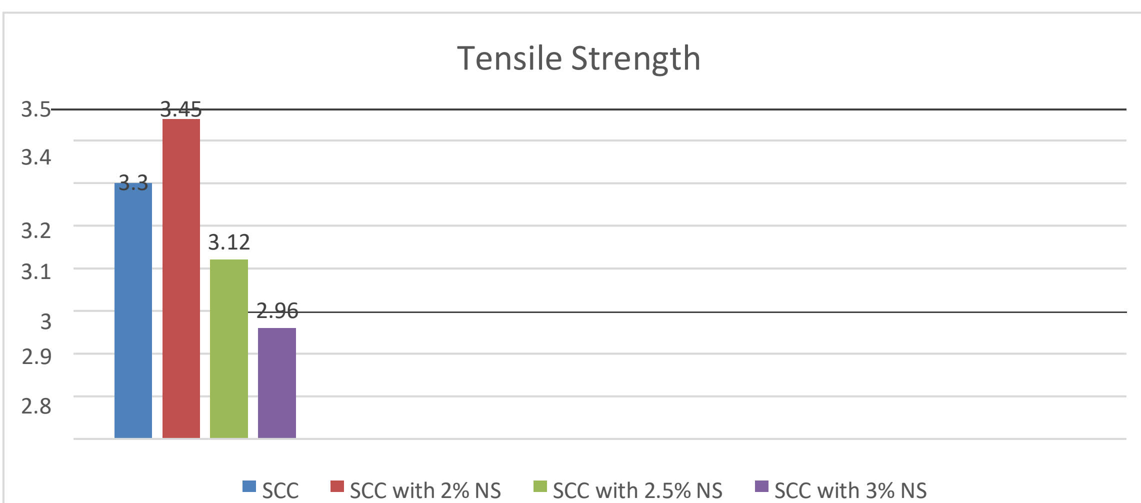
D= Diameter of cylinder

It can be observed that as the percentage of Nano-silica is increased, split tensile strength of concrete is also decreased. The split tensile strength of M20 grade controlled concrete is 3.306N/mm^2.

Table 4.4.5.1 Tensile strength of concrete

S.No	**Mix Designation**	**Tensile Strength(N/mm^2)**
1	SCC	3.30
2	SCC with NS 2%	3.45
3	SCC with NS 2.5%	3.12
4	SCC with NS 3%	2.96

Fig 4.5.1 Tensile Strength of SCC and SCC with NS dosages



4.5. *SEM Analysis (scanning electron microscopy*)

A **scanning electron microscope** (**SEM**) is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the surface topography and composition of the sample. The electron beam is scanned in a raster scan pattern, and the position of the beam is combined with the intensity of the detected signal to produce an image. In the most common SEM mode, secondary electrons emitted by atoms excited by the electron beam are detected using a secondary electron detector. The number of secondary electrons that can be detected, and thus the signal intensity, depends, among other things, on specimen topography. SEM can achieve resolution better than 1 nanometer.

Specimens are observed in high vacuum in conventional SEM, or in low vacuum or wet conditions in variable pressure or environmental SEM, and at a wide range of cryogenic or elevated temperatures with specialized instruments

In this current study, the hydrated cement pastes obtained from the samples are subjected to SEM analysis. The range of scale used in SEM analysis was 5 µm with the resolution of x30000. The detailed process of sample preparations for SEM analysis is described below.

After Compressive testing was finished, the cube samples are crushed and the hydrated cement was collected from the innermost core of the concrete cube sample. The collected samples are sieved through 300µ sieve.

The sample preparation was done by cone and quartering method for reducing the sample size. The sample was dispensed on flat surface so that it takes on a conical shape. The top of the conical shape was flattened. The cone is divided into quarters .Two opposite quarters was discarded; the other two are combined. The process was repeated until the suitable sample size was reached the sample preparation process for micro structural analysis is pictured below.

We went to SEM lab in OUCT (Osmania University College of Technology) at Osmania University, Hyderabad, Telangana.

3 samples of specimen was tested. This sample contain of

- Cement

- Nano silica
- Cement + nano silica gel.

Where cement + nano silica gel is made up by taking 300 grams of cement and 50 grams (0.3%) of nano silica and 0.55 water cement ratio. The sample is placed for 24 hours and allowed for harden the sample. After 24 hours sample is crushed and 10gm of powder is cared on to test.

Sample 1: Cement

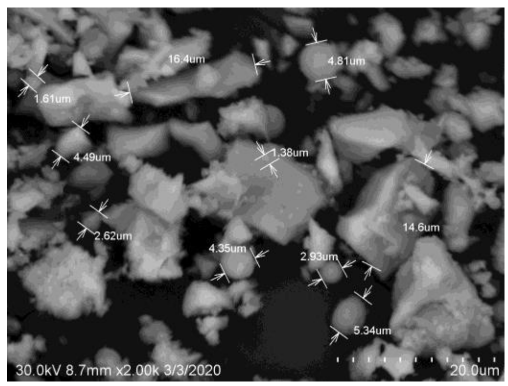


Figure 4.6.1:Cement

Specifications

- Pixel Size=49.60938
- Accelerating Voltage=30000 Volt
- Magnification=2000
- Working Distance=8700 um
- Emission Current=112000 nA
- Vacuum=60
- Micron Marker=20000
- Color Mode=Grayscale
- Condition=Vacc=30kV
- Mag=x2.00k

- WD=8.7mm
- Particles size of cement is in a range from 1.38 to 16.4 um.
- particles are in circular and irregular in shapes.
- Cement particles contain void spaces in between them.

Sample 2: Nano silica gel

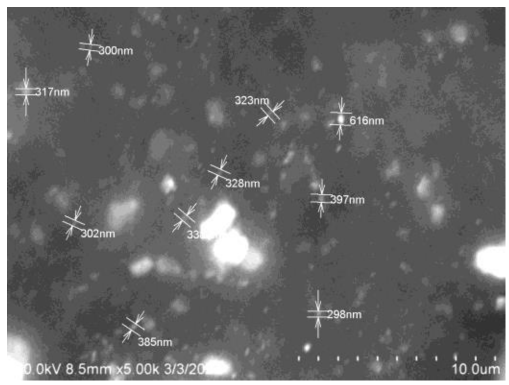


Figure 4.6.2: Nano silica gel

Specifications

- Pixel Size=19.84375
- Accelerating Voltage=30000 Volt
- Magnification=5000
- Working Distance=8500 um
- Emission Current=103000 nA
- Vacuum=60
- Micron Marker=10000
- Color Mode=Grayscale
- Condition=Vacc=30kV
- Mag=x5.00k

- WD=8.5mm
- Particles size of cement is in a range from 298 to 616 nm.
- particles are in circular and irregular in shapes.
- Surface tension between nano silica particles can be seen
- Particles of nano silica are closely packed and no space between particles is seen.

Sample 3: Nano silica gel + Cement

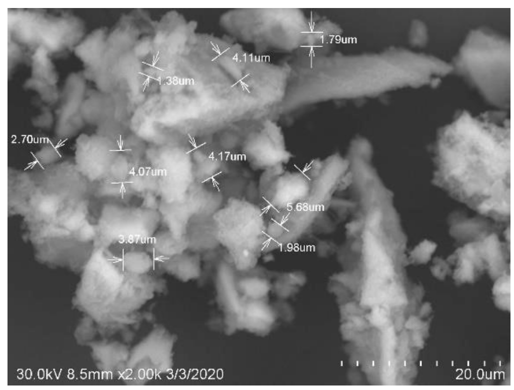


Figure 4.6.3: Nano silica gel + Cement

Specifications

- Pixel Size=49.60938
- Accelerating Voltage=30000 Volt
- Magnification=2000
- Working Distance=8500 um
- Emission Current=106000 nA
- Vacuum=60
- Micron Marker=20000
- Color Mode=Grayscale

- Condition=Vacc=30kV
- Mag=x2.00k
- WD=8.5mm
- Particles size of nano silica gel + cement is in a range from 1.38 to 5.68 um.
- particles are in angular, circular and irregular in shapes.
- Nano silica gel + cement particles are also closely packed they contain small amount void spaces in between them.

Chapter-5

CONCLUSION

From the above experimental study, it can be concluded that the optimum replacement of Nano Silica is 2.5% for M20 concrete. The compressive strength of cement concrete can be increased considerably by the addition of Nano-silica. Based on the experimental results, use of Nano- Silica as partial replacement of cement in small quantities is advantageous on the performance of concrete. Nano-Silica added in small quantities can improve the compressive strength. The increase in various strength characteristics of concrete containing nano-silica content can be due to the availability of additional binder in the presence of nano-silica. Nano silica has high amorphous silicon dioxide content. The Portland cement in concrete releases calcium hydroxide during the hydration process. The nano silica reacts with the calcium hydroxide to form additional binder material. The availability of additional binder leads to increase in the paste-aggregate bond, results improved strength properties of the concrete prepared with nano-silica combination.

From overall study, it is clear that the micro structural behaviour of concrete influences the strength characteristics of the mix. The addition of Nano materials changed the behaviour of microstructure of concrete and also influences the compressive strength of concrete mixes. From the test results of compressive strength, it was observed that replacement of concrete ingredients fairly improves on the strength of concrete mixes.

In SEM Observations, the existence of mineral elements and their reactions with the supplementary materials are studied which gives an initiative to understand the microstructure of the concrete mixes. Based on the comparison of the microstructure of concrete mixes, it is clear that the hydration process in the mixes with supplementary materials was different from conventional concrete mix.

Compressive strength with NS dosage of 2% has increased by 0.25 and 1.28 percentage for 7 and 28 days respectively compared to normal.

The percentage increase in compressive strength with NS dosage of 2.5% is 2.26 for 7 days and 1.38 for 28 days over normal concrete.

Similarly, a percentage increase of 1.25 for 7 days and 2.9 for 28 days has been observed when compared to that of concrete with 3% NS dosage.

The workability of the concrete along with Nano-silica has decreased.

The presence of nano silica is determined using sem Analysis in 4.3. There is increase in strength due to the density increase in Nano Silica.

Chapter-6

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CHAPTER 7

PUBLICATIONS

V.Rajesh ,MD shahed.,(2021) “Impact and structural analysis of ultra light weight self compacting concrete”, International Journal For Scientific Research & Development (IJSRD23210613)

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Fig.6 Marsh cone test

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Fig.8 IS: Sieve for fineness test of cement

Fig.9 Cement sample after sieving

Fig 10. Compressive Test Machine

Fig 11. Split Tensile Test

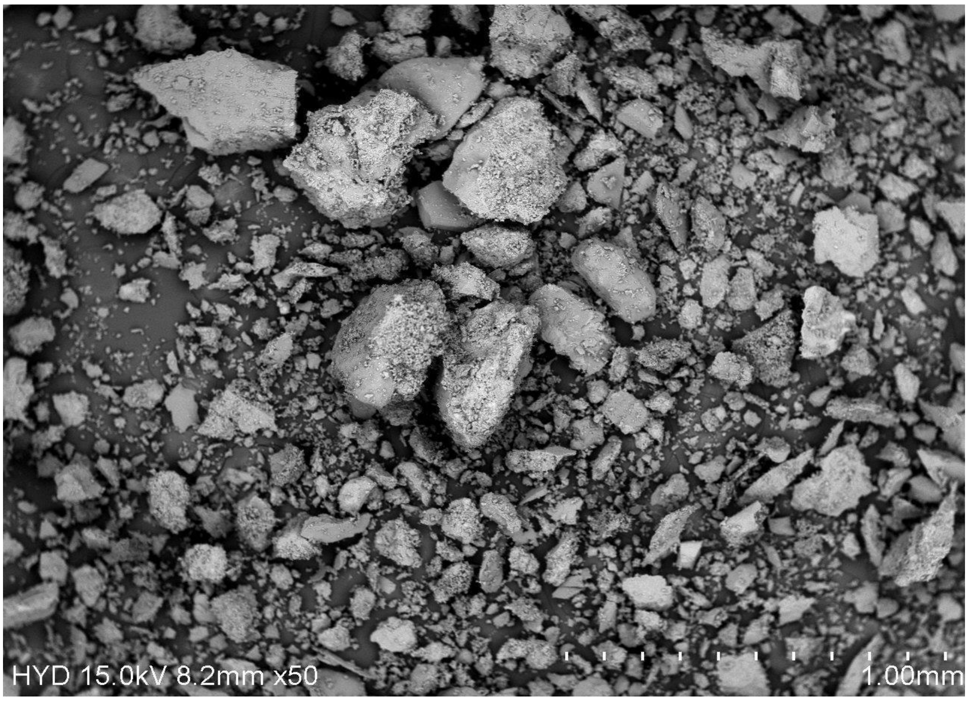

Fig 12.SCC WITHOUT NANO-SILICA

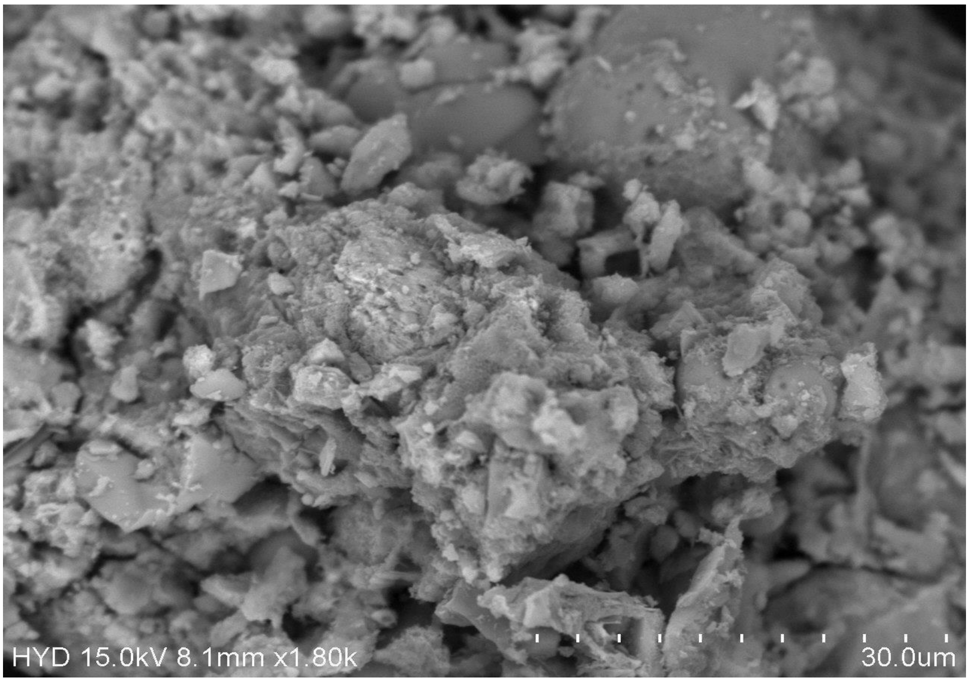

Fig 13.SCC WITH DOSAGE OF 2%
NANO-SILICA

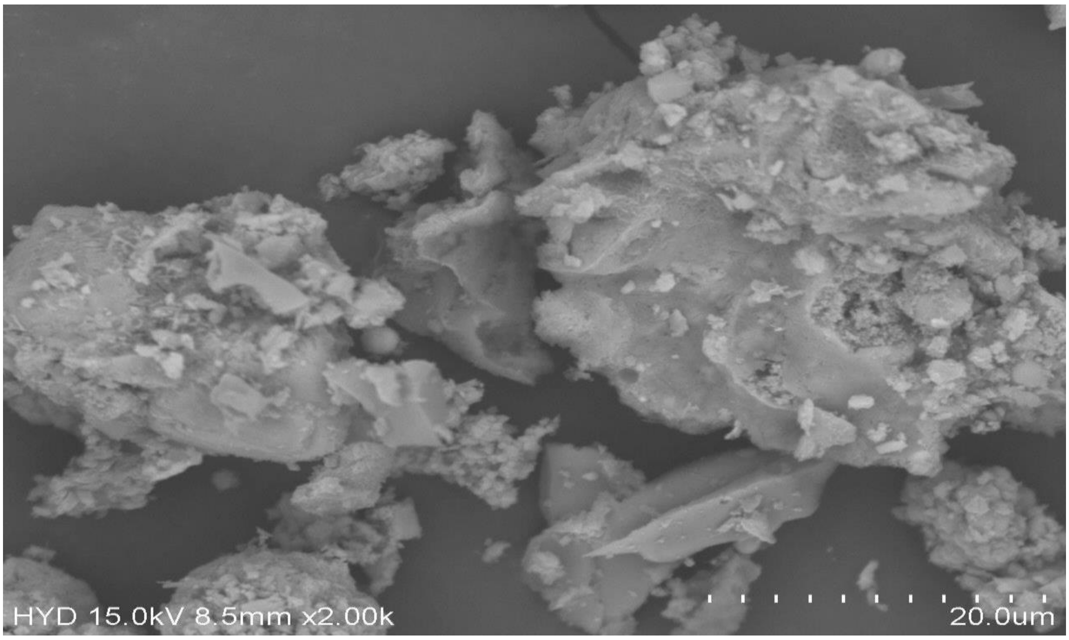

Fig 14.SCC WITH DOSAGE OF
2.5% NANO SILICA

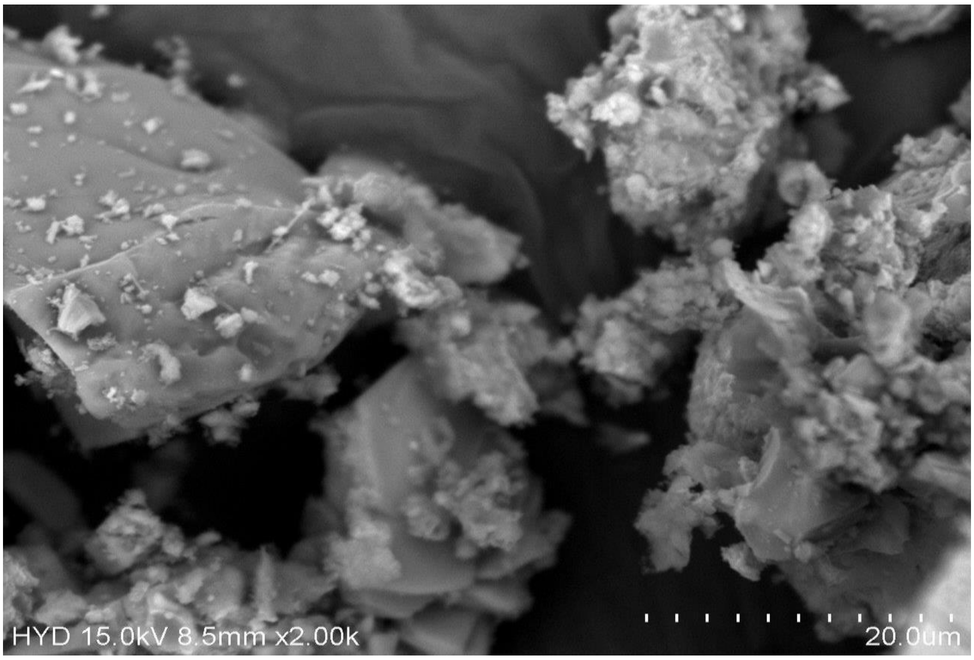

Fig 15.SCC WITH DOSAGE OF 3%
NANO SILICA

Fig 16. SEM Analysis

A MAJOR PROJECT REPORT

On

COLOURFUL TILES FROM PLASTIC WASTAGES

SUBMITTED TO

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY

HYDERABAD

Submitted by

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In partial fulfilment for the award of degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under Guidance Of

Mr. PANDLA GURUSWAMY GOUD,
M.Tech(Structural Engineering)
Assistant Professor, Civil Engineering.

ST.MARTIN'S ENGINEERING COLLEGE

(An Autonomous Institute)

Dhullapally,Secunderabad-500 100,June 2021

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BONAFIDE CERTIFICATE

This is to certify that the project entitled "**Colourful Tiles fron Plastic Wastages**" , is being submitted **by K.Tejasri(17K81A0134), P.Praveen(18K85A0107), CH.Umakanth(17K81A0116), A.Sravan Kumar(17K81A0102)** in the partial fulfilment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY** in civil engineering department is recorded of bonafide work carried out by them.This result embodied in this report have been verified and found satisfactory.

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Place:

Date:

DECLARATION

We **K.TEJASRI, P.PRAVEEN**, **CH.UMAKANTH, A.SRAVAN KUMAR** hereby declare that the report of the work entitled **"COLOURFUL TILES FROM PLASTIC WASTAGES",** which is being submitted to the St Martin's Engineering College, Hyderabad, in partial fulfilment of the requirements for the award of the Degree of **BACHELOR OF TECHNOLOGY,** is the outcome of our own bonafide report of the work carried out by us. The material contained in this report has not been submitted to any University or Institution for the award of any degree.

Place: **SMEC, HYDERABAD**

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ABSTRACT

The present investigation aims at manufacturing floor tiles using waste plastic in different proportions with sand, without use of cement and comparing it with the normal cement tiles. To evaluate different physical and mechanical properties,tests like water absorption test, transverse resistance, resistance to impact and abrasion resistance tests were carried out as per IS specifications on the plastic tile and these test results were compared with the normal cement tiles.The results obtained have shown better results as compared to the normal cement tiles.

As per this study it can be considered to use plastic waste as a binding material instead of cement in the manufacture of floor tiles. Now a days most of the plastic is wasted and thrown in garbage which causes lot of pollution to environment, To reduce this we can reuse plastic waste as colourfull floor tiles.

1. INTRODUCTION

Waste is defined as any material that is not useful and does not represent any economic value to its owner. Depending on the physical state of waste, wastes are categorized into solid, liquid and gaseous. Solid Wastes are categorized into municipal wastes, hazardous wastes, medical wastes, and radioactive wastes. Note that, gaseous waste that is held in a closed container falls into the category of solid waste for disposal purposes. However, this study will be focused on biodegradable and photodegradable materials to decompose the waste, along with sufficient moisture and nutrients to sustain microbial action. Thus, the deeper these plastics are buried in the landfill, the less likely they are to decompose. Therefore, it is reasonable to say that that the market for plastic recycling Managing solid waste generally involves planning, financing, construction and operation of facilities for the collection, transportation, recycling and final disposition of the waste.

Plastic is defined as synthetic or semi-synthetic materials which are polymeric and are composed of large molecules of organic substances known as monomers. The large molecules that are formed during a process known as polymerization are known as polymers.

[1]. Solid waste management (SWM) system includes the generation of waste, storage, collection, transportation,processing and final disposal.

[2]. Plastic waste is carried to melt and mixed with a varying proportion of reinforcement. Reinforcement of 40% sawdust gives better results than micro-concrete tiles.

[3]. The utility of plastic bags pieces can be used for a possible increase in split tensile strength.

[4]. The experimental results show that the plastic aggregate have low crushing, low specific gravity, and density value as compare to natural aggregate, with use of suitable admixture, around 0.4% by weight of cement will improve the bonding between matrix and plastic aggregate.

[5]. The expanding population and increased preferences for plastic have a negative impact on the environment.

[6]. The major divisions of plastics are thermoplastic and the thermosetting polymers. Thermoplastics are the form of plastics that do not undergo chemical changes in their composition when subjected to heat and can be remolded into another shape even after solidification. Thermosetting, on the other hand, are non-recycled polymers which undergo an irreversible chemical change when subjected to heat, they melt and take a shape once after which they cannot be molded into another shape. The role of plastics in human lives cannot be overemphasized ranging from use as household appliances, packaging materials, potable water, and beverage containers, kitchen utensils, furniture, toys, automobile parts, polythene bags etc.

[7]. Attributed the great attention given to their use as due to their generally light, cheap and durability nature and this account for their preference over other materials.

[8]. In view of all the hazards that accompany the improper disposal of plastic wastes, the need then arises for an alternative means to manage the plastics waste. The only means of adequately take care of several tons of plastic wastes being disposed of is through the adoption of the recycling process. This recycling process will go a long way to contribute to a cleaner environment. Plastic recycling is the process of recovering plastic wastes and turning old or scrap plastic into useable products that can re-enter the manufacturing chains. This will, in turn, generate revenue, create more job opportunities and reduce the hazards associated with improper disposal of plastic wastes.

[9]. For recycling of this plastic firstly, the sorting exercise is carried out. After this,

plastics are shredded into smaller, between 5 to 10 mm^2. The shredded plastics are melted and molded directly into a new product or melted and formed into pellets.

[10]. Thus, the quantity of plastic waste generated is very high in amount. Very less work has been done on the tiles made from the waste plastic bags. Objectives of this research are:

- To create a prototype which tackles the threatening issue of disposal of plastic.
- To recycle waste LPDE plastic.
- To manufacture plastic tiles from the used plastic bags.
- To test various mechanical properties of the manufactured product like compressive strength, flammability, friction properties etc.

2. LITERATURE REVIEW

1) **In 1998, Althos Poldidor "Method of making composite tiles containing waste plastic"**
   The present invention concerns a manufacturing process and a related product constituted of a tile in plastic material. The process comprises the following operative stages crushing a thermoplastic material of recovery.

2) **Athanus Konin "Use of plastic wastes binding material in the manufacture of tiles: Case of wastes with a basic of Polypropylene"**
   According to konin the plastic waste tiles have low porosity hence it makes tiles impervious in opposition to micro-concrete tiles The proportion of 40% of plastic binder gives best result hence gauging is to be used.

3) **Yong Liu "Mechanical performance of roof tiles made tire powder and waste plastics"**
   According to the principle that the impact strength is the most important mechanical performance and the modulus of elasticity and elongation at break are the secondly important; a sample that contains equal rubber powder and plastic was taken as best.

4) **M.A.Kamaruddin et al.(2000): "Potential use of plastic waste as construction materials : Recent Progress and Future Prospect"**
   Plastic associate products based have been considered as the world most consumer packaging solution. However, substantial quantities of plastic consumption have led to exponential increase of plastic derived waste. Recycling of plastic waste as valued added product such as concrete appears as one of the promising solution for alternative use of plastic waste. This paper summarized recent progress on the development of concrete mixture which incorporates plastic wastes as partial aggregate replacement during concrete manufacturing. A collection of data from previous studies that have been researched which employed plastic waste in concrete mixtures were evaluated and conclusions are drawn based on the laboratory results of all the mentioned research papers studied.

5) **K.S.Rebeiz and A.P.Craft(2000):"Plastic waste management in costruction: Technological and institutional issues"**
   The main objective of a solid waste management system is to effectively safeguard the public health, safety, and welfare. The various options invovled in a waste management process are landfilling, incineration, recycling wastes into useful products like tiles. Plastics recycling, in particular, would not be successful unless the proper infrastructure to collect the waste is being set, the technology to economically reprocess the waste into new products is available, and the establishments of markets for the cost-effective use of recycled plastics is important to both the construction and the plastics recycling industries.

3. MATERIALS USED

The various materials used for the manufacture of floor tiles using waste plastics are discussedbelow.

Figure 1-waste plastic and colourfull tiles.

3.1 Sand:

Well graded locally available sand, free from any organic impurities, passing through 600 micron IS sieve is used.

3.1.1 Sand is a important construction material and its uses:

Sand is really one of the most important construction materials. If we consider (1:2:4) proportion cement concrete work by its volume, the percentage of sand in totality is 2/(1+2+4) X 100=28.57.Thus, the role of construction sand would be more than 28 %. Similarly, if we consider cost basis in Kathmandu valley the role of sand would be more than 21 %. So, sand is an important construction material.

"Sand is an important construction material of natural origin. Mixed with cement and lime, millions of tons of sand are used every month for construction as mortar, plasters and concrete. The term sand is used for rock particles that range in grain size between 2mm and 1/16mm. In comosition, they are predominantly an oxide of silica (SiO_2).

Mineralogical, they consist mostly broken grains of mineral Quartz (SiO_2) produced as a result of breakdown of granites, sandstone and similar rocks by natural processes of weathering and erosion" (Sing, 2004-2005).

3.1.2 Uses of Sand:

Sand is massively used for concreting, Sand is used for preparation of mortar to bind with brick or stone or other materials, Sand is used for preparation of mortar to plaster and pointing on the wall and surfaces., Sand is massively used for concreting.,

Hydropower Work

a. Catchment

b. Dam construction

c. Power house and much more

Road works, Side drain work, Seal coat work, Pre-mix asphalt concrete work, Soling work, Pavement work, RCC pipe joining work

Canal work, Damp proof work, Tar felt work, Bitumen paint DPC.
Special work of sand: Sand is used for glass production., Sand is used for abrasive in sand blasting, Filtering water, Brick manufacture plant, Sand bags are used for protection against the flood, Sand castle building is popular activity for competition, Sand animation is a type of performance art., Aquaria are lined by sand, instead of gravel since it will be low cost., Rail road‟s use sand to improve the traction of wheels on the rails, Sandy soil will be ideal soil for some crops like watermelon, peaches and peanuts.

3.1.3 Sand for construction works:

Different construction works require different standards of sand for construction.
Brick Works: Finest modulus of fine sand should be 1.2 to 1.5 and silt contents should not be more than 4%. Plastering Works, Finest modulus of fine sand should not be more than 1.5 and silt contents should not be more than 4%.
Concreting Works: Coarse and should be used with finest modulus 2.5 to 3.5 and silt contents should not be more than 4%" (Praveen, et al 2015-2016).

3.1.4 Classification of Sand:

It is true people do not wonder about the origin of sand. Thousands of years need to pass for rocky material to finally turn into sand or clay. The sand that eroded from sandstone rocks, deposited as a beach, dune or desert. After millions of years, sandstone rocks turned into sandstone cliffs and eventually eroded for the second time. I noticed the differences in the various kinds of sand, e.g. from beaches, rivers, dunes, mountains, deserts and also from sandpits or quarries.

Generally sand can be classified into three categories from different prospect: Sand"s origin point of view, Composition Point of view and Grain size point of view.

Under origin point of view we can divided into 4 sub categories i.e.
i)river sand ii) Pit sand and iii) Marine sand and iv) Sand dune

Under composition point of view, we can divide into 3 sub categories i.e.
i) Clean sand ii) Silt sand and iii) Clayey sand

Under grain size point of view, we can devide into 3 sub categories i.e.
i)Course sand ii) Medium sand and iii) Fine sand

"Sand found in land deposits is known as "pit sand" such grains are generally irregular, shape and angular. Sand carried by water, such as found along banks of rivers or lakes is known as "river sand" such grains are generally rounded and smooth, due to the action of water. Both types of sand are suitable for cement work, so long as they are well-graded andclean"(Thomas&Jordan,1987).

"Texture: Sandstones are composed almost entirely of well-sorted, sub-angular to rounded sand grains. The texture of sand stone is: (i) "course grained" when the size of grains is 2 to 0.5mm, (ii) "medium grained" when the size of grains is 0.5 to 0.25mm, and (iii) "fine grained" when the size of grains is 0.25 to 0.1mm. Structure: The common structures seen in the sand stones are stratification, current bedding, ripple marks and rain prints" (Bangar, 1995)

Sand fraction: The fraction of soil composed of particles between the sizes 2.0mm to 0.06mm.The sand fraction may be sub divided as follows.

		BS test sieve sizes to be Used for separation
Course sand	2.0mm to 0.6mm	2mm to 600µm
Medium sand	0.6mm to 0.2mm	600µm to 212µm
Fine sand	0.2mm to 0.06mm	212µm to 63µm" (BS 1377:1975).

"(a) According to mode of origin, sands are of three types, namely, pit sands, stream sands, and marine sands.

(b) According to composition. Following three categories of sand are recognized in engineering fields:

Clean sands: These are well-graded containing entirely or mostly quartz (SiO_2) particles in wide range of grain size.

Silty sands: These are poorly graded sands, which have considerable proportion of silt (particle size between (1/16 – 1/256mm) and other non plastic-fines.

Clayey Sands: These are poorly graded sands having a prominent clay fraction (particle size below 1/256 mm) and also plastic fines.

Obviously, for the use of making mortars, plasters and concrete, sand of category clean sands must only be used. Sand is also obtained by crushing natural quartzite rock to the required grain size.

(c) According to the grain size, sand is classified as coarse, medium and fine sand: 2-1mm, 1-0.25mm, and 0.25mm- 0.15mm, respectively" (Sing, 2004-2005)

"Sand is generally considered to have a lower size limit of about 0.07 mm (0.003 in.) or a little less. Material between 0.06mm (0.002 in) and 0.02 mm (0.0008 in.) is classified as silt, and smaller particles are termed clay. Loam is a soft deposit consisting of sand, silt and clay in about equal proportions"(Neville & Brooks, 1997).

3.1.5 Grading:

The particle size grading of sand for use in mortars for unreinforced masonry work shall be within the limits specified in Table 1.

Table 1: Requirements of grading for sands for unreinforced masonry work:

IS SIEVE DESIGNATION (see IS:460-1962*)	**Percentage by weight passing IS Sieve**
4.75mm 2.36mm 1.18mm 600micr on 300micr on 150micron	100 90-100 70-100 40-100 5-70 0-15

The particle size grading of sand for use in mortars for reinforced masonry work shall be within the limits specified in Table 2.

Table 2: Requirements of Grading for Sands For reinforced masonry work:

IS SIEVE DESIGNATION **(see IS:460-1962*)**	**Percentage passing by weight**
4.75mm 2.36mm 1.18mm 600micr	100 90-100 70-100 40-80 5-40

on 300micr on 150micron	0-10

A sand whose grading falls outside the specified limits due to excess or deficiency of course or fine particles may be processed to comply with the standard by screening through a suitably sized sieve and/or blending with required quantities of suitable size of sand particles. Any deviation may be left to the discretion of the engineer or architect in charge of the work in the light of practical experience with the use of local material

The various sizes of particles of which the sand is composed shall be uniformly distributed through the mass.The required grading may often be obtained by screening and/or by blending together either natural sands or crushed stone screenings, which are by themselves, unsuitable."[Indian standards Specification for sand with masonry mortars :]"(IS2116-1965).

"Sieve analysis and Fineness Modulus. The object of this test is to study the grading of sand. The sample taken should be not les than 1.5 kg. Find the actual weight of the sample. The sample is separated into different sizes by sieving i.e. passing it through standard sieve. The percentage by weight of the residue on each sieve is noted. The standard sieve is noted. The standard sieves used are, 80mm, 63mm,40mm, 20mm, 10mm, No. 480 (480 micron), No. 240(240 micron), No.120(120 micron), No. 60(60 micron), No. 30(30 micron), No. 15(15 micron).

Table 3: Requirements of Grading for Sands for reinforced masonry work:

IS Sieve Number	**Percentage amount offine aggregate retained on each sieve**	**Percentage amount of course aggregate retained on each sieve**
80mm	-	-
63mm	-	-
40mm	-	3.5
20mm	-	15.0
10mm	-	59.5
No.48	3.5	90.5
0	19.5	100
No.24	29.5	100
0	53.3	100
No.12	88.5	100
0	109	100
No.60		
No.30		
No.15		
Total	249.5	668.5

The sum of percentage amount of fine aggregate retained on each sieve divided by 100 gives the fineness modules of the aggregate.

Based on the fineness modulus sand can be classified into (i) find sand (FM 2.2 to 2.60). (ii) Medium sand (FM 2.60 to 2.90), and (iii) Course sand (FM 2.90 to 3.20).

3.2 Plastic Waste

Waste plastic generated from the waste elements of plastic chairs and other elements of polypropylene basis is used. Figure 1 shows a waste plastic from plastic chairs,bottles,covers etc used for producing floor tiles.

3.2.1 The History of Plastics:

From a historical viewpoint, the development of plastics can be regarded as one of the most important technical achievements of the twentieth century. In just 50 years plastics have permeated virtually every aspect of daily life, paving the way for new inventions and replacing materials in many existing products. The success of these products has been based on their properties of resilience, resistance to moisture, chemicals and photo-biodegradation, their stability and the fact, that they can be molded into any desired form.

The original breakthrough for the first semi-synthetic plastics material – cellulose nitrate, occurred in the late 1850's and involved the modification of cellulose fibers with nitric acid. Cellulose nitrate had many false starts following its invention by a Briton, Alexander Parkes, who exhibited it as the world's first plastics in 1862. The world's first plastic was reproduced at the turn of the twentieth century, and was based mainly on natural raw materials. Only in 1930 were thermoplastics, made from the basic materials styrene, vinyl chlorine and ethylene, introduced onto the market. However, the main growth of the plastics industry did not take place before the 1960's, reaching production of over 40 million ton per year in 1973. Following a temporary drop in production during the oil crises and the economic recession in the beginning of the 1980's, the world production of plastics continued to increase to approximately 77 million ton in 1986, and 86 million ton in 1990.

3.2.2 What is Plastic?

Plastic is the general term for a wide range of synthetic or semi synthetic polymerization products. They are composed of organic condensation or addition polymers and may contain other substances to improve performance or economics. There are few natural polymers generally considered to be"plastics". These polymers are broken in presence of suitable catalyst, into monomers such as ethylene, propylene, vinyl, styrene and benzene. These monomers are then chemically polymerized into different categories of plastics This subject is dealt in a separate chapter in this document.

3.2.3 Categories of plastics:

A) Recyclable Plastics (Thermoplastics): PET, HDPE, LDPE, PP, PVC, PS, etc.
B) Non-Recyclable Plastics (Thermoset & others): Multilayer & Laminated Plastics, PUF, Bakelite, Polycarbonate, Melamine, Nylon etc.

As per BIS Classification, there are seven categories of plastics like; PET, HDPE, PVC, LDPE, PP, PS and other. The typical thermoplastic and thermosetting resins.The typical thermoplastic and thermosetting resins are shown in below table.

Table 4:For thermoplastic and thermosetting resins:

S.No	Thermo Plastic	S. No	Thermoset Plastic
1	PolyethyleneTetraphthalate(PET)	1	Bakellite
2	Polypropylene(PP)	2	Epoxy
3	Poly Vinyl Acetate(PVA)	3	Melamine
4	Poly Vinyl Chloride(PVC)	4	Polyester
5	Polystyrene	5	Polyurethane
6	Low Density Polyethylene(LDPE)	6	Urea-Formaldehyde
7	High Density Polyethylene(HDPE)		

3.2.4 Description of Plastic Waste:

Plastic products have become an integral part of our daily life as a basic need. It is produced on a massive scale worldwide and its production crosses the 150 million ton per year globally. In India approximately 8 Million ton plastic products are consumed every year (2008). Its broad range of application lies in films, wrapping materials, shopping and garbage bags, fluid containers, clothing, toys, household and industrial products, and building materials. It is a fact that plastics will never degrade and remains on landscape for several years. Mostly, plastics are recyclable but recycled products can again be recycled but the litter left over in earth system and water systems are more hazardous to the environment. The recycling of a virgin plastic material can be done many times, but after every recycling, The plastic material is deteriorated due to thermal pressure. Considering, 70% of plastic Consumption is converted as waste over time, approximately 5.6 million ton per annum (TPA) plastic waste is generated in country, which equals to 15342 ton per day (TPD).

Plastic waste has a significant portion in total municipal solid waste. Though, there is a formal system of waste collection in urban areas, however, informal sectors i.e. rag pickers, collect only value based plastics waste such as pet bottles etc. Plastic carry bags, metalized plastics and low quality plastic less than 20 micron do not figure in their priorities, because collecting them is not profitable. This is primarily because the rewards are not much as compared to the efforts required for collection, and this leads to plastic bags and other packaging materials continuing to pose a major threat to the environment.

Moreover, the major concern for this waste stream is that these are non- biodegradable and remains in the environment for many years. Clogging of drains by plastic waste is a common problem. The packaging and poly vinyl chloride (PVC) pipe industry are growing at 16-18% per year. The demand of plastics goods is increasing from house hold use to industrial applications. It is growing at an annual rate of 22% annually. The polymers production has reached to 8.5 million ton in 2007.

3.2.5. Plastic Materials:

Plastics are man-made organic materials that are produced from oil and natural gas as raw materials. Plastics consist of large molecules (macromolecules), the building blocks of all materials. The molecular weights of plastics may vary from about 20,000 to 100,000 mg/L. Plastics can be regarded as long chains of beads in which the so-called monomers. Development of plastics production worldwide ethylene, propylene, styrene and vinyl chloride are linked together to form a chain called a polymer. Polymers such as polyethylene (PE), polystyrene (PS) and polyvinyl chloride (PVC) are the end products of the process of polymerization, in which the monomers are joined together. In many cases only one type of monomer is used to make the material, sometimes two or more. A wide range of products can be made by melting the basic plastic material in the form of pellets or powder (1). Plastics can be either thermoplastics or thermosets, having melting which is given-in below table.

Table 5: Melting point of common thermoplastic:

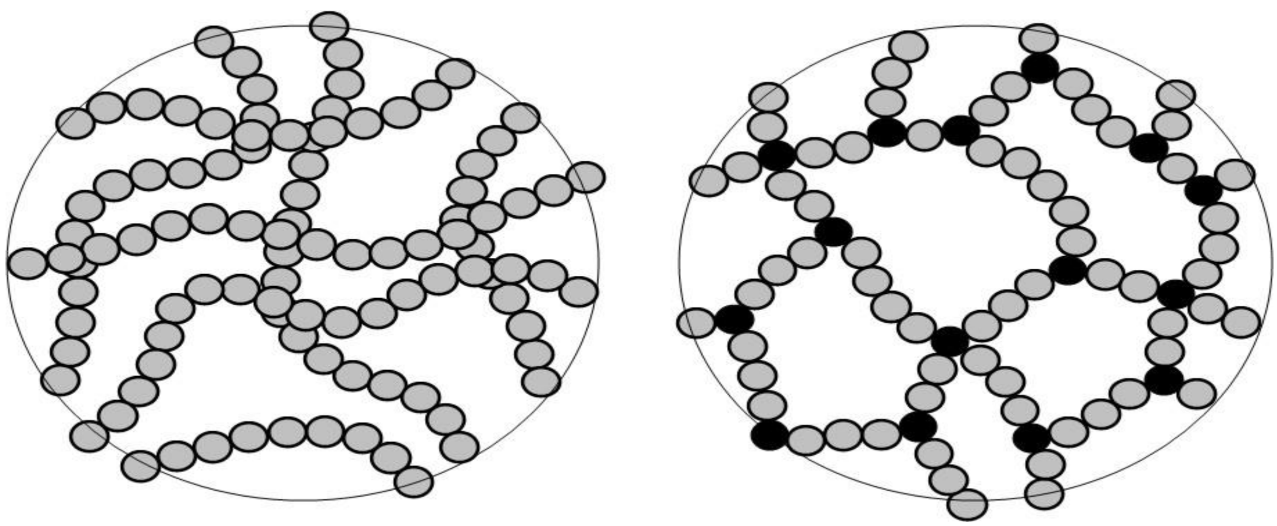
Polyolefin	**Melting Point(degree celsius)**
LDPE	115
LLDPE	123
HDPE	130
Polyethylene(PE)	135
Polypropylene(PP)	170
Polystyrene(PS)	240
Polyethylene terephthalate(PET)	245
Polyamide 6 (PA6)	233

Materials that repeatedly soften on heating and harden on cooling are known as thermoplastics. They can be melted down and made into new plastic end products. Thermo plastics are similar to paraffin wax. They are dense and hard at room temperature, become soft and moldable when heated, dense and hard again and retain new shapes when cooled (see Figure 3 for a schematic overview of the structure of thermoplastic and Thermoset).

This process can be repeated numerous times and the chemical characteristic of the material do not change. In Europe, over 80% of the plastics produced are thermoplastics (1). Thermosets, on the other hand are not suitable for repeated heat treatments because of their complex molecular structures (see Figure 3b).

The structure of thermosetting materials resembles a kind of thinly meshed network that is formed during the initial production phase. Such materials cannot be reprocessed into new products unlike thermoplastics. Thermosets are widely used in electronics and automotive products. The properties of plastics can be modified by a number of substances known as additives.

Below figure shows struture of thermoplastic and thermoset.



(A) Thermoplastic (B) Thermoset

Fig 2 :Structure of Thermoplastic and Thermoset

3.2.6 Types of Plastics:

In industrialized countries, literally hundreds of plastic materials are available commercially. In economically less developed countries however,fewer types of plastics tend to be used. In both economically less developed and industrialized countries, the four types of plastics that are most commonly reprocessed or recycled are polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC). Each of these can be subdivided according to their density, the type of process involved in their manufacture, and the additives they contain. These four types are briefly described below.

1) Polyethylene (PE):

The two main types of polyethylene are low density polyethylene (LDPE) and high density polyethylene (HDPE). LDPE is soft, flexible and easy to cut, with the feel of candle wax. When very thin it is transparent, when thick it is milky white, unless a pigment is added. LDPE is used in the manufacture of film bags, sacks and sheeting, blow-molded bottles, food boxes, flexible piping and hosepipes, household articles such as buckets and bowls, toys, telephone cable sheaths, etc. HDPE is tougher and stiffer than LDPE, and is always milky white in color, even when very thin. It used for bags and industrial wrappings, soft drinks bottles, detergents and cosmetics containers, toys, jerry cans, crates, dustbins, and other household articles.

2) Polypropylene (PP):

Polypropylene is more rigid than PE, and can be bent sharply without breaking. It is used for stools and chairs, high-quality home ware, strong moldings such as car battery housings, domestic appliances, suitcases, wine barrels, crates, pipes, fittings, rope, woven sacking, carpet backing netting surgical instruments, nursing bottles, food containers, etc.

3) Polystyrene (PS):

In its unprocessed form, polystyrene is brittle and usually transparent. It is often blended (copolymerized) with other materials to obtain the desired properties. High-impact polystyrene (HIPS) is made by add in grubber. Polystyrene foam is often produced by incorporating a blowing agent during the polymerization process. PS is used for cheap, transparent kitchen ware, light fittings, bottles, toys, food containers, etc.

4) Polyvinyl chloride (PVC):

Polyvinyl chloride is a hard, rigid material, unless plasticizers are added. Common applications for PVC include bottles, thin sheeting, transparent packaging materials, water and irrigation pipes, gutters, window frames, building panels, etc. If plasticizers are added, the product is known as plasticized polyvinylchloride (PPVC), which is soft, flexible and rather weak, and is used to make inflatable articles such as footballs, as well as hosepipes and cable coverings, shoes, flooring, raincoats, shower curtains, furniture coverings, automobile linings, bottles, etc. Other types of plastics include polycarbonate (PC), polyethylene terephthalate (PET), he polyurethane (PU) and nylon or polyamide (PA). Below table depicts the types of plastics and their variations in bending strength.

Table 6:Types of plastics and variation in bending strength:

Types of plastic	Percentage of Plastic	Bending Strength in kg	Compression strength (Ton)
PE	10	325	250
	20	340	270
	25	350	290
Poly propylene	10	350	280

	20	370	290
	25	385	310
PS	10	200	155
	20	210	165
	25	215	170
PE foam	10	310	250
	20	325	265
	25	335	290
PP foam	10	340	270
	20	360	290
	25	365	270
Laminated Plastic	10	360	290
	20	385	310
	25	400	335
BOPP	10	380	300
	20	400	310
	25	410	330

3.2.7 Sources of Plastic waste:

Plastics can be used for many purposes, and thus, waste plastics are generated from a wide variety of sources. The main sources of plastic waste can be classified as follows: industrial, commercial and municipal waste.

1) Industrial waste:

Industrial waste and rejected material (so-called primary waste) can be obtained from large plastics processing, manufacturing and packaging industries. Most of this waste material has relatively good physical characteristics; i.e., it is sufficiently clean,since it is not mixed with other materials. It has been exposed to high temperatures during the manufacturing process which may have decreased its characteristics, but it has not been used in any product applications. Many industries discard polyethylene film wrapping that has been used to protect goods delivered to the factory. This is an excellent material for reprocessing, because it is usually relatively thick, free from impurities and in ample supply. Many industries may provide useful supplies of primary waste plastics:

- The automotive industries: spare-parts for cars, such as fan blades, seat coverings, battery containers and front grills.
- Construction and demolition companies: e.g. PVC pipes and fittings, tiles and sheets.
- Electrical and electronics industries: e.g. switch boxes, cable sheaths,cassette boxes, TV screens, etc. Unregistered plastics processing industries sometimes recycle the waste they generate but this is relatively very low. Physical properties of waste plastics are given below in table.

Table 7:Physical properties of waste plastics:

Commercial Plastic Material	**Nature and Plastic**	**Thickness (μ)**	**Softenig Point(degree celsius)**
Cup	PE	150	100-120
Carry Bag	PE	10	100-120
Water Bottle	PET	210	170-180
Cool Drinks Bottle	PET	210	170-180
Chocolate Covers	Polyester+PE+Metalized Polyester	20	155
Parcel Cover	PE	50	100-120
Supari Cover	Polyester+PE	60	120-135
Milk Pouch	LDPE	60	100-120
Biscuit Covers	Polyester+PE	40	170
Decoration Papers	BOPP	100	110
Film	PE	50	120-130
Foam	PE	NA	100-110
Foam	PS	NA	110

Considerable amounts of waste plastics generated by many industries remain uncollected or end up at the municipal dump. Industries are often willing to cooperate with private collecting or reprocessing units.

2) Commercial waste:

Workshops, craftsmen, shops, supermarkets and wholesalers may be able to provide reasonable quantities of waste plastics for recovery. A great deal of such waste is likely to be in the form of packaging material made of PE, either clean or contaminated. Hotels and restaurants are often sources of contaminated PE material.

3) Municipal waste:

Waste plastics can be collected from residential areas (domestic or household waste), streets, parks, collection depots and waste dumps. In Jhansi, considerable amounts of plastic waste can be found within the Municipal Solid Waste stream due to the littering habit of the population. The most common type of plastic waste within the municipal waste stream is the "sachet" water film bags that are discarded in discriminately soon after consuming its contents. In Asian countries in particular, the collection of this type of waste is widespread. However, unless they are bought directly from households, before they have been mixed with other waste materials, such waste plastics are likely to be dirty and contaminated. Sometimes the plastics can be separated and cleaned quite easily, but contamination with hazardous waste is not always visible and may be more difficult to remove. Litter that has been waiting for collection for some time may have been degraded by sunlight. This is mainly a superficial effect, however, and does not always mean that the plastics cannot be reprocessed.

3.2.8 Hazardous effects of Plastics:

Polluting Substances:

In terms of environmental and health effects it is important to differentiate between the various types of plastics. Most plastics are considered nontoxic (PVC is an important exception). Polyethylene (PE) and polypropylene (PP), for example, are inert materials (2), but it should be realized that plastics are not completely stable.Under the influence of light, heat or mechanical pressure they can decompose and release hazardous substances. For example, the monomers from which polymers are made may be released and may affect human health. Both styrene (which is used to make polystyrene, PS) and vinyl chloride (used to make PVC) are known to be toxic, and ethylene and propylene may also cause problems (3). The environmental effects of plastics also differ according to the type and quantity of additives that have been used. Some flame retardants may pollute the environment (e.g. bromine emissions). Pigments or colorants may contain heavy metals that are highly toxic to humans, such as chromium(Cr), copper (Cu), cobalt (Co), selenium (Se), lead (Pb) and cadmium (Cd) are often used to produce brightly colored plastics. Cadmium is used in red, yellow and orange pigments. In most industrialized countries these pigments have been banned by law. The additives used as heat stabilizers (i.e.chemical compounds that raise the temperature at which decomposition occurs), frequently contain heavy metals such as barium (Ba), tin (Sn), lead and cadmium, sometimes in combination (Nagelh out, 1989).

4. Methodology

The methodology adopted for producing floor tiles using waste plastic involves following experimental work.

4.1 Melting of Plastic Waste:

The selected waste plastic from different elements is weighed, crushed to smaller pieces and then melted in a container at its melting point(150-170 degree celsius). Figure 3 shows the arrangement for melting the waste plastic using furnance and it indicates the waste plastic in its melted form.

Figure 3 - Melted plastic.

Materials made of thermoplastic polymers such as polyethylene (PE), polypropylene (PP), poly(methyl methacrylate) (PMMA), polyacrylonitrile (PAN), polystyrene (PS), polyamide (PA-6), polycarbonate (PC), polyvinyl chloride (PVC), polyurethane (PU), *etc.* are widely available on the market, and are increasingly being used in a range of commercial products, from textiles to moulded items. However, these materials are highly flammable and for their safe and wider usage they need to be sufficiently flame retarded, either using appropriate additive(s), or through adequate levels of chemical modification(s). The flammability and resulting destruction of property, and the detrimental effects on the environment, are not the only major problems. Fire fatalities are predominantly caused by the evolved smoke and toxic gases, exacerbated in some cases by poisonous fumes emitted from synthetic organic polymers. In addition, many thermoplastic materials tend to melt-flow and melt-drip under heat/fire, and this can pose a very serious secondary hazard in fires involving them—for instance, in the situations where polymeric materials are used in the construction of doors, windows, ceilings and roofs, curtains, etc. It is believed that in the Stardust night club fire (1981, Dublin,Ireland), which led to 48 fatalities and 214 serious injuries, one of the main reasons responsible for the escalation of the fire was that the melt-flow droplets from the polymeric lining of the ceiling caused ignition of the seat-cushions, which were made of polyurethane.

Generally, the combustion of a polymeric material is a highly complex process, which involves a series of interrelated and/or independent stages occurring both in the condensed phase and in the gaseous phase, or at the interphase between these two. Under the influence of heat/fire, thermoplastic polymeric materials often undergo deformations, and this will lead to corresponding drastic changes in their mechanical and associated properties. In addition, the effect of melt-flow, melt-drip behaviour and secondary ignition of other possible fuel loads in the vicinity can complicate the situation further and can also lead to the escalation of fire.Currently, a range of qualitative, semi-quantitative and quantitative testing techniques are employed, both at laboratory scale and for commercial purposes, to evaluate the complex behaviour of polymeric materials that are exposed to heat and/or fire. They include, but are not limited to, techniques such as: thermo-gravimetric analysis (TGA), oxygen bomb calorimetry, limiting oxygen index (LOI) measurements, Underwriters Laboratory 94 (UL-94) tests, cone calorimetry, etc. All of the above mentioned methods have their own advantages and disadvantages. For example, the UL-94 test which is commonly used as an industrial standard, is a vertical burning test of a solid plaque of the material, where an ignition source is applied to the bottom tip of the specimen hung in a chamber of ambient air. In this test, a specimen (125 mm ˆ 12.5 mm ˆ (3–4) mm in size) is placed above a Bunsen burner with a 20 mm flame height. Initially, the flame is applied to a polymer sample for 10 s and then removed. If the flame on the tested sample is extinguished, the burner is applied again for 10 s. The flaming times, any occurrence of dripping, and a propensity of melted drops to ignite surgical cotton placed underneath the sample, are usually observed and recorded in the test runs. Generally, the test leads to a pass/fail criterion of the material in terms of classifications, such as: V-0, V-1, V-2, *etc*. Here, a V-0 rating is considered as a "pass" (burning stops within 10 s on a vertical specimen; drips of particles allowed as long as they are not inflamed), whereas V-1 (burning stops within 30 s on a vertical specimen; drips of particles allowed as long as they are not inflamed) and V-2 (burning stops within 30 s on a vertical specimen; drips of flaming particles are allowed) are considered as a "fail" in the test. When objects containing thermoplastic polymers are exposed to heat and/or a fire, they usually exhibit a melt-flow and/or dripping behaviour. As a result of a polymer's melt-flow behaviour, effected downwards under the influence of the gravitational force, two scenarios are possible: either further burning ceases owing to the removal of mass and heat from the primary pyrolysis zone (safe route), or it could become a secondary source of ignition, which, in turn, could lead to the acceleration of the growth of the fire (hazardous route). The latter case occurs when the polymer droplets either constitute a pool of fuel for further burning or cause secondary ignition of other combustible materials that they come in contact with. Typically, when the liquid pool is ignited, the burning surface area increases drastically and the growing pool fire could ignite neighbouring objects, thus resulting in an increased overall burning rate and heat release rate; the thermal feedback from this could then result in the enhanced production of a polymer melt. If the pool fire is not contained, this may potentially lead to the spreading of the fire along the horizontal surfaces (e.g., flooring). Generally, the following factors can affect the development of the overall hazardous scenario: size of the burning object, chemical nature of the materials and surface area below the object, size and the temperature of melting drops,and frequency of dripping (i.e., number of drops formed in unit time).

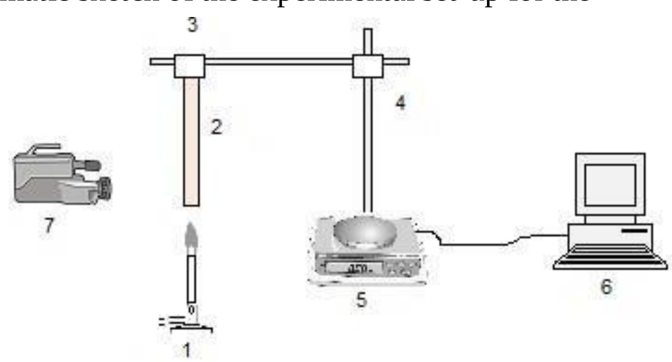
The melt-drip behaviour can be explained by a combination of physical factors that accompany the thermal/chemical decomposition pathways of a polymer. Thermoplastic polymers often will soften and flow when they are heated to temperatures exceeding their glass transition temperature, melting point, or viscous flow temperature. Generally, melting under the influence of an external heat source will result in the polymeric chains gaining a higher degree of translational mobility. Another factor that should be considered here is the concomitant reduction in the viscosity of the melt, which also increases as the thermal decomposition of polymeric chains leads to the formation of smaller fragments (oligomers) and or low molecular weight species. Zhang et al.found that the degree of melt-flow is directly proportional to the glass transition temperature (T_g) of a polymer: i.e., polymers with the lower glass transition temperatures melt-drip significantly more than those with higher values.The melt-flow/drip phenomenon among polymers, although reported widely, is yet to be fully understood. This problem still needs a rigorous quantitative approach in establishing the factors affecting melt-dripping behaviour of different thermoplastics. Although there are many tests available to measure the flammability of polymeric materials, only the UL-94 vertical burning test allows, at least, a qualitative evaluation of their melt-flow and melt-drip behaviours. Unfortunately, as mentioned earlier, this technique only yields qualitative information.

4.1.1 Experimental Approaches:

Many research groups have attempted to quantitatively assess the melt-flow and melt-drip behaviours of polymeric materials. The vast majority of these studies were based on the UL-94 experiments. Most of these research groups also suggested methodologies that were based on measurements of the mass of drops collected and weighted after the testing of vertically oriented polymer samples. For example, the size and the mass of the drops formed during the UL-94 test were measured in the study carried out on PA-6 systems (BASF, Florham Park, NJ, USA). Other studies, performed by different research groups were focused on the evaluation of polymers' melt-flow drip behaviour in fires, whilst those carried out at the University of Bolton, UK, also considered non-flaming operating conditions. The parameters measured and reported in the literature include: numbers, masses, shapes, sizes of individual drops; real-time mass data and mass loss rate; dripping time and the time at which the first drop appears and falls down; and the viscosity of melts.

Wang et al.have studied the burning and dripping behaviours of eight polymeric materials under the UL-94 vertical test conditions. The polymeric systems tested included: acrylonitrile butadiene styrene (ABS), low-density polyethylene (LD-PE), PA-6, PC, PMMA, PP, PS and white pine. The experimental set-up used in this work is schematically shown in Figure. A polymeric sample (2), attached to a clamp (3), was orientated vertically above the flame from a Bunsen burner (1). A clamp was fixed to a bracket (4), which was then placed on an analytical balance (5). The real-time mass data (*i.e.*, mass retention/mass loss) were recorded every second with the aid of a computer (6) connected to the balance. A camera (7) was employed for the entire duration of the testing to record the burning and dripping phenomena of the polymer in question. The experiments were carried out in a quiescent air environment.

Figure 4: A schematic sketch of the experimental set-up for the



UL-94 vertical test: 1—Bunsen burner; 2—tested polymer sample; 3—clamp; 4—bracket; 5—balance; 6—computer; 7—camera (used by Wang et al.).

Wang et al. also reported two modes of melt-drip phenomena: a wax-like dripping with smaller sized polymeric drops for samples of PP, LD-PE and PA-6, and another mode associated with larger sized drops, characteristic for ABS, PC, PMMA and PS. It should be noted here that these two types of melt-dripping were gauged by the size of the polymeric specimen before and after the dripping, rather than by the actual diameter of the drops. It was also observed that the melt-dripping of ABS, PMMA and PS happened relatively later (for example, for 2 mm thick samples, the first dripping occurred at 65–66 s for ABS, at 61–62 s for PMMA, and at 22–23 s for PS) during the experimental run and led to a significant mass loss, whereas LD-PE and PP began to melt-drip earlier on (for 2 mm thick samples time of first dripping for LD-PE was recorded at 13–14 s and for PP—at 12–13 s) and often with drops having relatively lower masses. In addition, the authors observed that the melt-flow of PA-6 and PC led to flame extinction, and there was no dripping for a white pine sample due to a char formation.

During the course of their investigation, Wang et al. found that the mass loss of tested polymeric samples was within 0.001–0.01 g/s range. In addition, it was reported that the mass reduction, before the flame reached the clamp and the polymer began to drip, only accounted for a small fraction of the initial mass of the specimen, which did not exceed 4 wt %. Thus, it was concluded that the UL-94 rating depended on the burning of a relatively small portion of the polymer specimen. For the polymers tested by the authors, the mass of the first drop was found to be in the range of 0.0012 to 0.9045 g, while the diameter of the first drop was within 2.0–10.0 mm range. The mass of the first drop also increased with the time taken for it to form and fall under gravity. It was concluded that the dripping rates decreased when the size and mass of the drops increased in a typical UL-94 vertical burning test. The research group at the University of Bolton, UK, has developed an experimental technique, which allowed them to quantitatively evaluate the melt-flow/drip behaviour of thermoplastic polymers in real time. They reported on the melt-drip behaviours of PP, PA-6, PMMA, PS, PC and polyethylene terephthalate (PET) exposed to a radiative heat flux imposed by a purpose-built furnace. For the purpose of comparison, the authors also conducted experiments that replicated the flaming conditions of the UL-94 vertical test. The schematic diagram of the experimental rig used by them is shown in below Figures. The polymer samples were prepared as plaques of two different sizes: “small size” 100 mm ˆ 6 mm ˆ (3–4) mm and “standard size” 125 mm ˆ 12.5 mm ˆ (3–4) mm.As is shown in below Figure, a polymer sample (2) was placed in an 800 W electric furnace (1) that was previously heated to a set temperature. The furnace had a tube-like borehole of dimensions: 120 mm long and 25 mm in diameter. The temperature in the furnace was adjusted with a temperature controller (3), which could measure the core surface temperature with the aid of a thermocouple. The polymeric sample was attached through a thin wire and a built-in hook to the bottom of a balance (5), which in turn was connected to a computer (6). The mass loss of the sample was recorded in real time by using appropriate data acquisition software. The furnace, equipped with a pulley mechanism, was able to move up or down until the bottom tip of the sample was located at the centre of the furnace bore. The thermocouple was inserted in a tube orifice in order to measure the air temperature inside the bore. A conveyer belt (4), moving back and forth at a constant rate of 11.2 cm/s, with a pre-weighed aluminium foil strip, was placed underneath the furnace borehole to collected the melt drops of the polymeric sample. By weighing the foil, before and after the test, the total mass of drops produced can be evaluated. In addition to this, the number, size (diameter and thickness), shape and distance (*i.e.*, time) between individual drops were evaluated by taking pictures of the aluminium foil during and after the experiments.Each polymer tested at the University of Bolton, UK, was characterised by a specific temperature interval T_DˆI, between the D-point, when sample began to melt-drip, and I-point, when it ignited and burned. Four temperature values were selected by the authors from the T_DˆI interval to set the furnacetemperature for each type of polymer. From the curves of mass retention (measured as percentages) versus time (in seconds), obtained through the experiments, the following parameters were evaluated: time to the first melt drip, mass of the first drop, total number and mass of the melt drops. The mass loss recorded on the balance was associated with volatilisation and melt-dripping of the polymeric sample. The degree of volatilisation was subsequently calculated by subtracting the total mass of drops collected on the aluminium foil from the total mass loss.

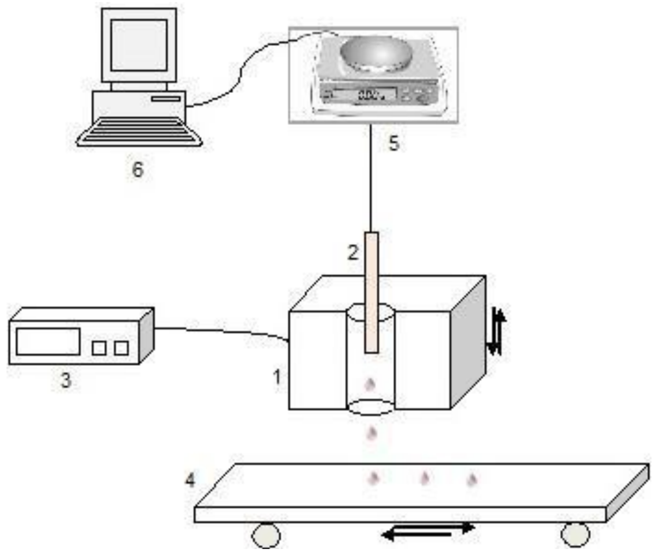


Figure 5:A schematic sketch of the experimental set-up to stud the melt-drip phenomenon in non-flaming conditions: 1—electric mobile furnace; 2—tested polymer sample; 3—adjustable temperature controller; 4—conveyer belt with aluminium foil; 5—balance; 6—computer.

As mentioned earlier, all the experiments were repeated by Kandola *et al.* in the experimental set-up without the furnace, i.e., in the flaming conditions similar to the vertical UL-94 test. As seen from the schematic sketch, shown in below Figure, a sample of a polymer (2) hung on a hook was attached to a balance (4) connected to a computer (5) for mass data acquisition. A bottom-end of the tested polymeric sample was placed above the flame (20 mm high) from a Bunsen burner (1) as per the standard UL-94 procedure. The drops produced during melting and burning of the sample were collected on a foil strip, placed on a conveyer belt (3) (below Figure).

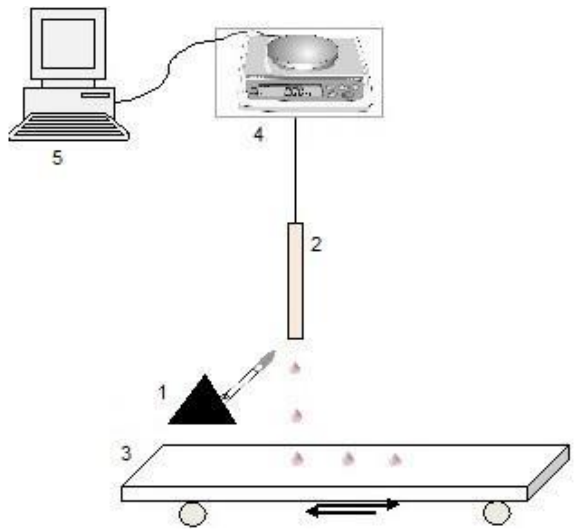


Figure 6: A schematic sketch of the experimental set-up equivalent to the UL-94 test: 1—burner; 2—tested polymer sample; 3—conveyer belt with aluminium foil; 4—analytical balance; 5—computer (used by Kandola et al.).

In addition to the above-mentioned experiments, the researchers also performed thermo-gravimetric and associated analyses (TGA/Derivative Thermogravimetric Analysis (DTG)/Differential Thermal Analysis (DTA)) of polymers and their droplets in air and nitrogen atmospheres. Based on the TGA data obtained in air for the polymers and droplets, the extent of decomposition (as a percentage) was calculated. The summary of the data reported by Kandola et al.including glass transition temperature T_g, $T_D - I$ interval, time range corresponding to first melt dripping, lower and higher values of masses and diameters of individual drops, total number of drops collected, as well as calculated values of degree of volatilisation and degree of decomposition in air and in nitrogen atmospheres is given in below Table.

Table 8: Summary of melt dripping data obtained by Kandola et al. [7].

Melt Dripping Date						**Polymers**
	PP	**PA-6**	**PC**	**PET**	**PS**	**PMMA**
T_g (°C)	26	- 54	147	68	96	110
T_D I (°C)	118	223	228	237	75	100
Time to First Melt Drip (s)	6–9	9–32	6–19	6–28	9–15	0–50
Mass of an Individual Drop (mg)	3–6	20–250	59–71	24–165	20–100	14–32
Diameter of an Individual Drop (mm)	4–6	11–17	11–12	9–11	9–10	4–5
Number of Drops	54–90	2–10	7–12	7–12	13–20	10–14
Degree of Volatilisation (%)	33–42	32–40	21–25	16–32	14–22	42–67

Degree of Decomposition in Air (%)	36.8	26.6	6.0	ˊ1.2	26.0	35.0
Degree of Decomposition in Nitrogen (%)	49.0	13.2	3.0	ˊ4.6	7.4	ˊ13

PP: polypropylene; PA-6: polyamide; PC: polycarbonate; PET: polyethylene terephthalate; PS: polystyrene; PMMA: poly(methyl methacrylate).

4.1.2 Mechanistic Aspects

The melt-flow/drip behaviour of polymers depends on the underpinning mechanism(s) of their pathways of thermal decomposition. Correlations between the mechanism of polymer decomposition and its melting/dripping pattern were suggested by many researchers.

The three most common schemes for polymer decomposition mechanism are:

1. A random chain cleavage followed by further chain scission is characterised by low monomer yields in decomposition products and a rapid drop in molecular weight (e.g., for PE, PP).
2. A random chain cleavage followed by chain unzipping is characterised by high monomer yields in the decomposition products and a slow decrease in molecular weight of the polymer (e.g., for PMMA, poly(α-methyl)styrene, polytetrafluoroethylene, etc.).
3. An intra-chain chemical reaction followed by cross-linking reaction and carbonaceous residue formation, or random chain cleavage. This process generates a relatively high yield of volatiles from the inter-chain reaction, produces very little monomer, and accompanied with no or only a very slight decrease in molecular weight during the initial stages of decomposition (e.g., for PAN, PVC, etc.).

In some cases, several of the above mentioned schemes may occur simultaneously, depending on the sample size, heating rate, pyrolysis temperature, environment, and presence of any additives.

Wang et al. attempted to correlate the melt-drip behaviour with the mechanism of polymer decomposition under the influence of heat/fire. For polymers such as PP and PE, decomposing via random chain scission, small-sized drops were found to occur. For polymers such as PMMA, which degrade mainly by chain unzipping reaction, large-sized drops are likely to appear in vertical burning tests like the UL-94. The results obtained by Kandola et al. were in conformance with the established routes of polymer decomposition—i.e., PMMA will undergo predominantly end-chain scissions, resulting in near quantitative yield of the monomer, while PP, PA-6, PC, PET and PS will degrade mainly via random chain scissions.

The work carried out at the University of Bolton, UK, also demonstrated that the number, shape and the size of the individual melted drop was measured with good reproducibility. These attributes associated with the melt-flow/drip behaviour actually depend on the chemical nature (i.e., depending on individual chemical classes, such as polyolefins, styrenics, acrylics, polyesters, polyamides, etc.) of the polymer in question and on the mechanism of its decomposition. The authors have classified the polymers they have tested in four groups.

Group I included PP that melt-drips rapidly, producing wax-like small drops (weighing from 3 to 6 mg and less than 6 mm in diameter), the number of which usually exceeds 50. It was characterised by the thermal range T_DˊI = 118 ″C. The degree of volatilisation for PP was in the range of 33%–42% and extent of decomposition in air was around 36.8%. The wax-like melt-drip behaviour of PP is explained in part by its low glass transition temperature (*ca.* ˊ26 ″C). Due to random chain cleavage, the thermal decomposition of PP leads to the production of shorter chains having lower viscosity, which, in turn, will increase its tendency to melt-flow and melt-drip. It was also found that the furnace temperature had no effect on the size of the drops, but the number of the drops increased as the temperature was raised. The TGA traces recorded for PP and its melted drops differed significantly, implying the significant degree of thermal decomposition (up to about 49%) in nitrogen atmosphere.

Group II included three polymers, PA-6, PET and PC, and the T_{D-I} range of these materials was higher than 220 ″C. The curves of mass loss had distinct steps, with each one of them corresponding to melt dripping. The formation of large drops, with their mass ranging between 20 and 250 mg and diameter in the interval of 10–17 mm, was observed for this group of polymers. The number of collected drops on average was also found to be less than 12. For PA-6, the number of drops increased with the increase of temperature, but at the same time the mass of each drop decreased. The degree of volatilisation was observed to be decreasing in the following order: 32%–40% for PA-6 > 21%–25% for PC > 16%–32% for PET. There was no decomposition recorded for PET, while for PA-6 it was around 26.6% and for PC: 6.0%. The thermal decomposition of PA-6 occurs through random chain cleavages at the amide groups, leading to the formation of gaseous compounds such as NH_3, CO and CO_2 as well as low-molecular fragments. PA-6 can also undergo depolymerisation producing its cyclic volatile monomer, caprolactam. Therefore, the data obtained for this polymer varied significantly from one sample to another. The thermal decomposition of PET leads to an increased production of acetaldehyde and other gases (ethane, CO, CO_2, etc.), whereas PC generates carbon dioxide and phenolic compounds. It was also noticed that the volatilisation rate for PET was doubled when the temperature increased from 415 to 635 ″C, indicating that the degree of decomposition substantially increases with temperature. Interestingly, there was no difference in TGA results of PET and its drops, implying that PET displayed only melting without any noticeable thermal decomposition. For PC, unlike for PA-6 and PP, the rise in temperature had no effect on the number, sizes, or masses of the drops.PS was allocated to Group III as its melt dripping in the furnace was noticeably different compared to other polymers studied. The temperature interval between the first melt drop and ignition, T_{D-I}, was equal to 75 ″C. The number of medium-sized drops was between 13 and 20. They were around 100 mm in diameter and their mass varied from 20 to 100 mg. The thermal decomposition of PS is dominated by random chain cleavage of the main carbon backbone, resulting in the formation of large oligomers, which may break down further to produce monomer, styrene, as well as the dimers and trimers. The PS decomposition in air was at approximately 26%, while in the nitrogen atmosphere was only 7.4%. It was also reported that the temperature increase inside the furnace did not affect the diameters of PS drops and the extent of volatilisation, although the number of drops tend to increase.

Group IV included PMMA, and its behaviour differed substantially from the other polymers. PMMA's temperature range between first dripping and igniting was about 100 ″C. The principle difference in the melt-drip behaviour of PMMA is that the volatilisation occurred prior to the melt dripping stage. PMMA's melt dripping was also characterised by the production of 10–14 small drops (with the mass of each lower than 25 mg, and diameter around 5 mm). PMMA is known to degrade via random chain scission followed by chain unzipping generating between 90% and 100% of the monomers. This was reflected in the degree of volatilisation, above 40%, the highest value among all the polymers tested in the furnace. Furthermore, the formation of volatiles increased as the temperature in the furnace was increased. It was also observed that the temperature does not affect diameters and thicknesses of the melted drops. The TGA data obtained in nitrogen atmosphere for PMMA and its molten drops were similar, indicating little changes in the molecular weights or its distribution for the polymer chains in the drops compared to the virgin polymer.

The effect of the external temperature on the mass loss during the melt-flow/drip was also reported in the literature. In general, the higher the temperature in the furnace, the earlier the volatilisation and melt-dripping commenced. The degree of volatilisation is increased, as the external temperature rises for PET and PMMA, which can be explained by the thermal decomposition mechanism of these polymers, where depolymerisation and chain unzipping dominate. It should be mentioned here that in the experiments with the furnace, the melt-dripping was caused only by heat, leading to a gradual decline in the mass of the sample. As for tests equivalent to the UL-94, when the polymer burns and generates more heat, its thermal decomposition occurred faster, thus leading to more rapid mass loss associated with the increased production of flammable volatiles and extent of melting. It was observed from the UL-94 equivalent experiments conducted that the samples of PP, PA-6, PS and PMMA were burnt completely, while PET and PC samples did not burn to a zero residual mass. The burning of PET was accompanied by the formation of drops, which took the flame away from the sample, causing it to self-extinguish. It was also concluded that, as the melt-dripping rate reduces, the burning rate increases.

Another critical parameter for the melt-flow/drip of polymers is the viscosity, which depends on the temperature and the molecular weight. The rheological studies carried out in the 170–380 ˝C temperature interval indicated that the dependence of complex viscosity on temperature for PET, PA-6, PS, PMMA and PC is non-linear; it decreases and reaches a minimum, and then increases again upon heating. It was also shown that the rate of dripping (i.e., the number of drops per second) did not depend on the complex viscosity of the melt only, and other factors can also influence the intensity of the melt-dripping. The rheological studies also indicated that the viscosity of the melted drips was significantly lower than that for the virgin polymers, once again confirming that melt-flow arises as a result of the combination of physical melting and partial polymer decomposition. The viscosity is usually affected by the additives or fire retardants (FRs), altering the melt-drip behaviour of thermoplastics. Some FRs have no effect on the rheological properties of polymers and hence will have minimum or no effect on the melt-flow/drip. Other FRs, such as char-promoting melamine phosphate added to PP, lead to an increase in complex viscosity at temperatures above 250 ˝C and can either reduce or stop the melt-dripping. Thus, a careful choice of FRs might enable one to modify the rheological behaviour, processability and fire performance of thermoplastics. For example, PP in the presence of a nanoclay additive, has been shown to have a lower number of melted drops but formed larger sized ones.

One of the factors directly linked to a degree of thermal decomposition is the temperature of the melted drops. Several experimental and modelling techniques are reported to evaluate the surface temperatures of the polymeric samples tested and the temperatures of melting drops produced by melting polymers.

4.1.3 Theoretical Considerations:

Understandably, the first port of call to try to quantify, or attempt to model, the rather complex phenomenon of the melt-flow behaviour of a polymeric sample is the UL-94 test as described by various authors. Previously, several researchers have also approached modelling of the problem through validating the results obtained through proprietary, in-house built experimental instrumentation. In this Section, brief accounts of some early theoretical studies are first described, followed by some recent developments in the subject area.

Butler et al. from the National Institute of Standards and Technology (NIST) have done pioneering work on a combination of experimental and modelling aspects of polymer melt-flow behaviours. In the course of their investigation, the dripping behaviour of several types of PP was studied, by employing an in-house built apparatus where the polymeric sample was mounted vertically and exposed to a uniform radiant heat on one face from a cone heater placed on its side. The measurements included: mass loss from the sample, mass collected in a catch pan, surface temperature, and surface velocities. There was also an experimental provision for measuring and extrapolating the viscosity to higher temperatures where formation of bubbles in the polymer makes the standard rheometric measurements impossible. The kinetic parameters, used to model the gasification of the polymeric samples, were obtained from thermo-gravimetric runs performed at dynamic conditions. The thermal conductivity of the polymers was also measured using a standard commercial apparatus based on transient heating for the temperature range from 40 through 265 ″C. The authors successfully employed a finite volume model to validate the experimental observations that used the volume of the method to tackle the highly distorted interface for the melting and dripping polymeric sample. The model also took into account the heat flux to the distorted interface, empirical viscosity as a function of temperature, flow due to gravity, and gasification.Given that the computational modelling and simulation of the burning, melt-flow and flame spread of thermoplastics are extremely complex phenomena, the standard finite element method (FEM) was combined with concepts from particle-based techniques to form the particle finite element method (PFEM). PFEM method tries to capture the extremely complex scenario involving fluid flow, heat transfer, material decomposition, flame chemistry, surface tension, and the drastic changes in the shape of the sample subjected to melt flow. The PFEM is a powerful Lagrangian technique for modelling and analysis of complex multidisciplinary problems in fluid and solid mechanics involving coupled thermal effects, fragmentation and separation of fluid particles and fluid-particle interaction effects, among others. In PFEM, the particles represent the nodes of a finite element mesh, which can move freely according to the velocity field, transporting their momentum and physical properties. The authors were able to demonstrate the potential of the PFEM to model the drastic change of shape of polymer objects as they burn, melt and spread in the underlying floor, including self-contained situations.

Kandola et al., in the course of their recent experimental investigations into the melt-flow behaviours of some commercially important thermoplastics, have also attempted quantifying the degradation and melt-dripping of polymers. Here they have developed a simple, one-dimensional heat transfer model with a view to computing the surface temperatures of the polymer sample, at various experimental furnace temperatures, thus measuring in effect the temperature of the molten drops dripping from the melting surface. The model has then been validated against the experimentally determined temperatures. The temperatures of the molten drops, in turn, were found to aid in predicting the degree of decomposition in a polymer during its melt dripping. The latter attribute could be calculated from the kinetic analyses of the thermo-gravimetric curves obtained for both the polymeric material and its drops.

4.2 Mixing of Materials:

After the waste plastic is melted, the sand is added to it in the same container during beating and the mixture is stirred continuously. The sand shall be added little by little in quantity and stirred well so that a homogeneous mix is obtained. Care shall be taken so that the mixture doesn't catch fire.figure shows the addition of sand to the melted waste plastic.

4.3 Placing of Mixture(plastic+sand) in Moulds:

Once the homogeneous mixture of waste plastic in melted form and sand is formed, the mixture is fed into a mould of size 30cm*30cm*2.5cm. The moulds are coated with oil for easy demoulding, before placing the mixture. The moulds are prepared by MS base plate and 2.5cm steel angle with nut and bolt connections for easy demoulding. Figure 3 shows the placing of mixture (Plastic+sand) in moulds.

Figure 4 shows completely prepared mould.

Figure 7-Placing of mixture in mould.

Figure 8-Completely prepared mould.

4.4 Demoulding: Once the mould is completely prepared, the mould is cooled either by air cooling or by placing it in water. After the mould is cooled, the tile is removed from the mould. The floor tile is now ready with a good surface finish at the top.

Figure 9-Placing the mould in oven.

Figure 10-Completely prepared tile.

5. TESTS AND RESULTS

For checking the properties of LDPE made tiles following test were done on the component:

1) Compression test:

Compression test was conducted as per the ASTM D 695-2015 Standard. For this, the standard specimen size is 12.7 x 12.7 x 25.4mm. The specimen is placed between compressive plates parallel to the surface. The specimen is then compressed at a uniform rate. The maximum load is recorded along with stress-strain data. An extensometer attached to the front of the fixture is used to determine modulus. Compressive strength and modulus are two useful calculations in this test. They are calculated using the following equations.

$$\text{Compressive strength} = \frac{\text{maximum compressive load}}{\text{minimum cross-sectional area}}$$

Equipment used in this test are:

- Instron universal tester
- Extensometer

2) Vertical flammability test:

This test was done as per IS 15061:2002 standard. For this test specimen size was 10x13x95mm. For passing this test the burning rte should be not more than 100mm/min.

3) Static friction test:

For this test, a block is placed on the component to be tested. The block is connected to a horizontal string which is passed over the pulley and made vertical. Another end of the string is connected to a weight box in which the weights are added. The weight at which the block just started moving was noted. Static friction coefficient was calculated using the following formula:

$$\mu = \frac{\text{Total weight of the weight box}}{\text{weight of block}}$$

- **Results and discussions:**

The density of the LDPE tile was observed to be 843 kg/mm^3. For conventional tiles, it is near to 2400. So, the tiles can be used in various applications where we require weight reduction. In the LDPE made tile, the total weight reduction was observed to be 57.7322% as compared to the conventional bathroom tile having the same dimension.

The compressive strength of 17.26 MPa was observed. According to IS 15622:2006, a minimum of 1500 N breaking force is required to pass the test. The manufactured LDPE component showed 2175.6 N breaking force. So, these tiles can be used in places where there is no high weight bearing requirement.

Burning rate was observed to be 52mm/min which was lesser than the standard 100mm/min required to pass the test.

The coefficient of friction was experimentally calculated to be 0.5 for test specimen which was equivalent to the commercially available bathroom tile of 0.512 which opens up new avenues for further research and improvement of the coefficient of friction to make antiskid tiles. This makes tiles we manufactured using LDPE usable for normal day to day applications avoiding any slippage.The data for this is shown in1,2,3 tables.

The waste plastic is added as a binding agent with sand in different proportions by weight of sand.Proportions of 10% and 20% were found to be insufficient to prepare the tile,since after removal of mould the tile will fail immediately.To evaluate different physical and mechanical properties,tests like water absorption test,transverse resistance test,resistance to impact and abrasion resistance tests were carried out for given specimens with percentages as per IS specifications on the waste plastic tiles and this test results were compared with normal cement tiles.The data for the tiles is shown in 4,5,6,7 tables.

- **Tables & Figures**

Table 9: Compression test result:

Sr. No	Sample Identification	Compressive strength (MPa)	Peak Strength
1.	LDPE	17.26	2175.6

Table 10: Vertical flammability test:

Sr. No	specified	Observed	Remark
1.	The burning rate should not be more than 100mm/min	Burning rate 52mm/min	Pass

Table 11: Static friction test:

Material	μ			Average μ
	1	2	3	
LDPE Composite	0.5	0.5	0.5	0.5
Bathroom Tile	0.5185	0.5	0.5185	0.5123

Fig 11:Final LPDE tile

Fig 12: Graph for load vs deformation

Fig 13: Friction test

Fig 14: Compression test

Fig 15: Flammability test

4) Water absorption test:

Water absorption of the oven dried and cooled specimens were tested for water absorption. After 24 hrs of saturation difference in weight is found as 3.8%.

Table 12: Water absorption of the specimens:

Sl.No	Specimen and % of Waste Plastic	Water Absorption(%)	Average water absorption(%)	Normsl Cement Tile
1	Specimen1 (30%)	3.80	2.66	9.5
2	Specimen2 (40%)	3.50		
3	Specimen3 (50%)	2.34		
4	Specimen4 (60%)	1.01		

5) Transverse strength (N/MM²):

The floor tiles are need to be stand against the transverse loads so it is tested under CTM according IS 1464 code provisions. For a normal tile transverse strength is 22.75 N/mm², as per results we got transverse strength about 10.80 N/mm².

Table 13: Transverse Strength of the specimens:

Sl. No	Specimen and % of wasteplastic	Transverse Strength (N/mm^2)	Average Transverse Shear Strength(N/mm^2)	Normal Cement Tile
1.	Specimen 1 (30%)	10.80	17.90	22.75
2.	Specimen 2 (40%)	13.74		
3.	Specimen 3 (50%)	20.80		
4.	Specimen 4 (60%)	26.29		

6) Abrasion resistance (Average loss in thickness in cm):

Abrasion strength of tile, resist against the abrasive action upon the tile in its life. It is found through Mohr scale.

Table 14: Abrasion resistance of the specimens:

Sl. No	Specimen and % of Waste Plastic	Abrasion Resistance (cm)	Average abrasion Resistance(cm)	Normal Cement Tile
1.	Specimen 1 (30%)	0.90	0.67	0.79
2.	Specimen 2 (40%)	0.82		
3.	Specimen 3 (50%)	0.72		
4.	Specimen 4 (60%)	0.24		

7) Impact resistance (Height of impact resistance in cm):

The free fall of metal sphere of 170gm from the increasing height of 75mm is used for finding the impact resistance test.

Table15:Impactresistanceofspecimens:

Sl. No	Specimen and % of Waste Plastic	Impact Resistance (cm)	Average Impct Resistance (cm)	Normal Cement Tile
1.	Specimen 1 (30%)	27	36.5	30
2.	Specimen 2 (40%)	30		
3.	Specimen 3 (50%)	39		
4.	Specimen 4 (60%)	50		

- **OBSERVATIONS WHILE TESTING OF TILES:**

Flexural Test: - Determine transverse strength of casting material for flooring tiles. Adhering to IS code the test is performed on flexure testing machine and load is applied through lead shots. But we observed that load applied through lead shot is not sufficient to breakthe tile. An alternative arrangement has been made on Universal Testing Machine as shown in the below photograph and the rest of the tiles are tested.

Fig 16: Setup of flexural strength on UTM machine.

Table 16 : Observations of Flexural Test (Sample Size L=250 mm, b=300mm, t=15 mm)

Sr. No.	Description	Breaking loadi.e. W(N)	Strength $F=3WL/2bt^2$ (N/mm^2)	Deflection (mm)
1.	Proportion1:1:2:4			
	1	15.85×10^3	88.05	21
	2	16.55×10^3	91.94	24
	3	16.20×10^3	90	23
2.	Proportion1:1:3:3			
	1	16.75×10^3	93.05	23
	2	17.35×10^3	96.39	20
	3	17.05×10^3	94.72	21
3.	Proportion1:1:4:2			
	1	17.15×10^3	95.27	19
	2	16.80×10^3	93.33	19
	3	17.00×10^3	94.44	19

Calculation: -L=Width –50

$=300-50$

$L = 250$ mm,

$b = 300$mm, $t = 15$mm,

$W = 15.85 \times 10^3$ N,

$F = 3WL / 2bt^2 = 3 \times 15.85 \times 10^3 \times 250 / 2 \times 300 \times 15^2$

$= 88.05$ N/mm^2.

The testing of tile is done as per IS code 1237:2012. The average transverse strength shall not be less than 3N/mm2. As per IS code our all tile have strength more than 3N/mm^2.We Observed that our tile proportions have more than 3 N/mm^2. So tiles are more safe tile in flexural test. Have good strength shock absorbing Capacity.

6. CONCLUSIONS

1. With reference to the literature and this study, plastix waste can be usedas abinding agent instead of cement in the manufacture of tiles,in pavement construction etc.
2. The waste plastic with proportions of 10% and 20% by weight ofsand wre foundto be insufficient to prepare tile.
3. With reference to the results shown I above tables,physical properties like wter absorption, and mechanical properties like transverse resistance, resistance to impact and abrasion resistance showed improved property with increase in percentage of waste plastic from 30% to 60%.
4. Test results for 50% of plastic waste by weight of sand is found to have transverse resistance nearer to normal cement tile and the other properties like water absorption,resistance to impact and abrasion resistance were on higher side.Hence 50% of waste plastic content can be considered as an ideal for preparation of floor tile using waste plastic as bindig agent instead of cement.
5. Overall the results obtained for waste plastic.
6. Waste plastic, which is available everywhere, may be put to an effective use in tile.
7. Plastic tiles can helps to reduce the environmental pollution, thereby making the environment clean and healthy.
8. Water absorption of plastic tile is zero percent.
9. With reference to the literature and this study, plastic waste can be used as a binding agent instead of cement in the manufacture of tiles in the pavement construction etc.
10. The plastic tiles are more durable than the traditional tiles with respect to various perspectives as written in results. Looking towards the flexural capacity of the tiles, those can be used under heavy loads. The areas of heavy loads can be garages, workshops, parking etc. The less wear and tear will be seen in these plastic tiles. Only thing, the cost of the tiles is slightly more than the traditional tiles but this can be overseen with the other properties.
11. The strength of the LDPE tile (2176 N) was found to be equally comparable to the strength of ceramic tile (2200 N).
12. The material is unbreakable as against ceramic tile.
13. The static friction factor is better than the available product making it suitable for anti- friction tile fittings.
14. Manufactured tiles have good machinability in cutting and finishing.
15. Manufactured tile floats on water, making it suitable for marine applications like rafts, floats.

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A Major Project Report On

SUSTAINABLE USE OF MINE WASTE AND IRON ORE TAILINGS IN FLEXIBLE PAVEMENT

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

By

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BONAFIDE CERTIFICATE

This is to certify that the SUSTAINABLE USE OF MINE WASTE AND IRON ORE TAILINGS IN FLEXIBLE PAVEMENT project entitled is being submitted by **1.Mrs. P. Niharika Goud (18K85A0101) 2. Mr. P. Rohit Kumar (17K81A0148) 3. Mr. P. Manoj (18K85A0103) 4. Mr. D. Anvesh (17K81A0121)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY** IN Civil Engineering is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

Signature of Guide	**Signature of HOD**
Mr.B.BHANU PRASAD	**Prof. SANDHYA KIRAN J.K.**
Assistant Professor	Head of the Department
Department of Civil Engineering	Department of Civil Engineering

Internal Examiner	**External Examiner**

Place:
Date:

DECLARATION

We, the student of **Bachelor of Technology** in Department of ‘Civil Engineering’, session: 2017 – 2021, St. Martin’s Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled SUSTAINABLE USE OF MINE WASTE AND IRON ORETAILINGS IN FLEXIBLE PAVEMENT Project is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

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ABSTRACT

Rapid growth of infrastructure in road construction need natural resources. There is a need to explore the feasibility of use of iron ore tailings and mine waste in road construction. Utilization of mine waste rocks and iron ore tailings in bitumen as aggregates will help in sustainable & greener development. This literature shows the potential use of iron ore tailings as a replacement of natural fine aggregates &mine waste as a replacement of coarse aggregates. As natural resources are depleting day by day, there is a need for substitution for aggregates in bitumen. A comprehensive overview of the published literature on the use of iron ore tailings & mine waste in bitumen is being presented. The various effects of various properties such as penetration, softening point, ductility, specific gravity, flash &fire point of bitumen have been presented here. In this paper the properties of fine aggregates, properties of coarse aggregates, and marshal stability values are determined.

KEY WORDS: Mine waste; iron ore tailings; fine aggregates; coarse aggregates; marshal stability.

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INTRODUCTION

1.1 Overview of the Project

Mining is a fundamental industry in the development of human society, playing an important role in the economies of many countries around the world. Most of the Highways in India constructed with flexible pavement having wearing course/surfacing course with bituminous concrete. This BC should be constructed to satisfy the recommendation and requirements of MORTH Section 509. This clause specifies the construction of Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single or multiple layer of bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 25 mm to 100mm in thickness. As per MORTH Section 500 clause 509 BC should be made with Bitumen Grade 60/70 (VG 30) for nominal aggregate size 19 mm with bitumen content 5-6% has layer thickness 50-65 mm and for nominal aggregate size 13 mm with bitumen content 5-7% having layer thickness 30-45mm. Transportation is vital for economical, industrial, social and cultural development of any country. The inadequate transportation facilities retard the process of socioeconomic development of the country. The road network is the only mode of transportation, which gives maximum service to all and is the only mode, which offers the maximum flexibility to travelers in selecting routes, direction, time and speed of travel (Morth 2012a). Road network alone serves the remote areas.

The well-being of citizen, economic growth and status of a country is judged by how well organized and efficient the road network is. A wide variety and range of roads is in use all-round the globe. The terrain, topography, population, culture, the function and structural requirements are the factors that decide that type.

Development of a country depends on the connectivity of various places with adequate road network. Roads are the major channels of transportation for carrying goods and passengers. They play a significant role in improving the socioeconomic standards of a region. They are important assets for any nation. In case of India, India is the second largest road network country in the world, with more than 4,699,024 km which includes 96,214 km of national highways and expressways.

There are two methods of mining, one is open-cast and the other is underground mining. Open-cast mining involves removal of complete waste rock to expose the ore body or coal. The process of removing the waste bound to damage the natural ecosystem by producing various types of pollution like land degradation, air pollution, dust pollution etc. The waste produced is generally dumped outside the mine in the form of overburden dumps. These dumps occupy a large amount of land, which loses its original value and generally gets degraded. Maintaining stability of the dump is also a major issue for the mining industry (Sastry and Ram Chandar 2013). Utilization of such waste rock is being investigated by various researchers for different purposes like building construction materials, pavements, back filling etc. Hence, a partial replacement of the aggregates in concrete by waste rock produced from mines not only saves considerable money in the handling and maintenance of waste dumps but also reduces the cost of construction of roads. In addition, it also reduces the environmental problems at mine site.

- Bituminous concrete is a type of construction material used for paving roads, driveways, and parking lots. It's made from a blend of stone and other forms of aggregate materials joined together by a binding agent. Despite its name, this material is quite different than standard concrete, and contains no cement.

BITUMINOUS CONCRETE:

Fig : 1

PAVEMENT COMPOSITION

Sub-base course

Granular Sub-base (GSB) materials conforming to clause 401 of MORT&H specifications for road and bridge works is recommended.

The sub-base material should have minimum CBR of 20% for cumulative traffic up to 2 msa and 30% for traffic exceeding 2 msa.

The material should be tested for CBR at the dry density and moisture content expected in the field.

The thickness of sub-base should not be less than 150 mm for design traffic less than 10 msa and 200 mm for design traffic of 10 msa and above.

Preferably the subgrade soil should have a CBR of 2%

If the CBR<2%, the design should be based on a CBR of 2% and a capping layer of 150 mm thickness of material with a minimum CBR of 10% shall be provided in addition to the sub-base

Where stage construction is adopted, the thickness of sub-base shall be provided for ultimate pavement section for the full design life

Base course

The recommended minimum thickness of granular base is 225 mm for traffic upto 2 msa and 250 mm for traffic exceeding 2 msa.

For heavily trafficked roads, use of WMM base laid by paver finisher or motor grader is recommended.

Where WBM construction should be adopted in the base course for roads carrying traffic more than 10 msa, the thickness of WBM shall be increased from 250 mm to 300 mm.

Bituminous Surfacing

Shall consists of either a wearing course or a binder course with a wearing course depending upon the traffic to be carried.

The selection criteria for the grade of bitumen to be used for bituminous courses are given in the table shown in the next slide.

Where the wearing course adopted is premix carpet of thickness up to 25 mm, the thickness of surfacing should not be counted towards the total thickness of the pavement.

Subgrade

The subgrade should be compacted to 97% of the dry density achieved with heavy compaction as per IS:2720

For Expressways, National Highways and State Highways, the material used for subgrade construction should have the dry density of not less than 1.75 gm/cc.

For determining the CBR value, the standard test procedure described in IS:2720 (Part 16) should be strictly adhered to.

The test must always be performed on remoulded samples of soils in the laboratory It is recommended that the samples be soaked in water for four days prior to testingIn situ CBR test is not recommended

Fig: 2

IRON ORE TAILINGS:

- Iron is the world's most commonly used metal –steel, for which iron ore is the raw material representing almost 95% of all metals used per year.
- Iron ore is a metal of universal use and it is the backbone of modern civilization.

Fig:3

- It is the foundation of our basic industry and it is used all over the world and Iron is taken out from mines in form of iron ore.

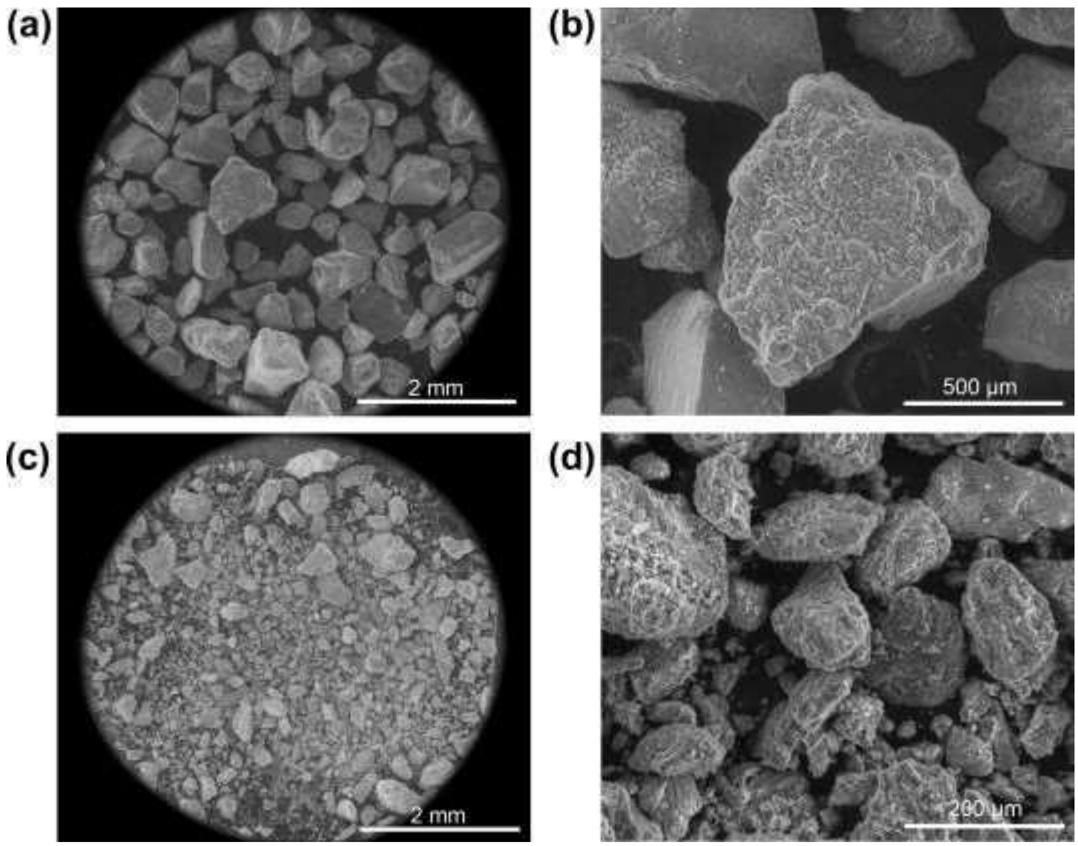

Fig:4

Iron is the world's most commonly used metal - steel, for which iron ore is the raw material, representing almost 95% of all metals used per year.It is used primarily in structural engineering applications and in marine purposes, automobiles and general industrial applications (machinery).

World production averages two billion metric tons of raw ore annually. The total recoverable reserves of iron ore in India are about 9,602 million tons of hematite and 3,408 million tons of magnetite. World consumption of iron ore grows 10% per annum on average with the main consumers being China, Japan, Korea, the United States and the European Union). Processing of such large quantity of iron ore produces good amount of tailings. The production trend of Iron Ore Tailings in India for the past 5 years

There are 4 types of iron ore

They are:

1- Magnetite: 72% pure iron.

2- Hematite: 62-70% pure iron.

3- Limonite: 40-60% pure iron.

4- Siderite: 40-50% and many impurities.

MINE WASTE:

The quantity of waste produced (shale and sandstone) in coal mines is in terms of millions of cu.m per year. The main condition of mine waste utilization is that the materials should satisfy all the geotechnical criteria and is environmentally friendly.

Fig : 5

These waste materials can be used as fill for subsided land (or) as aggregate in embankment dams, roads, pavements foundations and building constructions.

Along with growth of mankind, the mining industry has also grown in parallel to supply the raw material for various purposes along with infrastructure development. There are two methods of mining, namely surface mining and underground mining. In surface mining, the overburden will be removed and dumped aside, thus waste produced will be much higher than the coal or ore extracted based on stripping ratio. Almost every coal as well as metal mining produces waste rock. The quantity of waste produced (shale and sandstone) in coal mines is in-terms of millions of cu.m per year. Sandstone is a highly porous rock and the strength is medium, so it may not be suitable for pavements. On the other hand, iron ore waste will have better strength, which can be used for pavements and it is also available in large quantity

Fig : 6

The different types of mine waste are

1.Waste rock: Blasting, crushing, grinding.

2.Tailings: Flotation, thickening, drying/ filtering.

3 .Overburden.

Overburden: The soil and rock removed to gain access to the ore deposits in open pit mines are known as overburden. It is piled on the surface at mine sites where it will not disturb further expansion of the mining operation as moving large volumes of material is expensive.

Waste rock: Waste rock is a material that contains mineral in concentration considered too low to be extracted economically. The waste rock is suitable for earthworks on the site during mining operations and as aggregates for concrete works.

Tailings: Tailings are mineral waste products and finely ground rock of mineral processing operations. It also contains leftover of processing chemicals and is deposited in the form of water based slurry into tailing ponds. The tailings are difficult to utilize due to its finer grain size, but can be utilized in selective operations. Based on the type of tailings pond, the water can be drained so that the remaining waste can be dried

The main condition of mine waste utilization is that the materials should satisfy all the geotechnical criteria and is environmental friendly. A thorough characterization of mine waste is essential as it must not be a source of contamination. The value of utilization of mine waste can be enhanced on the basis of geotechnical properties and environmental constraints.

The suitable possibilities for utilization of mine waste rock are:

Road constructions and construction material for building industry

Material for landfill and for embankments designed for mitigating traffic noise

Material to stabilize pit walls or tunnels and to backfill stopes and galleries

Material for landscaping and stabilization during mine closure

Material in the neutralization of acidic groundwater generated in the mine pit

Tailings dams and as fertilizer or supplement to enhance soil quality/fertility. On the other hand, the natural resources (like sand) are becoming scarce and expensive due to the excessive cost of transportation and large scale depletion of river sand creating serious environmental problems. Restrictions are made for the collection of river sand from the river bed and some of the states have banned sand mining forcing concrete industry to look for alternative materials of river sand. Research is therefore required to investigate the use of cheaper, easily available and sustainable alternative materials to natural river sand Various researchers have studied the utilization of iron ore waste and tailings in various aspects including replacement of sand, aggregate or cement in concrete.

1.2 OBJECTIVES OF THE STUDY

1. To study the physical properties of bitumen (Ordinary bitumen of 60/70 grade) by adding mine waste and iron ore tailings at the various percentages.

2. To find out an optimum percentage of waste materials in the bituminous mix

3. To improve the properties of bituminous mix and to provide the solution for disposal in a useful way.

4.To increase the Marshall Stability Value

5. Improving the volumetric properties of BC mix.

6. To utilize iron ore tailings as filler material in bituminous mixes.

SCOPE OF THE PROJECT

To increase the life span of flexible pavement by using iron-ore tailings & mine waste.

To increase the strength and stability of the flexible pavement.

Deformations on flexible pavement can be minimised by using this innovative technology.

Water percolation through layers of flexible pavement leads to decrease soil properties can also be rectified by using mine waste & iron-ore tailings.

Chapter 2

LITERATURE REVIEW

In 1956, Prof. Ladis Csanyi, Lowa State University, realized the potential of foamed bitumen for use as a soil binder. Since then, foamed asphalt technology, which allows lower mixing temperatures, has been used successfully in many countries.

In the early 1970s, Chevron developed mixture design and thickness design methodologies for paving mixtures (base, open-graded, and dense-graded) stabilized with Emulsified asphalt.

In 1977, Chevron published their “Bitumlus Mix Manual” as a practical guideline, which contains much valuable information for specifying, designing, and producing emulsion-stabilized mixtures. Kuennen reported that emulsified asphalt mixes are popular in rural settings where distances from HMA plants and lower traffic volumes may preclude HMA.

In 1994, Maccarone and others, studied cold-mixed asphalt-based foamed bitumen and very high binder content emulsions and concluded that the use of cold mixes for use on was gaining acceptance worldwide due to energy efficiency and lower emissions.

In 1995, Shell Bitumen filed a patent to cover a warm-mix asphalt technique that used a two-component technique, of Shell Global Solutions, described an innovative WMA process that was tested in the laboratory and evaluated in large-scale field trials (in Norway, the United Kingdom, and the Netherlands) with particular reference to the production and placement of dense-graded wearing courses Jenkins and others, introduced a new process involving a half- warm foamed bitumen treatment. They explored the concepts and possible benefits of heating a wide variety of aggregates to temperatures above ambient but below 212°F before the application of foamed Bitumen.

Shifeng Wang et.al (2016) presented a study on recent developments in the application of chemical approaches to rubberized asphalt. A binder called Rubberized asphalt which is produced by adding crumb tire rubber modifier into heated asphalt. It shows better cracking resistance and fatigue resistance as compared to conventional asphalt. By adding chemical additives to rubberized asphalt, many improvements like low rutting resistance, high viscosity and poor storage stability are achieved.Degraded tire rubber hybridized with SBS is accepted for its usage in pavements. Inorganic filler can be used to improve rutting resistance and moisture resistance. However, the sediment of filler in the asphalt prevents it from being implemented on a large scale.Plasticizer improves process ability but influences high temperature properties. Therefore, different additives must be combined in order to maintain a suitable balance between processing and acceptable physical properties.

2.1 Review: 1

Dr. R. Vasudevan, Dr. Samuvel Paulraj has been studied “Reuse of Waste Plastic Coated Aggregate-Bitumen Mix Composite for Road Application-Green method” 920130. Waste plastics both by domestic and industrial sectors can be used in the production of asphalt mix. Waste plastic, mainly used for packing are made up of polyethylene, polypropylene, polystyrene this softening varies between 110◦c-140◦c and they do not produce any toxic gases during heating but the softened plastics have tendency to from a film like structure over the aggregate when they sprayed over the hot aggregate @ 160◦c. this PCA bitumen mix showed improved binding property and less wetting property and it also showed higher Marshall stability value in the range of 18-20KN and load bearing capacity of throad is increased by 100%. The roads laid since 2002 using PCA bitumen mixes are performing well. This added more value to the dry process as this process helps to dispose 80 percentage of waste polymers usefully by an eco-friendly method and also it reduced the cost to around Rs.3000/km of single lane road as on date.

2.2 Review: 2

H. K. Sharma, has conducted experiment on “Utilization of Waste Plastic in Construction of Pavement”(2014).He found that Waste plastics - as binder and modifier at 130°C using Thermo gravimetric analysis there is no gas evolution in the temperature range of 130-180°C. Moreover, the softened plastics have a binding property. Hence, the molten plastics materials can be used as a binder and/or they can be mixed with binder like bitumen to enhance their binding property. This may be a good modifier for the bitumen, used for road construction. The uses of plastic waste help in substantially improving the abrasion and slip resistance of flexible pavement and also allows to obtain values of splitting tensile strength satisfied the specified limits while plastic waste content is beyond 30% by weight of mix. If the consistent.

2.3 Review: 3

D R. Manju, Sathya.S, Sheema.Khas been studied on “use of plastic waste bituminous pavement” (2017).This paper reveals that the utilization of waste plastic in bituminous mix enhances its properties and strength. Titanium Di-oxide is used as smoke absorbent material, which will absorb the smoke from vehicle. Addition of waste plastic in construction reduces the plastic shrinkage and drying shrin/kage. Dry process is carried out for mixing process. The plastic pavements can with stand heavy traffic and are durable than flexible pavements. The stability of modified bitumen (10% bitumen replaced by plastic) is higher than the nominal bitumen. The use of plastic will reduce the bitumen content by10% increases the strength and performance of the road. The smoke absorbent material (titanium dioxide) by 10% of polymer content can reduce vehicular pollution. Thus the use of waste plastic improves the abrasion and slip resistance of bitumen pavement.

2.4 Review: 4

Vishal Rasal, L Nokfho K, P.M.Wale, Mrunalini Kasar, Anjali Thorat, Raunak Solanki, Ishan Dharmadikari, has been studied on “Experimental Study on Modified Bituminous Mix Using Waste High Density Polyethylene and Crumb Rubber” (2018).This paper presents an effort taken to produce modified bituminous mix and coated aggregates. Aggregate where coated with 6, 8, 10% of High density polyethylene (HDPE) and 8, 10, 12% of crumb rubber and were mixed with bitumen. Different molds are prepared with different combination and compared with conventional bitumen mix by conducting Marshall Stability test to check its strength, flow value and stability value. The dense based macadam (DBM) mix was designed for Marshall Stability test using VG30 grade. Dry process (polymer coating of aggregates) is more useful as compared to wet process (adding polymer in the binder) for the manufacturing modified mixtures, as it can accommodate higher amount of waste plastic as modifier and results most stable mixture. Penetration values and softening points of plain bitumen can be improved by modifying it with addition of crumb rubber. Optimum percentage of rubber was found to be 8% and 10% of HDPE gives more satisfied results comparing to conventional bitumen. Use of waste plastic in construction of bituminous road helps to improve strength, life of road, resistance to temperature and water.

2.5 Review: 5

Ala R. Abbas et.al (2013) presented an effect of recycled asphalt shingles on physical and chemical properties of virgin asphalt binders. A virgin asphalt binder was mixed with varying percentages (0%, 5%, 7%, and 10%) of RAS.However, significantly higher levels of aging were obtained for PAV-aged binders containing higher percentages of RAS, indicating that the addition of RAS will primarily impact the long term performance of the asphalt binders. The addition of RAS causes the asphalt binder to become stiffer and harder to mix and handle and the addition will also improve the asphalt binder performance in the context of rutting.

2.6 Review: 6

Mohd Ezree Abdullah et al. (2016),The objective of this study is to improve the properties of the asphalt binders using the addition of nano-clays and chemical WMA additive. In this study materials used are ,Nano-clay A (montmorillonite clay surface modified with 3545 wt.% dimethyl dialkyl (C14C18)amine, Nano-clay B (montmorillonite clay surface modified with 3545 wt.% octadecylamine, and 0.55.0 wt.% aminopropyl-triethoxysilane), and chemical WMA additive (fatty polyamines polymer non-ionic component).An asphalt binder of 80/100 penetration grade was modified with different percentages of Nano-clay A,Nano-clay B and chemical WMA additive. After modification, the asphalt binders were named Nanoclay A modified asphalt binder (NCMB A), Nano-clay B modified asphalt binder (NCMB B), and chemical WMA modified asphalt binder (CWAA),The NCMB A and NCMB B reduced penetration and increased softening point. The modified asphalt binders exhibited significantly higher Surface Free Energy when compared with unmodified asphalt binder and could have good adhesion between aggregates. Therefore, modified asphalt binders could potentially be good at increasing the resistance of asphalt mixes to moisture induced damage. NCMB B4% could potentially becom a new WMA binder in comparison to CWAA.The gap for this particular study is that, availability is not there and cost of nano-clay is almost 14,000 Rs/Kg., which lead to an uneconomical model.

2.7 Review: 7

Mahyar Arabani et.al (2017) presented a study on assessment of mechanical properties of rice husk ash modified asphalt mixture.The addition of RHA could improve significantly the rutting resistance of HMAs at different stresses and temperatures that could be attributed to the improvement of rutting parameter and elastic behavior of modified binders. Also, the rutting performance of HMAs with 15% RHA and 20% RHA are almost similar According to fatigue test results, mixtures containing RHA exhibited better fatigue life compared to control mixtures. This enhancement might be due to reduction of air void in mixture and/or improvement of adhesion between binder and aggregates. The mixture with 15% RHA had the highest fatigue life.

2.8 Review: 8

Nyoman Arya Thanaya et.al (2014) presented a study on properties of Cold Asphalt Emulsion Mixtures (CAEMs) using materials from old road pavement milling. Cold Asphalt Emulsion Mixtures (CAEMs) can be produced at room temperature which can incorporate milled old road pavement (upto 72.73%). Some virgin aggregate and rice husk ash as filler material and cement was added into the mixture.The samples containing ordinary Portland cement (OPC) showed higher stability, as the cement would assist the hardening of the compacted samples. All properties of the CAEMs well meet the specification, further tests like stiffness tests, creep tests, and fatigue tests are necessary, in order to attain a broader appreciation on the performance of CAEMs.

2.9 Review: 9

Obaidi et al. (2016) presented a fast pothole repair method using asphalt tiles and induction heating.In this method we are using an asphalt mixture tile with a bottom bonding layer made of bitumen, and steel fibers, exposed to high frequency electromagnetic fields to heat the fibers up and melt the bitumen(modified bitumen with 4% of SBS) in the bonding layer. Recycled steel fibers from old tyres were used to minimize the environmental impact .The bond between the tile and the old road is created by heating the fibers, by using of induction energy, and applying light compaction. With this technology, in less than 1 min of induction heating, the bonding layer reaches temperatures above 100C and tile and old pavement stick together.The physical principle behind the strength gain of tiles is the drain of bitumen towards the gap between the asphalt tile and block.This was powered by the (1) total pressure exerted over the bonding layer, e.g. by the weight of the tile, (2) viscosity of bitumen and (3) total amount of bitumen available. The rutting deformation of asphalt tiles under simulated traffic conditions was very similar to that of original asphalt mixture and approximately 40 times smaller for the same loading time and energy.

2.10 Review: 10

Yanping Yin et al. (2017),showed the study on the Effect of chemical composition of aggregate on inter facial adhesion property between aggregate and asphalt. This study compared the inter-facial adhesion properties of asphalt with SBSstone aggregate and asphalt with granite aggregate. The main chemical compositions of SBSstone and granite are CaCO3 and SiO2, respectively. The results show that the inter facial adhesion strength of the asphalt with SBSstone aggregate is higher than that of the asphalt with granite aggregate. The main chemical constituent of SBSstone is CaCO3, and the main chemical constituent of granite is SiO2. Carbon, oxygen, and sulfur are the main elements of asphalt, and the sulfoxide group has an influence on the adhesion property of asphalt. On the other hand, the adhesion function of the granite aggregate only depends on its physical adhesion with asphalt. In summary we can say that SBS stone aggregate show more adhesion strength with asphalt as compare to the granite aggregate.

MATERIALS

- Bituminous concrete (BC)
- Mine waste as replacement of coarse aggregate.
- Iron ore tailings replacement of fine aggregate.
- Water

METHODOLOGY

- The purpose of this study was to evaluate the laboratory performance for Dense bituminous macadam (DBM) Grade-2.
- After the determination of gradation, Marshall stability tests were conducted to determine the volumetric properties of the specimens.
- The iron ore tailings passing 2.36mm sieve is used as filler material. The mine waste passing above 20mm is also used as filler material.
- Various tests conducted to determine basic properties of aggregates and the tests conducted to determine the basic properties of bitumen.
- The coarse aggregates used in the present study are crushed hard rock passing 16mm, 12.5mm, 10mm and 6mm sieve sizes.

Table 1: Physical properties of Coarse aggregates

SI.No	Properties	Test Method	Range as Per IRC	Obtained Values
1	Crushing value	IS-2386 part IV	Less than 30%	24.9%
2	Abrasion value	IS-2386 part IV	Less than 30%	17%
3	Impact value	IS-2386 part IV	Less than 30%	16.8%
4	Combined Flakiness and elongation index	IS-2386 part I	Less than 15%	14%
5	Water absorption test	IS-2386 part III	Less than 2%	0.375%

Fig : 1

Table 2: Physical properties of Bitumen

SI. No .	Properties	Test method	Obtained Values
1	Penetration (mm) (100g, 25°C, 5 sec)	IS: 1203 -1978	65
2	Softening point (°C)	IS: 1205 -1978	120
3	Ductility at 25°C (mm)	IS: 1208 -1978	75
4	Specific gravity of bitumen	IS: 1202 -1978	1
5	Flash point test (°C)	IS: 1209 -1978	175°c
6	Fire point (°C)	IS: 1209 -1978	175°c+5°c

Fig : 2

Table 3: Physical properties of Fine aggregates

SI. NO.	**Properties**	**Test method**	**Range as per IRC**	Obtained values
1	Fineness modulus test	IS-2386 part I	2.0-3.5	2.449%
2	Bulking of sand	IS-1963 part III	20-40%	30%
3	Specific gravity test	IS-1963 part III	2.5-3	2.65

Fig : 3

DETERMINATION OF AGGREGATE CRUSHING VALUE

AIM:

1. To determine the aggregate crushing value of coarse aggregates
2. To assess suitability of aggregates for use in different types of road pavement

APPARATUS:

The apparatus of the aggregate crushing value test as per IS: 2386 (Part IV) – 1963 consists of:

1) A 15cm diameter open ended steel cylinder with plunger and square base plate, of the general form and dimensions as shown in Fig 1.
2) A straight metal tamping rod of circular cross-section 16mm diameter and 45 to 60 cm long, rounded at one end.
3) A balance of capacity 5kg, readable and accurate up to 1 gm.
4) IS Sieves of sizes 12.5 mm,10 mm and 2.36 mm.
5) A compression testing machine capable of applying a load of 40 tonnes and which can be operated to give a uniform rate of loading so that the maximum load is reached in 10 minutes. The machine may be used with or without a spherical seating.
6) For measuring the sample, cylindrical metal measure of sufficient rigidity to retain its from under rough usage and of the following internal dimensions: Diameter:11.5 cm, Height: 18.0cm.

Fig : 7

PROCEDURE:

The test sample: It consists of aggregates sized 12.5 mm - 10.0 mm (minimum 3kg). The aggregates

should be dried by heating at 100-110 C for a period of 4 hours and cooled.

1) Sieve the material through 12.5 mm and 10.0 mm IS sieves. The aggregates passing through 12.5 mm sieve and retained on 10.0 mm sieve comprises the test material.

2) The cylinder of the test shall be put in position on the base-plate and the test sample added in thirds, each third being subjected to 25 gentle blows with the rounded end of tamping rod.
3) The surface of the aggregate shall be carefully leveled.

4) The plunger is inserted so that it rests horizontally on this surface, care being

taken to ensure that the plunger does not jam in the cylinder

5) The apparatus, with the test sample and plunger in position, shall then be placed between the plates of the testing machine.

6) The load is applied at a uniform rate as possible so that the total load is reached in 10 minutes. The total load shall be 40 tonnes.

7) The load shall be released and the whole of the material is removed from the cylinder and sieved on 2.36mm IS Sieve.
8) The fraction passing the sieve shall be weighed and recorded.

DETERMINATION OF AGGREGATE IMPACT VALUE

AIM:

1) To determine the impact value of the road aggregates
2) To assess suitability of aggregates for use in different types of road pavement

APPARATUS:

The apparatus of the aggregate impact value test as per IS: 2386 (Part IV) – 1963 consists of:

1) A testing machine weighing 45 to 60 kg and having a metal base with a plane lower surface of not less than 30 cm in diameter. It is supported on level and plane concrete floor of minimum 45 cm thickness. The machine should also have provisions for fixing its base.
2) A cylindrical steel cup of internal diameter 102 mm, depth 50 mm and minimum thickness 6.3 mm.
3) A metal hammer weighing 13.5 to 14.0 kg the lower end is cylindrical in shape, is 50 mm long 100.0 mm in diameter, with a 2 mm chamfer at the lower edge and case hardened. The hammer should slide freely between vertical guides and be concentric with the cup. The free fall of the hammer should be within 380 ± 5 mm.
4) A cylindrical metal measure having internal diameter of 75 mm and depth 50 mm for measuring aggregate.
5) Tamping rod 10 mm in diameter and 230 mm long, rounded at one end.
6) A balance of capacity not less than 500 g, readable and accurate up to 0.1 g.

Fig:8

PROCEDURE:

The test sample: It consists of aggregates sized 10.0 mm to 12.5 mm. The aggregates should be dried by heating at 100-110^o C for a period of 4 hours and cooled.

1) Sieve the material through 12.5 mm and 10.0 mm IS sieve. The aggregates passing through 12.5 mm sieve and retained on 10.0 mm sieve comprises the test material.

2) Pour the aggregates to fill about 1/3rd depth of measuring cylinder.

3) Compact the material by giving 25 gentle blows with the rounded end of the tamping rod.
4) Add two more layers in similar manner, so that cylinder is full.
5) Strike off the surplus aggregates.
6) Determine the net weight of the aggregates to the nearest gram (W_1).
7) Bring the impact machine to rest without wedging or packing up on the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.

8) Fix the cup firmly in position on the base of machine and place whole of the test sample in it and compact by giving 25 gentle strokes with tamping rod.

9) Raise the hammer until its lower face is 380 mm above the surface of the aggregate sample in the cup and allow it to fall freely on the aggregate sample. Give 15 such blows at an interval of not less than one second between successive falls. Remove the crushed aggregate from the cup and sieve it through 2.36 mm IS sieves until no further significant amount passes in one minute. Weigh the fraction passing the sieve to an accuracy of 1 gm (W2). Also weigh the fraction retained in the sieve.

10) Note down the observations in the Performa and compute the aggregate impact value.
11) The mean of two observations, rounded to nearest whole number is reported as the Aggregate Impact Value.

DETERMINATION OF LOS ANGELES ABRASION VALUE

AIM:

1) To determine Los Angeles abrasion value.
2) To find out the suitability of aggregates for its use in road construction.

APPARATUS:

The apparatus as per IS: 2386 (Part IV) – 1963 consists of:

1) Los Angeles Machine: It consists of a hollow steel cylinder, closed at both the ends with an internal diameter of 700 mm and length 500 mm and capable of rotating about its horizontal axis. A removable steel shaft projecting radially 88 mm into cylinder and extending full length (i.e. 500 mm) is mounted firmly on the interior of cylinder. The shelf is placed at a distance 1250 mm minimum from the opening in the direction of rotation.
2) Abrasive charge: Cast iron or steel balls, approximately 48 mm in diameter and each weighing between 390 to 445 g; 6 to 12 balls are required.
3) Sieve: The 1.70 mm IS sieve
4) Balance of capacity 5 kg or 10 kg
5) Drying oven
6) Miscellaneous like tray etc

Fig :9

PROCEDURE:

Test Sample: It consists of clean aggregates dried in oven at 105 - 110 C and is coarser than 1.70mm sieve size. The sample should conform to any of the grading shown in table.

Table 3 Grading of Test Samples

Sieve size (square hole)		Weight in g of Test Sample for Grade						
Passing Mm	Retained on mm	A	B	C	D	E	F	G
80	63	-	-	-	-	2500*	-	-
63	50	-	-	-	-	2500*	-	-
50	40	-	-	-	-	5000*	5000*	-
40	25	1250	-	-	-	-	5000*	5000*
25	20	1250	-	-	-	-	-	5000*
20	12.5	1250	2500	-	-	-	-	-
12.5	10	1250	2500	-	-	-	-	-
10	6.3	-	-	2500	-	-	-	-
6.3	4.75	-	-	2500	-	-	-	-
4.75	2.36	-	-		5000	-	-	-

Fig : 4

*Tolerance of ±12 percent permitted.

1) Select the grading to be used in the test. It should be chosen such that it conforms to the grading to be used in construction, to the maximum extent possible.

2) Take 5 kg of sample for grading A, B, C or D and 10 kg for grading E, F and G. Choose the abrasive charge as per Table 4.

Table 4 Selection of Abrasive Charges

Grading	No. of Steel	Weight of charge,
A	12	5000 ± 25
B	11	4584 ± 25
C	8	3330 ± 25
D	6	2500 ± 25
E	12	5000 ± 25
F	12	5000 5

Fig : 5

3) The test sample and the abrasive charge shall be placed in the Los Angles abrasion testing machine.

4) The machine is rotated at a speed of 30 to 33 rev/min for grading A, B,C and D, the machine shall be rotated for 500 revolutions; for grading E, F and G, it shall be rotated for 1000 revolutions.

5) The material is discharged from the machine after the completion of the test and is sieved through 1.7 mm IS sieve.

6) The weight of the aggregate passing through 1.7mm sieve is taken and recorded.

SHAPE TEST

1. FLAKINESS INDEX

AIM:

This method of test lays down the procedure for determining the flakiness index of the coarse aggregate.

APPARATUS:

The apparatus shall consist of the following:

1) A balance – The balance shall be of sufficient capacity and sensitivity and shall have an accuracy of 0.1 percent of the weight of the test sample
2) Metal Gauge – The metal gauge shall be of the pattern.
3) Sieves – The sieves of sizes.

Fig : 10

PROCEDURE:

1) A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.
2) The sample shall be sieved with sieves specified in Table 6.

3) Then each fraction shall be gauged in turn for thickness on a metal gauge of the pattern shown in Fig 4 or in bulk on sieves having elongated slots. The width of the slot used in the gauge or sieve shall be of the dimensions specified in column 3 of Table 6 for the appropriate size of material.

4) The total amount of aggregate passing the gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample.

Table No.6 Dimensions of Thickness and Length gauge

SIZE OF AGGREGATE (mm)		THICKNESS GAUGE (mm) *	LENGTH GAUGE (mm) #
Passing through IS sieve	Retained on IS sieve		
63	50	33.90	-
50	40	27.00	81.0
40	31.5	19.50	58.5
31.5	25	16.95	-
25	20	13.50	40.5
20	16	10.80	32.4
16	12.5	8.55	25.6
12.5	10	6.75	20.2
10	6.3	4.89	14.7

Fig :6

*This dimension is equal to 0.6 times the mean sieve size.

#This dimension is equal to 1.8 times the mean sieve size.

2. ELONGATION INDEX

AIM:

This method of test lays down the procedure for determining the elongation index of the coarse aggregate.

APPARATUS:

The apparatus shall consist of the following:

1) A balance – The balance shall be of sufficient capacity and sensitivity and shall have an accuracy of 0.1 percent of the weight of the test sample.
2) Metal Gauge – The metal gauge shall be of the pattern.
3) Sieves – The sieves of sizes.

Fig : 11

PROCEDURE:

1) A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of The sample shall be sieved with sieves specified in Table 6.

   Each fraction shall be gauged in turn for length on a metal gauge of the pattern shown in Fig 5. The gauge length used shall be of the dimensions specified in column 4 of Table 6 for the appropriate size of material.

2) The total amount of aggregate retained by the length gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample.
3) any fraction to be tested.

DETERMINATION OF SPECIFIC GRAVITY AND WATER ABSORPTION OF COARSE AGGREGATE

AIM:

To determine specific gravity and water absorption of a given sample of coarse aggregate.

APPARATUS

A wire basket of not more than 6-3 mm mesh, A stout watertight container in which the basket may be freely suspended, well-ventilated oven, Taping rod, An airtight container of capacity similar to that of the basket etc.

Fig : 12

PROCEDURE:

1. shall then be removed from the water and allowed to drain for a few minutes, after which the, aggregate shall be gently emptied from the basket on to one of the dry clothes, and the empty basket shall be returned to the water and weighed in water (weight A2).
2. The aggregate placed on the dry cloth shall be gently surface dried with the cloth, transferring it to the second dry cloth when the first will remove no further moisture. The aggregate shall then be weighed (weight B). A sample of not less than 2000 g of the aggregate shall be thoroughly washed to remove finer particles and dust, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22°C to 32°C with a cover of at least 5 cm of water above the top of the basket.

3. Immediately. after immersion the entrapped air shall be removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop 25 times

at the rate of about one drop per second. The basket and aggregate shall remain completely immersed during the operation and for a period of 24 ± l/2 hours afterwards.

4. The basket and the sample shall then be jolted and weighed in water at a temperature of 22°C to 32°C (weight A1)
5. The basket and the aggregate

6. The aggregate shall then be placed in the oven in the shallow tray, at a temperature of 100 to 110°C and maintained at this temperature for 24 ± l/2 hours. It shall then be removed from the oven, cooled in the airtight container and weighed (weight C).
7. Calculations— Specific gravity, apparent specific gravity and water absorption shall be calculated.

MARSHAL STABILITY TEST

Overview

The mix design (wetmix) determines the optimum bitumen content. This is preceded by the dry mix design discussed in the previous chapter. There are many methods available for mix design which vary in the size of the test specimen, compaction, and other test speci_cations. Marshall method of mix design is the most popular one and is discussed below.

The Marshall stability and ow test provides the performance prediction measure for the Marshall mix design method. The stability portion of the test measures the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute. Load is applied to the specimen till failure, and the maximum load is designated as stability. During the loading, an attached dial gauge measures the specimen's plastic ow (deformation) due to the loading. The ow value is recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load is recorded. The important steps involved in marshal mix design are summarized next.

Properties of the mix

The properties that are of interest include the theoretical speci_c gravity Gt, the bulk speci_c gravity of the mix Gm, percent air voids Vv, percent volume of bitumen Vb, percent void in mixed aggregate VMA and percent voids _filled with bitumen VFB

DETERMINATION OF MARSHALL STABILITY MIX DESIGN.

AIM :

To design the Asphalt concrete mix using Marshall method

APPARATUS:

1. Mold Assembly
2. Sample Extractor
3. Compaction pedestal and hammer.
4. Breaking head.
5. Loading machine
6. Flow meter , water bath, thermometers.

Fig : 13

PROCEDURE:

1. Select aggregate grading to be used (Table 11.2)
2. Determine the proportion of each aggregate size required to produce the design grading.
3. Determine the specific gravity of the aggregate combination and asphalt cement.
4. Prepare the trial specimens with varying asphalt contents.
5. Determine the specific gravity of each compacted specimen.
6. Perform stability tests on the specimens.
7. Calculate the percentage of voids, and percent voids filled with Bitumen in each specimen.
8. Select the optimum binder content from the data obtained.
9. Evaluate the design with the design requirements.

Test Property	Specified Value	Values obtained after replacement
Marshall stability, kg	340 (minimum)	340
Flow value, 0.25 mm units	8-17	18-23
Percent air voids in the mix Vv%	3-5	7-9
Voids filled with bitumen V FB%	75-85	90-100

Fig : 7

EXPERIMENTAL RESULTS

SI. NO.	Test conducted	Test method	Range	Values obtained	Values obtained after replacement
1.	Crushing value	IS-2386 part IV	Less than 30%	24.9%	22.7%
2.	Abrasion value	IS-2386 part IV	Less than 30%	17%	15.7%
3.	Impact value	IS-2386 part IV	Less than 30%	16.8%	16.1%
4.	Combined Flakiness and elongation index	IS-2386 part I	Less than 15%	14%	12%
5.	Water absorption test	IS-2386 part III	Less than 2%	0.375%	0.325%
6.	Bulking of sand	IS-2386 part I	20-40%	30%	25%
7.	Specific gravity test	IS-1963 part III	2.5-3	2.63	2.5

Fig : 8

CONCLUSION AND FUTURE ENHANCEMENT

1.From Marshall stability test, it can be concluded that there is an increase in stability using the % mix at 120°c for 60/70 grade bitumen.

2.The max stability for the 60/70 grade bitumen is achieved at 120°c temperature with 35% mixing dosage rate.

3.Waste material (iron ore tailings / waste) can be used as filler material in bituminous concrete mixture for road construction.

4.Use of this innovative technology not only strengthened the road construction but also increased the road life.

5.Help to improve the environment.

6.This small investigation not only utilizers beneficially, the waste semi-degradable iron ore tailings and mine waste but also provides us an improved pavement with better strength.

7.Deformation on pavement takes place due to the application of heavy loads can also rectifies by use of mine and iron ore tailings.

8.Water percolation through layers of surface, base and sub base from grain can also be corrected by using mine waste and iron ore tailings.

9.By using mine waste and iron ore tailings, the life period of flexible pavement can be enhanced.

10.Workability can also be achieved using iron ore tailings / mine waste.

11.By the application of this new technology the strength of pavement also increases.

12.Soil properties also increases using mine waste /iron ore tailings.

13.It is an environment friendly project and it is economically adoptable.

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A Major Project Report
On

STUDY OF CONCRETE BY USING ZEOLITE

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

by

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JUNE 2021

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BONAFIDE CERTIFICATE

This is to certify that the project entitled **Study of Concrete by using Zeolite**, is being submitted by **T.Suchandra (17K81A0157), T.Veerendar (17K81A0155), Ch. Tulasi ram (17K81A0115), G.Manoj (17K81A0129)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN CIVIL ENGINEERING** is recorded of bonafide work carried out by them. The result embodied in this report has been verified and found satisfactory.

Signature of Guide	Signature of HOD
Mrs.S.GAYATHRI	**Dr. SANDHYA KIRAN.J.K**
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Department of Civil Engineering	Department of Civil Engineering

Internal Examiner **External Examiner**

Place:

Date:

DECLARATION

We, the students of **Bachelor of Technology** in **Department of Civil Engineering**, of the Academic Year:2017 - 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project entitled **Study of concrete by using zeolite** is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been carried by taking care of Engineering Ethics. The result embodied in this project report has not been submitted in any university for award of any degree.

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ABSTRACT

This study focuses on the use of zeolite powder in concrete as partial replacement of cement.The purpose of this research is to find the suitability of Zeolite with the high performance concrete M30 grade.Zeolite is a popular type of natural pozzolanic material which has been widely utilized in constructions since ancient times and zeolite is the largest group of silicate minerals. In this study the application of natural zeolite as a partial supplementary cementitious material has been carried out. .To this aim some castingss of concrete made with 5%, 10%, 15% replacement of cement with zeolite are studied. The mechanical properties such as compression strength of concrete were carried out.A fresh concrete test was made to study the workability properties of partial replacement of zeolite concrete and conventional concrete using slump cone test.We found the compressive strength of zeolitic concrete when we replace cement with zeolite powder and curing is done for 7,14,28 days.

KEYWORDS: Zeolite, Compressive strength, slump cone test.

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CHAPTER-1
INTRODUCTION

1.0 Overview of the Project

This projects report on the effect of using zeolite as a replacement of cement on the strength, workability, durability properties. Concrete is most popular, important and most economical construction material. Concrete is used very widely everywhere making architectural structure and infrastructure. Concrete is a mixture of different kind of materials which is composed of water, cement, coarse aggregate and fine aggregate. Cement is a most durable material of concrete. Now a day's cement production is abundant which causes the reduction in the source of cement. To fulfill this gap created by cement, we can use zeolite powder as replacement material. We found that zeolite powder is a good substitute of replacement of cement. It can reduce the cost of construction. Due to the production of cement the environment gets polluted and causes the source of CO2 emission. This entire process causes global warming and Global warming resulted from the emission of greenhouse gases has received widespread attention. In the sense of greenhouse gases, more than 60% to global warming caused due to contribution of CO2 because of its huge emission amount.

1.1 Objectives of the study

- The optimum percentage of zeolite at which maximum strength is found .
- Increasing the strength and workability of concrete.
- CO2 emission is reduced.
- To prepare mix design for M30 grade concrete.

1.2 Scope of the Project

- To increase the strength and workability of concrete. .
- The ZEOLITE reduces the co2 emission.
- To identify the various factors affecting strength and workability of concrete by using ZEOLITE.
- Cost of works can be reduced.

1.3 Material Requirement

- **Cement**

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete.

- **Coarse Aggregate**

Aggregates are the important constituents in concrete. They give body to the Concrete, reduce shrinkage and effect economy. Earlier, aggregates were considered as Chemically inert materials but now it has been recognized that some of the aggregates are Chemically active and also that certain aggregates exhibit chemical bond at the interface of aggregate and paste. The mere fact that the aggregates occupy 70-80 per cent of the Volume of concrete, their impact on various characteristics and properties of concrete is Undoubtedly considerable. To know more about the aggregates which constitute major Volume in concrete.

Aggregates are divided into two categories from the consideration of size

- Coarse aggregate
- Fine aggregate

The size of the aggregate bigger than 4.75 mm is considered as coarse aggregate and Aggregate whose size is 4.75 mm and less is considered as fine aggregate.

- **Water**

The amount of water in concrete controls many fresh and hardened properties in concrete including workability, compressive strengths, permeability and watertightness, durability and weathering, drying shrinkage and potential for cracking.

- **Zeolite**

Zeolite is a popular type of natural pozzolanic material which has been widely utilized in constructions since ancient times and zeolite is the largest group of silicate minerals. Zeolite occur naturally but are also produced industrially on a large scale naturally it is obtained by open pit mining and industrially it is produced synthetically by typical procedure heating aqueous solutions of alumina and silica with sodium hydroxide. equivalent reagents include sodium aluminate and sodium silicate. Zeolite Procured from Sri maruthi industries Hyderabad, Specific gravity 2.1.

1.4 Organization of Chapters

The dissertation has been divided into five chapters including Introduction. Chapter 1 consists of general introduction, overview of previous literatures are given in chapter 2, study area, components of the Concrete is explained in chapter 3, Data Analysis and Result are presented in chapter 4, chapter 5 consists of conclusion and scope of future work.

Chapter 1 presents the brief introduction about Zeolite in concrete. The objectives and scope of the study has also been presented and it gives an overview of the project in this chapter.

Chapter 2 presents literature reviews of the previous work of pioneer investigators. This chapter includes previous work already carried out in Concrete by using Zeolite.

Chapter 3 presents the study of the Concrete by using zeolite and also highlights the major components of the project such as tests conducted on concrete etc.

Chapter 4 presents the Sampling Plan and the results obtained for compressive strength of concrete 7,14 and 28 days.

Chapter 5 includes the concluding remarks and future scope of the research works.

Previous works carried out by other investigators have been cited in

references are provided at the last.

CHAPTER-2

REVIEW OF RELATED LITERATURE

2.1 LITERATURE REVIEW ON BASE PAPER

In this literature review the through study of research papers on partial replacement of cement with zeolite and concrete.

1. **B.Uzal et.al.(2009)** studied the Pozzolanic activity of clinoptilolite, the most common natural zeolite mineral, was studied in comparison to silica fume, fly ash and a non-zeolitic natural pozzolan. The results showed that the clinoptilolite possessed a high lime–pozzolan reactivity that was comparable to silica fume and was higher than fly ash and a non-zeolitic natural pozzolan.The high reactivity of the clinoptilolite is attributable to its specific surface area and reactive SiO2 content.Relatively poor strength contribution of clinoptilolite in spite of high pozzolanic activity can be attributable to larger pore size distribution of the hardened zeolite–lime product compared to the lime–fly ash system.

2. **Babak Ahmadi and Mohammad Shekarchi(2009)**studied the effectiveness of a locally quarried zeolite in enhancing mechanical and durability properties of concrete is evaluated and is also compared with other pozzolanic admixtures. The experimental tests included three parts: In the first part, the pozzolanic reactivity of natural zeolite and silica fume were examined by a thermogravimetric method. In this case, the results indicated that Natural zeolite was not as reactive as silica fume but it showed a good pozzolanic reactivity. In the second part, zeolite and silica fume were substituted for cement in different proportions in concrete mixtures, and several physical and durability tests of concrete were performed. Based on these results, the performance of concretes containing different contents of zeolite improved and even were comparable to or better than that of concretes prepared with silica fume replacements in some cases.

3. **B.Uzal andL.Turanl(2011)** studied the properties and hydration characteristics as well as paste microstructure of blended cements containing 55% by weight zeolitic stuff composed mainly of clinoptilolite mineral were investigated.Superplasticizer requirement and compressive strength development of blended cement mortars were also determined.The blended cements containing high volume of natural zeolites were characterized with the following properties; (i) no free Ca(OH)2 in hardened pastes at the end of 28 days of hydration, (ii) less proportion of the pores larger than 50 nm when compared to portland cement paste, (iii) complete decomposition of crystal structure of zeolite at the end of 28 days of hydration, (iv) presence of tetracalcium aluminate hydrate as a crystalline product of pozzolanic reaction, (v) more compatibility with the melamine-based superplasticizer when compared to the naphthalene based product, and (vi) similar 28 days compressive strength of mortars to that of reference portland cement.

4. **Canpolat et.al.(2013)** studied the effects of zeolite, coal bottom ash and fly ash as Portland cement replacement materials on the properties of cement are investigated through three different combinations of tests. These materials are substituted for Portland cement in different proportions, and physical properties such as setting time, volume expansion, compressive strength and water consistency of the mortar are determined. Then, these physical properties are compared with those of PC 42.5. The results showed that replacement materials have some effects on the mechanical properties of the cement. The inclusion of zeolite up to the level of 15% resulted in an increase in compressive strength at early ages,but resulted in a decrease in compressive strength when used in combination with fly ash. Also, setting time was decreased when zeolite was substituted. The results obtained were compared with Turkish Standards (TS), and it was found that they are above the minimum requirements.

5.**Mahdi Valipour et.al.(2013)** studied to improve the durability and serviceability of concrete structures in such environments, several investigations have been conducted that address the addition of silica fume and metakaolin, while less attention has been given to the newly introduced pozzolan called natural zeolite. In this paper, the performance of concretes containing natural zeolite, metakaolin and silica fume and that of concretes with different water-to-binder ratios under various exposure conditions in terms of chloride ion diffusivity were investigated. To achieve this objective, concrete specimens with water-to-binder ratios (w/b) of 0.35, 0.40, 0.45 and 0.50 were fabricated. In addition, to examine the performance of three different pozzolans, other specimens with constant waterto-binder ratios of 0.40 containing 10% natural zeolite, 5% metakaolin and 5% silica fume were prepared. The results were obtained from a field exposure site and indicate that natural zeolite exhibits good performance in terms of improving the durability of concrete in harsh environments.

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CHAPTER-3
PROJECT DESIGN

3.0 OVERVIEW OF PROJECT

This projects report on the effect of using zeolite as a replacement of cement on the strength, workability, durability properties. Now a day's cement production is abundant which causes the reduction in the source of cement. To fulfill this gap created by cement, we can use zeolite powder as replacement material. We found that zeolite powder is a good substitute of replacement of cement. It can reduce the cost of construction. Due to the production of cement the environment gets polluted and causes the source of CO_2 emission.

3.1 EQUIPMENT ANALYSIS

- **Compressive Testing Machine**

The Compression Testing Machine is a very common testing method that is used to establish the compressive force or crush resistance of a material and the ability of the material to recover after a specified compressive force is applied and even held over a defined period of time by measuring fundamental variables, such as, strain, stress, and deformation.

- **Cube Casting**

For cube test 15cm X 15cm X 15cm are used.The cube mould plates should be removed, properly cleaned assembled and all the bolts should be fully tight. A thin layer of oil then shall be applied on all the faces of the mould. It is important that cube side faces must be parallel. After taking concrete samples and mixing them, the cubes shall be cast as soon as possible. The concrete sample shall be filled into the cube moulds in layers . In placing each scoopful of concrete, the scoop shall be moved around the top edge of the mould as the concrete slides from it, in order to ensure a symmetrical distribution of the concrete with in the mould. Each layer shall be compacted either by hand or by the vibration.

- **COMPACTION BY HAND:**
  Each layer of the concrete filled in the mould shall be compacted by not less than 35 strokes by tamping bar. The strokes shall be penetrate into the underlying layer and the bottom layer shall be rodded throught its depth. Where voids are left by the tamping bar the sides of the mould shall be tapped to close the voids.

- **COMPACTION BY VIBRATION:**
  When compacting by vibration each layer shall be vibrated by means of an electric or pneumatic hammer or vibrator or by means of a suitable vibrating table until the specified condition is attained.

MODULES:

- Mixing of M30 grade concrete as per the code IS 10262-2019
- Determining the specific gravity of aggregates,water absorption

- Weighing the quantity of materials required for casting of cubes
- Concrete is mixed at different proportion of zeolite percentage 0%,5%,10% &20%.
- A fresh concrete test is made to study the workability of concrete at different proportions y using slump test .
- A hardened concrete test for cubes were made to study the strength of concrete at different percentages of zeolite.

CHAPTER-4
IMPLEMENTATION

4.0 MIXING OF M30 GRADE CONCRETE

- The measured quantity of sand is spread on the platform and then the cement is dropped over the sand.
- The sand and cement are mixed thoroughly for several times with the help of shovels in the dry state until the mixture attains an even colour throughout and is free from streaks.
- Next, the measured amount of coarse aggregates is spread out in uniform layer on the above mixture and mixed properly. Remember to use measurement boxes for batching of aggregates, i.e. to determine how much aggregates are to be used.Add zeolite in different proportioning (0%,5%,10% &15%) to improve the performance characteristics of concrete.

- Later, the whole mixture is blended properly like turning over by twist from the center to the side, then back to the center and again to the sides several times.
- After that, depression is made at the center of the mixed materials.
- And, 75% of the required quantity of water is added in the depression and mixed with the help of shovels.
- Lastly, the remaining amount of water is added and the mixing process is continued till a uniform colour and consistency of concrete is obtained. The total time taken for mixing of concrete should not exceed 3 minutes.

FIG 4.0 MIXING OF CONCRETE

4.1 CASTING OF CUBES

Cubes of size 15 x 15 x 15 cm are taken for casting the cubes.The cube mould plates should be removed, properly cleaned assembled and all the bolts should be fully tight. A thin layer of oil then shall be applied on all the faces of the mould. It is important that cube side faces must be parallel.After taking concrete samples and mixing them, the cubes shall be cast as soon as possible. The concrete sample shall be filled into the cube moulds in layers . In placing each scoopful of concrete, the scoop shall be moved around the top edge of the mould as the concrete slides from it, in order to ensure a symmetrical distribution of the concrete with in the mould. Each layer shall be compacted either by hand or by the vibration.

- The test specimens are stored in moist air for 24 hours and after this period the specimens are marked and removed from the molds and kept submerged in clear freshwater until taken out prior to the test.
- Tests on cubes is carried out for 7,14&28 days.

FIG 4.1 CUBE CASTING

4.2MIX DESIGN

The procedure for designing concrete mix as per new IS:10262-2019 code is highlighted using an M30 concrete.

Design stipulations for proportioning

a. Grade designation: M 30
b. Type of cement: OPC 43 grade, IS 269
c. Max. Nominal size of aggregate. : 20 mm
d. Minimum cement content: 3000 kg/m^3
e. Maximum water cement ratio: 0.45
f. Exposure condition: Severe
g. Degree of site control: Good
h. Type of aggregate: Crushed angular aggregate
i. Maximum cement content: 450 kg/m^3

4.3 TEST DATA FOR MATERIALS

a) Cement used : OPC 43 Grade conforming to IS 269

b) Specific gravity of cement : 3.15

c) Chemical admixture : Superplasticizer conforming to IS 9103

d) Specific gravity of 1) Coarse aggregate (at SSD condition) : 2.74
2) Fine aggregate (at SSD condition) : 2.65
3) Chemical admixture : 1.08

e) Water absorption 1) Coarse aggregate : 0.5 percent
2) Fine aggregate : 1.0 percent

f) Free (surface) moisture 1) Coarse aggregate : Nil (absorbed moisture also nil)
2) Fine aggregate : Nil (absorbed moisture also nil)

TARGET STRENGTH FOR MIX PROPORTIONING

$f'_{ck} = f_{ck} + 1.65\,S$

or

$f'_{ck} = f_{ck} + X$

whichever is higher.

where f'_{ck} = target average compressive strength at 28 days,

f_{ck} = characteristic compressive strength at 28 days,

S = standard deviation, and

X = factor based on grade of concrete.

From Table 2, standard deviation, *S* = 5 N/mm2.

From Table 1, *X* = 6.5.

Therefore, target strength using both equations, that is

a) $f'_{ck} = f_{ck} + 1.65\,S$

$= 30 + 1.65 \times 5 = 38.25$ N/mm2

b) $f'_{ck} = f_{ck} + 6.5$

$= 30 + 6.5 = 36.5$ N/mm2

The higher value is to be adopted. Therefore, target strength will be 38.25 N/mm2 as 38.25 N/mm2 > 36.5 N/mm2.

SELECTION OF WATER-CEMENT RATIO

From Fig. 1, the free water-cement ratio required for the target strength of 38.25 N/mm2 is 0.43 for OPC 43 grade curve. This is lower than the maximum value of 0.45 prescribed for 'severe' exposure for reinforced concrete as per Table 5 of IS 456.

0.43< 0.45, hence O.K.

DETERMINATION OF WATER ,ZEOLITE AND AGGREGATE CONTENT

REPLACEMENT DETAILS	ZEOLITE Kg/m3	CA(Kg/m3)		Fine Aggregate Kg/m3	Cement (Kg/m3)	Water (Kg/m3)
		20mm	10mm			
conventional concrete	0	769.98	513.32	811.5	358.97	139.78
5% zeolite	17.94	769.98	513.32	811.5	341.02	139.78
10% zeolite	35.87	769.98	513.32	811.5	323.07	139.78
15% zeolite	53.84	769.98	513.32	811.5	305.12	139.78

TABLE-4.3 DETERMINATION OF MATERIAL CONTENT

CHAPTER-5
TESTING

EXPERIMENTAL RESULTS AND TESTING

5.1 SPECIFIC GRAVITY TEST :

In Concrete technology, Specific gravity of aggregates is made use of in design calculations of concrete mixes. With the specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated.

Preparation of Test Sample

Coarse Aggregate

a) Sieve the test sample over the No. 4 (4.75 mm) sieve. The sample should be of sufficient size to produce approximately 2100 grams of material retained on the No. 4 sieve. Discard the material that passes this sieve.

b) Immerse the sample (plus No. 4 sieve size) in water for a period of not less than 15 hours.

c) After soaking, pour off the free water and allow the sample to come to a saturated surface dry condition by spreading the sample on a flat, non-absorbent surface. The forced circulation of air by means of a fan, if available, may hasten this process. The sample should be stirred frequently to secure uniform drying. The free moisture may be removed initially by rolling the sample back and forth in a clean, dry, absorbent cloth.

d)The sample may be considered to be saturated-surface-dry when the particles look comparatively dull as the free moisture is removed from their surfaces. For highly absorptive aggregates, the saturated-surface-dry condition is reached when there is an absence of free moisture.

Test Procedure

i. Weigh the saturated-surface-dry sample to the nearest 0.5-gram. For ease in calculations, the fine aggregate sample may be brought to exactly 1000 grams weight, and the coarse aggregate sample may be brought to exactly 2000 grams weight.

i. Place the sample in the appropriate pycnometer containing approximately two inches of water. Nearly fill the pycnometer jar with water at the same temperature plus or minus 3 °F(1.7 °C) as used in the calibration.

ii. Screw the cap down into the proper position by lining up the mark on the pycnometer top and the jar. Entirely fill the pycnometer by adding additional water through the hole in the pycnometer top.

iii. Hold one finger over the hole in the top and gently roll and shake the pycnometer to remove any trapped air in the sample. When further rolling and shaking brings no more air bubbles to the top, fill, dry and weigh.

Fig 5.1 specific gravity test for CA

EXPERIMENT RESULT:

Saturated surface dry (SSD) sample weight (A)	= 500.00 gm.
Pycnometer + water + SSD sample (B)	= 1790.00 gm
Pycnometer + water (C)	= 1539.00 gm
Oven dry Sample (D)	= 498.00 gm.
Specific gravity	= 2.5937 gm/c

WATER ABSORPTION TEST:

This test helps to determine the water absorption of coarse aggregates as per IS: 2386 (Part III) – 1963. For this test a sample not less than 2000 g should be used. The apparatus used for this test are:

- Wire basket, perforated, electroplated or plastic coated with wire hangers for suspending it from the balance
- Water-tight container for suspending the basket
- Dry soft absorbent cloth – 75 cm x 45 cm (2 nos.) Shallow tray of
- minimum 650 sq. cm area Air-tight container of a capacity similar to
- the basket and Oven.

Procedure to determine water absorption of Aggregates.

i) The sample should be thoroughly washed to remove finer particles and dust, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22 and 32 ^{o} C .

ii) After immersion, the entrapped air should be removed by lifting the basket and allowing it to drop 25 times in 25 seconds. The basket and sample should remain immersed for a period of 24 + ½ hrs afterwards.

iii) The basket and aggregates should then be removed from the water, allowed to drain for a few minutes, after which the aggregates should be gently emptied from the basket on to one of the dry clothes and gently surface-dried with the cloth, transferring it to a second dry cloth when the first would remove no further moisture. The aggregates should be spread on the second cloth and exposed to the atmosphere away from direct sunlight till it appears to be completely surface-dry. The aggregates should be weighed (Weight 'A').

iv) The aggregates should then be placed in an oven at a temperature of 100 to 110 ^{o}C for 24 hrs. It should then be removed from the oven, cooled and weighed (Weight 'B'). Formula used is Water absorption = [(A - B)/B] x 100%. Two such tests should be done and the individual and mean results should be reported.

EXPERIMENT RESULT:

Coarse aggregate-20mm:

Weight of Saturated Surface Dry (SSD) sample (A) =705.00 gm.

Weight of Oven dry Sample (B) =703.00 gm.

Weight Absorption = 0.28 %

Coarse aggregate – 12mm:

Weight of Saturated Surface Dry (SSD) sample (A) =653.50 gm.

Weight of Oven dry Sample (B) =650.00 gm.

Weight Absorption = 0.54 %

5.2 SLUMP TEST:

After the fresh concrete is prepared Slump test is done. Slump test is the most commonly used method of measuring workability of concrete which can be employed either in laboratory or at site of work .It does not measure all factors contributing to workability, nor is it always representative of the playability of the concrete.

Fig: 5.2: Slump cone apparatus

- The apparatus for conducting the slump test essentially consists of a metallic mould in the form of a frustum of a cone having the internal dimensions as under:

- Bottom diameter : 20 cm
- Top diameter : 10 cm
- Height : 30 cm

i. The mould is then filled in four layers, each approximately l/4 of the height of the mould. Each layer is tamped 25 times by the tamping rod taking care to distribute the strokes evenly over the cross section.

ii. After the top layer has been ridded, the concrete is struck off Level with a trowel and tamping rod. The mould is removed from the concrete immediately by raising it slowly and carefully in a vertical direction.

iii. This allows the concrete to subside. This subsidence is referred as SLUMP of concrete.

iv. The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured. This difference in height in mm is taken as Slump of Concrete.

v. If the concrete slumps evenly it is called true slump. If one half of the cone slides down, it is called Shear slump. In case of a shear slump, the slump value is measured as the difference in height between the height of the mould and the average value of the subsidence. Shear slump also indicates that the concrete is non-cohesive and shows the characteristic of segregation.

FIG 5.2.1 SLUMP TEST

TEST RESULTS FOR SLUMP TEST

ZEOLITE PERCENTAGE	SLUMP IN MM
0%	64
5%	66
10%	54
15%	56

TABLE 5.2 SLUMP TEST RESULTS

5.3 COMPRESSIVE STRENGTH

Why do we test at 7, 14 & 28 days? Concrete is a macro content with Sand, Cement, Coarse aggregate as its micro-ingredient Mix Ratio) and gains its 100% strength over time at the hardened state.

Take a look at the below table.

Table 5.3 - Concrete Strength Overtime

Days after Casting	Strength Gain
Day 1	16%
Day 3	40%
Day 7	65%
Day 14	90%
Day 28	99%

Required Equipment & Apparatus

- 150 mm Cube Moulds (with IS Mark)
- Electronic Weighing Balance GI Sheet (For Making Concrete)
- Vibrating Needle & other tools
- Compressions Testing Machine

Cube Casting

Measure the dry proportion of ingredients (Cement, Sand & Coarse Aggregate) as per the design requirements. The Ingredients should be sufficient enough to cast test cubes

Thoroughly mix the dry ingredients to obtain the uniform mixture

Add design quantity of water to the dry proportion (water-cement ratio) and mix well to obtain uniform texture

Fill the concrete to the mould with the help of vibrator for thorough compaction

Finish the top of the concrete by trowel & tapped well till the cement slurry comes to the top of the cubes.

FIG: 5.3. Cube Casting

Curing

After some time the mould should be covered with red gunny bag and put undisturbed for 24 hours at a temperature of 27 ° Celsius ± 2

After 24 hours remove the specimen from the mould.

Keep the specimen submerged under fresh water at 27 ° Celsius. The specimen should be kept for 7 or 28 days. Every 7 days the water should be renewed.

The specimen should be removed from the water 30 minutes prior to the testing.

The specimen should be in dry condition before conducting the testing

The cube weight should note less than 8.1 Kg.

Fig: 5.3.1 – Air Dry Curing

COMPRESSIVE STRENGTH TEST

1. The specimen is removed from water after specified curing time and excess water is wiped out from the surface.
2. Clean the bearing surface of the testing machine
3. The specimen is placed in the machine in such a manner that the load is applied to the opposite sides of the cube cast.
4. Tthe specimenis alligned centrally on the base plate of the machine.
5. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
6. The load is applied gradually without shock and continuously at the rate of 140 kg/cm2/minute till the specimen fails.
7. The maximum load is recorded and note any unusual features in the type of failure.
8. The specimen is tested by compression test machine after 7 days, 14 days and 28 days curing

Compressive Strength = Load / Area

Size of the test specimen=150mm x 150mm x 150mm

FIG 5.3.2 COMPRESSION STRENGTH TEST

ZEOLITE PERCENTAGE	Load in KN	7 days N/mm2	14days N/mm2	28days N/mm2
conventional concrete	556.4	24.56	35.6	40.16
5%	577.2	25.37	37.61	42.12
10%	446.4	20.28	31.58	37.39
15%	506.4	23.44	34.72	38.94

TABLE -5.3.1 COMPRESSION STRENTH TEST RESULT

CHAPTER-6
CONCLUSION AND FUTURE ENHANCEMENT

CONCLUSION

- Zeolite helps for consuming the amount of CO_2 .
- The purpose of this research is to find the suitability of Zeolite with the high performance concrete M30 grade.
- The Highest Compressive strength value obtained 42.12N/mm2 at 5% replacement of cement with zeolite.
- A fresh concrete test was made to study the workability properties of partial replacement of zeolite concrete and conventional concrete.
- Slump is decreasing with the addition of zeolite. More the zeolite-cement ratio, more is the decrease in slump due to absorbency of water by zeolite.Maximum slump is found at 5% zeolite
- Hardened concrete tests on cubes, were made to study the strength of concrete made of partial replacement of zeolite concrete and conventional concrete.
- Compressive strength is compared with the results obtained form the conventional mix, . The maximum compressive strength was obtained at 5% replacement of cement by zeolite.
- Cement replacement can be done as cement is costly compared to zeolite and CO_2 emission can be reduced.
- Test results confirmed that the addition of zeolite was promising and favourable in enhancing the compressive strength, crack resistance and reducing the autogenous shrinkage of high performance concrete.

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A Major Project Report

On

INTERLINKING OF KRISHNA AND GODAVARI RIVERS: AN IRRIGATION PROJECT

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

by

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JUNE 2021

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BONAFIDE CERTIFICATE

This is to certify that the project entitled Interlinking of Krishna and Godavari rivers: An Irrigation Project is being submitted by 1. **Mr. U. Moiz (17K81A0145) 2. Mr. K. Srujan (17K81A0137) 3. Mr. R. Madhan (17K81A0154) 4. Mr. Y. Dinesh (17K81A0111)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN** Civil Engineering is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

Signature of Guide

Dr. JNANA RANJAN KHUNTIA
Assistant Professor
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Signature of HOD

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Head of the Department
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Internal Examiner

External Examiner

Place:

Date:

DECLARATION

We, the student of **Bachelor of Technology** in Department of 'Civil Engineering', session: 2017 – 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled Interlinking of Krishna and Godavari rivers: An Irrigation Project is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

Mr. U. Moiz (17K81A0145)
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ABSTRACT

The rivers play a vital role in the lives of the Indian people. The river systems help us in irrigation, potable water, cheap transportation, electricity as well as a source of livelihood for our ever increasing population. Indian agriculture largely depends upon Monsoon which is always uncertain. This problem of the irregular distribution of water can be overcome to a greater extent by interlinking of rivers.

The interlinking of rivers is a major endeavor to create additional storage facilities and transfer water from water-surplus regions to more drought-prone areas through inter-basin transfers. Interlinking of major rivers in India, aims at modifying the acute spatial inequity in the availability of water resources in India. Some of the benefits due to interlinking of rivers are in the area of irrigation, flood prevention, hydropower generation, navigation etc., whereas the area of concerns are ecological issues, deforestation, aqua life, submergence of habitable or reserved lands, displacement of people, etc.

The Godavari has been characterized as a ‘surplus’ basin whereas the Krishna Basin as a ‘deficit’ one. As the water availability in the Krishna river was becoming inadequate to meet the water demand, Godavari River is linked to the Krishna river by commissioning the Polavaram right bank canal with the help of Pattiseema lift scheme in the year 2015. The main objective of this present study is to independently evaluate the water availability as against the water demand in one of the NRLP links i.e., from the Godavari River (at Polavaram) to the Krishna River (at Vijayawada). In the Krishna-Godavari link at Polavaram command area, groundwater is the most dominating form of irrigation. The present paper is an attempt to study issues and challenges in interlinking of rivers in India from the point of view of society at large.

Keywords: Increasing population, Interlinking, Availability, Water demand, Ground water.

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LIST OF ABBREVIATIONS

<FRL	Full Reservoir Level
<TMC	Thousand Million Cubic
<MW	Mega Watt
<MSL	Mean Sea Level
<ECRF	Earth Cum Rockfill Dam
<RMC	Right Main Canal
<LMC	Left Main Canal
<CWC	Central Water Commision

Chapter-1

Introduction

1.1 Overview of the Project

National River Linking Plan (NRLP) was designed to alleviate emerging water scarcity problems in India. Transfers of ‘surplus’ water from primarily Himalayan Rivers to more ‘deficient’ peninsular rivers has been predicted to reduce imbalances in water availability in the country. The Himalayan component intends to transfer 33 km^3 and the peninsular component 141 $km^3$of water through the combined network of 30 links, amounting to a total length of 14,900 km(GOI 1999). The proposed plan, if fully completed, will be the largest ever infrastructure project in the world, costing an estimated 120 Billion US Dollars. The additional benefits claimed by the NRLP include, flood control, drought mitigation, increased irrigation, additional food-grain production and electricity generation. The NRLP, however, remains a controversial issue in India. This is partially due to the non-transparent and, largely, uni-sectoral nature of water resources planning, which places the major focus on irrigation development, as well as a lack of confidence in the characterization of particular river basins as either ‘surplus’ or ‘deficient’. The main objective of this present study is to independently evaluate the water availability as against the water demand in one of the NRLP links i.e., from the Godavari River (at Polavaram) to the Krishna River (at Vijayawada). This transfer is further referred to in the paper as the ‘Polavaram Project’. The Godavari has been characterized as a ‘surplus’ basin whereas the Krishna Basin as a ‘deficit’ one (GOI 1999). In Indian engineering practice, ‘surplus basins’ are defined as those which have a positive balance: i) of 75 % assured annual river flow volume; and ii) in the total annual volume of all water demands, projected up to the year 2050. Basins which have a negative balance of the above two components are classified as 'water deficient'. The analysis to characterize the rivers is done using annual flows (GOI 1999). Smakhtin et al. 2007 have argued however, that this planning process adopted by the Indian Government has ignored the seasonal variability of flow within a year, which is extremely high in monsoon-driven Indian rivers. As a result, much more water is perceived to be originally available at a site of transfer than is the actual case. This paper attempts to examine whether the planned water transfers will satisfy the growing water demands in the Polavaram link command area as well as identify the link's impacts outside of the command area, and uses the Water Evaluation and Planning Model Version 21 (WEAP 21) for this exercise. Further, in order to examine the effects of seasonal variability, the analysis is done at a monthly time step. The main reason for selecting this particular link is because the Polavaram Project is to be implemented in the near future, regardless of other NRLP water transfers.

The Godavari River is the second largest river in India with a catchment area of 312,812 km^2 and a long-term average annual surface flow of 110 km^3, of which 76 km^3 is estimated as non-utilizable (NCIWRD 1999). The cultivable area in the basin is about 18.9 million ha. There are already two major diversion structures in the basin. The Sri Ram Sagar Project (upstream of Polavaram) and the Arthur Cotton Barrage (downstream of Polavaram) provide irrigation water to 390,000 ha and 170,000 ha, respectively, in the Lower Godavari Basin. Similar to other parts of India, the use of groundwater to meet irrigation water demands is also a common practice in the Basin. Based on annual water balance calculations as well as the current and projected (for 2025) water requirements, the Central Water Commission (CWC) has concluded that the Godavari Basin has sizeable surpluses that can be transferred to the water-deficit Krishna Basin. The Krishna River basin is the fourth largest in India with a total catchment area of 258,948 km^2 and a long-term average annual surface flow of 78

km^3, of which 58.0 km^3 is considered to be utilizable. The cultivable area in the basin is about 20.3 million ha.

The National Water Development Agency (NWDA) of India has identified 30 Himalayan and peninsular rivers for such inter-basin water transfers (NWDA 1999). The Himalayan component consists of 14 links that involves transfers from the Ganges-Brahmaputra-Meghna basins, while in the peninsular component the water transfers would take place among 16 rivers that include the Mahanadi, Godavari, Krishna, Pennar, and Cauvery river basins. Among the peninsular component, the Godavari River has been considered as the sizeable surplus, and it is proposed that this river will transfer its surplus water to the Krishna, Pennar and Cauvery river basins. The paper illustrates the Godavari Link, and explores the potential economic agricultural sector as much of the water is used for agricultural purposes.

1.2 Statement of the Problem

- The water availability even for drinking purposes becomes critical, particularly in summer months as the rivers dry up and the ground water recedes.

- Water is an important element and one of the most essential natural resources. Some researchers have estimated that by 2025 more than half of the world population will be facing water-based crisis and suggested that by 2030, in some developing regions of the world, water demand will exceed supply by 50%.

- So, it became imperative that we use all the water that we can. This is where the idea of interlinking of rivers rises.

- By interlinking the rivers we can harness the water that is going waste to the ocean. Irrigation using river water and ground water has been the prime factor for raising the food grain production in our country, it leading us to attain self-sufficiency in food

- For example every year about 1500 to 2000 TMC of Godavari water is going waste. This can be harnessed by linking Godavari to Krishna.

1.3 Objectives of the study

- To analyze the possible irrigation benefits from surface water augmentation through river linking.
- To propose information about Polavaram cropping pattern and potential net irrigated area.
- To evaluate the existing agricultural and irrigation condition of the proposed irrigation command area of Polavaram project.
- To solve the problem of drought and flood in region where water is not sufficient enough.
- To analyze the economic benefit for the cropping pattern yield and fertilizer uses.
- To raise hydrological concerns about the potential role of surface water irrigation in cases, where groundwater has been the dominant form of irrigation.
- To signify the issue of importance of the farmers who are growing high-value crops using costly groundwater and shifting to low value water-intensive crops such as paddy with surface irrigation.

- To assess the benefits of surface water irrigation and facilitating groundwater recharge.

1.4 Scope of the study

The National River Interlinking Project will comprise of 30 links to connect 37 rivers across the nation through a network of nearly 3000 storage dams to form a gigantic **South Asian Water Grid**. It includes two components:

- **Himalayan Rivers Development Component:**

  - This component aims to construct storage reservoirs on the Ganga and Brahmaputra rivers, as well as their tributaries in India and Nepal.
  - The aim is to conserve monsoon flows for irrigation and hydropower generation, along with flood control.
  - The linkage will transfer surplus flows of the Kosi, Gandak and Ghagra to the west. A link between the Ganga and Yamuna is also proposed to transfer the surplus water to drought-prone areas of Haryana, Rajasthan and Gujarat.

- **Southern Water Grid:** It includes 16 links that propose to connect the rivers of South India. It envisages linking the Mahanadi and Godavari to feed the Krishna, Pennar, Cauvery, and Vaigai rivers. This linkage will require several large dams and major canals to be constructed. Besides this, the Ken river will also be linked to the Betwa, Parbati, Kalisindh, and Chambal rivers.

Proposed Benefits of the Project

- Hydropower generation
- Irrigation benefits
- Round the year navigation

- Employment generation
- Resolution of problem of droughts and floods
- Ecological benefits as dried up forests and lands will be replenished.

1.5 Organization of Chapters

The dissertation has been divided into five chapters including Introduction. Chapter 1 consists of general introduction, overview of previous literatures are given in chapter 2, study area, components of the Polavaram Project are explained in chapter 3, present irrigation and cropping pattern are presented in chapter 4, chapter 5 consists of conclusion and scope of future work.

Chapter 1 presents the brief introduction about the interlinking of Indian rivers. The objectives and scope of the study has also been presented and it gives an overview of the project in this chapter.

Chapter 2 presents literature reviews of the previous work of pioneer investigators. This chapter includes previous work already carried out in interlinking of rivers: Krishna and Godavari interlinking and its benefit for irrigation.

Chapter 3 presents the study area of the interlinking of Krishna and Godavari River in Polavaram and also highlights the major components of the project such as spillway, earth cum rock fill dam diaphragm wall etc.

Chapter 4 presents the present irrigation in the command area, cropping pattern followed with yield and net return of major crop i.e paddy, benefits from irrigation and livestock benefits.

Chapter 5 includes the concluding remarks and future scope if the research works.

Previous works carried out by other investigators have been cited in references are provided at the last.

Chapter-2

LITERATURE REVIEW

2.1 LITERATURE REVIEW ON BASE PAPER

Lakra et al. (2011) investigated that presence of rich fish diversity and threatened fishes in river Betwa and improved aquatic environment in river Ken which makes it a high priority area in view of proposed interlinking. The current state of knowledge indicates that large dams, interbasin transfers and water withdrawal from rivers have many negative as well as positive impacts on freshwater aquatic ecosystem. As regards to the impact on fish and aquatic biodiversity, there could be positive as well as negative impacts. The present paper is aimed at explaining and synthesizing the long term plan and its implications, creating baseline database, requirement of appropriate technology, manpower and related issues especially with reference to riverine aquatic ecosystem and conservation of fish biodiversity.

To face the problem of food scarcity **Bandyopadhyay and Perveen (2004)** has given that food security and food grain requirements are the most important and probably the most powerful justification of the proposed interlinking of rivers is the perceived link of the project with India's food security. No scientific justification for this has been given separately by the task force on interlinking of rivers. Based on population projections, socio-economic and demographic changes, and assumed changes in the pattern of food consumption, the NCIWRDP had estimated total food grain demand in 2010, 2026 and 2050 at high and low growth rates. These projections were made on the basis of an unpublished work by Ravi (1998), which results in a great increase in the projected food grain demand. While, according to the estimates of NCIWRDP, food grain demand in India (direct and indirect) in 2010 under the low and high demand scenario is 245 and 247 mn tonnes respectively.

Amariasinghe (2004) investigated that the 'degree of development', the ratio of primary withdrawals to the PUWR, of all basins was 38 %. A higher degree of development indicates: a) physical water scarcity, i.e., whether adequate quantities of water are available for meeting future development without affecting the environment or other water users; and, b) the increasing costs of further water development. When the degree of development exceeds 60 %, the basins are classified to be physically water-scarce (Seckler et al. 1998; IWMI 2000) Indeed, several river basins in India are already physically water-scarce, which include the Indus, Western Flowing Rivers Group 1(WFR1), Mahi and Sabarmati. The Indus Basin is physically water-scarce but it produces a substantial part of the nation's grain requirement. The Western Flowing Rivers, Group 1 (WFR1), Mahi and Sabarmati basins are physically waterscarce and are also recording deficits in crop production. Many river basins in India also experience unsustainable regional groundwater use. The groundwater abstraction ratios—the ratios of total groundwater withdrawals to the total recharge from rainfall and return flows— of many basins are significantly high. This indicates that certain regions experience unsustainable groundwater depletions.

Anand et al. (2008) investigated that emerging water scarcity problems by transferring water from well-endowed to more deficient areas. This study evaluated the plausible future scenarios of water availability and use under conditions of various cropping patterns, and with the explicit inclusion (for the first time) of environmental water requirements for one of the links of the NRLP: from the Godavari River at Polavaram to the Krishna River at Vijayawada—the 'Polavaram Project'. The scenarios were evaluated using the WEAP (Water Evaluation and Planning) model. The study generates information for use in managing emerging trade-offs. The importance of explicit accounting for monthly variability in description of water supply and demand, in the monsoon-driven climate conditions of the region, is advocated. Such detailed scenario simulations and inclusion of previously unaccounted for factors/uses can help to create awareness of potential future problems, inform water management practices and suggest management alternatives. Results show that the proposed water storage and transfer will reduce water deficit within the project command area and significantly reduce dry slow river flow into the Lower Godavari Delta

Krishnaveni and Prakashvel (2003) investigated that Interlinking of rivers involves multidisciplinary data on hydrological, environmental, agricultural, socio-economic and political aspects. Moreover, these data will be derived from various sources such as toposheets, remote sensing imagery, aerial photographs, paper maps and field data. For decision making on such complicated project issues, the related data and information should be stored at one place in digital form for easy retrieval, updation and analysis for effective planning and execution purposes. GIS, a powerful spatial technology, provides the scientific environment to store and analyze multidisciplinary data for solving such real world problems. GIS combines spatial database management, statistical analysis and cartographic modelling capabilities within computer hardware and software configuration. The objective of the paper is to explore the capabilities of GIS that will be very useful in solving the various issues of interlinking in order to expedite the process of interlinking.

Trivedi (2021) investigated this study aims to study the barriers to the implementation of *IWT*s in India by establishing and analyzing the complex inter relationships between them. Decision Making Trial and Evaluation Laboratory (*DEMATEL*) and Interpretive Structural Modeling (*ISM*) methods are employed to analyze the cause-effect relationship among the barriers and to further identify the key influential barriers from an identified set of factors. The results reveal that governance issues, policy bias, high cost requirements, and lack of river-interlinking are the most critical inhibitors for IWT development in India and the policymakers should focus on eliminating these ‘key’ inhibitors to ensure effective implementation of IWT in India. The findings of this study provide useful insights from a strategic and policy-making perspective.

Pasi and Smardon (2012) investigated that the overall objective of this research study is to examine the planning, policy process and decision-making for water resources in India. This was done using the case study of the proposed Interlinking of Rivers (ILR) scheme in India and exploration of the specific events, processes, and strategies used by different actors and stakeholders to influence agenda setting, policy formulation and decision-making. The study also explores the perspectives associated with the overall water resources management in India. Using a responsive interviewing model that involves in-depth qualitative interviewing, key governmental actors and non-governmental stakeholders were interviewed. The interview data was analyzed through thematic analysis using both inductive and deductive coding.

Ravi and Padmavathi (2016) has given that due to interlinking of rivers the uniqueness of biodiversity will disturb and due to invasion of non-native species the native species will go for extinction. Krishna River has unique fish biodiversity. When Krishna river inter link with Godavari river, it will lose its unique biodiversity. Already exotic fishes like Piranhas present in Godavari River enter the Krishna River causing damage to the fish nets in Krishna River. Piranha fishes are carnivore. Due to this carnivorous habit, it can cause the damage to the native species.

Jeet and Sundaram (2020) has given that in a monsoonal climate that is already erratic and highly seasonal in nature, this increased variability due to climate change will further impact water availability and salt water intrusion. To overcome such problems, one of the most effective ways is interlinking of rivers. It is the interbasin water transfer from the water surplus rivers to water deficit rivers or regions. It will increase water supply, irrigation potential, mitigate floods, and droughts and reduce regional imbalance in the availability of water. Interlinking of rivers will reduce regional imbalances significantly and provide benefits by the way of additional irrigation potential, domestic and industrial water supply, hydropower generation, and transport facilities.

Sharma (2020) investigated on the study the primary purpose of the current report is to analyze the spatial variation of water supply and demand across river basins in India. The study identifies basins that are water-scarce because of inadequate water availability to meet the effective demand. The study also identifies issues that are important for estimating the future water demand and for the formation of policy for future water-resources development and management. The development and management of water resources in India is an inter-state activity. Yet, substantial areas of different states cut across river basins, making water allocation a trans-state issue; disputes regarding water sharing between riparian states are on the increase. Thus, analyzing water supply and demand at river-basin level is an important step forward, and is even more topical in the context of today's increasing focus on integrated water resources management (IWRM) in river basins

Rogers (2018) has given that, this paper addresses the challenges and evaluates potential NRLP-derived changes to mean monthly water and sediment discharge and delta sedimentation for the Mahanadi, Godavari, Krishna, Kaveri, and Ganga-Brahmaputra deltas. Interbasin water transfer systems are a common solution to water scarcity, and the NRLP is the largest of many new diversion schemes proposed or underway in China, Brazil, and Central Africa (Zhang, 2009; Lemoalle et al., 2012). However, large-scale river diversion projects such as the NRLP can result in far-reaching consequences for downstream river discharge and delta maintenance. For example, due to damming, diversions, and increased water usage, the Colorado, Nile, Indus and Yellow (Huanghe) rivers discharge little to no sediment today, whereas they previously accounted for 10% of the global sediment flux to the ocean (Syvitski and Milliman, 2007).

Bhaduri (2005) has given that the paper particularly explores the benefits of surface water augmentation in the agricultural sector water scarcity can be met by augmenting the supply of water. Inter-basin water transfer often is viewed as an instrument to mitigate water scarcity through the diversion of water from a water-surplus part of a given river basin system to one or more water-deficit areas in another river basin. The main objective behind the implementation of such projects is to continuously meet the existing and future water demand in the face of decreasing relative water availability. Creating new sources to augment water supply requires large investments and effective institutions for allocating water. As part of the CPWF program, International Water Management Institute (IWMI) has undertaken a study to examine the viability of inter-basin water transfers in meeting water scarcity in water-deficient zones.

Verdhen (2016) investigated that the basic principle of Interlinking of rivers in the country was to transfer the surplus water of a basin to water-deficient basin. But the basin/region identified for surplus at present may face severe water scarcity and crisis in future. Few developed basins might have utilized their water resources fully and ask for more for smart services which are needed to be assessed. National Water Policy emphasises on hydrological unit, such as basin as a whole or a sub-basin, taking into account of surface and ground waters and transfer to water short areas from other areas or to reduce the vulnerability of drought through water conservation. Indian Water Resources Society presented critique on the effectiveness of Bhakhra dam and agreement to utilize it fully. Studies and investigations are needed to be undertaken through integrated basin-wise (Intra & Inter sub-basin) development with consensus amongst all the co-basin states. However, complexities of irrigation models for estimation depend upon the nature of data available/required. The water surplus basins experiencing frequent flood may have massive water during the monsoon when everywhere water is surplus. Furthermore, flood mitigation may not be possible by transferring a small amount of water through a limited capacity of canal. Storage dam (having risk of dam breach) attenuates the flood peak up to a certain extent (10-15%) only. Therefore, expert hydrological study/investigation of each sub- basin and basins are required to meet the present and projected demands.

Chapter-3

Methodology

3.1 Study Area:

Polavaram Project is a multi-purpose irrigation project which has been accorded National Project status by the Union Government. This dam is under construction located in West Godavari district &East Godavari district in Andhra Pradesh state and its reservoir spread in states of Odisha & Chattisgarh.

The below figure is extracted from the Google Earth Pro application. Google Earth is a computer program, formerly known as Keyhole Earth Viewer, that renders a 3D representation of Earth based primarily on satellite imagery. The program maps the Earth by superimposing satellite images, aerial photography, and GIS data onto a 3D globe, allowing users to see cities and landscapes from various angles. Users can explore the globe by entering addresses and coordinates, or by using a keyboard or mouse.

Figure 3.1: Overview of Polavaram by Google Earth Pro Version 3.7786

Purpose: National River-Linking Project, which works under the aegis of the Indian Ministry of Water Resources, was designed to overcome the deficit in water in the country.

History:

1. In 1980, then Chief Minister of Andhra Pradesh T.Anjaiah laid the foundation stone for the project. However the project stayed idle until 2004 when the Y.S Rajasekhar Reddy -led government came to Power.

2. In 2004, the Government of Andhra Pradesh sanctioned 1320 crore for the project. Soon after, tenders were issued for the commensurate worth of the project. For the left canal, another 1353 crore were sanctioned by the state government.

Initially efforts were made to build RAMPADASAGAR DAM with these capacities

- FRL : 59.4m
- Storage : 690 TMC
- Spill way length : 1260m
- PMF : 21 lakh cusec
- Cost : 129cr
- Power : 150MW
- Gates 16

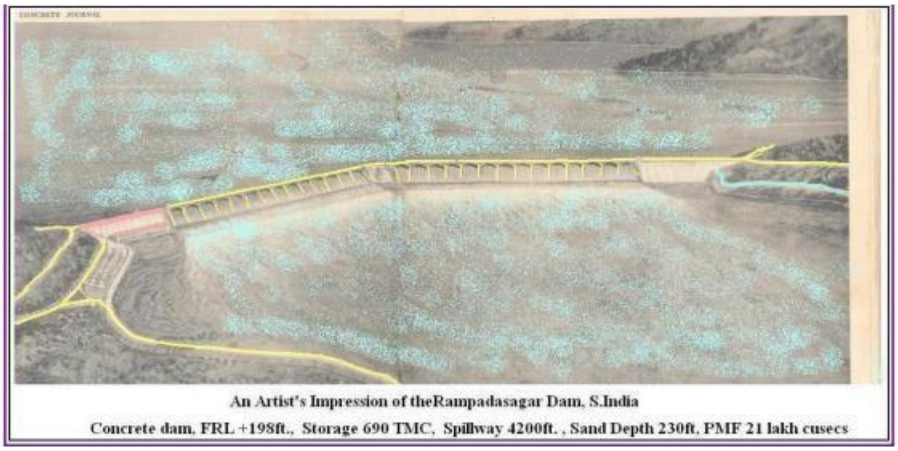

Figure 3.2: First proposal of Polavaram

3.2 Main components of project:

HEAD WORKS:

- Spill Way with Radial Gates
- Earth Cum Rock Fill Dam
- Hydro Electric Power House
- Connectivity Works

MAIN CANALS:

- Right Main Canal
- Left Main Canal
- Distributory Systems

3.2.1. SPILLWAY WITH RADIAL GATES:

- Spill way is a passage for surplus water from a dam.
- Length of spill way of Polavaram Project is 1.28 Km.
- Spill way is of Ogee section &its capacity is 50,00,000 cusecs at 140 ft. MSL.
- Radial Gates control the flow of water over spill ways or into canals by having the upstream face curved in the form of an arc which is at the center of gate hinge.

• Long radial arms, trunnion bearings and rounded face allow to close with less effort than for a flat gate.

• Width and Height of Radial gate are 16 m & 20 m respectively.

Figure 3.3: Representative image of Spill way (Orange coloured mark) Extracted from the Google Earth Pro Version 3.7786

3.2.2. EARTH CUM ROCK FILL DAM:

• The dam construction involves building of a 1.5 m thick concrete Diaphragm wall upto depths from 40 to 120 m below the river bed under the earth dam .The purpose of diaphragm wall is to secure the river bed stability for withstanding the water pressure across the dam.

• Length of ECRF dam is 2310 m.

• Two Cofferdams were planned. The Upstream Cofferdam and Downstream Cofferdam are constructed to prevent the entrance of water during construction of ECRF &divert water towards Spill way.

Figure 3.4: Image of Earth cum Rockfill Dam (Polavaram Dam) from Google application

3.2.3. HYDRO ELECTRIC POWER HOUSE:

- It consists of 12 Vertical Francis turbines, each having 80 MW capacity
- Power House generates 960MW energy.

3.2.4. RIGHT MAIN CANAL:

- The RMC is 173 km long, discharges 17,500 cusec.
- It is designed to supply 80 TMC of water from Polavaram to Budameru in Vijayawada, connecting Godavari and Krishna Rivers.
- The objective of RMC is to irritate an area of 3.19 Lakh acres in the upland area of West Godavari and Krishna districts.

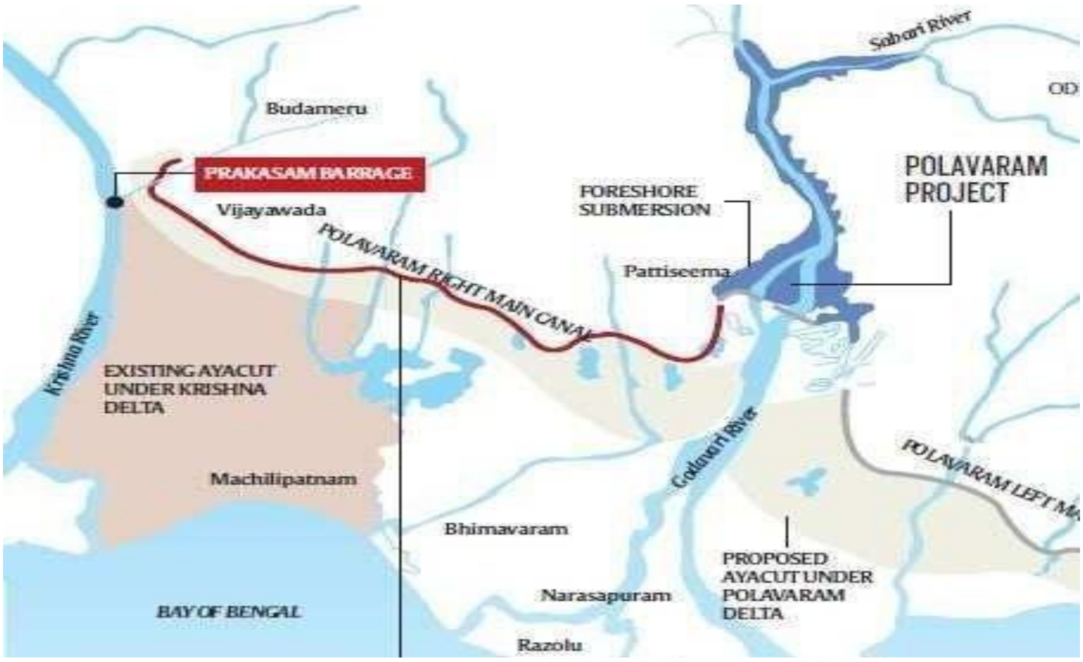

Figure 3.5: Areas benefited by Right main Canal from Google Application

3.2.5. LEFT MAIN CANAL:

- The LMC is 182 Km long, discharges 17,500 cusec of water.
- It is designed to provide water to 12 Lakh acres in North coastal districts of Andhra Pradesh besides meeting the drinking water needs of urban and rural areas .It will connect with Yeleru LMC to supply water for industrial (Vizag steel plant) and drinking water purposes .
- It will also supply coastal AP with irrigation water in Vishakhapatnam, Vizianagaram and Srikakulam districts.

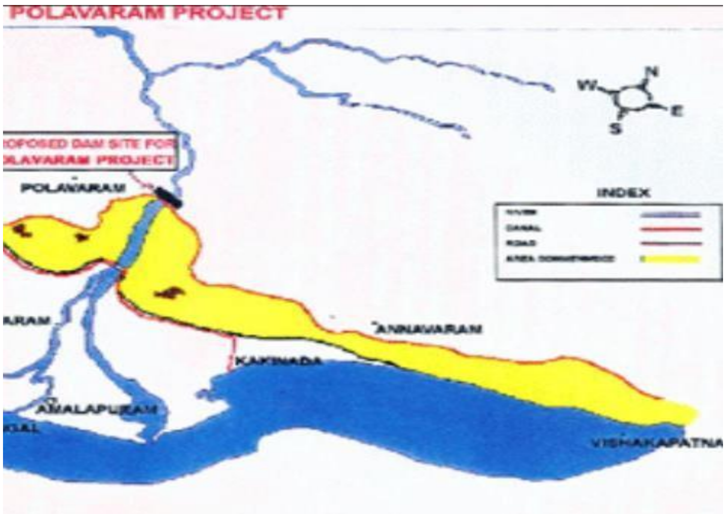

Figure 3.6: Areas benefitted with Left Main Canal From Google application

3.2.6 ADVANTAGES AND DISADVANTAGES OF CONSTRUCTION OF POLAVARAM PROJECT

- AP has most fertile districts in the country like East and West Godavari. At the same time severely drought affected districts like Anantapur in Rayalaseema region.
- Godavari is one of the most flooded rivers in South India, and nearly 2400TMC water flows into ocean as wastage whereas water levels in other major rivers Krishna and Penna reducing year by year, which has become a serious concern to lakhs of farmers. Utilising this water can serve the Agricultural and drinking needs of the state.
- Directly or Indirectly Polavaram will benefit all the 13 districts of A.P. it is termed as Lifeline of Andhra Pradesh. If executed well this project can make the state drought free forever.
- Based on the estimated water requirements in 2025 the study recommended that sizable surplus water was to be transferred from Godavari to Krishna basin.
- The supply and demand equation can be balanced elegantly with the integration of Rivers

Advantages:

- Irrigation of 7.20 Lakh acres in East Godavari,West Godavari , Vishakhapatnam and Krishna districts.
- Checks, Reduces and eliminates Flooding
- Stores water for future use - Irrigation, Navigation, Human & Industrial consumption
- Both RMC & LMC discharges 17,500 cusecs of water.
- Improves Transportation, Recreation and Habitat.
- Multipurpose dams provide multiple benefits from a single investment and also their maintenance is very less.

- Diversion of 80 TMC of Godavari water to Krishna Delta.
- Water supply of 23.44 TMC for industrial and drinking water purposes in Vishakhapatnam district.
- Generation of 960MW of Hydro Electric Power.
- Navigation facilities, development of Pisciculture and Tourism.
- Drinking water for 25 Lakh people.

Disadvantages:

- Submergence of 276 villages in AP alone.
- Displacement of 1.93Lakh people.
- The project would displace 293villages (AP -276, Odisha -10, Chattisgarh -7).
- The project not only will displace several thousands of families,it will also submerge several Archeological sites, coal deposits, a Wild life sanctuary and several hectares of Farm land and Forests.
- Excessive sedimentation of the reservoir.
- Due to Anaerobic Respiration by the submerged plants, Methane (CH4) is released causing the water to become poisonous.
- It can also cause stoppage of Aquatic fauna migration.
- Loss of Livelihood and Biodiversity.
- Inundation of thousands of acres of forests and agricultural land, there'll be a loss of arable land and salination of Irrigated land.

3.3 Spillway:

Spillway is a man-made structure used to provide controlled release of flow from upstream side to downstream side when required. The figure shows a typical spillway.

Figure 3.7: Location of Spillway

Table 3.1: Details of Spillway

Type of spillway	Ogee profile
Location	Polavaram, west Godavari district
Impounds	Godavari river
Length	1128.4m
Height	48.38m
Capacity	50,00,000 cusec
Rock strata	-18.5 msl
Full Reservoir Level (FRL)	45.72m
Crest level	25.72m
Trunion level	35.5m
Road top level	54m
Length of stilling basin	110.5m
Stilling basin top level	7.25m
Spill channel bed level	8.8m
Type of gates	Radial gates
No. of gates	48
Size of gates	16*20.85m
Founding level	-9.25m
Ground level	24.0m

Gross capacity of spillway	194.603TMC
Live storage	75.2TMC
Dead storage	119.403TMC

Spillways release water so that the water does not overtop and damage or even destroy dam. Floodgates and fuse plugs may be designed into spillways to regulate water flow and reservoir level. Such a spillway can be used to regulate downstream flows – by releasing water in small amounts before the reservoir is full. The main purpose of providing spillway to a dam is to supply water to downstream irrigation field

Spillway: Representative image constructing the Spillway is the first step in the process. After constructing the Spillway, 48 huge radial Spillway gates will be fitted to it. After the gates are fitted, then the Approach and Spill channels will be constructed to channelize river water through Spillway each gate is fitted with 2 hydraulic cylinders to enable faster movement of the heavy gates, to secure dam from heavily flooded Godavari River. The 96 hydraulic cylinders for 48 gates are being manufactured in Germany. Approach and spill way channels completed The excess flood water is released through the remote controlled spillway gates.

Table 3.2: Spillway Dimensions

Height	45 ft
Width	1000m
Concrete required	17 lakh cubic meters
Spillway Radial Gate dimensions	
Each spillway radial gate height	21m;
Width	16m
Weight	350 tonnes

3.4 Radial Gates

- Width of the gate = 16 m
- Height of the gate = 20 m

• Tallest gates in India

Generally gates are used to control the flow of water and storage purposes. Gates are divided based on different purposes.

CREST GATE: A gate on the crest of a spillway that controls overflow or reservoir water level.

RADIAL GATE: A gate with a curved upstream plate and radial arms hinged to piers or other supporting structures .the operation of this gate is very simple compared with other gates. It was lifted bg using either hydraulic cylinders or ropes. Radial shape provides efficient transfer of flow. Gate bottom lip gives good hydraulic discharge profile. It was moved upwards and downwards by using the help of trunnion.

SLIDE GATE (SLUICE GATE): A gate that can be opened or closed by sliding in supporting guides. These are commonly controls water level and flow rates in rivers and canals. They are also used in waste water treatment plant and to recover minerals in mining operations and in water mills.

OPERATION OF GATES: Based on lifting technique various types of equipment used to lift gate. Hydraulic cylinders, ropes, pressure lifters etc.

Figure 3.8: Radial gates

3.5 Diaphragm Wall (Slurry Wall)

It is a plastic concrete wall built in underground

➢ It can be executed in any type of soil or sand

➢ The main advantage of diaphragm wall is the great retention capacity and water tightness

TYPES OF DIAPHRAGM WALL

Based on use of construction materials

1. Rigid type

  - RCC

2. Flexible type

  - Plastic concrete
  - Cement bentonite slurry trench
  - Earth backfilled slurry trench

Figure 3.9: Diaphragm wall

DIAPHRAGM WALL CONSTRUCTION IN POLAVARAM

1. It is constructed in way of river Godavari
2. It is substructure in the earth
3. The length of diaphragm wall is 1485m

4. The width of diaphragm wall is 1.5m

5. The depth of diaphragm wall varies from 40m to 100m

6. Fix the alignment by surveying

7. In stage -1 (2016) 1485 m to 800m the work completed

8. In stage -2 (2017) remaining work is on process

3.6 Earth cum Rock fill Dam & Diaphragm wall:

ECRF dam is the most crucial component of the entire project constructed across the river Godavari and plays a major role in holding river water. The ECRF dam will be built between the two Cofferdams. It can withstand up to 50 lakh Cusecs water flow, whereas peak flow of Godavari River recorded till now is 30 Lakh Cusecs. ECRF is being built by Mega Engineering Company

ECRF dam dimensions:

Length	: 1750 m
Height	: 41m
Width	: 300 m at the bottom and 30 m in the top

Diaphragm Wall:

Diaphragm wall is the foundation of ECRF dam. It is constructed below the ECRF dam and prevents leakage of water across the dam from the bottom of ECRF through sand pores. Without Diaphragm wall the ECRF will not sustain and will succumb to water leakage from the bottom of it.

Diaphragm wall dimensions:

Depth (below the ECRF dam)	: 40–100 metres
Length	: 1450 metres
Width	: 1.5 metres.

3.7 HYDRO ELECTRIC POWER STATION

HYDROELECTRIC POWER

- It is a form of energy which provides major percent of the renewable energy in any developed or developing countries.
- It doesn’t use up the resources to create electricity nor do they pollute air, land and water as the other electric power stations may.
- It plays a major role in the development of Nation’s Electric Power Industry

COMPONENTS OF HYDRO-ELECTRIC POWER STATION

- Dam: Dam creates a head which helps the water to flow towards downstream
- Reservoir: A reservoir is an enlarged natural or artificial lake ,storage pond or Impoundment created using a dam or lock to store water.
- Sluice Gates: A sliding gate for the flow of water
- The Penstock: It is an enclosed pipe that deliver ware to hydro turbines and sewage systems
- Water turbines

Turbines are generally of two types

- Impulse and Reaction Turbines
- Impulse turbine is again classified into 3 types
    1. Pelton turbine
    2. Turgo turbine
    3. Cross flow turbine
- Reaction turbine is classified into 2 types
    1. Propeller Turbine
    2. Francis Turbine

- Generators

SALIENT FEATURES OF POLAVARAM POWER HOUSE

- The installed capacity of this power house is 960MW/ Year.
- The total number of turbines will be installed are 12.
- The turbines are of Francis type.
- Each turbine can produce 80 MW of power.

3.8 CANAL HEAD REGULATOR:

A canal head regulator is required to serve the following function:

(i) To regulate the discharge into the off taking canal, functions:

(ii) To control the entry of sediment into the canal.

Figure 3.10: Right main Canal

Figure 3.11: Right Main Canal Regulator

Table 3.3: Descriptions of canals

Right Main Canal:	
Length of the canal	174.00 KM
Design discharge at head	499.299 Cumec.
Bed width	85.50 m
Full supply depth.	5.0 m
Bed fall	1 in 20,000
Full supply level at start	+ 40.232 m
proposed Ayacut	1.295 Lakh Hectares
Left Main Canal:	
Length of main canal	181.50 KM
Design discharge at head	497.277 cumec
Full supply level at start	+ 40.54 m
Bed width	85.50 m
Full supply depth	5.00 m
Bed fall	1 in 20,000
Proposed ayacut	1.619 lakh Hectares.

Chapter-4

DATA ANALYSIS AND RESULTS

4.1 Sampling Plan

A stratified random sampling scheme is used for assessing the direct and indirect economic benefits of irrigation water transfers, as a stratified sample can provide greater precision than a simple random sample of the same size, and thus requires a smaller sample to estimate the true characteristics of the population.

In the stratified random sampling scheme, we first identify the ‘mandals’ in the command area, which could directly benefit from surface irrigation water transfers. Next, we stratify the mandals/villages according to their distance (head, middle and tail) along the canal. Three mandals/villages are selected from each stratum. The water diverted along the canal may supplement areas already irrigated with surface water or groundwater, or may supply new irrigation water to rain-fed areas. Thus we select the three mandals/ villages from each stratum with one each from the surface irrigation, groundwater irrigation and rain-fed agriculture dominated districts.

The survey consists of 37 mandals and 50 villages. From each selected village, a sample of 20 farmers is selected. Out of 1,000 farmers surveyed, 521 farmers are located in the right command area and the remaining 479 are located in the left command area.

4.2 Present Irrigation Conditions of the Proposed Polavaram Command Area:

Assessment of the economic benefits of irrigation requires information about the present irrigation area in the command area. The feasibility report of the project prepared by the National Water Development Authority suggests that 70 % of the cultivable command area en route the right bank was already irrigated a decade back. However, our sample survey data, indicates that presently only 9 % of the cultivable area in that area remains un-irrigated. On the other hand, in the left canal command area, which forms the other part of the Polavaram Project around 66 % of the farm land, is irrigated. In both components of the command area, however, groundwater is the predominant form of irrigation, and accounts for 85 % and 63.82 % of the net cultivated area in the right bank and left canal command areas, respectively. This also confirms the national trend of groundwater irrigation growth in India. Today, much of the cultivable area in India is irrigated from groundwater resources. In the absence of new large-scale surface irrigation schemes, and the availability of low-cost electric and diesel pumps coupled with little or no electricity charges, groundwater has been a major driver in the expansion of irrigated area.

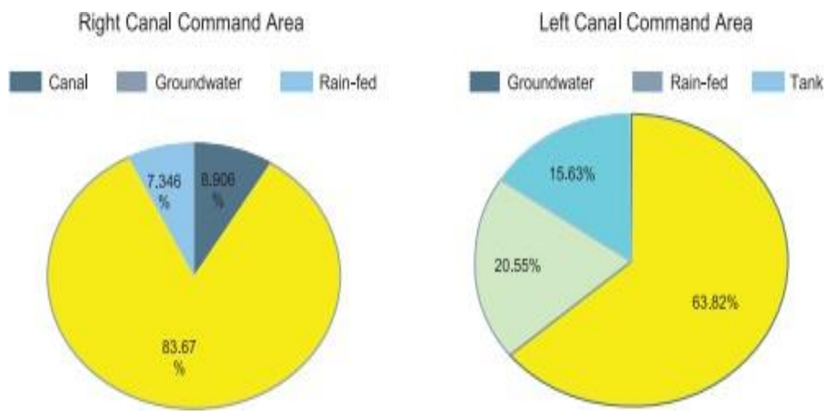

Figure 4.1: Irrigated area source-wise in the canal command area.

Based on such observations, the premise of our research lies in exploring how the Polavaram command area could benefit from surface irrigation in the case where much of the cultivable area is already irrigated from the groundwater irrigation source.

The hypothesis of the additional source of surface water irrigation can be beneficial but in a limited way, if the farmers in the command area are already using groundwater. After the construction of the Polavaram Dam, surface water can benefit the farmers in the following three ways:

1. After the construction of the Polavaram Dam, farmers who are presently utilizing groundwater may use surface water instead. Lesser dependency on groundwater may help to reduce the agricultural cost.

2. Farmers may adopt conjunctive use of groundwater and surface water, which can increase the productivity further.

3. Another potential benefit of a large dam is that seepage from its canals recharges the aquifers, which provide groundwater.

To derive the benefits from surface irrigation, it is imperative to consider the sustainability of groundwater usage. Hence, it is essential to understand a farmer’s agricultural behavior to changes in groundwater conditions. In the region, groundwater irrigation has been reported to be beneficial in terms of higher productivity and cropping intensity. However, the growing concern is about groundwater over exploitation and falling groundwater tables in the proposed command area. In about 40 % of the samples, the depth of tube wells is more than 50 meters, and in 12 % of the sample it is deeper than 100 meters. The groundwater situation is worse, particularly in the right bank command area where in 25 % of the samples, the depth of the tube wells is above 100 meters.

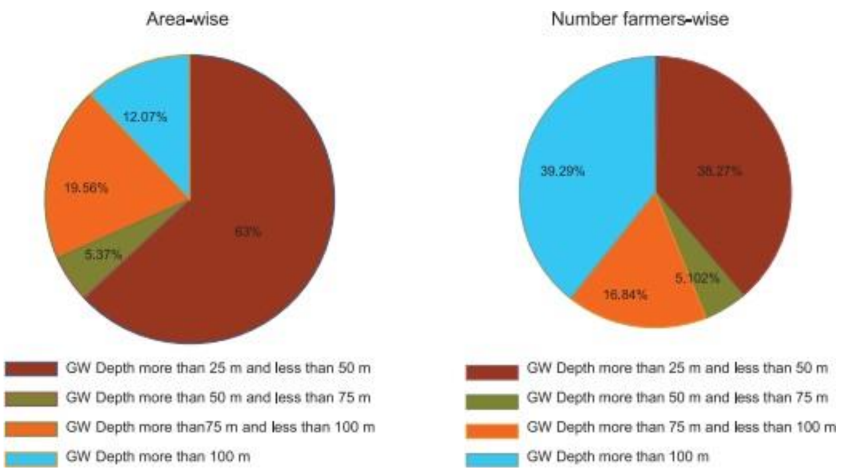

Figure 4.2: Groundwater depth in the command area: Area and number farmer-wise

Our analysis suggests that as the depth of groundwater tables increases, farmers invest more in higher capacity pumps, and this is reflected in a concave fitted relationship between the depth of groundwater and cost of tube wells. Farmers install maximum worth of pumps when the depth of the tube well is 110 meters. After that the farmers find it economically unfeasible to invest more money in higher capacity pumps for groundwater exploitation, as the marginal cost of groundwater extraction would exceed the marginal benefit.

Groundwater depth also could impose constraints in the choice of crops. Our research exhibits that farmers are averse to taking risks and, as such, they prefer to grow multiple crops when there is an increase in the groundwater depth. It suggests that in regions where groundwater depth is less than 25 meters, farmers mainly grow paddy and sugarcane. As groundwater depth increases farmers cultivate different kinds of crops and particularly, cash crops for risk diversification. Then as the depth of groundwater table increases further, the crop choice of the farmers is similar to that of a rain-fed area, where they grow less-valued crops given the limited water availability in such areas.

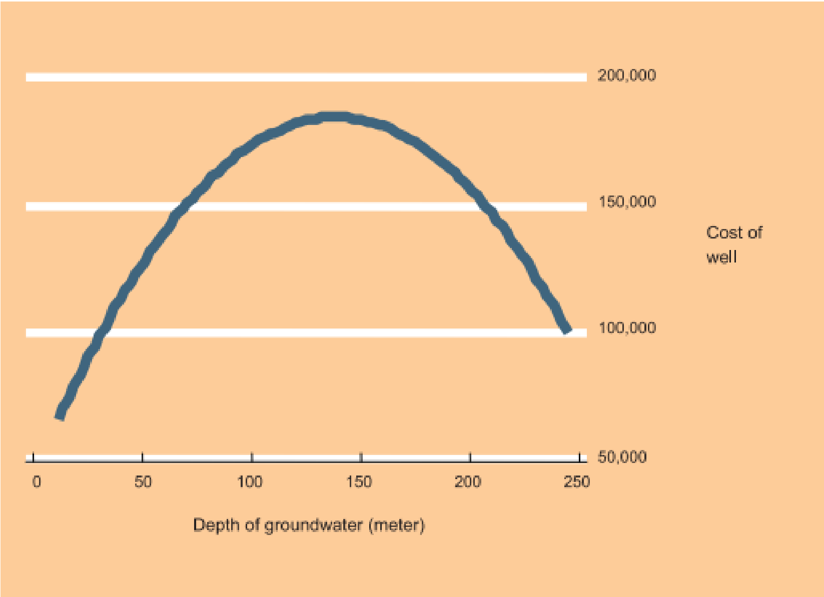

Figure 4.3: Fitted relationship between groundwater depth and cost of well.

Net returns from land are also dependent on the groundwater depth. This is evident in figure, which shows the average net value per hectare of land generated at different levels of groundwater. It shows that the average returns per ha of land is high when the groundwater depth lies between 75 and 100 meters and after that the average returns begin to fall. It could imply that as depth of groundwater table rises, farmers employ higher capacity pumps, and to recover the extra cost they grow cash crops, which allows farmers to get higher average returns.

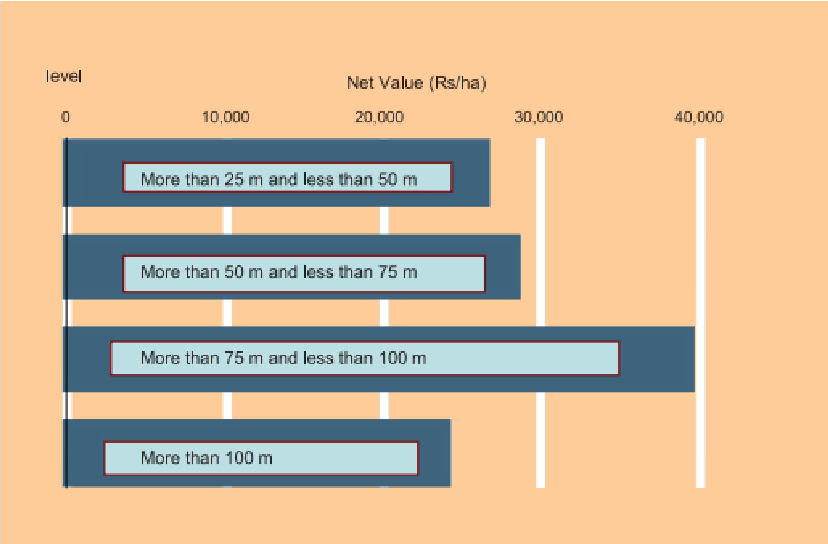

Figure 4.4: Average net returns at different level of groundwater

After this, the opportunity cost of groundwater increases and farmers cannot afford costly pumps and it restricts their income at a lower level. Our analysis also suggests that with increasing groundwater depth, the yield of crops, particularly paddy, decreases. And beyond a certain depth of groundwater, the farmers find the opportunity cost of water to be high. Even though electricity is free, the high cost of groundwater extraction is very much related to the cost of operation and maintenance of the pump including higher horse power used, both of which increase with the depth of groundwater. Figure 6 reveals the fitted relationship between the yield of paddy and groundwater depth. It indicates that the yield of paddy decreases with groundwater depth when the latter is more than 65 meters. Higher groundwater depth represents relative water scarcity and therefore, restricts farmers to use less water and leads to lower crop yield .The relationship highlights the need for a sustainable use of groundwater and to avoid a situation that may constrain the productivity of crops. Hence, surface water could have a bigger role to play in regions where farmers face rising groundwater depth.

As surface water would come in, it could sustain the groundwater usage and allow farmers to get higher productivity with a lower agricultural cost for extracting water. Additional surface water can also help farmers to take more risks to invest in higher capacity pumps and adopt crop diversification in groundwater-irrigated areas, where the average depth is more than 100 meters. Given that nearly 40 % of the farmers are irrigating in areas where the groundwater depth is more than 100 meters, the benefits of the surface water irrigation could be substantial in this region.

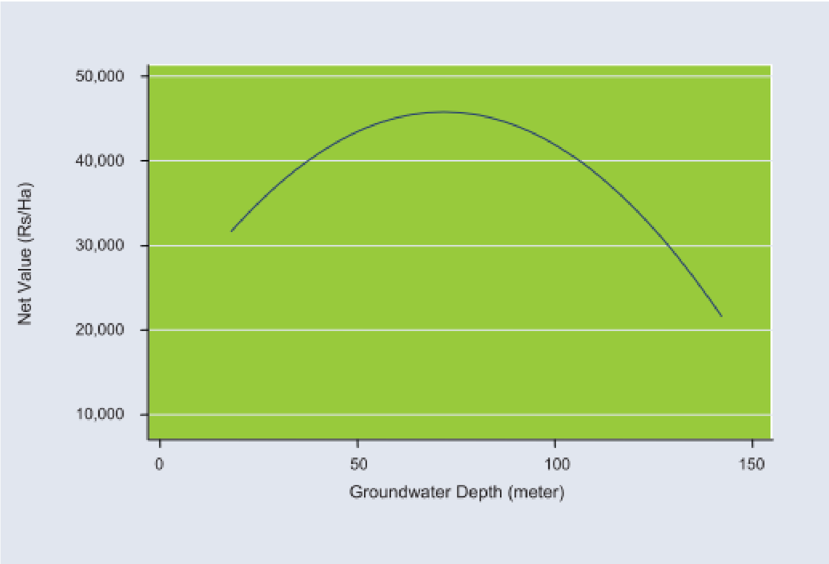

Figure 4.5: Fitted relationship between yield and groundwater depth

4.3 Present Cropping Pattern of the Polavaram Command Area:

The benefits of irrigation projects depend very much on the present and future cropping patterns in the command area. From the sample survey we have tried to understand the present cropping pattern in the proposed command area and make a hypothesis of the future cropping pattern of the farmers after the advent of surface irrigation.

In the proposed command area in the right bank, the three main crops are paddy, sugarcane and tobacco. Paddy is grown mainly in the kharif season, while tobacco and sugarcane are the annual crops. In this region, the annual crops are very popular among the farmers. In the right bank command area, annual crops are grown in nearly 65 % of the cropped area, while kharif crops account for only 26 %. Sugarcane and tobacco are the two major crops among the annual crops in the right bank. During the kharif, paddy comprises more than 95 % of the area.

Why is it that the majority of the farmers grow annual crops in the region? Our survey suggests that farmers grow annual crops mainly in the groundwater-irrigated area. It could be argued that groundwater irrigation provides the kind of reliability in water supply that is needed to grow high-valued crops. Also in the case where there is no alternative source of irrigation other than groundwater irrigation, farmers rely on high-valued crops to cover the cost of groundwater extraction, mainly the cost of pumps, operation and maintenance.

In the proposed command area of the left bank, paddy, sugarcane and black gram are the major crops. Here, the dominance of annual crops is much less than in the right bank, and accounts for only 32 % of the cropped area. Sugarcane is the major crop among the annual crops. Much of the cropped area is used to grow one-season crops, and particularly paddy in the kharif.

In the downstream of the Godavari where much of the land is irrigated from the surface irrigation source, the popular crop choice of farmers is paddy. Paddy is grown in more than 90% of the farm land having access to canal irrigation. With groundwater irrigation, the crop choice is much more diversified like in the rain-fed regions. However, with groundwater irrigation, more high-valued and water-intensive crops are grown than in rain-fed areas.

The key issue that emerges here is how the cropping pattern in the region would change after the introduction of surface water. If the farmers are growing high-valued annual crops by means of groundwater irrigation, would they shift to traditional crops like paddy with the advent of surface water or continue to grow their annual crops with groundwater irrigation?

Would the farmers continue to grow-high value annual crops and increase the value of surface water or else like downstream Godavari farmers, grow paddy in both the seasons? The answer to the issue is also related to the existing cropping pattern trend in Andhra Pradesh, which suggests a paradigm shift in the choice of crops over the past decade. Farmers are shifting from growing traditional crops to high-valued crops. Such a behavioural change in farmers was also reflected in our one-to-one interaction with them. Once the surface water reaches the Polavaram command area, the farmers may show an interest in growing annual crops as before. However, much of this change is due to the demand factor and irrigation conditions. Due to storage constraints the entire area is proposed to be irrigated mainly during the kharif season only (NWDA 1996). Given the limited availability of surface water in the rabi, the farmers may continue to use groundwater in the alternate season. The surface irrigation would help the farmers in sustaining groundwater usage during the rabi season and facilitate the growing of annual crops. The return flow factor as a fraction of surface water usage could be 10-20 %, and this additional water could be used in the rabi season in the form of groundwater irrigation (NIH 199).

4.4 Yield and Net Returns of Major Crops

The overall objective of a surface irrigation project is to increase the net value of land and support the livelihood of the farmer. However, it is imperative to know whether the increase in net value of cultivable land would be generated from a productivity difference or through a reduction in agricultural cost. The analysis of the difference in yield through the different sources of irrigation is shown. Figure shows the yield of paddy, one of the major crops in the region. The average yield of paddy from conjunctive water use is significantly higher than that of only using either surface or groundwater. Moreover, there is no significant difference in the yield whether the source is groundwater or surface water.

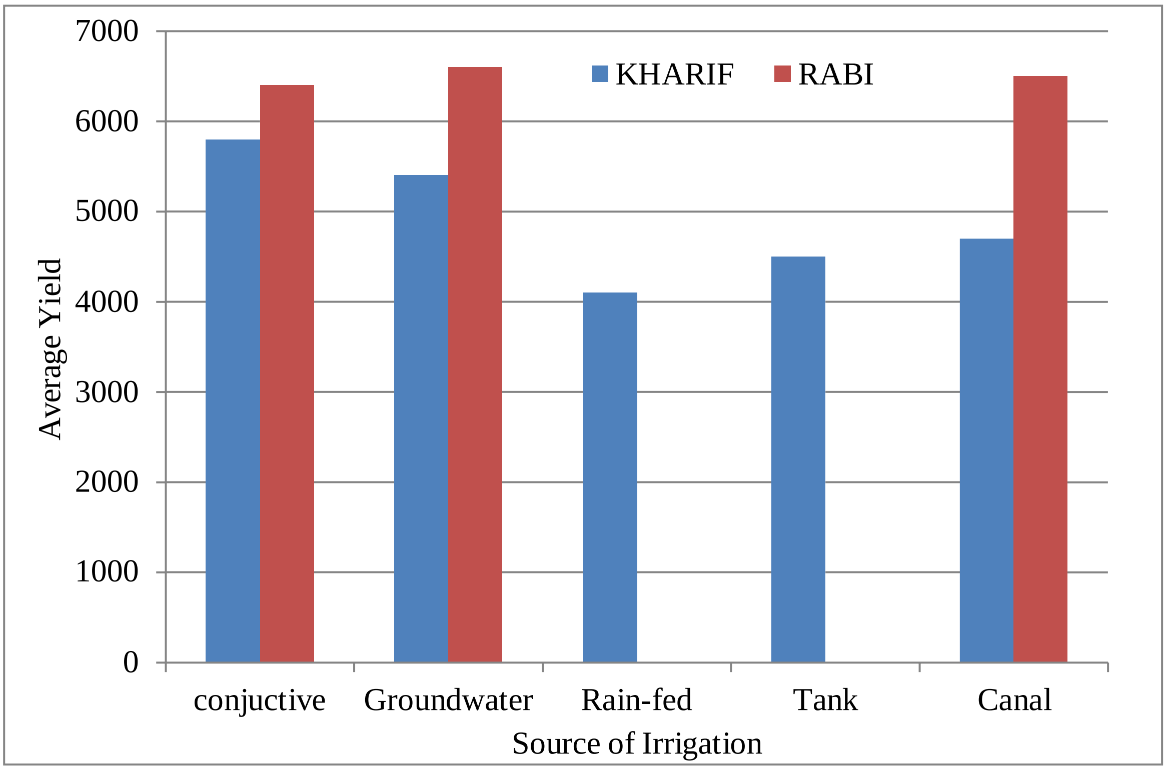

Figure 4.6: Paddy yields (kg/ha) in kharif and rabi seasons under different sources of water supply.

The average yield of paddy is only 2.43 % higher in farms irrigated from surface irrigation compared to what is obtained in groundwater-irrigated farmland. It implies that from a productivity point of view, we may not expect any substantial difference in the areas that are already irrigated by groundwater, even after the completion of the Polavaram Project. However, if the farmers use conjunctive irrigation, the project could lead to better productivity. The propensity of the farmers to use both groundwater and surface water is higher as the farmers in the groundwater-irrigated areas have already incurred the sunk costs of pumps. The average fixed cost would only decrease if the farmers continue to use groundwater.

A significant proportion of the land in the proposed command area, particularly in the left canal command area, is rain-fed. Presently the rain-fed yield in the region is 1.6 tonnes per acre, and there is not much variation across the farms. However, the rain-fed yield of paddy is higher than the national average. In these areas, if the farmers grow paddy after the introduction of surface water, our analysis suggests that the productivity difference would become significant.

In the past, much of the irrigated area in the proposed command area was irrigated by ancient tanks. However, today, tank-irrigation has decreased considerably. Tank- irrigation accounts for only 11 % of the left command area. There are several factors, which caused this decline in tank irrigation. In the last couple of decades much of the focus, priority and investment have been shifted to minor irrigation structures and mega projects. Tank-maintenance has also been neglected due to inadequate management resources. Much of the tanks in the area are rain-fed, and for the crops that are grown from tank irrigation, the yield is lower like in the rain-fed area. In the proposed command area, the average yield of tank irrigated paddy is lower than 2 tons per acre. So, the tank-irrigated area may also expect an increase in productivity with the proposed water transfers.

It has been calculated that the net return from cultivating one hectare of land in the region. The return from land is dependent on the choice of crops. As paddy is one of the major and most popular crops, we have compared the net returns of paddy across different sources of irrigation, which is illustrated .Figure shows that net returns per ha of cultivation is high in the surface-irrigated areas in comparison to other sources of irrigation. The difference is higher mainly in the rabi seasons, for instance, net returns in the surface-irrigated area during the latter season is on average Rs. 3,000 higher than in the groundwater-irrigated area. With no significant difference in yield between the two sources of irrigation, the difference in net value can be attributed to the difference in cost due to the higher groundwater extraction cost. In regions where there is a higher depth of groundwater, the difference is even bigger. In the rain-fed area, the net return from paddy is around Rs. 10,000 per hectare compared to Rs. 44,000 per hectare annually in the surface-irrigated areas. An annual increase of Rs. 34,000 per hectare in the rainfed area is substantial if the farmers grow paddy in both seasons. Since the major proportion of the rain-fed area is located in the left bank of the command area rather than in the right bank, much of the benefits could be reaped in the former part of the proposed command area.

It also shows the net value decrease with a higher groundwater depth. The increase in net returns from the groundwater-irrigated areas would be significant, provided surface water irrigation reduces the stress on groundwater irrigation or facilitates groundwater recharge. Though higher recharge helps in reducing the operation and maintenance cost of the pumps, this is still a small proportion of the total cost of groundwater irrigation. Hence, a higher recharge from surface irrigation would increase the net returns from the groundwater irrigated areas in a limited way. However, there is a possibility that a proportion of the current groundwater irrigated area could become unsustainable and thereby inappropriate to use, if the farmers continue to exploit the groundwater resource. Without the Polavaram Dam, these areas could well turn into rain-fed areas, as a result of the opportunity cost of groundwater extraction exceeding the economic benefits. The Polavaram Dam, by diverting surface water can create an opportunity for these farmers to rely more on surface irrigation and thereby sustain their agricultural livelihood.

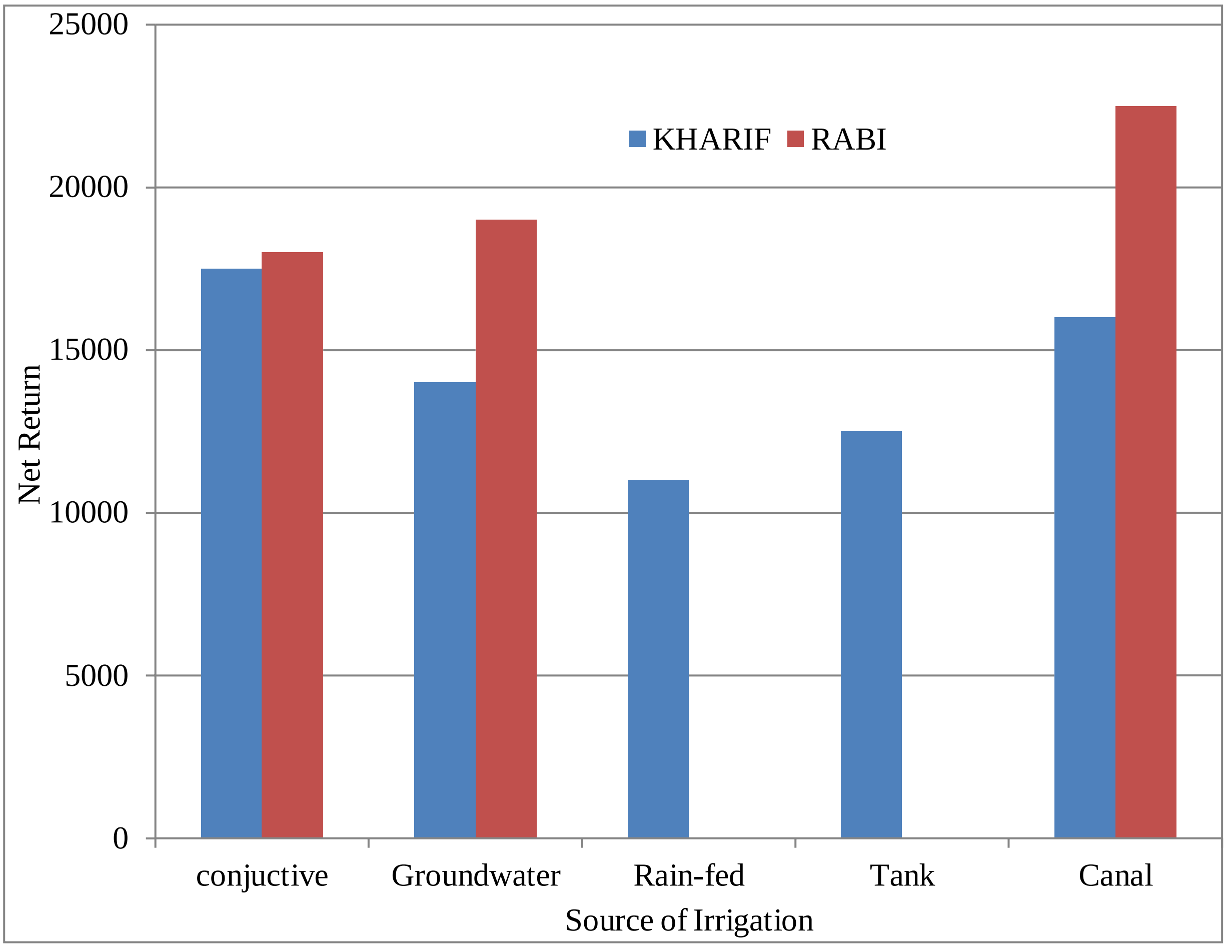

Figure 4.7: Net returns from paddy production from different sources of water supply.

4.5 Benefits of irrigation:

Irrigation benefits from the water diversion at the Polavaram Dam is to a certain extent subjective and depends on several factors .Given the ex-ante characteristics of the project, the best approach would be to analyze the different plausible scenarios. We attempt to assess the possible irrigation benefit from the water diversion at the Polavaram Dam under four alternative scenarios. We have constructed several scenarios mainly based on the different cropping patterns that the farmers may adopt after the advent of surface water irrigation by the Polavaram Dam.

In the first scenario, the proposed cropping pattern is taken as suggested by the Andhra Pradesh Environmental Impact Assessment Report (Gujja et al. 2006). A similar cropping pattern is suggested for both the left and the right bank command area. The report suggests that paddy would be grown in the kharif season followed by pulses in the rabi. The report also indicates that the farmers would grow sugarcane and chillies as annual crops.

In the given cropping pattern, although the yield of paddy in the rabi is higher than that of the kharif, pulses have been proposed as a crop choice instead of paddy during the rabi. This could be to reduce the stress on the water demand during the dry season.

In the second scenario given the present popularity of growing maize during the rabi in Andhra Pradesh, the assumption of that of the farmers may grow high-valued maize instead of pulses in the rabi season. Again, high-valued cash crops like tobacco and sugarcane are grown in the region as annual crops with the help of groundwater irrigation. The farmers have already invested in high sunk cost and they are unlikely to shift completely to surface water irrigation unless the state government imposes a tariff on electricity for groundwater extraction. Under the prevailing circumstances, the farmer may continue to grow these high-valued annual crops even after the completion of the Polavaram Project.

When constructing these scenarios we have also considered the sustainability of groundwater. Our sample survey's results indicate that without the Polavaram Dam it may be difficult for the farmers to continue groundwater extraction in the right canal command area. We have assumed that without the water diversion from the Polavaram Dam, there could be a 25 % reduction in the present groundwater irrigated area. This assumption could be reasonable in that in much of the groundwater-irrigated area of the proposed right canal command area, the depth of the water table is more than 100 meters. The four scenarios constructed are described in Table.

Table 4.1: Description of Scenario

Scenario	Description
Scenario-I	Proposed cropping pattern from the Andhra Pradesh Environmental Impact Assessment Report: Paddy-Kharif: Pulses Rabi: Annual crops: Sugarcane and chillies
Scenario-II	Different cropping pattern - Paddy-Kharif: Maize Rabi: Annual crops:

	Sugarcane and chillies.
Scenario-III	Present cropping pattern for annual crops
Scenario-IV	25 % reduction in groundwater-irrigated areas in the right canal command area

Table 4.2: Benefits from irrigation

	Scenario-I	Scenario-II	Scenario-III	Scenario-IV
Annual increase in the value of the crop output (in crores)-Left bank	236.34	276.81	325.6	236.34
Annual increase in the value of the crop output (in crores)-Right bank	83.42	141.61	127	146.16
Annual increase in the value of the crop output (in crores)-in total command area	319.76	418.43	452.6	382.5
With multiplier effects (20 %)	383.71	502.11	543.12	459.00
Increase in value (Rs.) per cubic meter of water	0.77	1.00	1.09	0.92

Using the estimated cropping pattern, irrigated area and the net value of crops per ha, is is estimated that the total value of the agricultural benefits of crops before and after the completion of the Polavaram Project, for both the right and left command areas. The above table shows the possible irrigation benefits from the Polavaram Dam.

The overall annual increase in value of crop per cubic meter of water ranges from Rs. 0.77 to Rs. 1.09 under alternative scenarios. Assuming the cropping pattern proposed by the Andhra Pradesh Environmental Impact Assessment (APEIA) report, the annual increase in the net value of crop output would be 319.76 crores; while taking into account a multiplier effect of 1.20, the overall benefit inclusive of indirect benefits stands at 383.71 crores under the same scenario.

The study indicates that the benefit would be at a maximum of Rs. 1.09 per cubic meter if the farmers continue to grow annual crops, particularly in the right bank canal command area. And the benefit would be at a minimum of Rs. 0.77 per cubic meter of water under the scenario proposed by the Andhra Pradesh Environmental Impact Assessment Report. However, if the farmers grow maize instead of pulses during the rabi season, the benefit will increase to Rs. 1 per cubic meter of water.

The study suggests that the viability of the project depends a lot on the choice of the cropping pattern. If the farmers continue to grow high-valued annual crops with additional surface water, then the benefit would be substantial. As noted earlier, right bank canal command area is part of the river linking project. Since the right bank command area is already irrigated, our analysis suggests that there is insufficient room to increase the economic benefits any further. On the contrary, the annual increase in the value of output could be much higher in the left bank canal command area than in the right bank, where the proportion of rain-fed area is larger. However, benefits for the right command area would increase by 70 % if the assumption that the present trend of groundwater growth may not continue and there would instead be a 25 % reduction in the present groundwater irrigated areas.

4.6 Livestock Benefits

Livestock is an important source of livelihood in the region. Of the farmers surveyed in the command area, about 66 % possess livestock, which mainly includes cattle and buffalo. Animals are heavily dependent on water largely because of its use for their feed productionan estimated 400 cubic meters or more of water is used per year for the maintenance of livestock. The total water needed may be more than double this amount, with drinking water being less than 2 % of what is required for feed production. We investigated how the livestock population would benefit through the introduction of surface water in the region.

Animal densities are strongly correlated with human densities and are highest in areas of intensified agriculture, especially in and around irrigation systems. In the proposed command area, which is largely irrigated, the proportion of livestock in the region is much less, and one possible reason could be the higher application of tractors and mechanical devices, which reduces the demand for bullocks. However, an important observation that emerged from our study is that the density of livestock is higher in the rain-fed areas. The number of buffaloes per hectare in the rain-fed area is higher than that in the irrigated areas. In the rain-fed areas, livestock provide a steady source of income for the farmers thereby reducing the variability of income. An important hypothesis is that with the advent of surface irrigation, farmers may invest their effort more in agriculture and retain less livestock.

In this study, it is also highlighted another relevant issue, i.e., whether surface irrigation would help increase the milk production of the livestock. Our survey suggests that the milk production of buffalo and cattle are 20 % and 32 % higher, respectively, in the surface irrigated area than in the rain-fed area The likely reason for this could be that surface irrigation provides farmers an opportunity to grow fodder as second crop and this generates extra biomass for application to livestock. Hence, with more surface irrigation after the completion of the Polavaram Dam, it could be possible for the farmers to feed their livestock better and increase the latter's milk production. In calculating the net economic returns, is has been analyzed with the fodder cost for livestock. The fodder comprises dry fodder, green fodder and concentrates. Concentrates account for more than 50 % of the total fodder cost for both cattle and buffaloes, while green fodder accounts for 40 %. The results indicate that in rainfed areas with a lower production of fodder, the farmer may have to buy fodder, which can in turn contribute to increasing the marginal cost of milk production.

Figure 4.8: Image of livestock

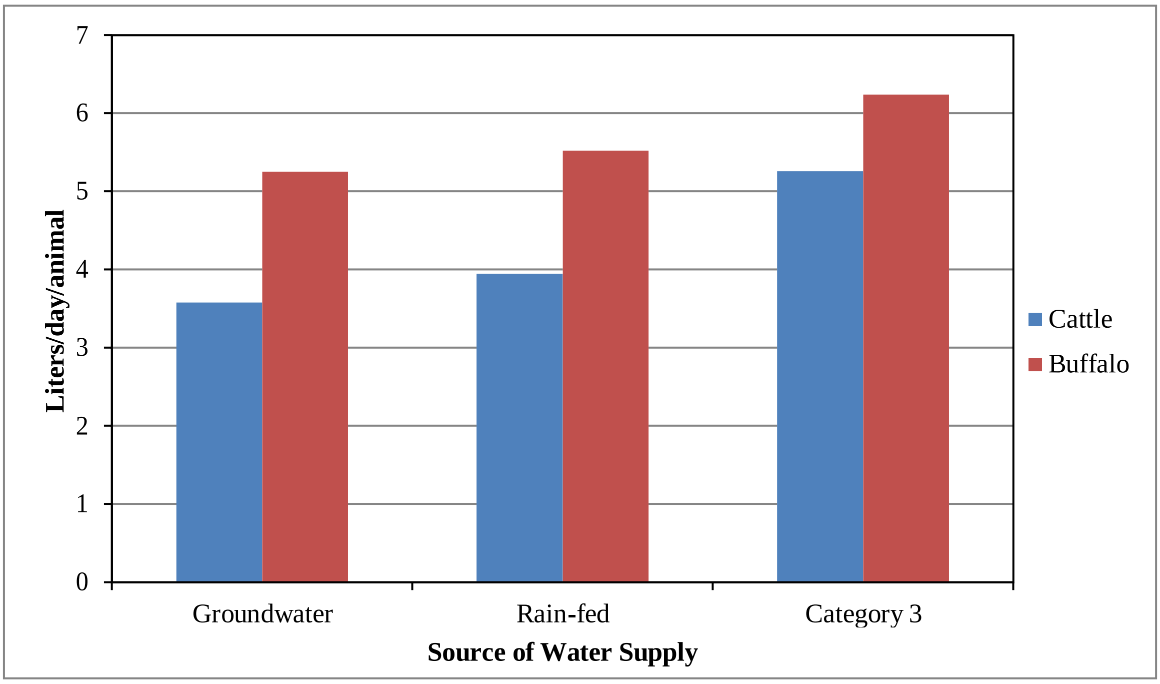

Figure 4.9: Milk Productivity in areas with different sources of water supply

Figure suggests that the net value of milk production (cattle and buffalo) per day in the surface irrigated area is 121 % and 72 % higher for cattle and buffalo, respectively, than that in the rain-fed area. The net gain is Rs. 40.78 per day from a buffalo in a surface irrigated area.

The net value of milk production from a buffalo is also much higher than that of a cow across all sources of irrigation, and that is why farmers prefer to keep buffaloes instead of cattle. In groundwater irrigated areas, for instance, the net value of a buffalo is 72 % higher than that of a cow, but it is only 44 % in the surface irrigated areas.

As the density of livestock is higher in the rain-fed areas, particularly for buffaloes, the net value of a buffalo per hectare in the rain-fed area is similar to that of one in the surface irrigated area, but 23 % higher than that of one in the groundwater irrigated area.

It has been attempted to assess the livestock benefits from the Polavaram Dam under several alternative scenarios. In our analysis, we found that the number of livestock per hectare is much higher in the rain-fed areas than in the irrigated area, which resulted in a higher net value per hectare. With the advent of surface irrigated water from Polavaram, farmers in the rain-fed area may retain the livestock that is currently providing a continuous income to sustain their livelihood. Farmers may also however, overall retain less livestock with the introduction of canal water and engage themselves more in agricultural activities. In another scenario is has been considered a case where there could be a 10 % reduction in fodder cost due to higher fodder production in the irrigated area.

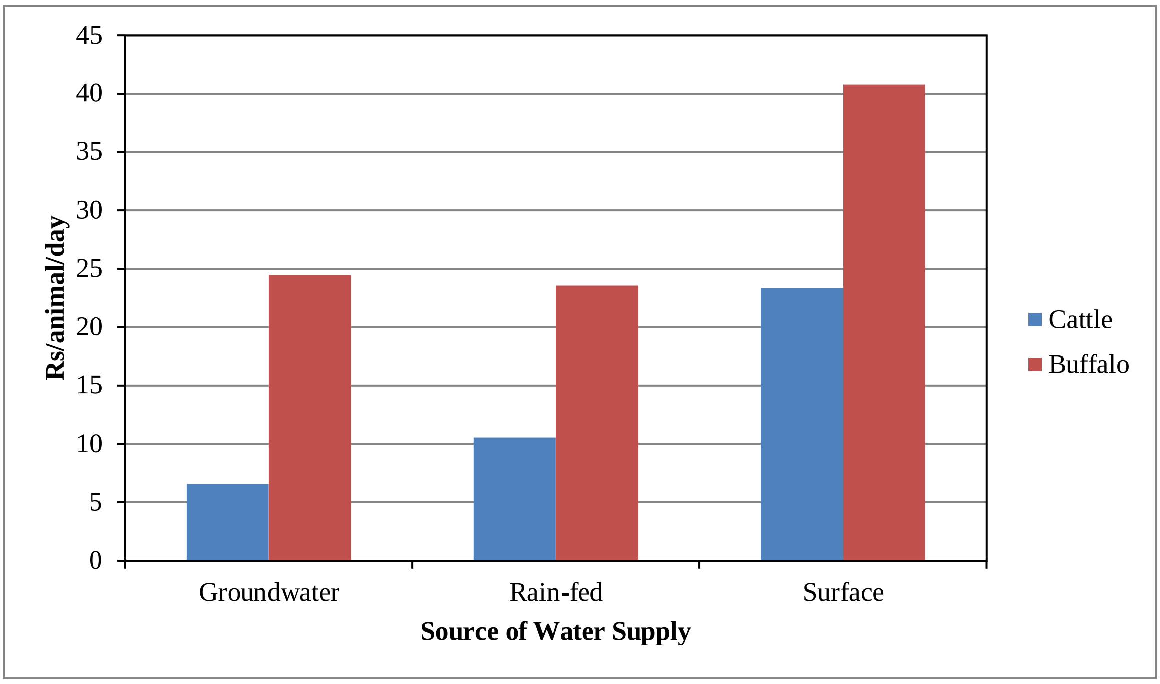

Figure 4.10: Net returns per day from milk production in areas with different sources of water supply

Chapter-5

Conclusion and Future Enhancement

5.1 Conclusion:

- The Polavaram project has been a dream project for those living in Andhra Pradesh. The project seeks to benefit all the districts of Andhra Pradesh and make the state both flood free and drought-free at the same time. It will have a flood discharge capacity of 36 Lakh cusecs.
- 80 TMCs of Godavari water can be diverted every year to the Krishna River. The Godavari water travels for 174 KM in the Polavarm Right canal with the help of gravity and then meets River Krishna at 'Pavithra Sangamam' near Vijayawada, located in the upstream of Prakasam barrage.
- The diverted Godavari water will be utilised for irrigation and drinking purposes in Krishna Delta region. The river linking benefits a whopping 14 lakh acres in Krishna delta region. Four districts Krishna, West Godavari, Guntur and Prakasam under Krishna delta region will benefit from the Godavari water.
- The hydroelectric power project will enable 960 Mega Watt power generation, which would be very crucial for the new state
- In the Krishna-Godavari link at Polavaram , the ground water is the most dominating form of irrigation in the command area.
- Surface irrigation helps the farmers in increasing agricultural productivity in much of the already irrigated area.
- As the water will be available at short depth due to seepage, the cost of installation of tube wells will decrease.
- The Polavaram Dam, by diverting surface water can create an opportunity for the farmers to rely more on surface irrigation and thereby sustain their agricultural livelihood.
- In the region, the growing concern is about groundwater overexploitation and falling groundwater tables in the proposed command area. Results indicate that the yield (paddy) and net returns decrease dramatically as the groundwater depth increases.
- Currently there is a popular trend among the farmers to grow high-valued annual crops, mainly in the groundwater irrigated areas. The project demonstrates the

higher benefits from the Polavaram Dam could be reaped if the farmers continue to grow annual crops.

- The study shows that livestock benefits will be substantial if the farmers retain their livestock even after the introduction of surface water or with a reduction in fodder cost. The gains will be at their maximum if the farmers grow maize for fodder in the rabi season and retain their livestock.

5.2 Future Enhancement

- To stabilize the existing irrigated ayacut area under Nagarjuna Sagar Right Canal, by having five step ladder pumping stages and a gravity canals to transfer 7,000 cusecs of Godavari water from Prakasam Barrage into the Nagarjuna Sagar Right Canal near Nekarikallu by utilizing 73 tmcft of Godavari water.

- There is a proposal to link Nagarjuna Sagar Dam across the Krishna River and Somasila Dam across Penna River with 400 km canal as part of national river linking program.

- In future a new massive dam named Palnadu Sagar across hill range near Bollapalle with 700 TMC capacity reservoir is possible using of flood water of Krishna River and Godavari River diverted with this lift project.

- In future the water stored in Palnadu Sagar will be used for irrigation and drinking in drought years.

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A Major Project Report

On

FLOW COMPUTATION THROUGH CONVEYANCE ESTIMATION SYSTEM (CES)

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

by

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BONAFIDE CERTIFICATE

This is to certify that the project entitled "Flow Computation Through Conveyance Estimation System (CES)", is being submitted by1. **Mr. P. Keshavardhan(17K81A0149), 2. Ms. T. Nagarani (17K81A158), 3. Mr. G. Arun(17K81A0125), 4. Mr. Suresh (17K81A0139)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN** Civil Engineering is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

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Place:

Date:

DECLARATION

We, the student of **Bachelor of Technology** in Department of 'Civil Engineering', session: 2017 – 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work 'Flow Computation Through Conveyance Estimation System (CES)' the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

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ABSTRACT

The paper deals with flow computation through Conveyance Estimation System (CES). This paper presents results, calculated from field measurements taken in several frequently flooded natural rivers, which include stage-discharge relationships, variation of flow resistance with depth of flow, the apparent friction factor, and the composite friction factor for flooded natural rivers. The results obtained have shown the complexity of flow resistance in natural rivers due to the interaction between the main channel and floodplain flow. The estimation of conveyance is a core component of flood management, water level prediction and flood defense design. All river modelling software includes one or more methods for conveyance estimation, usually based upon methods dating from research completed more than 50 years ago with little or no account taken of recent advances in knowledge and understanding. In 2001 the Environment Agency commissioned a scoping study on reducing uncertainty in conveyance estimation. The paper describes some of the conclusions of that scoping study including the needs of different users, the diversity of current knowledge and provides the outline for a targeted programme of research to make a step forward in the management of river capacity. This Targeted Programme is now underway involving a partnership between academic researchers, experts and users. Particular issues of concern are the effects of riverine vegetation, the influence of natural shaped (and re-naturalised) channels and the interaction between river channels and flood plain flows. The output from the programme will be a new Conveyance Estimation System (CES) as open code and enabled for use within modelling packages. The CES includes a roughness advisor to provide access to the wide body of knowledge on the estimation of river resistance. The flow parameters such as depth averaged velocity, bed shear stress distribution curve along with stage-discharge, Fr, average velocity conveyance against flow depth has been plotted and discussed. The variation of the flow parameter has been found with different river conditions.

Keywords: Flow Resistance; Friction Factor; Conveyance; Natural River; Overbank Flow; depth averaged velocity; bed shear stress distribution.

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LIST OF ABBREVIATIONS

<SKM	Shiono Knight Method
<MC	Main Channel
<RFC	Right Flood Plain
<LFC	Left Flood Plain
<DAV	Depth Averaged Velocity
<SV	Shear Velocity
<BSS	Bed Shear Stress

Chapter-1

Introduction

1.1 Overview

The estimation of resistant coefficient and hence discharge capacity in a channel or river is one of the fundamental problems facing the river engineers. Without an accurate estimate of conveyance, very little confidence can be placed in the subsequent design calculations or predictions. At the present moment, the accuracy of the friction factor for predicting flow characteristics in a particular reach, with a dynamic vegetation and flow regime remains questionable. Many studies of flow resistance have been carried out to provide an accurate estimate of resistance coefficient in any given circumstance especially under overbank conditions. However, none as yet has led to a general applicable method. In addition, as most of this work is based on laboratory experiments, these results may not reflect the real situations in natural rivers with highly irregular shape and variations in surface roughness. In the work presented, an attempt was made to focus on the estimation of flow resistance in natural rivers under flood conditions. The transfer of momentum at the junction of a main river section and a floodplain makes discharge predictions of a compound river channel difficult. Many investigators have observed that this interaction phenomenon is responsible for nonuniformity of the distributions of velocity and boundary shear stress. The transfer of momentum at the junction of a main river section and a floodplain makes discharge predictions of a compound river channel difficult. Many investigators have observed that this interaction phenomenon is responsible for nonuniformity of the distributions of velocity and boundary shear stress. This exchange of momentum between sub-sections and discharge assessments for compound sections have been reported in many other works (e.g. Hin et al., 2008; Seckin, 2004). Prinos and Townsend (1984) and Christodoulou (1992) parameterised the apparent shear stress at a junction in terms of geometric and hydraulic parameters. Huthoff et al. (2008) and Yang et al. (2014) parameterised the apparent shear stress in terms of the velocities of the main channel and floodplains. Khatua et al. (2012) developed a modified divided channel method for flow prediction based on interaction lengths at the interfaces. Kordi and Abustan (2011) showed that the slope–area method overestimates the flow rate in a compound channel and developed an improved slope–area method applicable to non-homogeneous cross-sections. Mohanty and Khatua (2014) proposed a methodology based on zonal roughness coefficients to estimate the flow distribution in a main channel and floodplains. Fernandes et al. (2014) presented flow characteristics, taking the influence of the relative flow depth (β) and floodplain roughness into consideration, with β defined as the ratio between the flow depth over the floodplain to the flow depth over the main channel. Shiono and Knight (1991) and Van Prooijen et al. (2005) presented analytical models to resolve the depth-averaged flow velocity as a function of lateral channel coordinates. Although two-dimensional (2D) and three-dimensional (3D) methods can predict discharge more accurately, they are complicated and require a large number of empirical constants in their application. Compared with 1D modelling, there are a number of disadvantages of 2D and 3D modelling, such as undefined flow paths, more advanced data requirements, difficulty in data integration, greater expense in terms of both initial output and gathering data, longer computational times and so on. An improved solution for solving the Reynolds-averaged Navier–Stokes equation for the prediction of the depth-averaged velocity for a uniform open-channel flow. Proust et al. (2010) distinguished the concepts of energy loss and head loss for non-uniform flow conditions. Furthermore, the non-uniformity of flow in compound channels was emphasised. Flow modelling of non-uniform flow has been carried out by Rezaei (2006), who analysed longitudinal variations in the roughness coefficient and depth-averaged velocity and noted the importance of lateral variations of the energy slope. The objective of the work reported in this paper was to investigate the influence of the boundary shear force in a nonhomogenous bed as compared with a homogenous bed. Considering large datasets on rough compound channels, a generalised expression of the boundary shear force carried by floodplains for a non-homogenous rough compound channel was developed. A methodology for determining the flow distribution in each compartment of an unsymmetrical compound channel was also devised on the basis of the momentum transfer coefficients at the interfaces and differential roughness parameters.

Figure 1.1: Flood at Kochi Airport, Kerala

1.2 Statement of the Problem

- Proper flood management and evacuation of people from the flood plain area are highly crucial during flood.
- So, flood forecasting is required prior to the flood for analyzing the above problem.

- Through CES software the flood prediction can be obtained in terms of velocity distribution diagram and rating curves.

- Further boundary shear distribution curve can be helpful for investigating erosion and sediment deposit problems in the river.

1.3 Objectives of the study

- To estimate the flow assists in predicting the flood and its protection measures.

- To predict flow conveyance, rating curve and depth averaged velocity distribution of open channel by Conveyance Estimation System (CES) software.

- To analyze numerical solutions of Shiono and Knight Method and to predict flow parameters to predict Depth Averaged velocity in an open channel flow through CES.

- To predict bed shear stress distribution curve for investigating erosion and sediment deposit problems in the river by Conveyance Estimation System (CES) software.

- To investigate of three calibrating coefficients (friction factor, eddy viscosity coefficient and secondary flow coefficient) required for solution of SKM and CES.

1.4 Scope of the study

- The potential economic benefits of the use of improved methods for conveyance estimation will come from altering design, operation and maintenance practice as the degree of uncertainty is reduced.

- Strategic decisions made early in the project life cycle can have far reaching consequences and it is at this early stage that uncertainties in information and data are greatest.

- There is a close relationship between uncertainty and risk in that the greater the uncertainty the greater the probability of the project or maintenance activity of not achieving its objective.
- This is linked to the confidence on the performance of the scheme or process to meet its intended objectives.
- Thus, optimisation of performance and the confidence with which performance can be delivered are linked inexorably with understanding and controlling uncertainty.

1.5 Organization of Chapters

The dissertation has been divided into five chapters including Introduction. Chapter 1 consists of general introduction, overview of previous literatures are given in chapter 2, study area, components of the Conveyance Estimation System is explained in chapter 3, Data Analysis and Result are presented in chapter 4, chapter 5 consists of conclusion and scope of future work.

Chapter 1 presents the brief introduction about the Conveyance Estimation System. The objectives and scope of the study has also been presented and it gives an overview of the project in this chapter.

Chapter 2 presents literature reviews of the previous work of pioneer investigators. This chapter includes previous work already carried out in Conveyance Estimation System

Chapter 3 presents the study area of the Conveyance Estimation System and also highlights the major components of the project such as Roughness Generator, Conveyance Generator etc.

Chapter 4 presents the Sampling Plan and the results obtained for 4 rivers for which we have collected the data of the river

Chapter 5 includes the concluding remarks and future scope if the research works.

Previous works carried out by other investigators have been cited in references are provided at the last

Chapter-2

LITERATURE REVIEW

2.1 LITERATURE REVIEW ON BASE PAPER

Palacios (1977) investigated a new methodology for estimating conveyance efficiency within irrigation systems is presented. Based on statistical analysis of daily water releases from the source of supply and deliveries to the farmers in an irrigation district in Mexico, a linear model is obtained for estimating conveyance efficiency and two component factors. In the last part of this paper, an analysis of the expected benefits and costs accruing from system improvement permits derivation of a decision rule which may be used for analyzing the economic feasibility of lining in-place canals.

Konishi (1994) investigated that an object is levitated and carried by controlled air flow from many microactuators in the system. We designed a fluidic microactuator which has two on-off nozzles and fabricated an array of these microactuators on an SOI (Silicon on Insulator) substrate. The dimension of each actuator is about 100 /spl mu/m/spl times/200 /spl mu/m. Each microactuator can control the direction of air flow by electrostatically closing one of nozzles and can carry a flat object on the flow to the desired direction.

Manuela (2001) investigated that Targeted Programme aims to build upon the considerable body of research knowledge and understanding that currently is not implemented in practice. Thus, the TP will not involve much new basic research but will be development of practical tools and guidance.

Samuels et al. (2002) investigated as a research project, a scoping study to define actions for reducing uncertainty in conveyance estimation. The paper describes some of the conclusions of that scoping study including the needs of different users, the diversity of current knowledge and the outline of the targeted programme of research that is now underway to produce an improved conveyance estimation system.

Mc Gahey and Samuels et al. (2003) investigated that a practical approach to uncertainty in conveyance estimated conveyance in a range of channel types and flow conditions, including straight, skewed and meandering plan form shape; simple, twostage and multi-thread channels; and a variety of vegetation and substrate covers

Lane (2004) investigated that these drivers do not impact the amount of water that is conveyed through the river system during a flood, but they have a bearing on the probability of a flood event overtopping the banks and/or flood defences as they affect the relationship between discharge and stage–that is the water surface elevation for a given flood discharge, through their effects on the conveyance capacity of the channel.

Helmio (2004) aimed of this study was to investigate the additional friction factor due to lateral momentum transfer at the interface of vegetated and nonvegetated channel parts in two rivers: (1) the Rhine River, a large dredged river with partially vegetated floodplains, and (2) the River Päntäneenjoki, a small boreal lowland river with dense bank vegetation and an undulating longitudinal profile. The friction factors of the interfaces were computed backward from the topographical field data, while the measured depth-flow regime data were computed with the help of an unsteady one-dimensional (1-D) flow model.

Knight (2005) investigated that floodplain roughness can have a significant effect on conveyance capacity, division of flow between a river channel and its associated floodplains, resistance, bed-load transport and dune migration rate. Although much may be gained from such small-scale experiments, typically conducted under steady flow conditions, flood flows in natural rivers are known to be much more complex.

Karamisheva (2005) examined the Comparisons between different velocity calculation methods were made. A simple calculation method for predicting the main channel mean velocity has been proposed.

Knight (2006) investigated the CES methodology is applied to fourteen river sites from England, Northern Ireland, New Zealand, Ecuador and Argentina, illustrating reasonable model predictions over a broad application range. Discharge and lateral velocity predictions are compared to observed data, with emphasis on practical application, calibration technique and effects of scale.

Karamisheva et al (2006) investigated. A simple algorithm for stage–discharge prediction based on a lumped resistance approach was then proposed. It requires calibration of the overbank Manning n for a relative depth zero and a coefficient of proportionality, and this is achievable if measurements of the flow depth and velocity are taken for at least three overbank flow discharges. The application of the lumped approach to various flume and field data showed good agreement between the measured and predicted flow depths.

Baik (2006) proposed a method to estimate the transition probabilities of different condition states in Markov chain-based deterioration models for wastewater systems using an ordered probit model. The proposed model is applied and evaluated using the condition data of sewer pipes managed by the City of San Diego's Metropolitan Wastewater Department. The developed model presents some advantages in estimating transition probabilities over the approaches developed in the past, including the nonlinear optimization-based approach, in terms of versatility in the implementation, precision of the estimated data, and appropriateness of the assumptions in the model.

Samuels et al. (2007) examined Programme is now underway involving a partnership between academic researchers, experts and users. Particular issues of concern are the effects of riverine vegetation, the influence of natural shaped channels and the interaction between river channels and flood plain flows.

O'Hare (2010) examined that This in turn reduces the uncertainty in estimating water levels in channels where aquatic vegetation is present. Roughness plays an essential role in water level estimation as it reduces the discharge capacity through energy expenditure on boundary generated turbulence as well as through physical blockages by vegetation.

Beaman (2010) investigated that a variety of conveyance estimation methods have been developed with the objective of accurately capturing these flow characteristics through a simplified user-friendly approach. However, these methods usually require calibration of one or more empirical constants.

Devi et al. (2017) investigated that in this paper, the application and suitability of using the standard software Conveyance Estimation System (CES) for predicting the flow is described. The approaches were also applied to a number of experimental data sets, and the results were compared well.

Nagy (2018) investigated that vegetation affects the flow velocity, therefore has a considerable impact on flood height and rate and pattern of sedimentation. However, climate change promotes the spread of invasive species, and their rapid growth results in dense vegetation stands, thus they have a significant impact on floodwater hydraulics.

Barkhordari (2020) examined the potential of Automatic Control Systems (ACS) to simultaneously reduce seepage losses and improve the operational performance of structures. To achieve this goal, a seepage model was integrated with an operational simulation model. The former model simulated the seepage flow throughout the main irrigation canal for different operational conditions imposed by the operational model. The ability of the integrated models to simulate reduction in losses was tested for the main canal of an irrigation district in southwest Oklahoma, United States (U.S.). Three combinations of the ACS and seepage model were studied, where ACS included or lacked inline water storage as an operational strategy and the seepage model simulated seepage rate for existing or maximum potential conditions. Three scenarios of reducing target levels in the canal to reduce seepage losses were considered for each combination.

Chapter-3

Methodology

3.1 Governing Equation:

3.1.1 Shiono Knight Method (SKM)

CES is based on Shiono Knight Method (SKM). SKM is a numerical modelling based on RANS equation. The Shiono and Knight method (SKM) (1988; 1990; 1991) is a lateral distribution method based on the depth averaged Reynolds Averaged Navier-Stokes (RANS) equations. The quasi 2-D model includes some of the key 3-D flow structures that occur in rivers and simple or compound channels and is able to predict the lateral variation of depth-averaged velocity and boundary shear distributions within natural river channels of any cross section shape. Its promising results for both laboratory channels and natural rivers have been led it to being adopted by the UK's Environmental agency for use in its 'Conveyance and Afflux Estimation System' software which is also popularly known as CEAS or CES software.

3.1.2 Theoretical background of Shiono and Knight Method

In SKM method, the streamwise depth-averaged momentum equation is solved for steady uniform turbulent flow. In a prismatic open channel, the equation for the streamwise component of momentum in a steady uniform flow may be combined with the continuity equation to give:

$$\rho(\partial UV\partial y + \partial UW\partial z) = \rho g S_0 + \partial\partial y(-\rho uv) + \partial\partial z(\rho uw) \qquad (1)$$

where (U, V, W) are the mean velocity components in the x (stream wise), y (lateral) and z (normal to bed) directions, respectively; (u, v, w) are turbulent fluctuations of velocity with respect to the mean, ρ is the density of water, g is the gravitational acceleration and So is the bed slope. The depth-averaged momentum equation can be obtained by integrating Eq. (1) over the water depth, H, assumed W(H) = W(0) = 0, as given by Shiono and Knight (1991):

$$\partial\rho gHS_0 + \partial Hryx\partial y - rb1 + 1s = \partial(H(\rho UV)d)\partial y \tag{2}$$

in which τb is the bed shear stress, s is the side slope (1:s = vertical: horizontal), and

$$(\rho UV)d = 1H \int OH(\rho UV)dz \text{ and } ryx = 1H \int OH(-\rho uv)dz \tag{3}$$

Based on the commonly used eddy viscosity assumptions, the depth-averaged Reynolds stress (ryx) can be given as follows:

$$ryx = \rho\epsilon yx\partial Ud\partial y \text{ and } \varepsilon yx = \lambda U \times H \tag{4}$$

where εyx is depth-averaged eddy viscosity, λ is the dimensionless eddy viscosity coefficient and (U=τ b/ρ) is the local shear velocity. Using the customary flow resistance relationship that relates local boundary shear stress (τb) with the depth-mean velocity (Ud) and the Darcy–Weisbach friction coefficient (f), τb can be computed by:

$$rb = \rho f8U2dorU = f8 - \sqrt{UD} \tag{5}$$

Then, substituting Eqs. (4) and (5) into (2) yields:

$$\rho gHS_0 - \rho f8U2d1 + 1s2 + \partial\partial y(\rho\lambda H2f8 - \sqrt{Ud\partial Ud\partial y}) = \partial\partial y(H(\rho UV)d) \tag{6}$$

Based on experimental results, the secondary flow term (ρUV)d is assumed to vary approximately linearly with respect to y. Therefore, the lateral gradient of the secondary flow force per unit length may be written as:

$$\partial\partial y(H(\rho UV)d) = r$$ U (7)

where Γ is a dimensionless secondary flow parameter which is different for each part of the flow.

Equation (6) can be solved to give Ud as a function of y either analytically (Shiono and Knight 1991; Knight and Shiono 1996) or numerically (Knight and Abril 1996; Abril and Knight 2004).

An analytical solution to Eq. (6) for the lateral distribution of depth-mean velocity, can be obtained as follows.

For a sub-area with a constant water depth H, the analytic Ud distribution is written in the form:

$$\mathrm{U}\, d = (A1e\gamma y + A2e - \gamma y + k)1/2 \tag{8}$$

where

$$k = 8gS_0Hf(1-\beta) \tag{9}$$

$$\gamma = 2\lambda - \sqrt{}(f8)141H \tag{10}$$

$$\beta = r\rho gHS_0 \tag{11}$$

For a sub-area with a main channel side slope of 1: s, the Ud distribution has the form:

$$\mathrm{U}\, d = (A3 \in \alpha + A4 \in -\alpha - 1 + w\epsilon + \eta)1/2 \tag{12}$$

where

$$\alpha = -12 + 121 + s(1+s2)12\lambda(8f)12 \tag{13}$$

$$\omega = gS_0(1+s2)12s(f8) - \lambda s2(f8)12 \tag{14}$$

$$\eta = r(1+s2)12s\rho(f8) \tag{15}$$

$$\varepsilon = H - y - bs \tag{16}$$

A 1 , A 2 , A 3 and A 4 are integration constants and can be determined by considering the relevant boundary conditions. The accurate prediction of depth averaged velocity and boundary shear stress depends on proper estimation of the three calibration parameters in SKM model (i.e. f, λ, and Γ) and specifying the appropriate boundary conditions.

The simplified form of Navier-Stokes equation in steady uniform flow is as follows:

$$\rho\left[v\frac{\partial u}{\partial y} + w\frac{\partial w}{\partial z}\right] = \rho g sin\theta + \frac{\partial \tau_{yx}}{\partial y} + \frac{\partial \tau_{zx}}{\partial z}$$

Shiono Knight integrated the Navier-Stoke's equation that is the momentum equation over the flow depth H, mainly to find out the depth-averaged velocity distribution. The method of solving this equation is known as Shiono-Knight method. They provided a analytical solution for this model from which both depth-averaged distribution and boundary shear stress distribution can be simply found out. Integrating the equation (1) over a flow depth H, Shiono and knight obtained a quasi-2-D equation indicated in equation (2)

$$\rho g H S_0 - \rho \frac{f}{8} U_d{}^2 \sqrt{1+\frac{1}{s^2}} + \frac{\partial}{\partial y}\left\{\rho \lambda H^2 \left(\frac{f}{8}\right)^{1/2} U_d \frac{\partial U_d}{\partial y}\right\} = \frac{\partial H(\rho UV)_d}{\partial y}$$

The right-hand side of equation (2) is taken as secondary flow effect, which is also known as transverse gradient of secondary flow. Γ is the symbol to define the secondary flow parameter

Darcy-Weisbach friction factor (f)

$$f = \frac{8gn^2}{R^{1/3}}$$

Also calculated by using following equation:

$$f = \frac{8\tau_b}{\rho U_d{}^2}$$

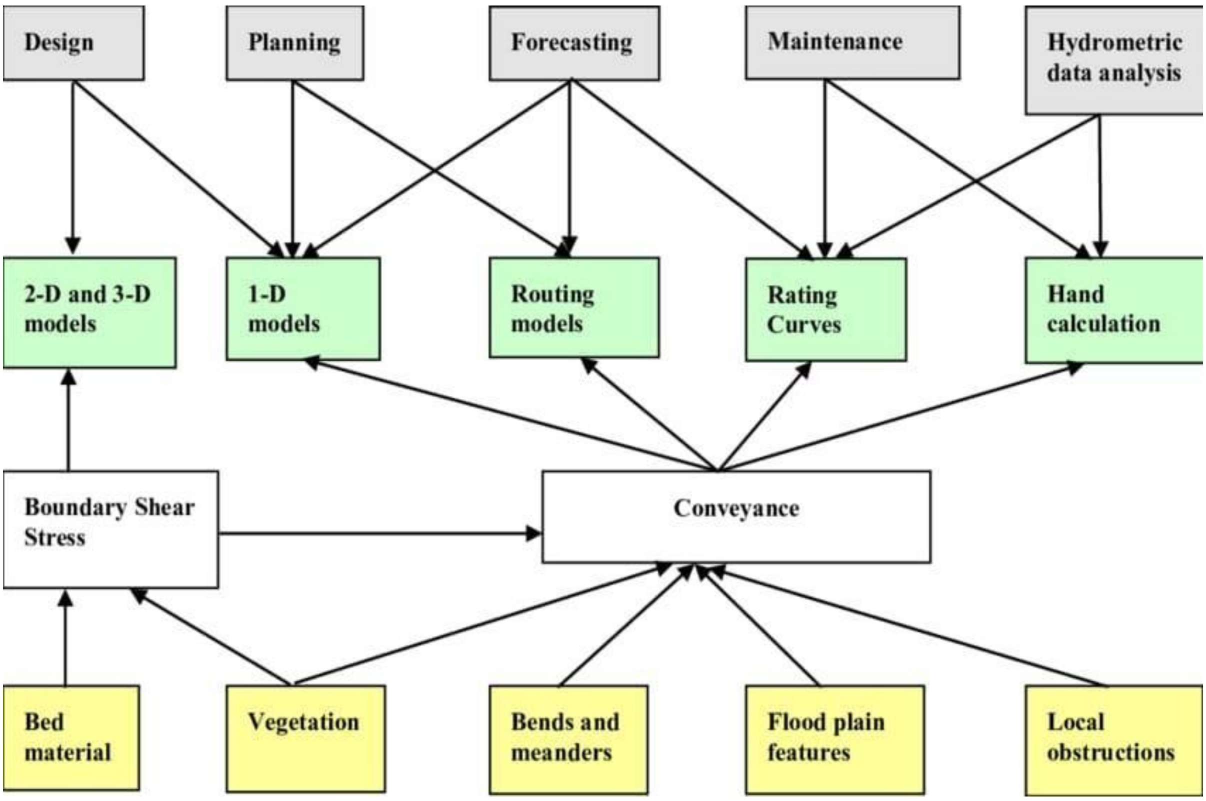

Figure 3.1: The conceptual Fame Work of CES

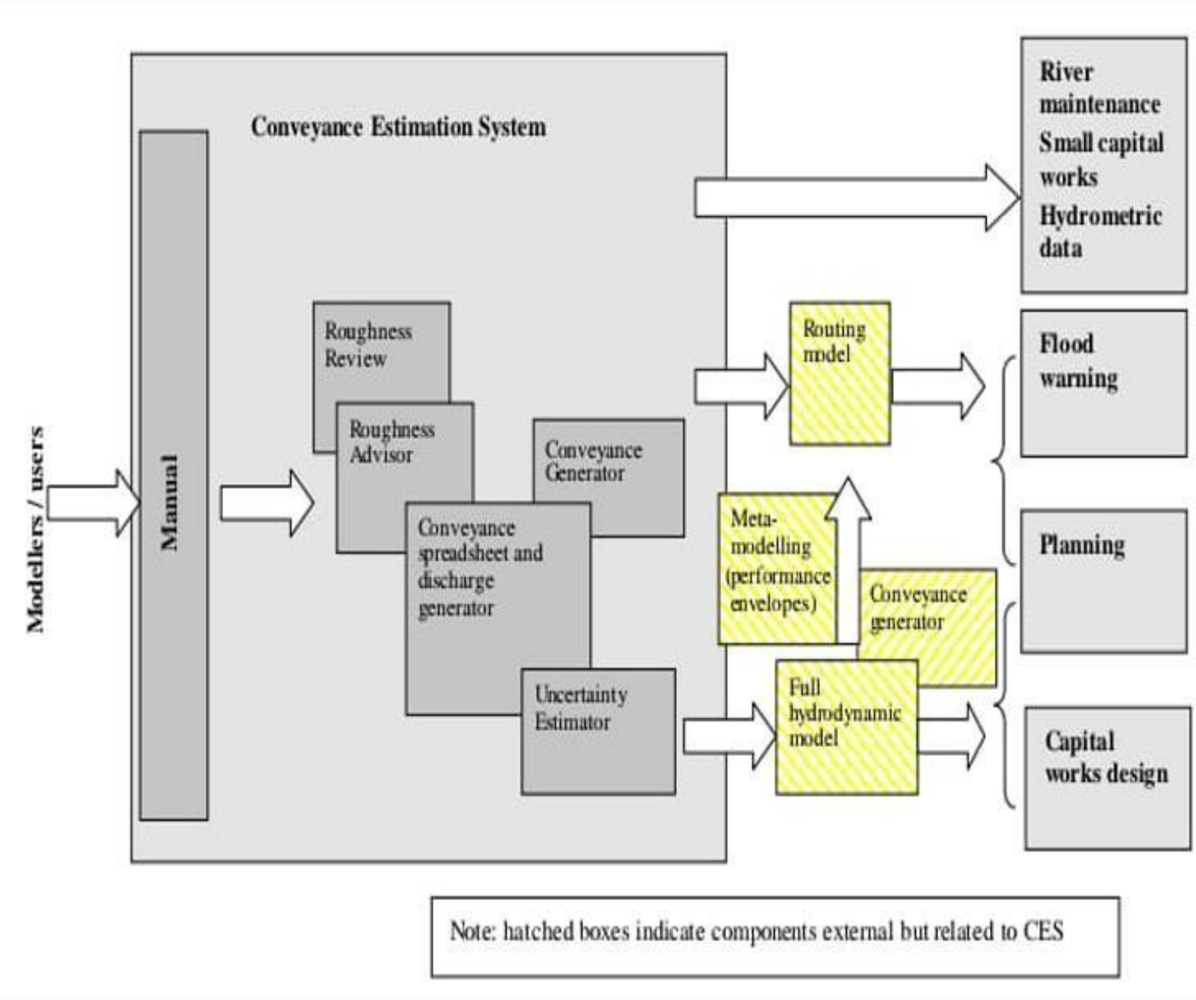

Figure 3.2: Components of Conveyance Estimation System

3.2 Main components of CES:

• **Roughness Advisor,** which is a database of roughness information including descriptions, photographs and unit roughness values for a range of natural and man-made roughness types. These are sourced from over 700 references (including the River Habitat Survey) and include aquatic vegetation, crops, grasses, hedges, trees, substrates, bank protection and irregularities. The Roughness Advisor also includes information on seasonal variations in vegetation roughness, cutting and suggested regrowth patterns following cutting.

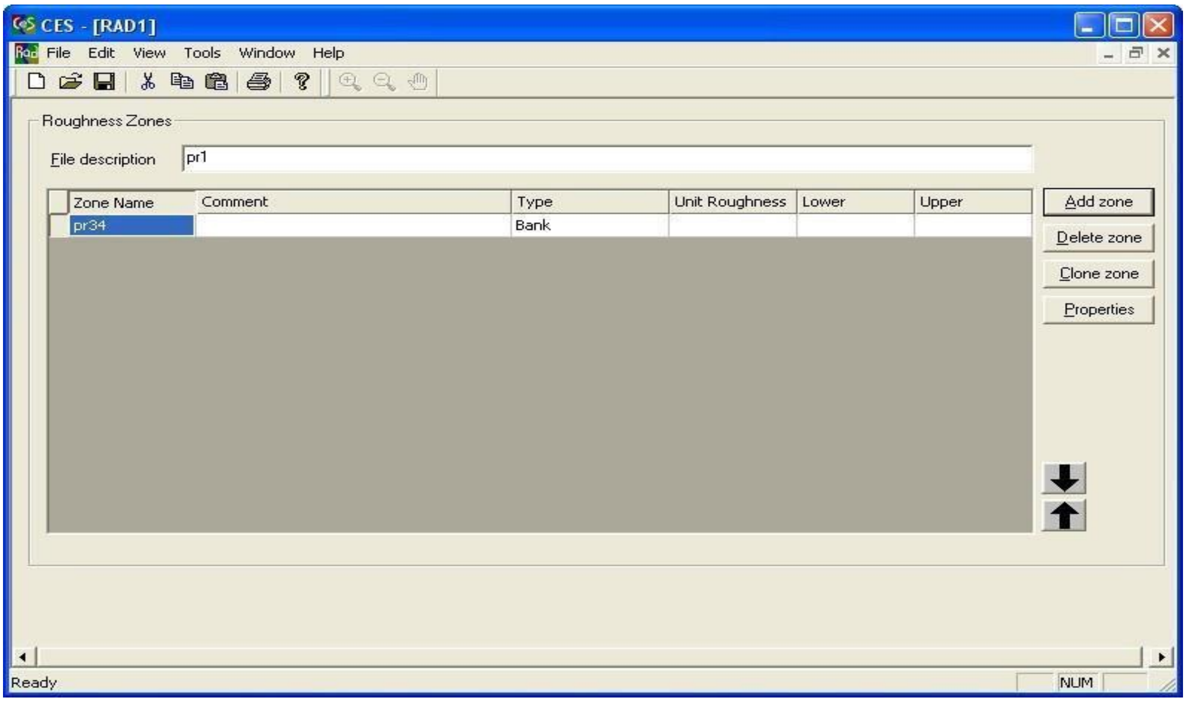

Figure 3.3: CES Interface 1: Roughness Generator

- **Conveyance Generator**, which estimates the channel conveyance based on the roughness information and cross-section description. The calculation is based on a lateral distribution method, where the unit flow rate is estimated at 100 points across the channel and the overall flow is then determined by integrating across the river section. The available outputs with depth include water level, flow, rating curves, velocity, area, perimeter, Froude Number, Reynolds Number etc. It is also possible to obtain spatial distributions (across a section) of velocity, boundary shear and shear velocity.

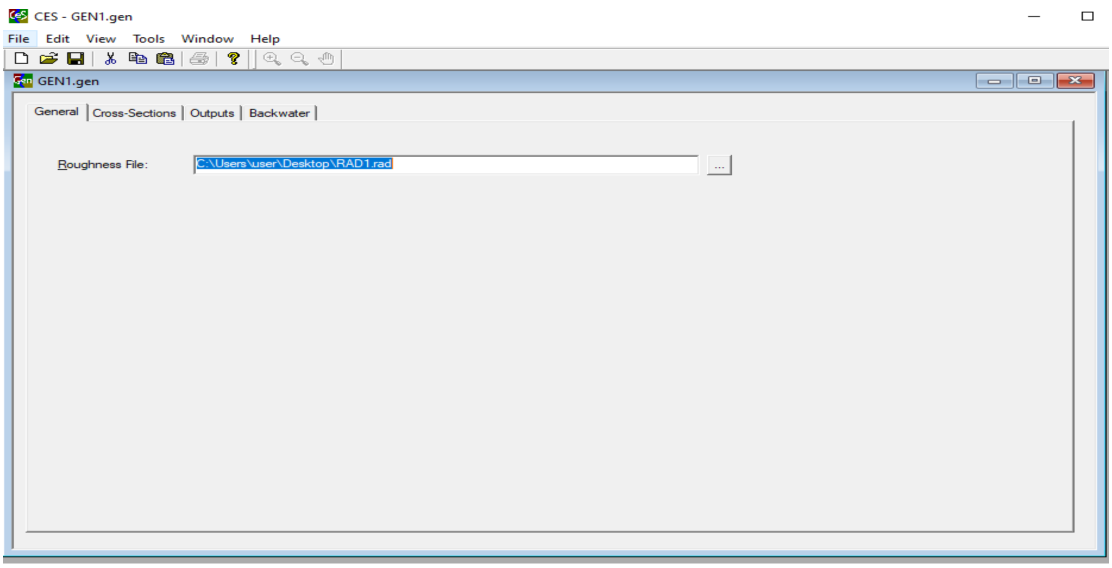

Figure 3.4: CES Interface 2: Conveyance Generator

- **Uncertainty Estimator**, which provides an upper and lower credible scenario, providing some measure of the uncertainty associated with each predicted water level. These values are derived from the upper and lower roughness estimates from the Roughness Advisor.
- **Backwater Module**, which includes a simple calculation of the backwater profile upstream of a control i.e. a point of known stage and flow. This is based on a simple energy balance, working from downstream to upstream, and includes the option to incorporate the velocity head term (kinetic energy term). Available within
- **Afflux Estimator**, which is a code for use with gradually varied flows. AE models arch and beam bridges with up to 20 openings, and pipe, box and arch culverts with up to 10 identical barrels. This code is embedded within the bridge and culvert units in the CES/AES stand-alone desktop application, and produces a longitudinal water surface profile.
- **Afflux Advisor**, which is a separate spreadsheet application to provide a relatively quick calculation of the afflux for simple bridge and culvert structures in a uniform channel. The calculation is based on the same field and laboratory data as the Afflux Estimator but assumes a uniform flow and does not provide a longitudinal water surface profile. It requires data for a single channel cross section and returns an afflux rating curve as an output.

Chapter-4

DATA ANALYSIS AND RESULTS

4.1 Overview

Many assume that flooding is due to heavy rainfall. This is true, but only part of the explanation. Floods also occur when the amount of water running off the land exceeds the capacity of rivers to carry that flow. So, floods are partly caused by the amount of rain falling, partly by the moisture that is already in the ground, and partly by the capacity of rivers to contain water within their channels. This means that if the capacities of river channels change, then two identical rainfall events falling on similarly wet ground can cause flooding of very different severity Most rivers are forever changing. They are shaped by the sediments and water they carry. Humans have modified most of the world's rivers in some way. In some cases this is through direct influence, such as dam construction or river engineering. Other influences are indirect – building on nearby land reduces the capacity of ground to absorb water, agriculture draws water from rivers, and deforestation leaves more water to flow elsewhere. Rivers respond to changes in climate as well. During drier periods, less water flows through river systems. This means that there is often less energy to move the sediments at their beds, so riverbed levels may progressively rise, decreasing the capacity of the river. Abundant plant growth within the channel can also reduce a river channel's capacity by slowing the flow. But it is not always easy to predict how rivers will change. Extreme shifts in channel shape and capacity can occur very rapidly. After a recent flash flood in Spain, one river rose almost a metre as huge volumes of sediment from upstream were displaced and dumped further along. In tropical river systems, which tend to carry more sediment than temperate rivers, these changes can be several metres.

Unfortunately, such changes are typically ignored by flood engineers and modellers, who generally treat the channel as a fixed feature. If rivers actually change their capacity in space and time, then estimates of flood probability may be incorrect, putting people and property at risk. Motivated by these concerns, we investigated the pace at which channel changes occur, and to what extent these alterations might be driven by climate. We began with a simple conceptual model: climate controls rainfall, rainfall affects river flow, and river flow shapes channel capacity.

Direct observations of this link were lacking in river systems over short timescales. So, we took 10,000 measurements of the capacity of 67 rivers in the US, covering a period of nearly 70 years. We also gathered rainfall and river flow data, to assess how climatic changes affected the capacity of the rivers.

We discovered that temporary shifts in river capacity, lasting years to decades, were far more frequent than had previously been assumed. Overall, river capacity tends to increase during periods that are wetter than average due to greater erosion of river channels, and decrease in drier periods.

In temperate regions such as the UK, where rivers tend to be vegetated, heavily engineered and relatively stable, delicate changes in channel capacity are hard to detect and unlikely to be life threatening. However, in river systems that carry high volumes of sediment, or in parts of the world where rainfall varies considerably during the year, sudden reductions in river capacity may dramatically increase flood risk for nearby settlements. For example, the Ganges-Brahmaputra river in India and Bangladesh falls under this category. Its capacity is already changing, and its floodplains are some of most densely populated in the world.

4.2 Results

Field measurements taken in several frequently flooded equitorial rivers, including velocity distributions, stage discharge relationships, roughness behaviours and discharge estimation.

These have illustrated the large difference in velocity between the main channel and floodplain under flood conditions, and the effects of momentum transfer between deep and shallow flow, which include reduction in main channel velocity and discharge capacity, leading to a reduction in compound section capacity at depth above bankfull.

Another significant characteristic that has been found is that the floodplain regions behave as storage reservoirs in most cases due to high resistance of long and thick grasses along the flood plains.

Flow resistance relationships have been presented in terms of Manning's coefficient and Darcy-Weisbach friction factor, showing the complex nature of flow resistance in the rivers and further explaining the danger inherent in the conventional practices of extrapolating inbank data for the analysis of overbank flows.

Results for discharge estimation have been shown for comparison with actual data, the errors incurred by applying empirical methods to compound channel flows have been quantified and found to depend on the particular method used.

The study was carried out on the natural rivers namely River Senggai, Senggi (B) and River Batu located in Kuching, the capital city of Sarawak State, Malaysia. These rivers were selected due to serious floods occurrence during Monsoon season in the past few years. Extensive flood data from River Main in Northern Ireland has also been obtained for comparison.
The selected rivers are shown in Figures 1 to 3. The rivers selected have almost straight and uniform cross section, free from backwater and tidal effect. Table 1 shows the geometrical properties and surface conditions of the rivers at the gauging stations for comparison. The typical cross sections of these rivers are shown in Figures 4 to 6.Flow gauging of the rivers was carried out from an adjustable bridge built across the rivers, using the velocity-area method.

Geometrical Properties	**River Severn**	**River Senggi(B)**	**River Senggai**	**River Batu**
Bank full Depth	5.75	1.306	1.060	1.544
Top width, B(m)	35	5.500	5.285	5.150
Aspect Ratio, B/h	6.086	4.211	4.986	3.335
Bed slope -main channel ,So	0.032	0.0010	0.0010	0.0016
Bed slope -Left flood plain ,Sl	0.04	0.00085	0.0010	0.0013
Bed slope -Right Flood plain ,Sr	0.04	0.00085	0.0010	0.0013
Surface condition-main channel	Erodible soil	Erodible soil	Erodible soil	Large boulder
Surfave condition-right side bank	Long Vegetation	Long Vegetation	Erodible soil	Erodible soil
Surface condition-flood plain	Vegetation	Long Vegetation	Long Vegetation	Long Vegetation

4.2.1 River Severn

Figure 4.1: Morphological cross-section of River Severn

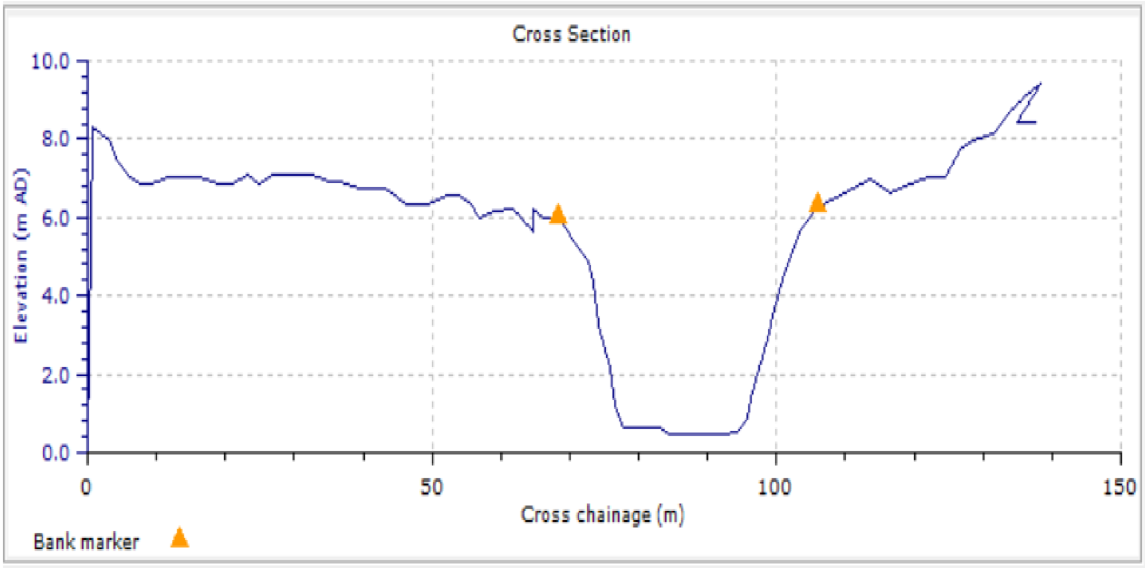

Figure 4.2: Elevation vs Cross-Chainage

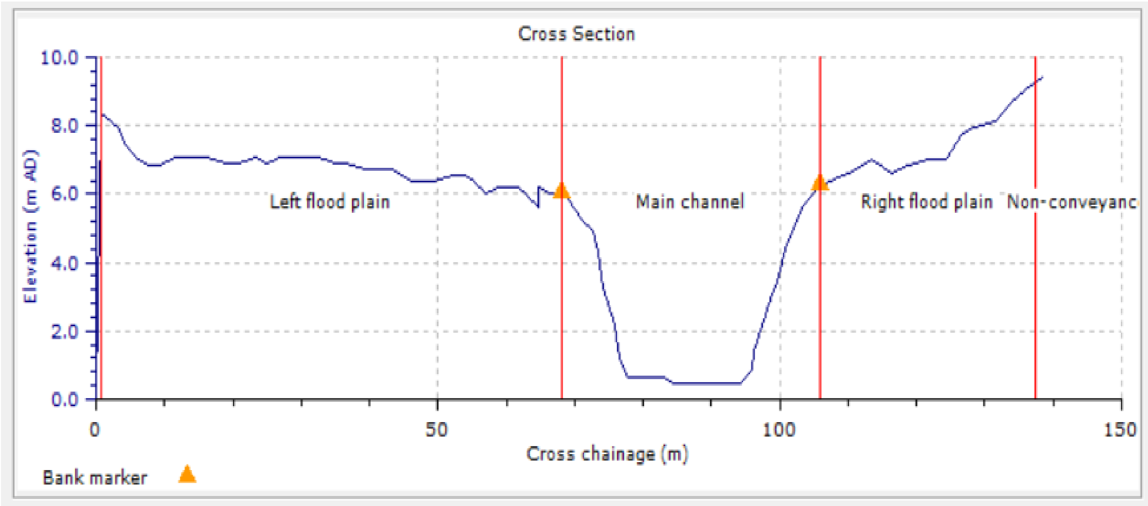

Figure 4.3: Bank Marker and Roughness Zones

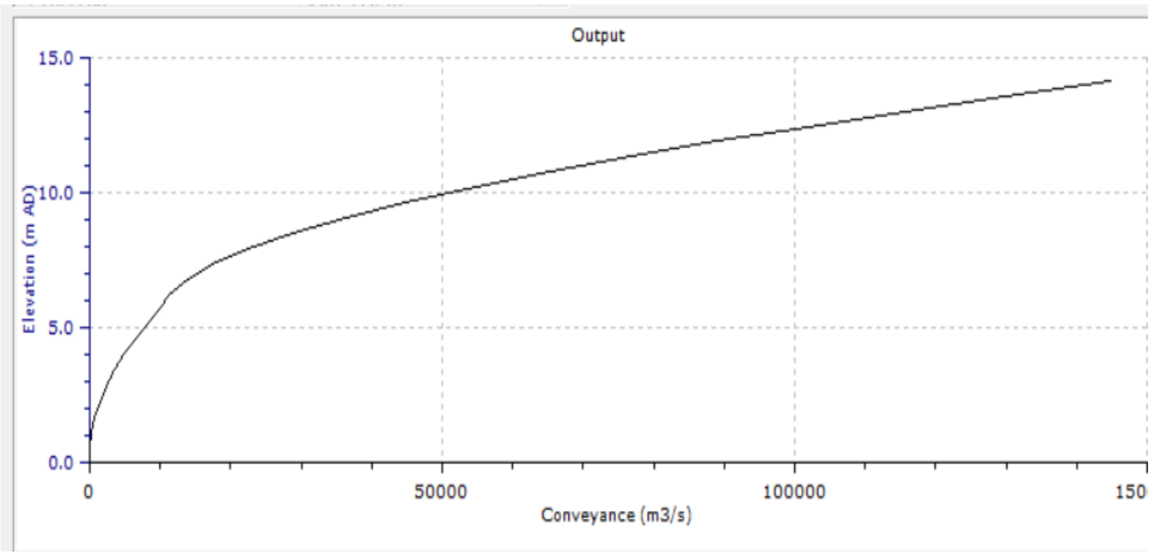

Figure 4.4: Elevation vs Conveyance

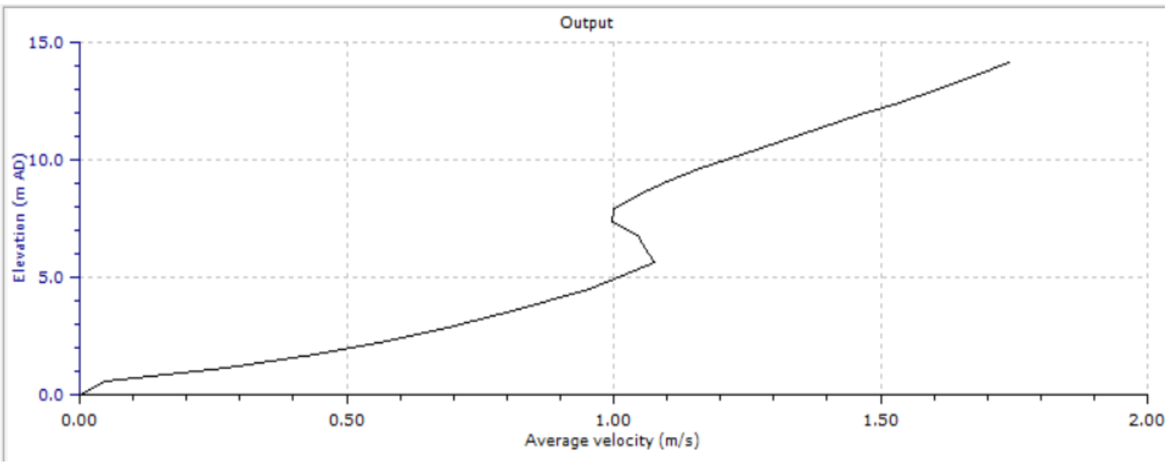

Figure 4.5: Elevation vs Average velocity

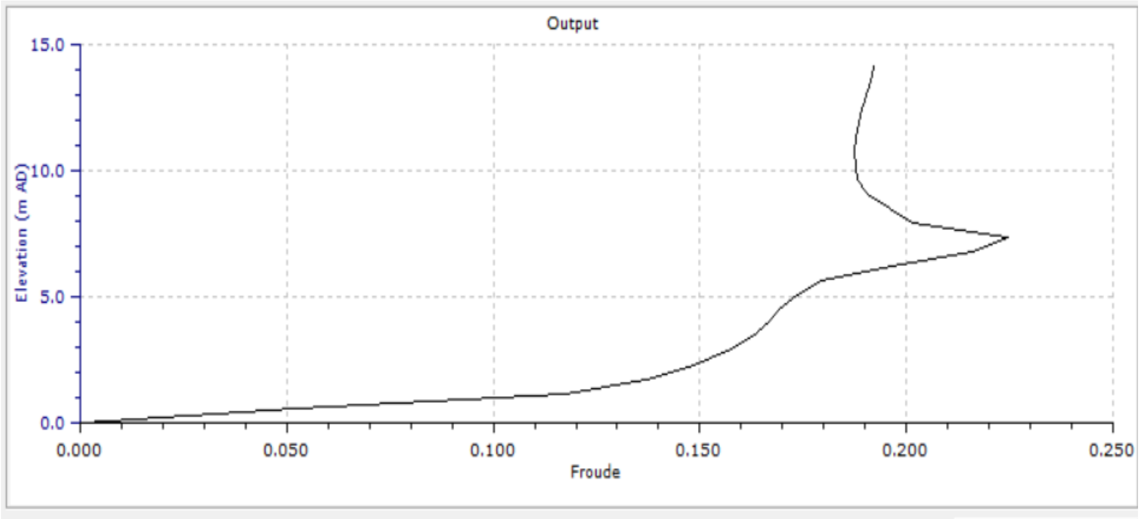

Figure 4.6: Elevation vs Froude

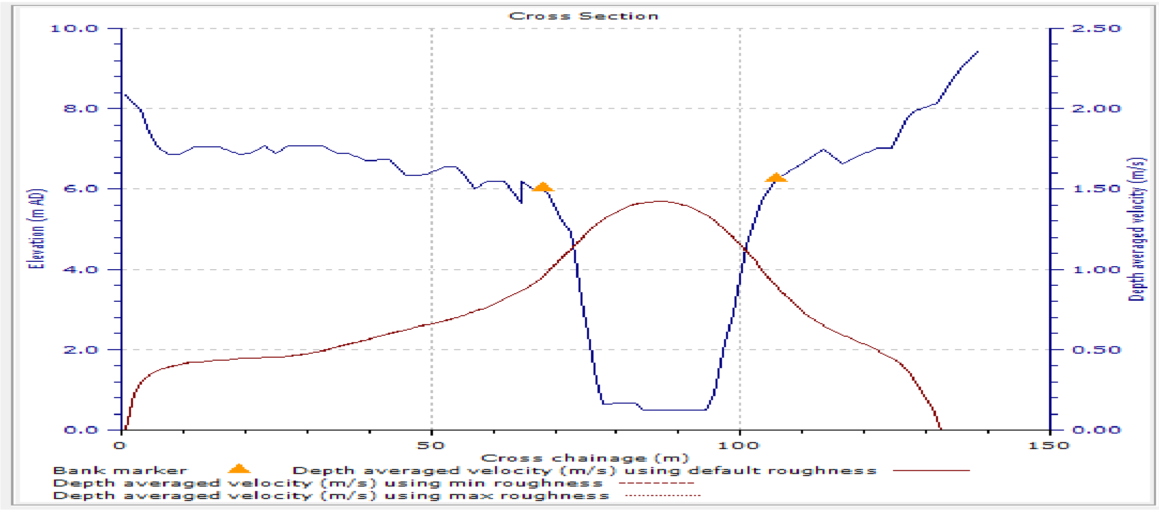

Figure 4.7: Elevation vs Spatial velocity

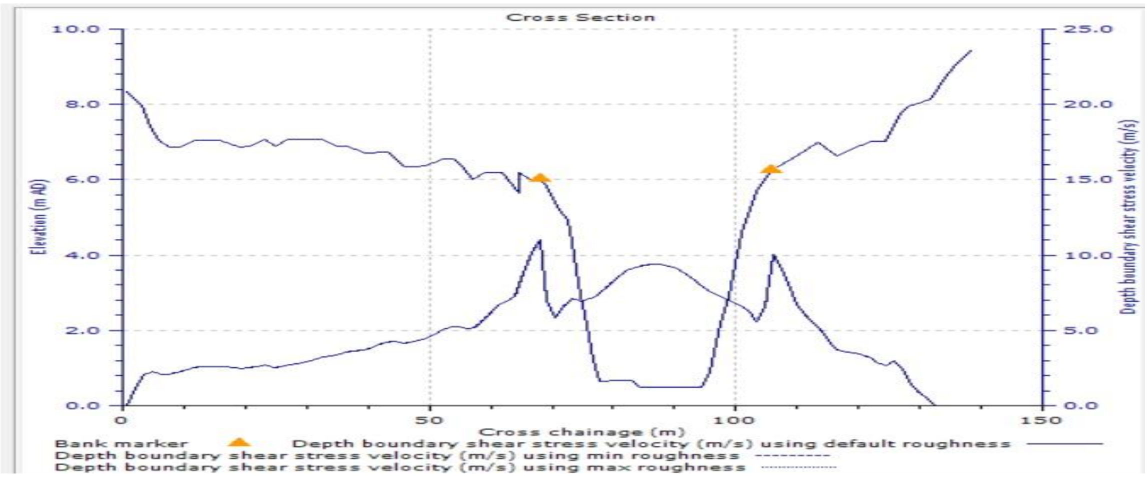

Figure 4.8: Elevation vs Boundary shear stress

4.2.2 River Senggi(B)

Figure 4.9: Morphological Cross Section of River Senggi(B)

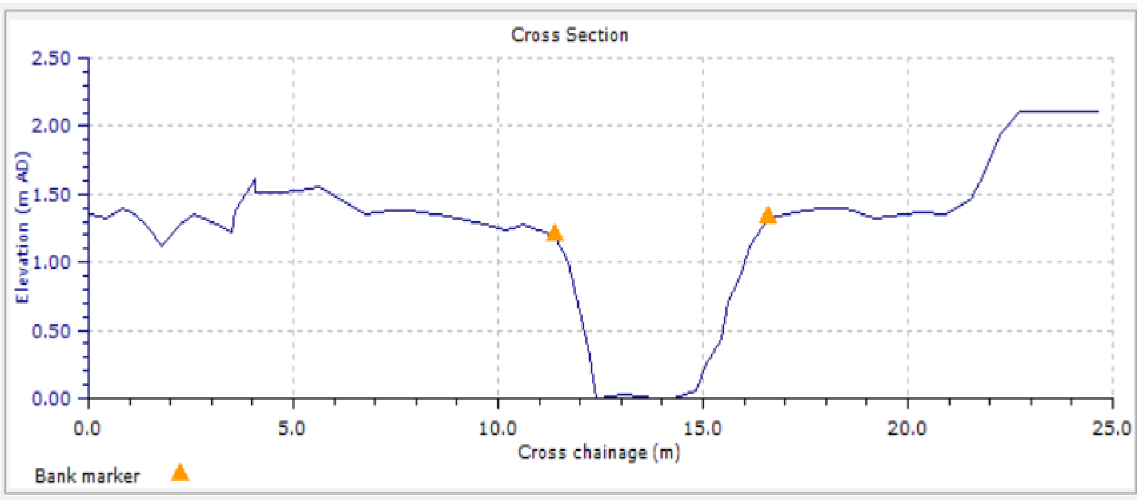

Figure 4.10: Elevation vs Cross-Chainage

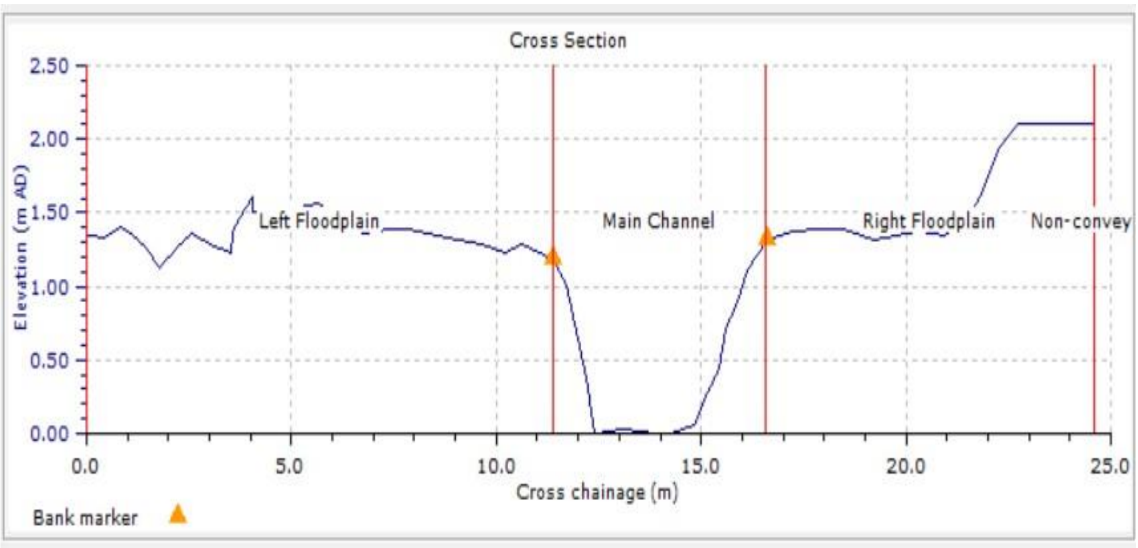

Figure 4.11: Bank Marker and Roughness Zones

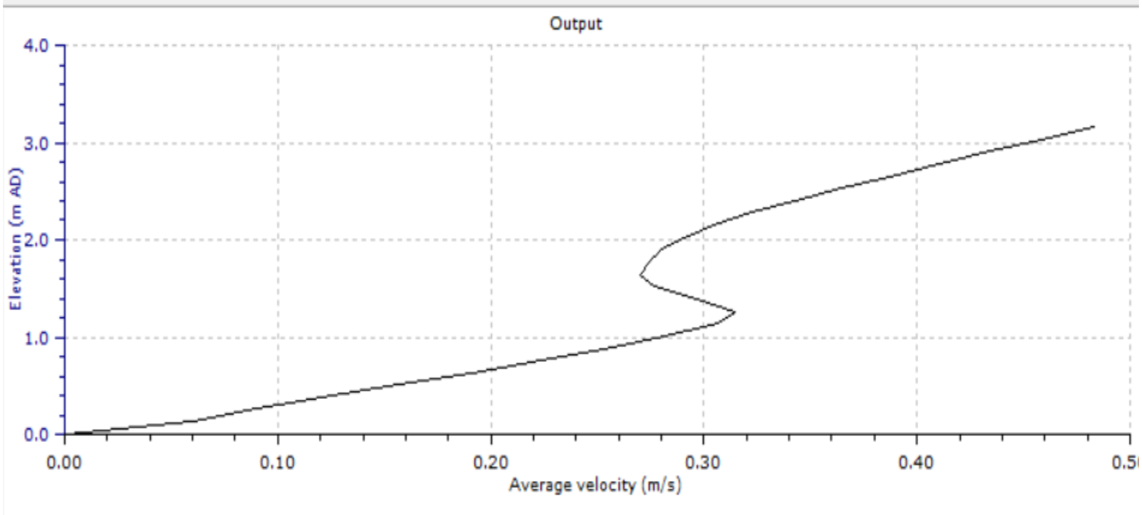

Figure 4.12: Elevation vs Average velocity

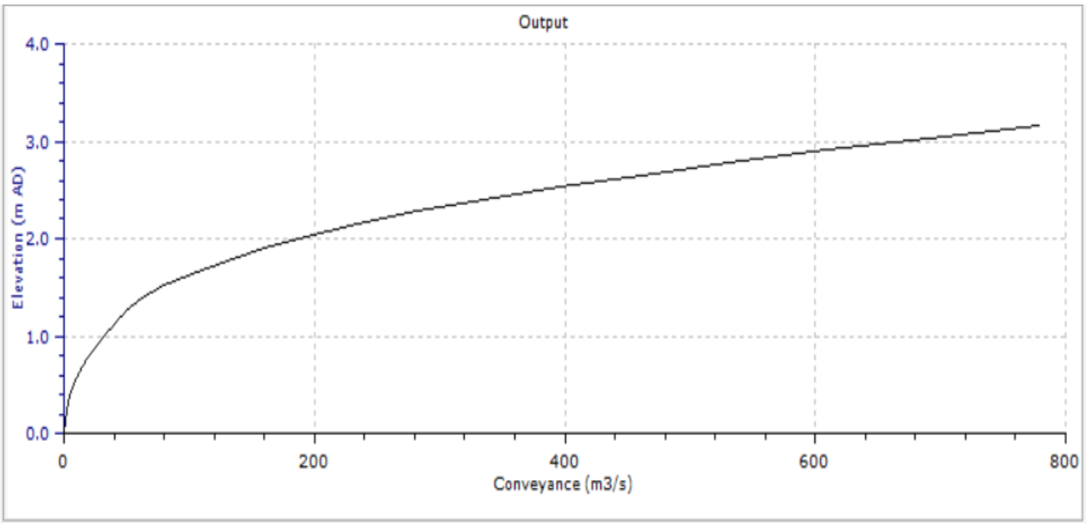

Figure 4.13: Elevation vs Conveyance

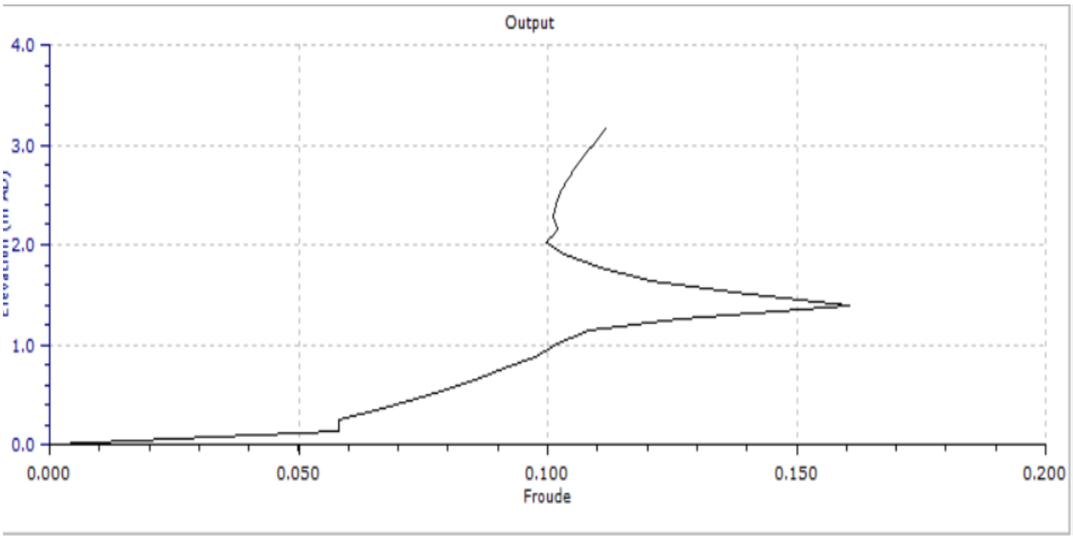

Figure 4.14: Elevation vs Froude

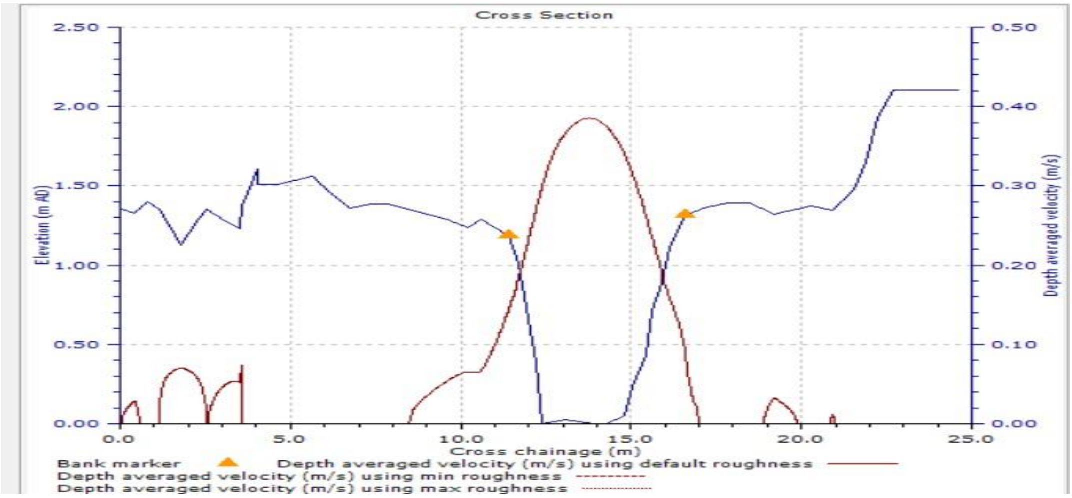

Figure 4.15: Elevation vs Spatial velocity

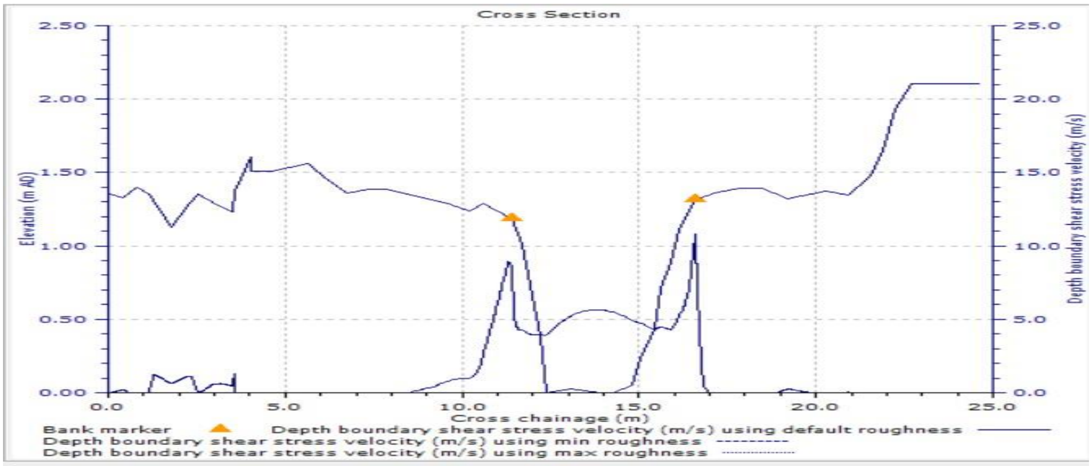

Figure 4.16: Elevation vs Boundary shear stress

4.2.3 River Senggai

Figure 4.17: Morphological Cross Section of River Senggai

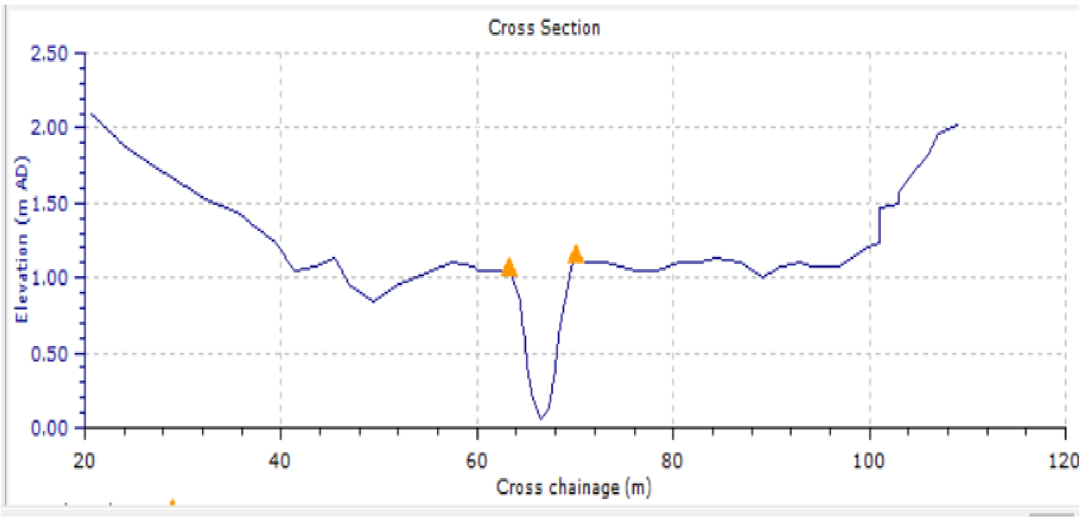

Figure 4.18: Elevation vs Cross-Chainage

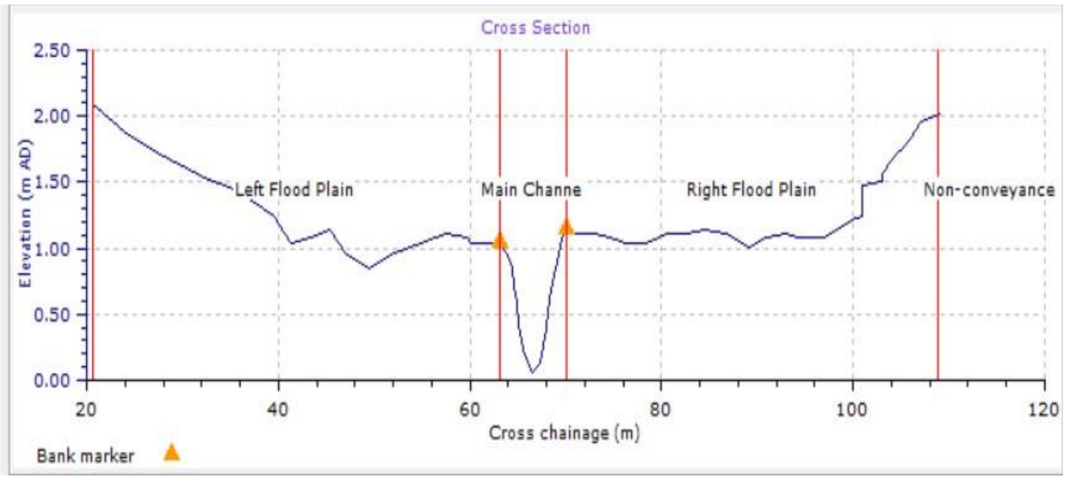

Figure 4.19: Bank Marker and Roughness Zones

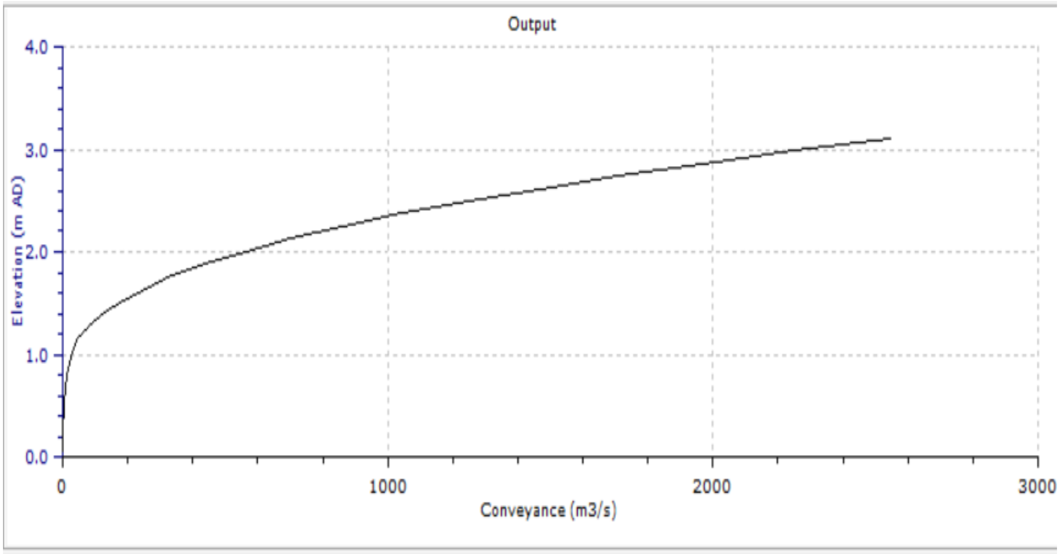

Figure 4.20: Elevation vs Conveyance

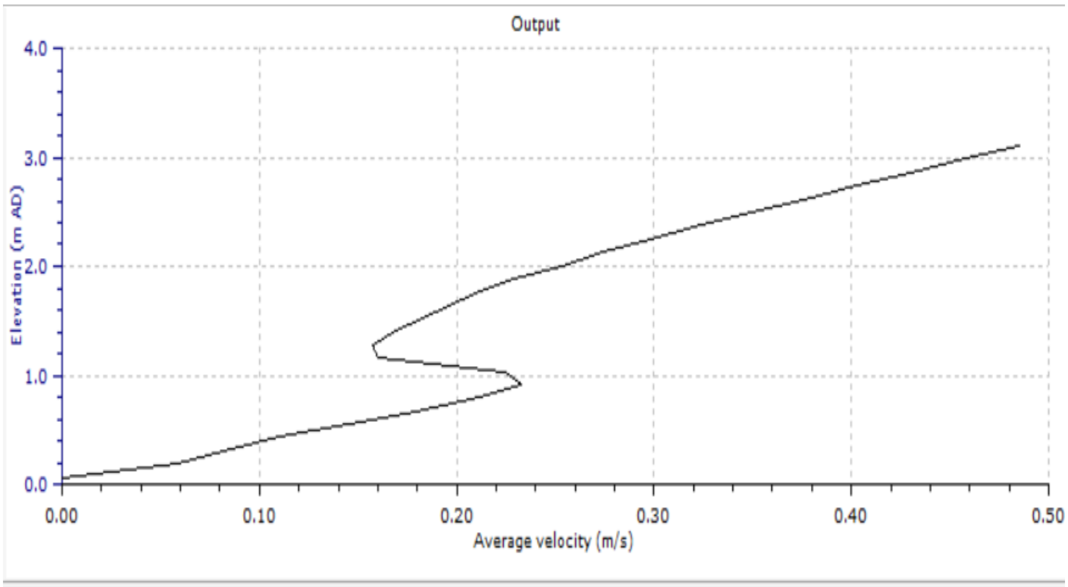

Figure 4.21: Elevation vs Average velocity

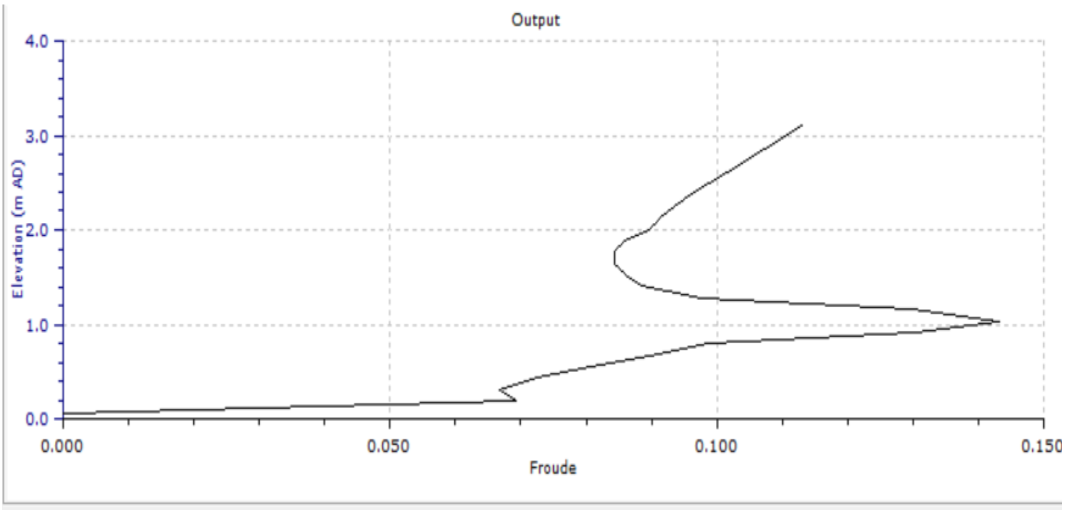

Figure 4.22: Elevation vs Froude

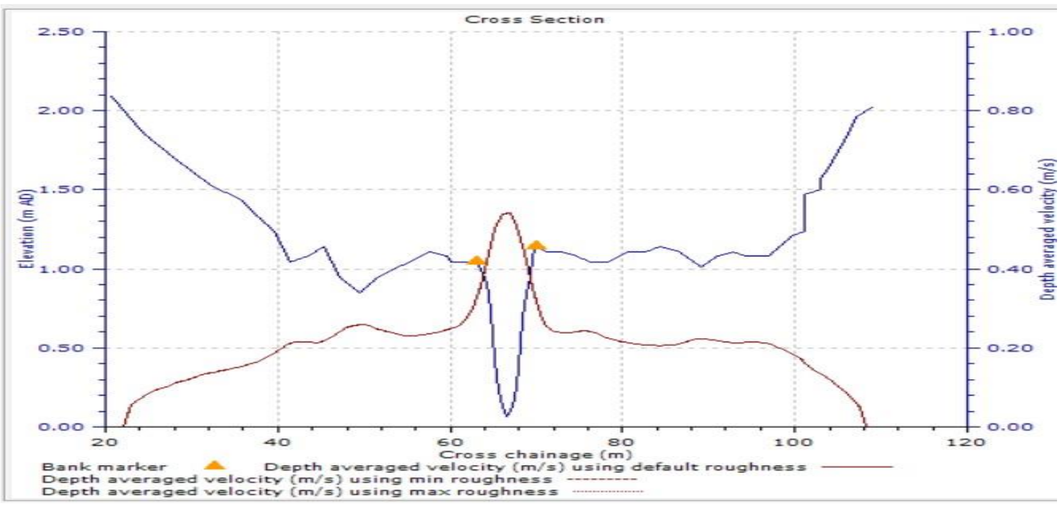

Figure 4.23: Elevation vs Spatial velocity

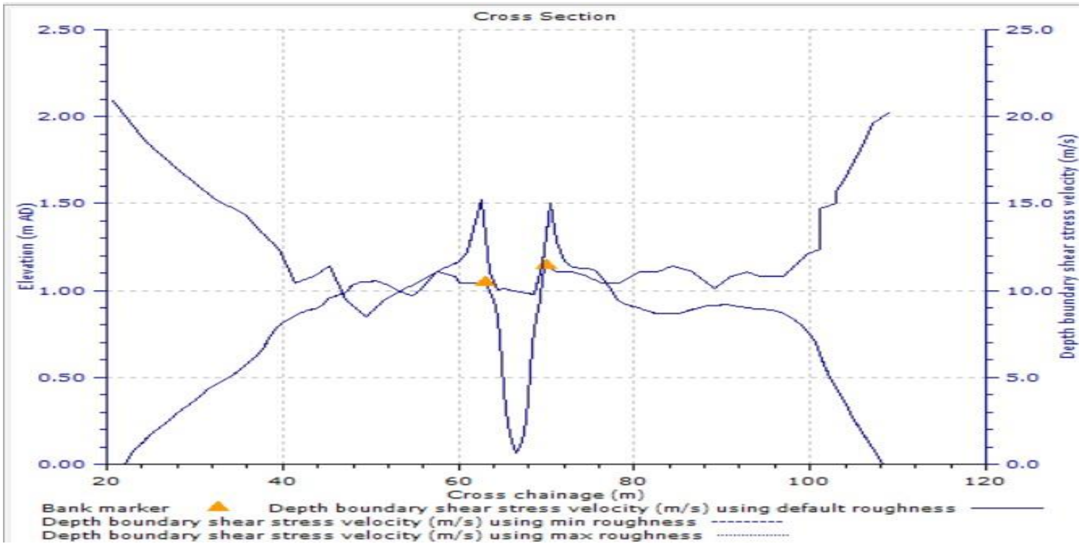

Figure 4.24: Elevation vs Boundary shear stress

4.2.4 River Batu

Figure 4.25: Morphological Cross Section of River Batu

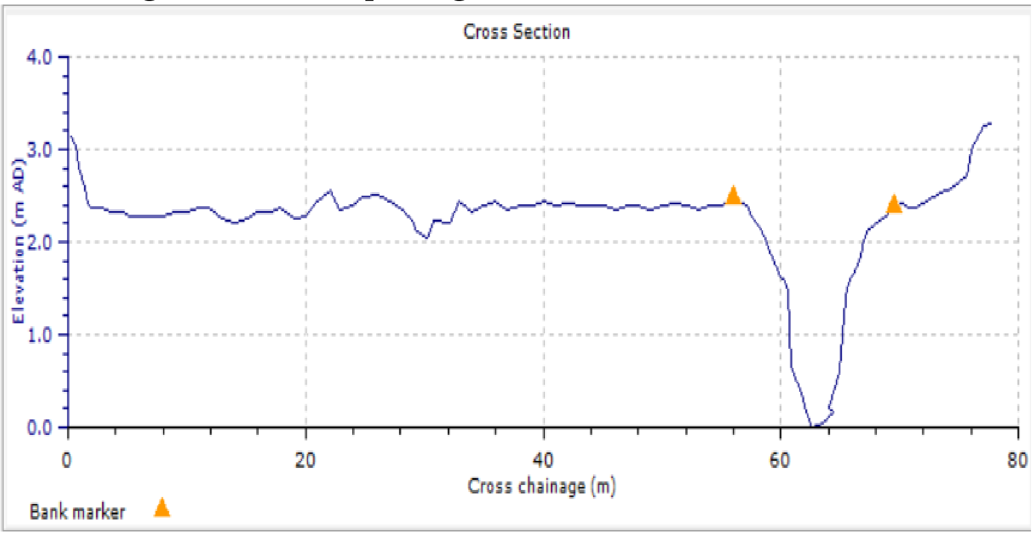

Figure 4.26: Elevation vs Cross-Chainage

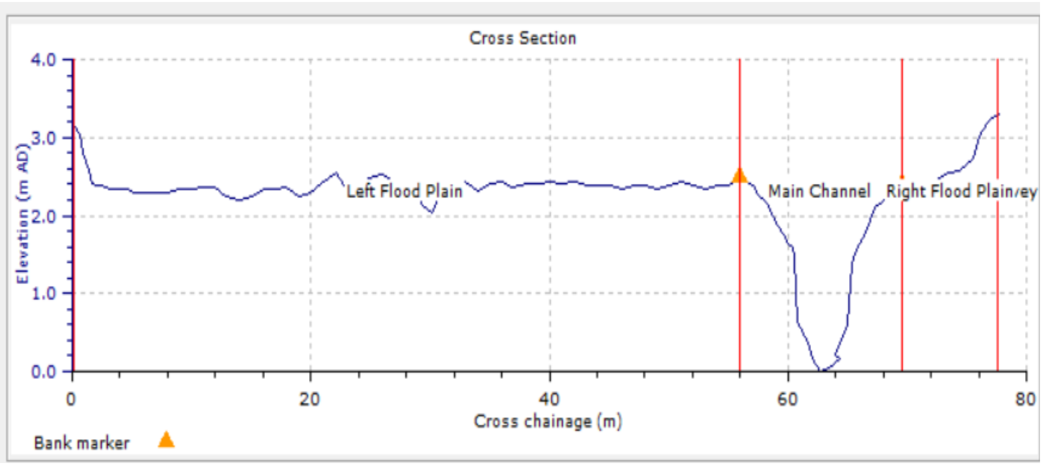

Figure 4.27: Bank Marker and Roughness Zones

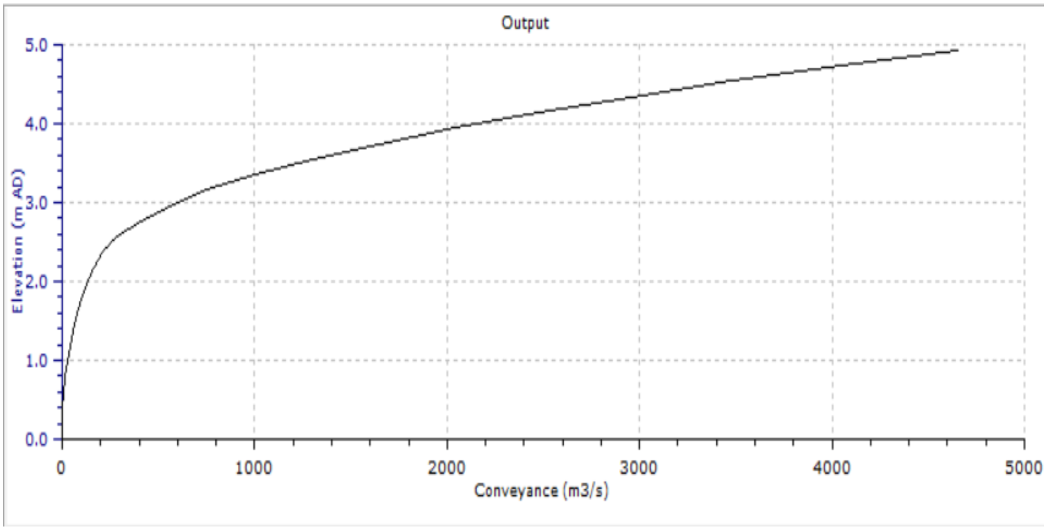

Figure 4.28: Elevation vs Conveyance

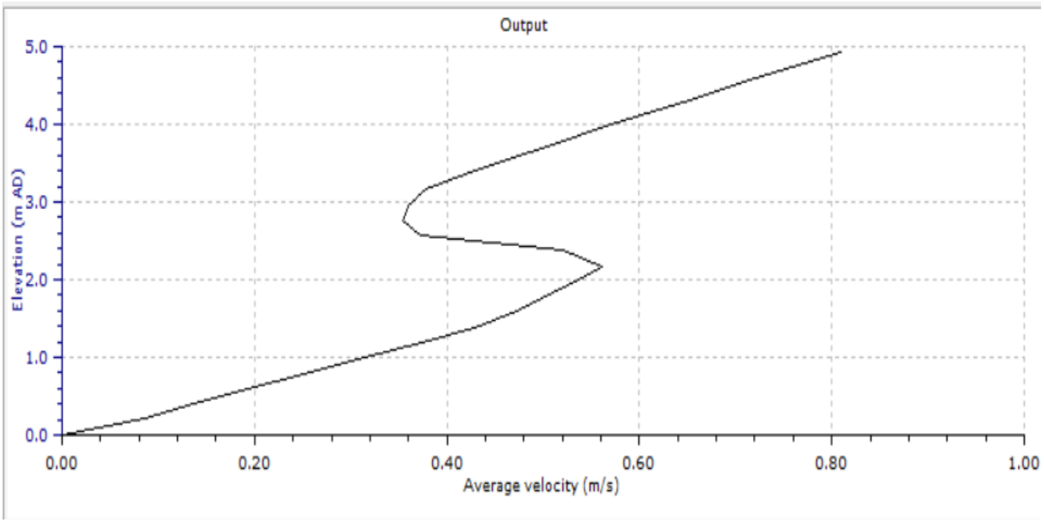

Figure 4.29: Elevation vs Average velocity

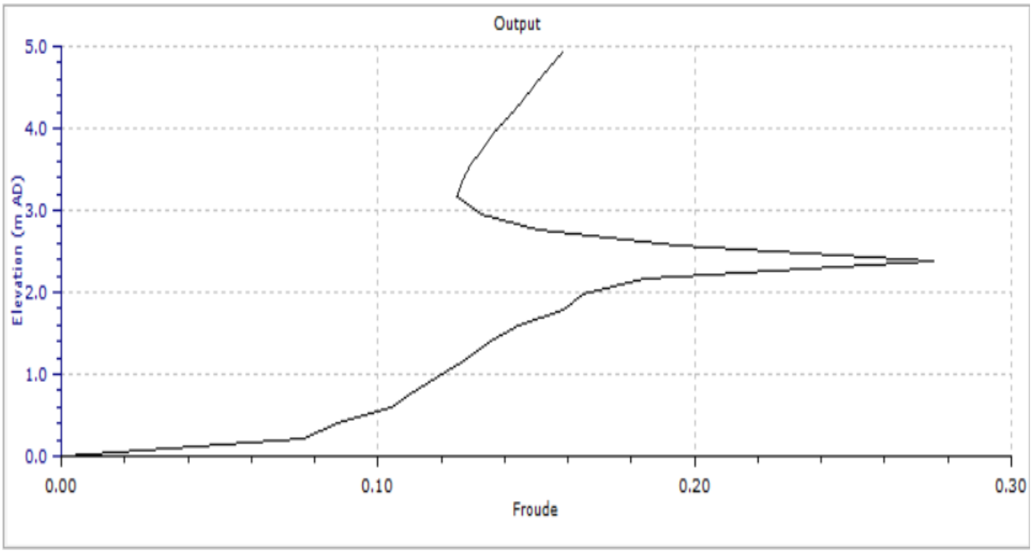

Figure 4.30: Elevation vs Froude

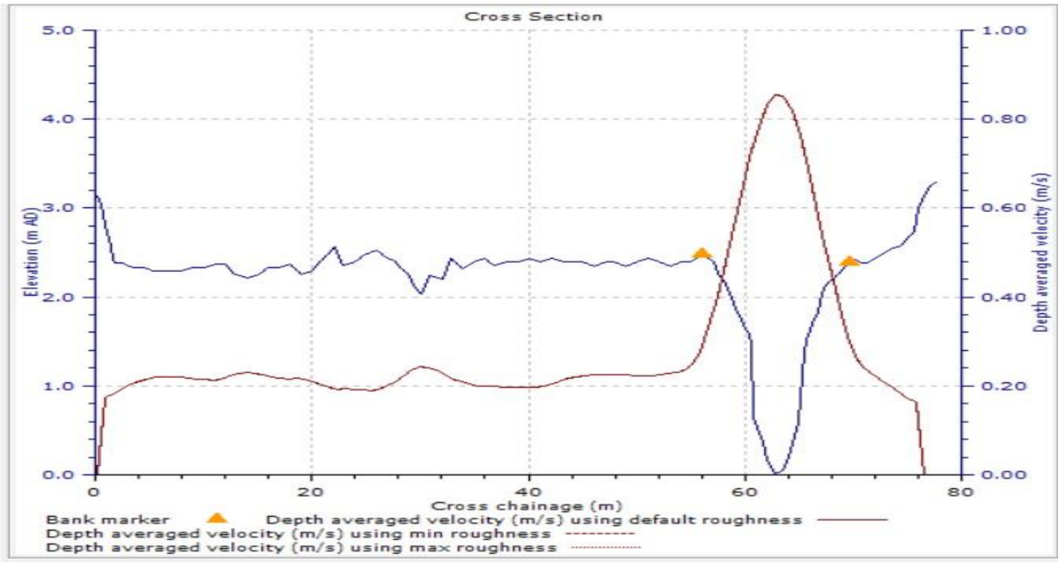

Figure 4.31: Elevation vs Spatial velocity

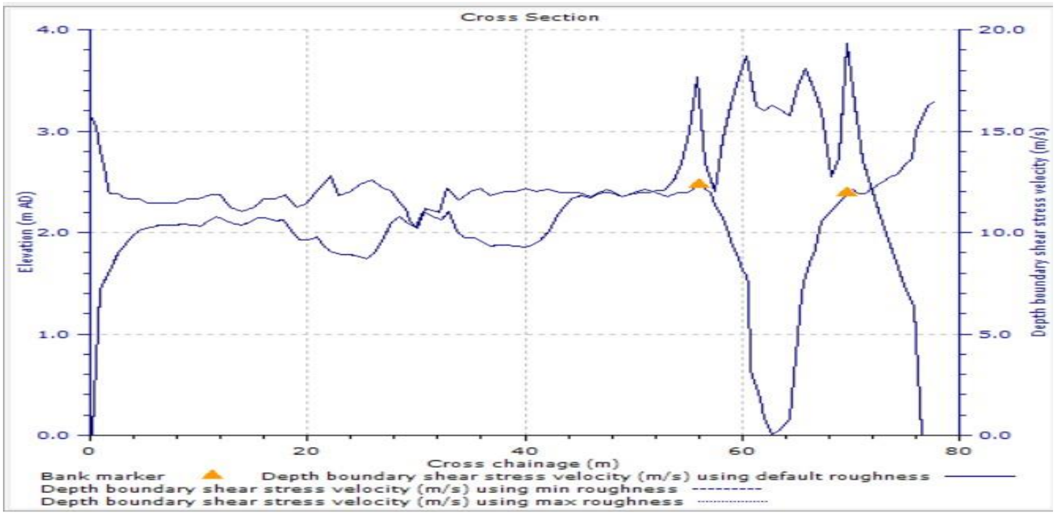

Figure 4.32: Elevation vs Boundary shear stress

Here, the fluctuations of the graphs are due to the unevenness of the surface of the rivers. The resistance to flow in the main channel region for each river has been calculated in terms of Manning roughness coefficient, n and Darcy-Weisbach friction factor, f. Selected graphs are shown in Figures 21 and 22. In each case, the graphs plotted can be divided into two distinct zones: The first zone is characterized by the inbank flow of the rivers, in which the Manning coefficient and Darcy-Weisbach friction factor are decreasing linearly with flow depths due to the decreased of relative roughness in the main channel region. Generally, for the main channel regions, the Manning roughness coefficients are similar for River Senggai, River Senggi (B), and River Batu, with values range from 0.07 to 0.10, whereas the values of f calculated range from 0.54 to 0.89. This shows that the surface roughness for the main channel regions of the selected rivers are much higher than that of laboratory compound channels studied before, which normally have main channel roughness.

Chapter-5

Conclusion and Future Enhancement

5.1 Conclusion:

Based on the present study on rivers flow data collected and important findings obtained are as follows:

- Findings of a reduction in main channel parameter due to the interaction between main channel and flood plain, with a consequence reduction in compound section capacity when flood plains are inundated.
- The flow velocity on the flood plains remained near to zero due to high resistance of surface vegetation, and therefore, it has little contribution to overall discharge capacity of flooding rivers.
- The results also further confirmed the significant increase of flow resistance under flood conditions, and the consequent danger of using inbank data to overbank flows calculations.
- The Shiono and Knight Method (SKM) is known as a capable tool to model flow in prismatic compound channels. This research explores whether SKM can be used to predict depth-averaged velocity and boundary shear stress in compound channels with non-prismatic floodplains.
- The comparison between predicted and experimental data indicated that SKM predictions for the depth-averaged velocity and boundary shear stress improve significantly when calibrated secondary coefficients.
- Flow computation through CES software can help the hydraulic engineer to predict the flood event.

5.2 Future Enhancement

- The CES methodology has been demonstrated for river sites, all located in straight river riches. For further testing,

- It is recommended that a targeted data acquisition program is implemented, where the data collection focuses on straight and meandering two-stage natural channels, and measurements include discharge, water level, depth-averaged velocities and, where possible, turbulence measurements.

- The importance of the lateral shearing term in two-stage channels is highlighted. Thus, further investigation of the applicability of SKM for the lateral distribution of the dimensionless eddy viscosity λ in two-stage rivers is advocated.

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1. Khuntia, J. R., Keshavardhan, P., Nagarani, T., Arun, G., Suresh, L., (2021). "Flow Computation through Conveyance Estimation System" Conference paper id - (CES) ICCSDC-21 -1042, International Conference on Computing for Sustainable Development in Civil Engineering (ICCSDC 2021), St. Martin's Engineering College, Secunderabad, 24 &25th June, 2021.

2. Khuntia, J. R., Keshavardhan, P., Nagarani, T., Arun, G., Suresh, L., (2021). "Experimental Study on Durability Properties of Concrete by Using Quarry Dust as Partial Replacement of Cement" Conference paper id -ICRAITMS_202012_060, International Conference on Recent Advances and Innovations in Technology, Management and Applied Sciences in Civil Engineering (ICRAITMS 2021), St. Martin's Engineering College, Secunderabad, March, 2021.

A Major Project Report

on

EXPERIMENTAL INVESTIGATION ON MECHANICAL PROPERTIES OF GEOPOLYMER CONCRETE WHEN RIVER SAND IS REPLACED WITH MANUFACTURING SAND IN FINE AGGREGATE.

Submitted to

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY
IN
CIVIL ENGINEERING

By

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Mr. MD.ABDULMOEED - (17K81A0142)
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JUNE 2021

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BONAFIDE CERTIFICATE

This is to certify that the project entitled **EXPERIMENTAL INVESTIGATION ON MECHANICAL PROPERTIES OF GEOPOLYMER CONCRTE WHEN RIVER SAND IS REPLACED WITH MECHANICAL SAND IN FINE AGGREGATE** is being submitted by **1.Mr.B.RAMA KRISHNA (18K85A0109) 2. Mr. MD.ABDUL MOEED (17K81A0142) 3. Ms.CH.SRIMUKHI (17K81A0114) 4. Ms.B.PRAHARSHINI (17K85A0130)** in partial fulfilment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN** Civil Engineering is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

Signature of Guide
Mrs.A.SRAVANI (M.TECH)
Assistant Professor
Department of Civil Engineering

Signature of HOD
Prof. SANDHYA KIRAN J.K.
Head of the Department
Department of Civil Engineering

Internal Examiner

External Examiner

Place:
Date:

DECLARATION

We declare that this project report titled **EXPERIMENTAL INVESTITAGATION ON MECHANICAL PROPERTIES OF GEOPOLYMER CONCRETE WHEN RIVER SAND IS REPLACED WITH MANUFACTURING SAND IN FINE AGGREGATE submitted in partial fulfillment of the degree of B. Tech in CIVIL ENGINEERING** record of original work carried out by us under the guidance and supervision of **Mrs.A.Sravani**, and has not formed the name basis for the award of any other degree or diploma, in this or any other Institution or University. In keeping with ethical practice in reporting scientific information, due acknowledgements have been made whenever the findings of others have been cited.

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Date:

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1. B.RAMA KRISHNA
2. MD.ABDUL MOEED
3. CH.SRIMUKHI REDDY
4. B.PRAHARSHINI

ABSTRACT

Concrete is the world's most versatile, durable and reliable construction material. The production of Ordinary Portland Cement and usage of river sand are increased due to the demand of concrete in the construction industries. There are many ecological issues connected with the manufacture of OPC i.e. calcination of limestone and ignition of fossil fuel releases 1 ton carbon dioxide for every 1 ton of OPC manufactured affecting the ecological balance. At the same time availability of natural sand is also becoming costlier and scarcity due to illegal dredging of river sand. The main purpose of the research is to focus on the environmental friendly alternative material for cement and natural sand.

Geo-polymer concrete is the best alternative material for Ordinary Portland Cement concrete. The geo-polymer concrete having low calcium fly ash is an inorganic non-metallic alternative material for cement and manufactured sand an alternative for natural sand. The geo-polymer concrete mixes are casted using fly ash (Class F), GGBS, fine aggregate, coarse aggregate and alkaline liquids, such as sodium silicate (Na_2SiO_3), sodium hydroxide (NaOH). The parameters considered while preparing the mix are molarity of NaOH used 12M and 16M for G30 grade of concrete. The sodium silicate to sodium hydroxide ratio as 2.5, silicon dioxide (SiO_2) to sodium oxide (Na2O) ratio as 2, Oven curing temperature of 60^0 C and river sand is replaced with manufactured sand in different proportions viz. 0%, 50% and 100%.

The main objectives of the present work into study the mechanical properties of geo-polymer concrete of grades G30 which are equivalent to controlled concrete of grades M30. Compressive strength, Split tensile strength and Flexural strength and also comparing the strength properties of geo-polymer concrete with controlled concrete.

From the experimental investigation, following results are obtained

1. The compressive strength of G30 increases by 2.47% when compared with controlled concrete of M30.
2. The split tensile strength of G30 increase by 2.45% when compared with controlled concrete of M30.
3. The flexural strength of G30 increases by 2.5% when compared with controlled concrete of M30.

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LIST OF ABBREVATIONS

S. No.	Symbol or Abbreviation	Description
1	OPC	Ordinary Portland cement
2	CO_2	Carbon dioxide
3	FA	Fly ash
4	GGBS	Ground granulated blast furnace slag
5	RHA	Rice husk ash
6	GPC	Geopolymer concrete
7	OPCC	Ordinary Portland cement Concrete
8	SiO_2	Silicon dioxide
9	CaO	Calcium oxide
10	Fe_2O_3	Ferric oxide
11	Al_2O_3	Aluminium oxide
12	BRHA	Black rice husk ash
13	NaOH	Sodium hydroxide
14	Na_2SiO_3	Sodium silicate
15	Na	Sodium
16	K	Potassium
17	ASH	Alumino silicate hydrate
18	AAS	Alkaline activator solution
19	Na_2O	Sodium oxide
20	FM	Fineness modulus
21		Indian standard
22	MPa	Megapascal
23	Psi	Pound force per square inch
24	CTM	Compression testing machine
25	ASTM	American Society for Testing

		and Materials

CHAPTER-1

1. INTRODUCTION

1.1 OVERVIEW OF THE PROJECT

Concrete plays an extremely important role in the construction of various structures for the improvement of our living environment. An enormous amount of concrete has been used as a construction material. In present time, construction is the one of the fast growing fields worldwide. Concrete is most used by manmade material all over the world. After the water most used material is cement concrete. Every year thousand tons of concrete is producing by construction industry. As per the statistics every year on an average of 3 tons of concrete is consumed by each person. Concrete is a vital construction material it has many advantages and applications. The demand for concrete is increasing day by day, as of now India, China and USA account for approximately half of the worlds demand. Concrete is a versatile, durable and reliable construction material. It is globally used to build buildings, roads, runways, bridges and dams etc. it is due to fact that concrete can be produced from locally available materials such as river sand, aggregates and cement. The usage of concrete increases as the demand of Ordinary Portland Cement is also increases. As per the world statics, total global annual production of OPC is more than 4.1 Billion Metric tons. This quantity will be increased by more than 25% within next 10 years (Shitam Marathe et al. [2016]). The OPC is used as biding material in concrete.

There are two major problems are associated with production Ordinary Portland Cement (OPC). First is that for the manufacturing of OPC main materials such as lime stone, so the availability of which might end within next 40years. The formation of lime stone, clay and minerals is far lengthier than the rate at humans use it. Second one is the most of CO_2 released during the preparing of OPC due to the calcinations of the lime stone and combustion of fossil fuels in the equal to 1 ton for every 1 OPC produced, which is major problem for the sustainable development. The global warming is caused due to emission of greenhouse gases, such as CO_2, to the atmosphere by human activities. Among the greenhouse gases, CO_2 contributes to nearly 65% of global warming. The cement industry is responsible for about 7% of all carbon dioxide emission into the atmosphere.

For making concrete one more important material is river sand (fine aggregate). Now a day's river sand is becoming scarcer and costlier due to illegal sand mining. So the researchers try to find an alternative material for natural sand which is reliable, low cost and easily available. The M-sand becomes an alternative material to natural sand. Because of the above present problems M-sand used for research.

On the other side, the abundance and availability of waste materials such as fly ash (FA), GGBS, red mud and rice husk ash (RHA) worldwide create opportunity to utilize these by-product of different industries, like partial or full replacement for OPC in concrete. Each year so many tons of industrial wastes are produced and majority of these wastes are utilized. By using these waste materials we can minimize the quantity of CO_2 production in the environment and also can solve the problem of waste disposal. By seeing all these problems there is a requirement for other material for OPC. The geo-polymer concrete is such a promising material for this problem. Geo-polymer concrete is manufactured without using any amount of OPC.

In 1972, joseph davidovits given the name “geo-polymers” to describe the zeolite like polymers. Geo-polymers are the alumina-silicate polymers which consists of amorphous and 3D structures formed from the geo-polymerization of alumina-silicate monomers in alkaline solution. Research has been done on industrial wastes.

Geo-polymers are well-known for their superior properties as compared to OPC, which are more durable, high compressive strength, low shrinkage, acid resistance and there is no toxic fumes emission, low thermal conductivity, excellent heavy metal immobilization, high temperature stability, low manufacturing energy consumption for construction purposes and engineering application, etc. they are potentially found as being used in construction engineering, fire proof, biomaterials, and waste treatment, etc. new applications are still being discovered. The geo-polymerization process is differs from the OPC which require more energy and release more amount of CO_2 into the atmosphere. Thus, an alternative material was found with less energy consumption, less emission and added with good physic-mechanical properties to solve the problem raised from OPC production.

Table No. 1.1 Milestones in alumina-silicate chemistry

	Zeolite molecular Sieve	**Alkali-activation (slag)**	**Hydrosodalite (kaolin)**	**Geopolymer**
1930			1934:Olsen (Netherland)	
1940	1945: Barrer, (UK)	1940:Purdon (Belgium)	1945:US Bureau of Standard 1949: Borchert, Keidel(Germany)	
1950	1953: Barrer, White(UK) 1956: Milton (USA)	1953: Trief Cement (USA) 1957:Glukovsky(Ukraine) Soli-silicate concrete		
1960			1963: Howell (USA) 1964: Berg et al (USSR) 1969: Besson et al (France)	

1970				1976: Davidovits (IUPAC terminology) 1979:Davidovits (France) Geopolymer

1.2 STATEMENT OF PROBLEM

Manufacturing of OPC main materials such as lime stone as lime stone, clay and other natural resources are required and amount of CO_2 released during preparing of OPC.

1.3 OBJECTIVE OF THE PROJECT

The main objective of geo-polymer technology is to reduce the total energy demand for producing concrete, lower the CO_2 emission in to the atmosphere caused by cement and aggregates industries by about 80%, thereby reducing the global warming.

To find an alternative to OPC concrete.

To know the influence of concrete in using fly ash and GGBS.

To know the influence by using of manufactured sand at different proportions.

To decrease creep and drying shrinkage.

1.4 SCOPE OF THE STUDY

Utilization of geo-polymer concrete brings economy in construction, reduce pollution and less harmful to the environment.

So far in India, geo-polymer concrete has been used in the Delhi Metro Project.

In today's time, this technology is being used widely in the USA, Europe and Australia.

The current trend of research is under way to develop geo-polymer systems that create a low embodied energy, low carbon dioxide binder that has similar properties to Portland cement.

Thus it can be considered that geo-polymer concrete, as a replacement for Portland cement has wide scope in India.

CHAPTER-2

2. REVIEW OF RELATED LITERATURE

2.1 LITERATURE REVIEW ON BASE PAPER

This chapter presents a review of recent research on geo-polymers and geo-polymers concrete, with an emphasis on fly ash and slag based geo-polymers paste and concrete. New building materials that enhance strength and durability could reduce long term costs by eliminating the need for the replacement of new structures and thereby reduce the environment problem. Geo-polymers concrete has great environment advantages, so we need to

study more on V concrete. Improvement of both mechanical and durability aspects of geo-polymers concrete requires an extensive literature study and so some of geo-polymers concrete requires and extensive literature study and so some of geo-polymers related literature are presented in this chapter.

The interest in the use of fly ash (class F) and slag based geo-polymers concrete has increased since 2000 due to the sustainable issue of using industrial waste to form a new useful material. In the 1970s, JOSEPH DAVIDOVITS, a great French material scientist, applied the term called geo-polymers for the first time. The development of geo-polymer concrete mix design has been done previously at CURTIN UNIVERSITY, WESTERN AUSTRALIA.

HARDJITH and RANGAN have done the experiments work on the effects of some aspects such as alkaline, w/c ratio and curing conditions in "Development and properties of low calcium fly ash based geo-polymers concrete". According to them, geo-polymers are practically shapeless to semi-crystalline 3D alumina-silicate polymers like zeolites.

In the polymerization process the –ve charge created by AI is balanced by the presence of +ve ions such as Na+, K+ and Ca+. The empirical formula of these mineral polymers is $Mn[-(SiO_2)z-AIO_2]n.wH_2O$, where M is an alkalization such as potassium or sodium, the symbol-indicate the presence of a bond, z is 1, 2 or 3, and n indicates the degree of polymerization. Geo-polymerization is heat liberated process which consists of dissolution and poly condension. In Malaysia (UTM) as a pioneer in the advanced civil engineering materials is an extensive researching on the geo-polymer concrete due to its environmental friendly issues and its better performances.

Recent research shows that shifting from chemistry domain to engineering applications for commercial production of geo-polymer concrete. Above the above, key hardened properties of fly ash and slag based geo-polymer concrete in terms of strength and durability are also discussed in detail, from the earlier published research work. Some of them are presented in this chapter.

2.1.1. REVIEW ON RELATED LITERATURE

M. Sugapriyaet al. (2017) have done experimental investigation on geo-polymer concrete using manufactured sand. In this study, geo-polymer concrete mixes are manufactured using fly ash (class F) and GGBS in different proportions with M-sand as fine aggregate. IS Code Method is used for Mix Design of M30 grade concrete. The specimens are casted and stored for room temperature of 27^0 C for 24hours then cubes are kept in water for curing. For mix of 70% fly ash + 30% GGBS observed an increase in compressive, tensile and flexural strengths values are 43.6 N/mm^2, 4.21 N/mm^2 and 5.39 N/mm^2 respectively.

B. Pradeep Kumar et al. (2017) studied the difference properties of geo-polymer concrete (M30) with replacement of manufactured sand. Present study on the effect of NaOH molarities on mechanical properties of geo-polymer concrete. The sodium hydroxide of 5M and 10M is used. The replacement of manufactured sand reduces the hydration and also shows increase in the value of compressive strength for 5M and 10M by 9.2% and 4.5% respectively.

Ajay Takekar and Prof.G.R. Patil (2017) are investigated on mechanical properties of fly ash (Class F) and slag based geo-polymer concrete. In this study, fly ash was replaced at different proportions (0%, 25%, 50%, 75% and 100%) with GGBS. M25 grade GPC is tested for strength properties and curing conditions (ambient curing and oven curing) is studied. By adopting GGBS in GPC mix the heat curing of geo-polymer concrete eliminated. Rate of gain of strength of geo-polymer concrete is high at early stage. The higher content of GGBS results in higher compressive, tensile and flexural strengths of geo-polymer concrete.

S. Nagajoti and S. Elavenil (2016) are investigated on the mechanical properties of fly ash (class F) based geo-polymer concrete (G30) with partial replacement of river sand by M-sand in the difference percentages (0%, 20%, 40%, 60%, 80% and 100%). The test results shows that at 100% M-sand gives maximum strength results. The compressive and tensile strength of geo-polymer concrete values are 35.25 N/mm^2 and 2.69 respectively.

J. Guru Jawahar and G. Mounika (2016) are experimentally studied on mechanical strength properties of geo-polymer concrete various at replacements of fly ash by GGBS. Specimens are casted and curd under room temperature. Test results show that increases in all cases and the GPC is cured is cured at normal temperature without need of heat curing.

Mr.V.S Kamble et al. (2016) have studied on compressive strength properties of low calcium fly ash based geo-polymer concrete (M40). A constant 85% of fly ash (Class F) was used as an OPC replacement for the mix. Compressive strength analyzed by replacing cement by 85% of fly ash with alkaline solution (NaOH & Na2SiO3) with extra water and superplasticizers. The sodium silicate (Na2SiO3) to sodium hydroxide (NaOH) ratio as 1 and alkaline solution to fly ash ratio was taken as 0.35. From the experiment the compressive strength value observed is 42.40 N/mm^2.

Manjunatha M Katti et al. (2016) have done an exclusive study on strength properties of geo-polymer concrete (M40). This geo-polymer concrete was prepared by varying molar concentration (6M, 8M, and 10M) of NaOH. In this study fly ash and GGBS quantity increases the strength. The GPC will be used in repairs works and for rehabilitation works.

T. Srinivas and Ramana Rao N V (2016) have done their experimental investigation on compressive strength of fly ash (class F) and slag based GPC for standard grades of concrete using natural sand. The comparative study has been done with OPC finally optimum value of compressive strength has been selected for both G30 and G50 which are similar to that of M30 and M50 respectively. As from the results it is obtained that optimum compressive strength of cubes is achieved at 85% fly ash and 15% GGBS at 12M and 16M for G30 grade and G50 grade concrete respectively. Early strength not attained for ambient temperature curing and oven curing cubes almost equal.

K. Arul priya (2016) has done experimental study on mechanical and durability properties of fly ash (class F) based geo-polymer concrete (M30) with manufactured sand. From the test results it observed that the manufactured sand based GPC have good workability. The compressive strength, tensile strengths of M-sand are 23.78% and 40.38% more than river sand based cement concrete. M-sand based geo-polymer concrete shows excellent resistance to sulphate attack and acid attack.

Genani R and Revathi A (2015) have done experimental study on fly ash (class F) based geo-polymer concrete with M-sand on mechanical strength properties of M30 grade of GPC. In this study six different mixes were prepared by replacing river sand with M-sand of varying properties as 0%, 20%, 30% up to 100%. The test results have shown that at 100% replacement of manufactured sand yields high strength as compared to other mixes. The compressive, tensile and flexural strengths GPC with M-sand are increased by 9%, 12% and 10% respectively.

2.1.2. CONCLUSIONS ON REVIEWS

Based on the above literatures, it is seen that over the last two decades, vast advancements have made in this alkali-activated geo-polymer technology and more researches have been conducted on the chemical and micro structural aspects of geo-polymers. However, little effort has been put on to find out mechanical aspects and thermal conductivity of geo-polymer with manufactured sand. It is observed from literature tour that geo-polymer concrete has many positive aspects over OPCC and hence the mechanical properties of fly ash and slag based GPC with manufactured sand has been studied experimentally in research work. Moreover, it is obvious from the available literature; no such work has been experimented on Indian fly ash.

CHAPTER-3

MATERIALS AND MIX PROPORTIONS

This chapter gives a shot review of the materials, its properties and mix design of Geo-polymer Concrete and Conventional Concrete.

3.1 Materials

Materials used in the experimental work were

- Ordinary Portland Cement (53 grade)
- Fly Ash (class-F)
- Coarse aggregate
- River sand
- Manufactured sand
- GGBS
- Sodium silicate solution
- Sodium hydroxide pellets
- Water
- Super plasticizer Gelenium (B_{233})

3.1.1 Fly Ash

Low calcium fly ash was collected from the Vijayawada thermal power station is used as the source material to make Geopolymer Concrete in the laboratory. Composition of Fly ash is tabulated below in Table No.3.1.

Table No 3.1. Composition of fly ash as determined by XRF (mass %)

SiO2	Al2O3	CaO	Cr	Fe2O3	K2O	MgO	Na2O	P2O5	SO3	TiO2	MnO	LOI*

47.8	24.4	2.42	0.01	17.4	0.55	1.19	0.31	2	0.29	1.328	0.12	1.1

LOI = Loss on ignition

3.1.2 Ordinary Portland cement

Cement is the primary binder in the conventional concrete. Cement collected from local suppliers. In the experimental investigation we have used 53 grade of cement.

Table No.3.2 Physical properties of Ordinary Portland Cement

S. No	Property	Test Method	Test Results	IS Standard
1.	Normal Consistency	Vicat Apparatus (IS: 4031 Part - 4)	31%	
2.	Specific gravity	Sp. Gr bottle (IS: 4031 Part - 4)	3.15	
3.	Initial setting time Final setting time	Vicat Apparatus (IS: 4031 Part - 4)	45 minutes 182 Minutes	Not less than 30 min Not less than 10 hours
4.	Fineness	Sieve test on sieve no.9 (IS: 4031 Part – 1)	1.3%	10%
5.	Soundness	Le-Chatlier method (IS: 4031 Part – 3)	2 mm	Not more than 10 mm

6.	Compressive Strength		55.3 N/mm^2	

3.1.3 Coarse Aggregate

20 mm aggregates of uniform size are used which are produced from locally available crusher Physical properties are tabulated below in Table No.3.3

Table No.3.3 Physical Properties of Coarse Aggregate 20mm

S. No	Property	Method	20mm Aggregate
1	Specific gravity	Pycnometer IS:2386 part 3-1986	2.672
2	Water absorption		1.116
3	Flakiness Index	IS:2386 part 2-1986	4.18
4	Elongation Index	IS:2386 part 2-1986	5.85
5	Bulk density(compact)	IS:2386 part 3-1986	1574 Kg/cum
6	Bulk density(loose)	IS:2386 part 3-1986	1424Kg/cum
7	Fineness modulus	Sieve Analysis (IS:2386 Part 2 1963)	7.01

3.1.4 Fine Aggregate

3.1.4.1 River sand

The fine aggregate used in the present work collected from local suppliers. The River sand full filling specifications of IS: 383 – 1970. The river sand was tested for its physical properties such as specific gravity, FM and bulk density in accordance with code IS: 2386 – 1963 [Methods of test for aggregate for concrete] and it is shown in the below Table 3.4.

Table No.3.4 Physical Properties of River Sand

S.NO	Property	Method	Fine Aggregate
1	Specific gravity	Pycnometer IS:2386 part 3-1986	2.70
2	Flakiness Index	IS:2386 part 2-1986	-
3	Elongation Index	IS:2386 part 2-1986	-
4	Bulk density(compact)	IS:2386 part 3-1986	1711Kg/cum
5	Bulk density(loose)	IS:2386 part 3-1986	1631Kg/cum
6	Fineness modulus	Sieve Analysis (IS:2386 Part 2-1963)	2.64
7	Bulking	IS:2386 Part 3-1986	4% wc
8	Grading		Zone -II

Table No.3.5 Sieve Analysis of Natural Sand

Sl. No	IS Sieve Size	Weight retained gm.	Cumulative Weight retained gm	Cumulative %Weight retained	Cumulative % Passing	Limits of Grading (IS 383-1970) Zone II
1	10 mm	0	0	0	100	100
2	4.75mm	9	9	0.9	99.1	90-100
3	2.36mm	25	34	3.4	96.6	75-100
4	1.18mm	163	197	19.7	80.3	55-90
5	600 microns	408	605	60.5	39.5	35-59
6	300 microns	210	815	81.5	18.5	8-30

7	150 microns	165	980	98.0	02.0	0-10
8	<150 microns	20	--	--	--	--
9	Total	1000		264		

Fineness Modulus = Cumulative Percentage weight retained / 100

= 264/100 = 2.64

Fine aggregate belongs to Zone II

3.1.4.2 Manufacturing Sand

Manufacturing sand nothing but crushing of big rock stone aggregates to the size of normal river sand. The manufactured sand used is collected from local suppliers. The manufactured sand full filling specifications of IS: 383 – 1970. The M- Sand was tested for its physical properties such as specific gravity, FM and bulk density in accordance with code IS: 2386 – 1963 [Methods of test for aggregate for concrete] and it is shown in the below Table 3.6

Table No.3.6 Physical Properties of Manufactured Sand

S.NO	Property	Method	Fine Aggregate
1	Specific gravity	Pycnometer IS:2386 part 3-1986	2.71
2	Flakiness Index	IS:2386 part 2-1986	--
3	Elongation Index	IS:2386 part 2-1986	--
4	Bulk density(compact)	IS:2386 part 3-1986	1720Kg/cum
5	Bulk density(loose)	IS:2386 part 3-1986	1663.27Kg/cum
6	Fineness modulus	Sieve Analysis (IS:2386 Part 2-1963)	2.67
7	Bulking	IS:2386 Part 3-1986	4% wc
8	Grading		Zone –II

Table No.3.7 Sieve Analysis of Manufactured Sand

Sl. No	IS Sieve Size	Weight retained gm.	Cumulative Weight retained gm	Cumulative %Weight retained	Cumulative % Passing	Limits of Grading (IS 383-1970) Zone II
1	10 mm	0	0	0	100	100
2	4.75mm	12	12	1.2	98.8	90-100
3	2.36mm	28	40	4.0	96	75-100
4	1.18mm	165	205	20.5	79.5	55-90
5	600 Microns	410	615	61.5	39.5	35-59
6	300 microns	205	820	82.0	18	8-30
7	150 microns	160	980	98.0	02.0	0-10
8	<150 Microns	20	--	--	--	--
9	Total	1000		267		

Fineness Modulus = Cumulative Percentage weight retained / 100

= 267/100 = 2.67

Fine aggregate belongs to Zone II

3.1.5 Sodium Hydroxide

Sodium Hydroxide is one of the important ingredients of Geopolymer Concrete. The following are the specifications of Sodium hydroxide pellets and this material is procured from the local laboratory chemical vendors in Hyderabad. Specifications of NaOH are given in table 3.8.and collected from the local suppliers.

Table 3.8 The Physical properties of NaOH

Appearance	White solid
Molar mass	40 gm/mol
Density	2.1 gr/cc
Melting point	318^{o}C
Boiling point	1390^{o}C
Amount of heat liberated when dissolved in water	266 cal/gr

Table No.3.9 The Chemical properties of NaOH Pellets

Purity	97%(Assay)
Na_2Co_3	2%
CI	0.01%
SO_4	-0.01%
SiO_2	0.02%
Zinc	-0.02%
PO_4	0.00%
Aluminium(Al)	0.00%

3.1.6 Sodium Silicate Solution

The Na_2SiO_3 solution is a type of alkaline liquid and it plays major role in the polymerization process. This material is procured from the local laboratory chemical vendors in Hyderabad. Specifications are given in table 3.10 as given by the suppliers.

Table 3.10: Properties of Na_2SiO_3 Solution

Specific gravity	1.57
Molar mass	122.06 gm/mol
Na_2O (by mass)	14.35%
SiO_2 (by mass)	30.00%
Water (by mass)	55.00%

Weight ratio (SiO_2 to Na_2O)	2.09
Molarity ratio	0.97

3.1.7 Ground Granulated Blast Furnace Slag

It is a by-product from Steel industries. GGBS is produced when Iron is operated at a temperature of about 1,500°C. In the present work we have collected GGBS from local suppliers. It is used in making Geopolymer concrete. In the Geopolymer concrete GGBS plays a major in decrease the setting time and strength gain. GGBS has many environmental benefits.

Table No.3.11 Chemical Properties of GGBS

SiO_2	32.78
Al_2O_3	22.4
Fe_2O_3	1.1
MgO	0.08
CaO	34.86
Na_2O	-
LOI	0.62

3.1.8 Water

Water is an essential ingredient of Conventional concrete and GPC. It actively involved in the chemical reaction takes with the cement. As per IS 456: 2000 the H_2O used for mixing of concrete and curing is must be free from all impurities. If they present in water they will dangerous to concrete and steel. The pH value is not less than 6 for water. In the present investigation, portable water is used for both mixing concrete and curing of specimen's.

3.1.9 Super Plasticizer

Super plasticizer GLENIUM B233of Fosroc chemical India Ltd. was used as water reducing admixture. It increases workability. The details of the super plasticizer used are given in Table No.3.9

Table No.3.12 Details of Super Plasticizer

Parameters	Specifications	Results
Physical state	Reddish brown liquid	Reddish brown liquid
Chemical name of active ingredient	Polycarboxylate polymers	Polycarboxylate polymers
Relative density @25 C	1.08 +/- 0.1	1.08
Ph	Min 6	7.1
Chloride ion content %	Max 0.2	0.073
Dry material content	34 +/- 5%	34.09

3.1.10 Advantages of Super Plasticizer

- To Improve Workability of Concrete mix
- It provides light early strength for the pre-cast concrete elements
- Improves quality of concrete with making it as less permeable and hence improves durable properties.
- Minimize the segregation and bleeding in the concrete, thus pumping of concrete is easier.

3.2 Mix Design

The mix ratio was taken from literature. Different mix proportions were used to find out the strength properties.

3.2.1 MIX DESIGN FOR CONTROLLED CONCRETE (M30)

The procedure for designing concrete mix of M30 concrete is adopted as per IS 10262: 2009 and IS: 456-2000.

Table No. 3.13 Test data of materials of M30 Concrete

Test Data of Materials		
1	Cement Used	OPC of 53 grade
2	Specific gravity of cement	3.15
3	Specific gravity of coarse aggregate	2.672
4	Specific gravity of fine aggregate	2.84
5	Specific gravity of water	1
6	Water absorption of the coarse aggregate	1.12%
7	Water absorption of the fine aggregate	1%
8	Free (surface) moisture content of coarse aggregate	NIL
9	Free (surface) moisture content of fine aggregate	NIL
10	Sieve Analysis of Fine Aggregate	Separate Analysis Done

Table No.3.14 Stipulations for Proportioning M30 Concrete Mix Design

M30 CONCRETE MIX DSIGN		
AS per IS 10262-2009		
Stipulations for Proportioning		
1	Grade Designation	M30
2	Type of cement	OPC of 53 grade

3	Maximum Nominal Aggregate Size	20 mm
4	Minimum Cement Content	320 kg/m^3
5	Maximum Water Cement Ratio	0.45
6	Workability	50-75mm(slump)
7	Exposure Condition	Normal
8	Degree of Supervision	Good
9	Type of Aggregate	Crushed Angular Aggregate
10	Maximum Cement Content	540 kg/m^3

Target mean strength of concrete:

$f'_{ck} = f_{ck} + 1.65\ S$

i.e., $f'_{ck} = 30 + 1.65 \times 5 = 38.25\ N/mm^2$

f'_{ck} = target avg compressive strength at 28 days curing time,

f_{ck} = characteristic compressive strength at 28 days curing time, and

s = standard deviation.

Selection of water to cement (w/c) ratio:

From Table 5 of IS 456,

The water to cement ratio required for the target mean strength of 38.25 N/mm^2 is 0.45.

Adopt W/C ratio of 0.45

Selection of water content

From Table 2 (IS 10262: 2009), maximum water content =186 liter (for 50 to 75 mm slump range) for 20 mm aggregate.

Calculation of cement content

Water-cement ratio = 0.45

Cement content = 186/0.45

= **413.33 kg/m³**

Cement content 320 kg/m³< 413.33 kg/m³>540 kg/m³

As per clause 8.2.4.2 of IS 456:2000 (Cement content not including fly ash and GGBS more than 450 kg/m³ should not be used)

Estimated water content = 162.10 liters

Cement Content = (162.10/0.45)

= **362.64 Kg/m³**

Proportion of vol. of coarse aggregate and fine aggregate content

From Table 3(IS 10262: 2009), volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone II) for water-cement ratio of 0.50 =0.62.

Here water-cement ratio is 0.45.

Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water to cement ratio is lower by 0.10, the proportion of volume of coarse aggregate is increased by 0.02 (at the rate of -/+ 0.01 for every ± 0.05 change in water to cement ratio).

Therefore, corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.45 = 0.62.

Therefore, Volume of coarse aggregate = 0.62

Volume of coarse aggregate = 1- 0.62

Volume of fine aggregate = 0.38

Mix calculations

The mix calculations per unit volume of concrete shall be as follows:

- Volume of concrete = 1m³
- Volume of cement = mass of cement/ (specific gravity of cement x1000)

= 362.64 / (3.15*1000)

= 0.115 m³

- Volume of water = mass of water / (specific gravity of water x1000)

  = 162.10 / (1*1000)

  = 0.162 m^3

- Volume of all in aggregates = 1 – (Volume of cement + Volume of water)

  = 1 – (0.115+0.162)

  = 0.72 m^3

- Mass of coarse aggregate = Volume of all in aggregate x1000x Volume of coarse aggregate x specific gravity of coarse aggregate x1000

  = 0.72*0.62*2.672*1000

  = 1184.18 kgs

- Mass of fine aggregate = Volume of all in aggregate x I 000 x Volume of fine aggregate x specific gravity of fine aggregate x 1000

  = 0.72*0.38*2.84*1000

  = 681kgs

Table No. 3.15 Mix Proportions of M30 Concrete

Mix Proportion		
1	Cement	1
2	Fine Aggregate	1.88
3	Coarse Aggregate	3.26

3.2.2 Mix Design for Geopolymer Concrete (G30)

Unit weight of concrete =2400Kg/m^3

Mass of combined aggregate

= 78.14% of unit weight of concrete = ((78.14/100) *2400)

=1875.36Kg/m^3

Mass of flyash (class F) and alkaline liquid = Unit weight of concrete – Mass of combined aggregate

= 2400 – 1875.36

= 524.64 Kg/m^3

Considering Alkaline liquid to flyash ratio= 0.45

Calculation for mass of flyash = ((Mass of flyash and alkaline liquid)/ (1+Alkaline liquid to Fly ash ratio))

= ((524.64)/ (1+0.45)) = 361.82 Kg/m^3

Calculation for Mass of Alkaline liquid = Mass of flyash and alkaline liquid – Mass of flyash

= 524.64 – 361.82 = 162.81 Kg/m^3

Considering Na_2SiO_3 to NaOH ratio = 2.5

Calculation for Mass of NaOH = Mass of alkaline liquid/ (1+ratio of Na_2SiO3 to NaOH))

= (162.81/ (1+2.5))

= 46.51 Kg/m^3

Calculation for Mass of NaOH for 12M (NaOH Solids) = (36.1/100) * Mass of NaOH

Where 36.1 = Number of moles for 12M

= ((36.1/100) * 46.51

= 16.79 Kg/m^3

Calculation for Mass of Na_2SiO_3 = Mass of Alkaline liquid -Mass of NaOH

= 162.81 – 46.51

= 116.299 Kg/m^3

Calculation for Mass of water = Mass of NaOH – Mass of NaOH solids for 12M

= 46.51 – 16.79 = 29.72 Kg/m^3

Table No. 3.16 Details of G30 GPC Mix Design

Geopolymer Concrete (G30)		
1	Unit weight of concrete	2400 Kg/m^3
2	Mass of combined aggregate 78.14% of 2400	1875.36 Kg/m^3
3	Mass of flyash and alkaline liquid	524.64 Kg/m^3

4	Considering Alkaline liquid to flyash as	0.45
4(a)	Mass of flyash	361.82 Kg/m^3
4(b)	Mass of Alkaline liquid	162.819 Kg/m^3
5	Considering Na2SiO3 to NaOH ratio	2.5
5(a)	Mass of NaOH	46.51 Kg/m^3
	For 12 Molarity(NaOH solids)	16.79 Kg/m^3
5(b)	Mass of Na2SiO3	116.3 Kg/m^3
6	Mass of water	29.72 Kg/m^3
7	From Na2SiO3	162.81 Kg/m^3

Table No. 3.17 Mix proportions of G30 Concrete

Mix Proportion		
1	Flyash	1
2	GGBS	0.17
3	Fine Aggregate	2.21
4	Coarse Aggregate	3.85

CHAPTER – IV

EXPERIMENTAL INVESTIGATIONS

4.1 General

Low calcium (class F) dry fly ash collected from Vijayawada thermal power station was used as the source material to make Geopolymer Concrete in the laboratory. For the alkaline activator, a combination of sodium silicate (Na_2SiO_3) to sodium hydroxide (NaOH) solution was used. The NaOH solution of required molarity is prepared by dissolving the sodium hydroxide solids, either in the shape of pellets or flakes, in water. In order to improve workability of fresh fly ash and slag based Geopolymer Concrete we have added master gelenium sky B233-based superplasticizer and some extra water as per the mix design. The sodium silicate solution used contained Na_2O=14.35%, SiO2=30.00%, and 55% of water, by mass. All the liquids are mixed jointly before adding to the solids.

The Parameters Considered are as follows:

1. The molarity of NaOH used 12M for G30 grade of concrete.
2. The Silicon Dioxide (SiO_2) to Sodium Oxide (Na_2O) ratio as 2
3. Alkaline liquid to fly ash ratio
4. One day rest period
5. The ratio of Na_2SiO_3 to Sodium hydroxide (NaOH) as 2.5.
6. Oven Curing temperature of 60^oC for 24 hours
7. Effect of super plasticizer on compressive strength
8. Effect of replacement of fine aggregate on mechanical properties of Geopolymer Concrete. In the present study river sand is replaced with manufactured sand in different proportions viz. 0%, 50% up to 100%.

Figure No. 4.1.1 The tilting drum type concrete mixer used for Manufacturing GPC

Figure No. 4.1.2 Solution of Sodium hydroxide and Sodium Silicate (Na_2SiO_3)

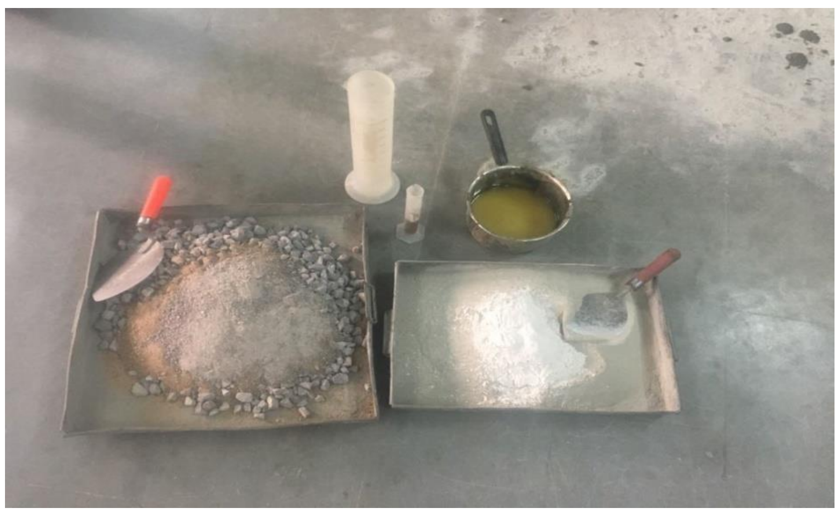


Figure No. 4.1.3 Materials ready to mix

4.2 Preparation of Specimens

In the preparation of specimens primarily alkaline activator solution was prepared by together mixing the sodium hydroxide (NaOH) pellets and Sodium silicate (Na_2SiO_3) solution according to the mix proportions. The NaOH and Na_2SiO_3 solution is prepared before 2 hours. In this experimental work, G30 grade of Geopolymer Concrete was prepared with different molarities of NaOH solutions i.e. 12 M. The mass of NaOH varied depending on the concentration of solution. The ratio 2.5 of sodium hydroxide to sodium silicate is used in experimental study. The fly ash, GGBS, fine aggregates, coarse aggregates and alkaline activator solution are weighted according to the mix design and together mixed by using a tilting drum type concrete mixer in the laboratory to produce Geopolymer Concrete.

A Tilting drum type concrete mixer used for obtaining uniform mixture of concrete with less effort. The fresh Geopolymer Concrete was used to cast cubes of size 100mm X 100mm X 100mm to determine its compressive strength, 150mm X 300mmsize cylinders to determine its split tensile strength, 100mm X 100mm X 500mm size prism to determine Flexural strength. Each specimen was casted and compacted by using table vibrator. This is the most commonly used vibrator for concrete. The period of vibration is 30 sec to 2min.

Figure No. 4.2.1 Cubes and Cylinders after casted

4.3 Curing

The specimens are cured in oven at a temperature of 60˚C after one day rest period for 24 hours and the specimens are kept in atmosphere until testing. Controlled Concrete specimens were cured in water.

Figure No. 4.3.1 Oven curing of cubes

Figure No. 4.3.2 Cubes after oven cured

Figure No. 4.3.3 Cylinders after Oven Curing

Figure No. 4.3.4 Prisms after Oven Curing

4.4 Tests on Geopolymer Concrete and Conventional Concrete

4.4.1 Compressive Strength Test

The concrete is more strong compression and weak in tension. In this present study the cube specimens of size 100 X 100 X 100mm are tested in accordance with IS Code : 516 – 1969. The testing was done on a CTM of 200 tons capacity. The machine has been calibrated to the required standards. The plates are cleaned and checked for oil level.

After 3, 7 & 28 days of curing, cube specimens were removed from the curing. The smooth surfaces of the specimen are placed on the bearing surfaces. The test was repeated for the 3 cubes and the average value is taken as the mean strength of concrete. The test set up is shown in **Fig.4.4.1**

Figure No. 4.4.1 Testing of cubes on Compression testing machine

4.4.2 Split Tensile Test

Tensile strength tests are used to know the cracking resistance of concrete and bond strength to reinforcing bars. However direct tests for knowing tensile strength of the concrete is very difficult to conduct. The most commonly adopted tests for determining the indirect tensile strengths are the flexural strength and the splitting test.

A concrete cylinder of size 150 mm diameter and 300 mm height is subjected to the action of a compressive force along two opposite edges, by applying the force in this manner. The cylinder is subjected to a uniform (constant) tensile stress.

Horizontal tensile stress (fs) =2P/ΠDL

Where

(fs) = splitting strength (MPa),

P = failure load (KN),

L = length of cylinder (mm) and

D = diameter of cylinder (mm).

Figure No. 4.4.2 Testing of cylinders on Compressive testing machine

4.4.3 Flexural Strength Test

Flexural strength is used to know the bending strength of concrete prisms. It is used to measure of unreinforced concrete prisms to resist failure load in bending. It is measured by giving loading 150 mm x 150mm concrete prisms with a span length at least 3 times the depth. To determine by MR the three-point loading (ASTM C 78) or l

293) used. MR is nearly 10 to 20 % of compressive strength depending on the size, type and vol. of coarse aggregate used.

For a sample under a load in a 3-point bending

$$\sigma = 3FL/2bd^2$$

- F = load (force) at the fracture point (N)
- L = length of the support span
- b = width
- d = thickness

Figure No. 4.4.3 Testing Beam on Flexural strength machine

CHAPTER V

RESULTS AND DISCUSSIONS

5.1 General

This chapter gives in details the results and graphs of experimental soundings carried out in different stages. In this present experimental work, G30 grade of GPC was prepared with two different molarities of NaOH. I.e. 12 M and 16 M. The mass of NaOH varied according to the molarity of solution. The ratio of the Na_2SiO_3 to NaOH taken as 2.5. The alkaline solution is mixed 2 hr ahead of the casting.

A tilting drum type concrete mixer is used for obtaining uniform mixture of concrete with less effort. The fresh Geopolymer Concrete was used to cast cubes of size 100mm x 100mm x 100mm to determine its compressive strength, 150mm X 300mm size cylinders to determine its split tensile strength, 100mm X 100mm X 500mm size prisms to determine the flexural strength. Specimens are compacted by using table vibrator. The GPC specimens are cured in oven at 60˚C for 24 hours and then kept in atmosphere until testing. The Conventional concrete cubes are casted and kept under water curing until testing.

5.2 Results and Discussions

Mix design is done as per IS: 10262-2009 and IS: 456-2000. In this work mix design for two water cement ratios is considered for two different molarities of NaOH for Geopolymer concrete (G30). The results obtained from tests are presented below

5.2.1 Compressive Strength of M30 and G30

The Mix proportion of GPC of G30 grade of concrete obtained like OPCC. From experimental investigation it was seen that higher compressive strength obtained when river sand is completely replaced with M- Sand. There is 2.47% increase of compressive strength for Geopolymer concrete (G30) when compared to normal concrete (M30) after 28 days of curing time.

Table No. 5.2.1 Shows type of mix and composition of mix

Type of Mix	Composition of Mix	
	River Sand (%)	M- Sand (%)
Mix 1	100	0
Mix 2	50	50
Mix 3	0	100

Table No.5.2.2 Compressive strengths of M30 Concrete

Type of Mix	Compressive Strength (MPa)		
	3 days	7 days	28 days
Mix 1	19.45	27.68	38.39
Mix 2	21.98	29.31	40.03
Mix 3	24.03	31.64	41.32

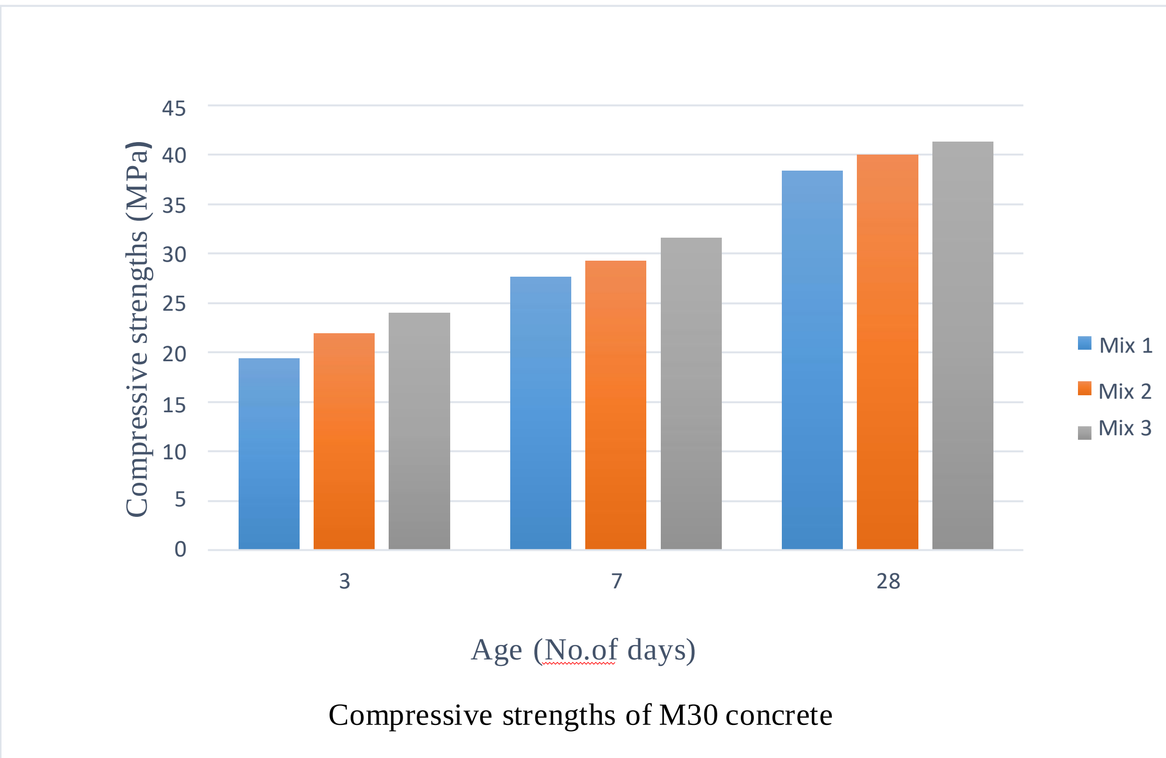
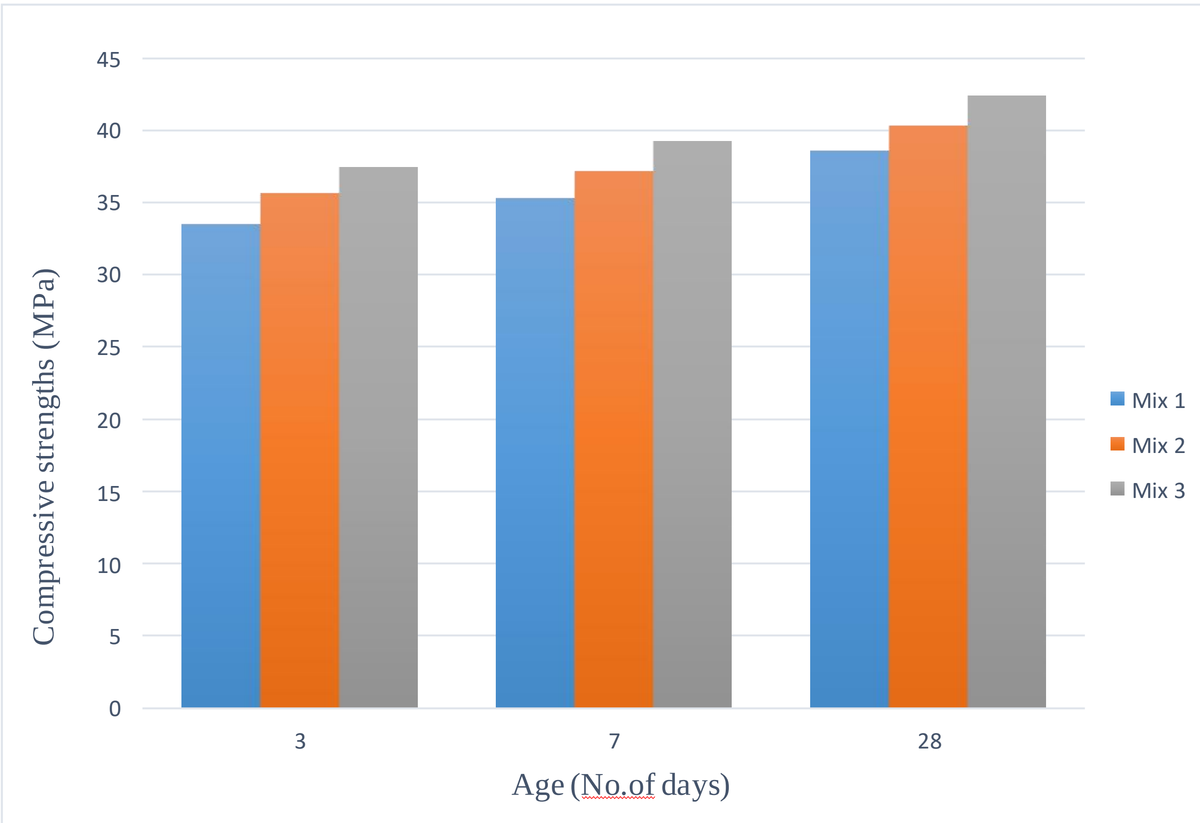


Figure 5.2.1 Compressive strengths of M30 Concrete

Table No.5.2.3 Compressive strengths of G30 grade Concrete

Type of Mix	Compressive Strength (MPa)		
	3 days	**7 days**	**28 days**
Mix 1	33.45	35.29	38.53
Mix 2	35.56	37.16	40.29
Mix 3	37.42	39.25	42.37



Compressive strengths of G30 concrete

Figure No.5.2.2 Compressive strengths of G30 Concrete

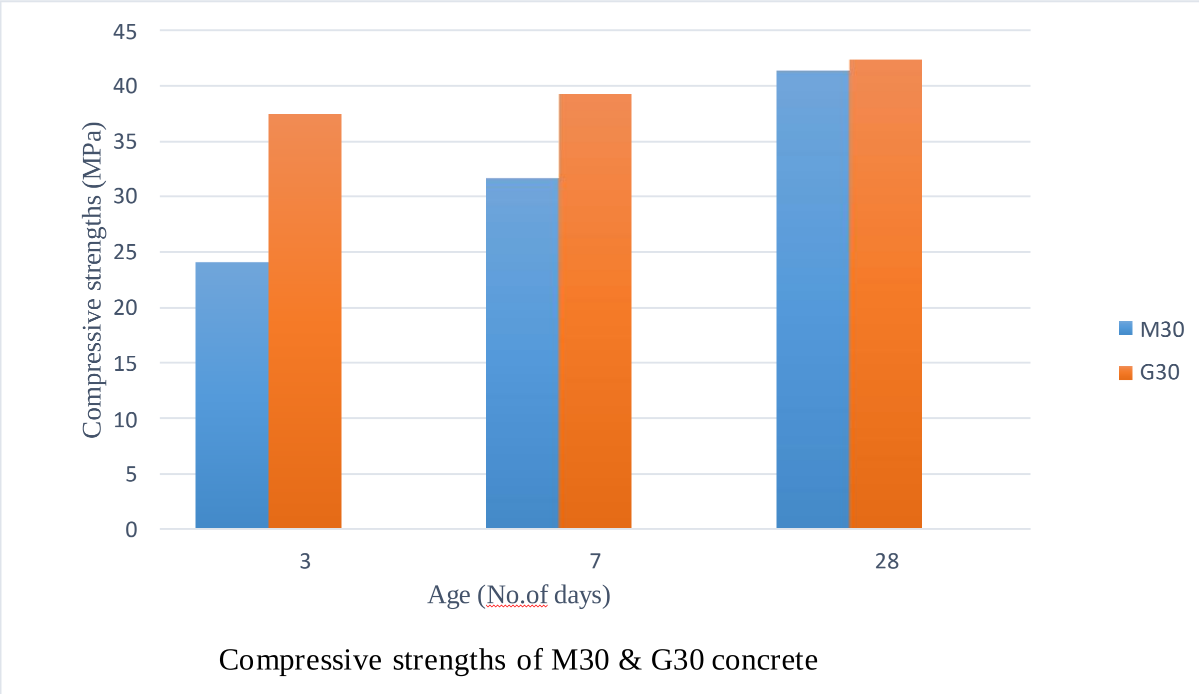


Figure 5.2.3 Compressive strengths of M30 & G30 grades of Concrete

5.2.2 Split Tensile Strength of M30 and G30

The Mix proportion of GPC of G30 grade of concrete obtained like OPCC. The specimens are casted using manufactured sand. From experimental results the maximum value I was noted that, 2.45% increase of tensile strength for GPC when compared to Normal Concrete for 28 days of curing time.

Table No.5.2.4 Split Tensile strengths M30 & G30

Grade of concrete	3 days (N/mm^2)	7 days (N/mm^2)	28 days (N/mm^2)
M30	1.99	2.79	3.98
G30	3.26	3.67	4.08

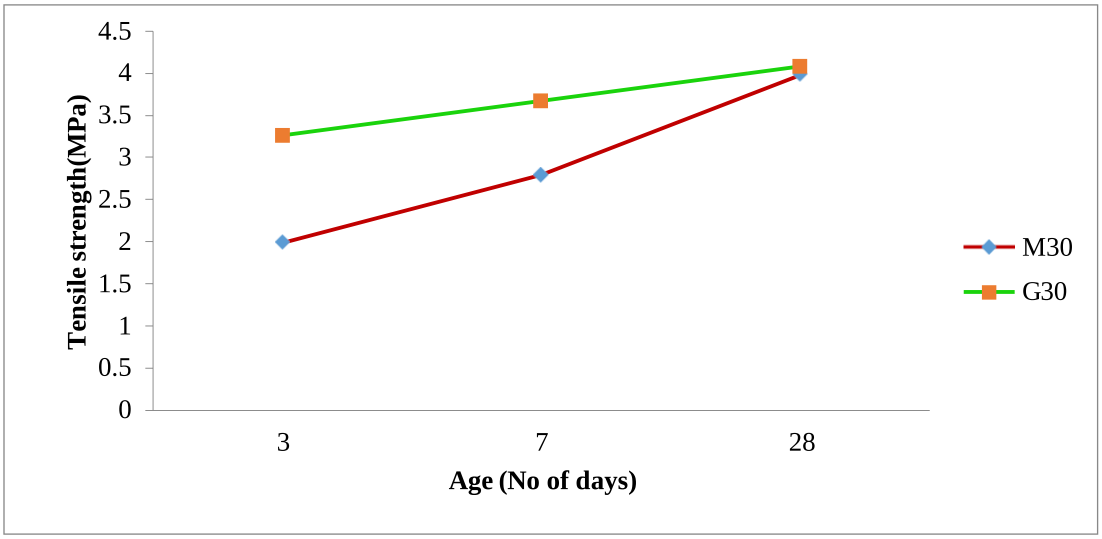


Figure No.5.2.4 Split Tensile strengths of M30 & G30 grades of Concrete

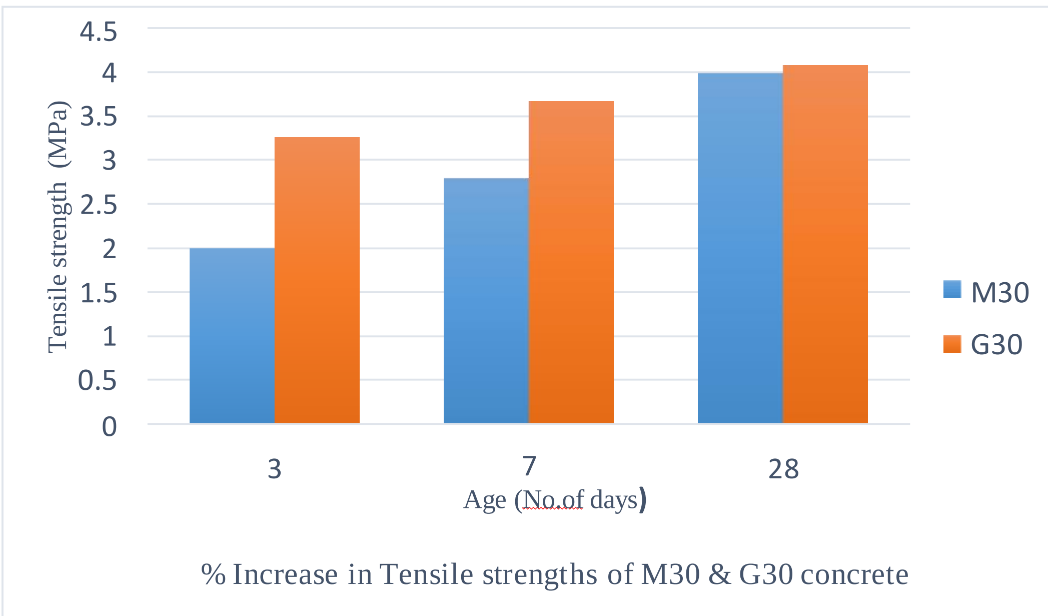


Figure 5.2.5 % Increase in Tensile strengths of M30 & G30 Concrete

5.2.3 Flexural Strength of M30 & G30

The Mix proportion of Geopolymer Concrete of G30 grade of concrete obtained like OPCC. The specimens are casted using manufactured sand. From the test results, 2.5% increase of Flexural strength for Geopolymer concrete when compared to Controlled Concrete for 28 days of curing. Cracks were appeared at 25 cm from left.

Table No.5.2.5 Flexural strength of M30 and G30

Grade of concrete	3 days (N/mm^2)	7 days (N/mm^2)	28 days (N/mm^2)
M30	2.53	3.54	5.06
G30	4.15	4.67	5.19

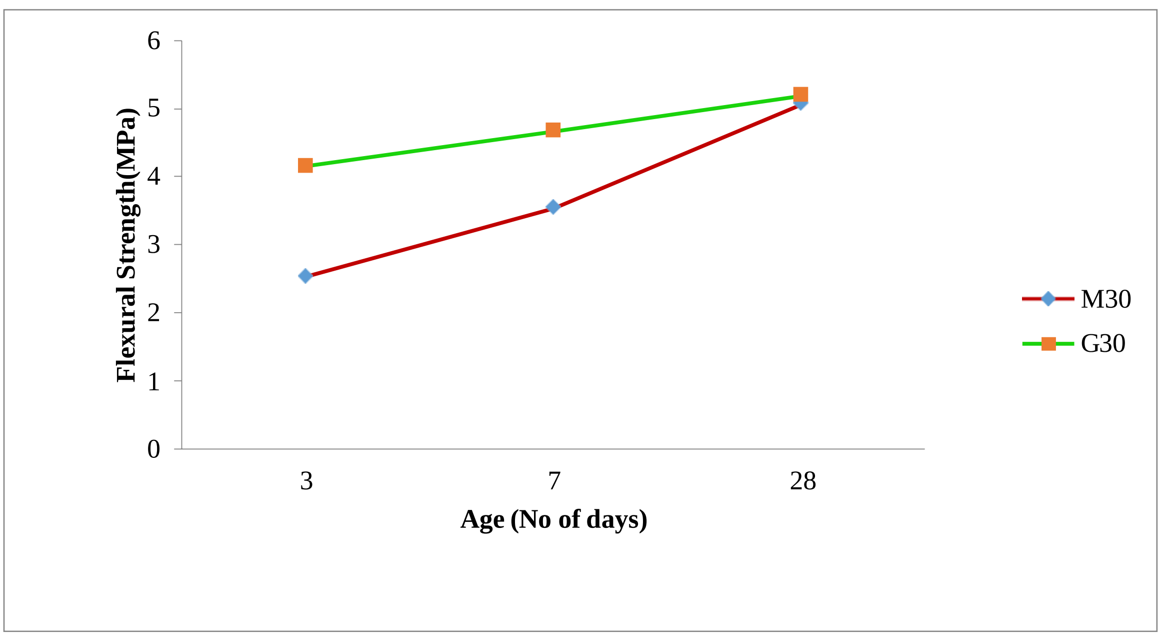


Figure No.5.2.6 Flexural Strength of M30 & G30 grade Concrete

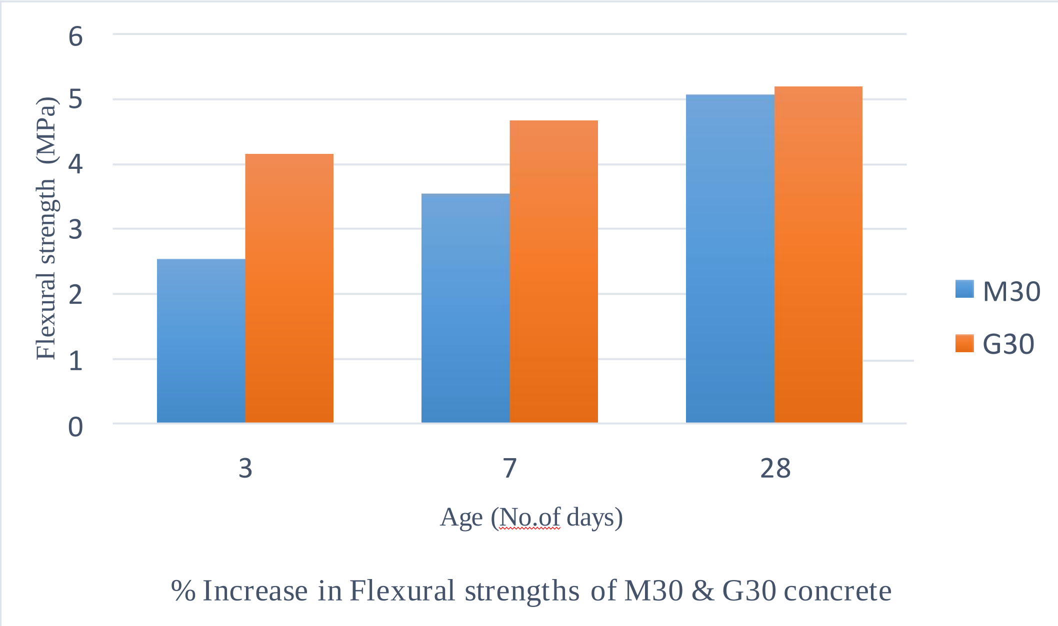


Figure 5.2.7 % Increase in Flexural strengths of M30 & G30 Concrete

5.3.1 Environmental Benefits of the Technology

The use of fly ash (class F) as a source material has environmental advantages in addition to those presented by the replacement of Portland cement. The use of the industrial by products such as GGBS, fly ash in a high value product like concrete imparts better value-addition to these materials. It significantly decreases the use of normal resources and energy, geopolymer concrete developed using fly ash is an environment friendly green material.

5.3.2 Economic Benefits of the Technology

In preparing the geopolymer concrete, the OPC is replaced 100 percent by fly ash and GGBS, hence geopolymer concrete is termed as cement less concrete and also river sand is completely replaced by manufactured sand. The Cost analysis for GPC and Conventional concrete are done and values are tabulated below.

5.3.2.1 Cost Analysis

Table No.5.3.1 Cost for Production of OPC M30 Concrete

SI. No.	Material	Rate	Unit	M30	
				Quantity in Kg	Amount in Rs.
1	Cement	7	Kg	362	2534
2	M- Sand	600	MT	682.6	409.56
3	Coarse Aggregate	500	MT	1184.4	592.2
4	SP	60	Kg	3.62	217.2
				Total	**3752.96**

Table No. 5.3.2 Cost for Production of Geopolymer Concrete G30

SI. No.	Material	Rate	Unit	G30	
				Quantity in Kg	Amount in Rs.
1	Fly ash	1000	MT	307.7	307.7
2	GGBS	2000	MT	54.3	108.6
3	M- Sand	600	MT	682.6	409.56
4	Coarse Aggregate	500	MT	1184.4	592.2
5	Sodium silicate	10	Kg	116.36	1163.6
6	NaOH	40	Kg	16.80	672
7	SP	60	Kg	3.62	217.2
				Total	**3470.66**

Table No. 5.3 Cost Comparison of Conventional Concrete and Geoplymer concrete

Type of Concrete	Total Cost of Concrete (Rs. Per M^3)
M30	3752.96
G30	3470.66
Decrease in %	**7.52**

From the table 5.12, It is Seen that the cost Geopolymer Concrete in both grades considered is less than that of conventional concrete. In Geopolymer Concrete of G30 grade, it is decreased by 7.52 % to that of M30 grade of Conventional Concrete.

CHAPTER – VI

6. CONCLUSION AND FUTURE ENHANCEMENT

6.1 CONCLUSION

From the experimental investigation, the following conclusions are made:

1. The maximum compressive strength 42.37 N/mm^2 was observed in 12M concentration of NaOH after 28 days of curing period (G30).
2. The maximum compressive strength 41.37 N/mm^2 was observed for M30 Conventional Concrete.
3. The reason for the improvement in compressive strength Geopolymer Concrete is the chemical reaction due to the speedy polymerization process under oven curing and aging of the alkaline liquid.
4. In oven curing an optimum temperature of 60^{0}C can be adopted for 24 hours to get better results.
5. The compressive strength of G30 increase by 2.47% when compared with Conventional Concrete of M30 respectively.
6. The split tensile strength of G30 increase by 2.45% when compared with Con Conventional concrete of M30 respectively.
7. The flexural strength of G30 increase by 2.5% when compared with Conventional Concrete of M30 respectively.
8. The early strengths are possible in oven cured Geopolymer Concrete compared to Conventional concrete.
9. Compressive strength of Geopolymer Concrete increases with increase in molarity of NaOH solution (8M up to 16M only).
10. . The cost of G30 grade concrete is decreased by 7.52 % when it is compared to Normal concrete M30 respectively.

6.2 FUTURE ENHANCEMENT

1. Since there is demand for natural sand, the fine aggregate shall be replaced partially by quarry dust. Quarry dust is having high content of Si, which may be increase the compressive strength of Geopolymer Concrete.
2. Same work will studied under ambient curing conditions
3. Different molarities of NaOH solution (8M, 10M, 12M, 14M & 16M) shall be used and the characteristics Geopolymer Concrete shall be studied.
4. For different curing methods Geopolymer Concrete shall also be studied.viz Steam curing and ambient curing with different Molar ratios of NaOH solutions.
5. To study the use of Geopolymer Concrete as of OPC concrete, we can go for study different structural elements like, RCC Beam, Plain Cement Concrete Beam, RCC Columns and Reinforced Beam Column joints shall be cast for the above mentioned concentrations of NaOH solution.

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A Major project report

On

EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENT BY COCONUT SHELL ASH IN CEMENT BRICKS

Submitted to

Jawaharlal Nehru Technological University Hyderabad

In partial fulfilment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

by

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S.MADHURI	-	18K85A0102
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JUNE 2021

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BONAFIED CERTIFICATE

This is to certify that the project entitled "EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENT BY COCONUT SHELL ASH IN CEMENT BRICKS",is being submitted by **Mr. B. Indrasena reddy (17K81A0109), Ms. S. Madhuri (18K85A0102), Mr. I. Bhanuprakash (17K81A0130) and Mr. D. Abhishek (17K81A0122)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN CIVIL ENGINEERING** is recorded of bonafide work carried out by them. The result embodied in this report have been verify and found satisfactory.

Signature of Guide

Mr. J. ANVESH
Assistant Professor**,**
Department of Civil Engineering

Signature of HOD

Prof. SANDHYA KIRAN J. K.
Head of the Department
Department of civil Engineering

Internal Examiner

External Examiner

Place:

Date:

DECLARATION

We, the student of **Bachelor of Technology** in Department of Civil Engineering, session: 2017 – 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled "EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENT BY COCONUT SHELL ASH IN CEMENT BRICKS" is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

Signature	Signature	Signature	Signature
B. INDRASENA REDDY 17K81A0109	S. MADHURI 18K85A0102	I. BHANUPRAKASH 17K81A0130	D. ABHISHEK 17K81A0122

Place:
Date:

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ABSTRACT

This is a study on CSA Cement bricks made by using an agricultural waste i.e., coconut shell ash as partial replacement of cement. The cement is the main ingredient used for cement brick. The production of cement gives rise to CO2 emissions generated by the calcinations of CaCo3 & by the fossils, being responsible for about 5% of the Co2 emissions in the world. Cement bricks were produced by using replacement levels of 5 and 10 percent of cement with CSA in cement bricks. The CSA cement bricks produced have good results in the tests like size test, shape test, structure test, impact test, soundness test, hardness test and efflorescence test. For replacement of 5% and 10 % of cement with CSA in CSA bricks the water absorption is found to be 11.5%, 12.8% and compressive strength is 8.3N/mm^2, 9.4N/mm^2 respectively. These results showed CSA bricks have slightly better performance compared to regular red bricks and similar performance compared to fly ash bricks.

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CHAPTER – 1

INTRODUCTION

1.1 GENERAL

Brick is one of the important material in the construction of which is widely used and highly demand in the construction of a structure in the civil engineering sector. However, the consumption of natural resources such as sand in brick production resulted in resource depletion, environmental degradation, and energy consumption.

In cement bricks the main materials are sand and cement. But the manufacture of ordinary Portland cement releases large amount of carbon dioxide (CO_2) to the atmosphere that contributes to greenhouse gas emissions. Currently, the world annual OPC production is about 1.6billions tons. By the year of 2011, the global cement consumption is expected to reach 2 billion tons, meaning that approximately 2 billion tons of carbon dioxide released into the atmosphere. So, in this project the cement is replaced with coconut shell ash to further reduce the amount of natural resources.

Most of the researchers have already worked a lot to reduce the use of cement and replace cement with such suitable materials, which give the properties like the concrete. The emphasis is being put forth on the utilization of industrial and agricultural wastes, as they are the environmental burden .It takes long time to dispose of agricultural waste; it still creates an environmental burden. However, it is beneficial when used in cement bricks. It will not only save money, but it will also cause a reduction in the use of cement in order to reduce the carbon dioxide emissions. Therefore, this study mainly emphasizes on the durability of coconut shell powder (CSP) cement bricks in comparison with normal cement bricks.

1.2 Utilization of coconut shell ash in cement bricks

There were many experimental work conducted to improve the mechanical properties by putting new materials. In this case, agriculture waste material i.e., coconut shell is used in cement bricks. The coconut shell in the form of ash is a material which can be as a substitute of cement in cement bricks. Coconut shell ash material is rich in amorphous silica can be used as partial replacement of cement can lead to increase the compression strength.

The high cost of construction materials like cement and reinforcement bars, has led to increased cost of construction. This, coupled with the pollution associated with cement production, has necessitated a search for an alternative binder which can be used solely or in partial replacement of cement in concrete production. More so, disposal of agricultural waste materials such as rice husk, groundnut husk, corn cob and coconut shell have constituted an environmental challenge, hence the need to convert them into useful materials to minimize their negative effect on the environment. Research indicates that most materials that are rich in amorphous silica can be used in partial replacement of cement. It has also been established that amorphous silica found in some pozzolanic materials reacts with lime more readily than those of crystalline form. Use of such pozzolans can lead to increased compressive and flexural strengths. The American society of testing materials (ASTM) defines Pozzolans as siliceous or aluminous materials which possess little or no cementitious properties but will, in the presence of moisture, react with lime [Ca(OH)2] at ordinary temperature to form a compound with pozzolanic properties. Examples of pozzolans include class C fly ash, which contain more than 10% CaO, blast furnace slag and silica fumes. ASTM C 618 – 78 specifies that any pozzolan that will be used as a cement binder in concrete requires a minimum of 70% silica, alumina and ferric oxides. BS 3892: 1965 parts 1 and 2 specify a maximum loss on ignition of 12%, maximum MgO content of 4% and SO3 of 2.5% respectively.

1.3 Coconut shell production and research about coconut shell ash

Coconut is grown in more than 92 countries in the world. Currently, the world production of coconuts stands at 62,450,192 metric tons and Nigeria as the 19th producer in the world and 5th in Africa, contributes a total of 295,000 metric tons to the total world production (FAOSTA, 2015). Previous researches on coconut shell are work of Utsev and Taku (2012) which has reported recent study on the "use of coconut shell ash (CSA) as a supplementary cementing material in concrete". They recommended that up to 10-15% replacement of OPC with CSA could be used for both heavyweight and lightweight concrete production. Ranjith Kumar *et al*. (2017) concluded that coconut shell ash and eggshell powder can be formed into binding materials. They also added that replacement of cement by coconut shell ash and eggshell powder has found to be attaining nearer strength as like conventional concrete. Lalit *et al.*, (2017) in his work concluded that the partial replacement of cement with CSA gives an average optimum compressive strength of 21.7 MPa at 28 days, and they added that the use of coconut shell ash as a partial replacement of cement produced a cheaper structural light weight concrete. Vigneh *et al.* (2014) concluded that the OPC–CSA mix gives an average optimum compressive strength of 31.78MPa at 28 days.

Coconut production plays an important role in the national economy of India. India is one of the world's largest producers of coconut, with a turnout of 11,706,343 tonnes (11,521,459 long tons) in year 2018. Traditional areas of coconut cultivation are the states of Kerala, Karnataka, Andhra Pradesh and Tamil Nadu. Also Maharashtra, Odessa, west Bengal, Gujarat, Puducheery and Goa; and the island territories of Lakshadweep and Andaman and Nicbar are other areas of coconut production.

Figure1.3 coconut shell

Table 1.3.1 Year-wise coconut production

Year	Production in million metric tons
2019	62.46
2018	63.77
2017	60.44
2016	60.59
2015	59.42
2014	61.44
2013	62.19
2012	62.06
2011	58.62
2010	60.3
2009	61.38
2008	60.41
2007	61.91

With this much of production of coconut, the production of shell of these coconuts which is considered a waste material also is huge. The coconut shell was sun dried for forty eight hours to remove moisture from it. It was then subjected to uncontrolled combustion using open air burning for three hours and allowed to cool for about 12hours. The burnt ash was collected and sieved through a BS sieve (75 microns) to get required fineness

Coconuts are grown in over 86 countries across the globe, with an average production of 54 billion coconuts every year. India ranks at 3rd position, behind Philippines and Indonesia, in its coconut production. With the cultivation of over 13 million coconuts India is an agricultural state, which is known for its crop exports. India dedicates approximately 21 Lakh hectares of its land for coconut plantation.

1.4 Scope and objective of study

- The cost of cement bricks can be reduced by replacing cement partially with coconut shell ash in cement bricks.

- The disadvantages of regular cement bricks and fly ash bricks can be solved by using coconut shell ash as partial replacement of cement in cement bricks.
- By using CSA as binding materials because of its pozzolanic property better quality of bricks can be produced.

Objective:

- To find the quality of CSA bricks by testing them through field tests.
- To find the water absorption of the CSA bricks.
- To find the compressive strength of the CSA bricks.

CHAPTER- 2

LITERETURE REVIEW

General:

In this chapter, there are numerous researchers have been studied within the result of replacement of coarse combination by coconut shell and also results shown on the mechanical and hardness properties of traditional cement concrete. The literature being reviewed as below

DAMRE SHRADDHA1, FIRAKE HITALI1 (2014)

In this paper we studied that among the useful agricultural waste materials the family of palm shells namely palm shell and coconut shell are highly available in torrid zones of the world. According to research coconut shell aggregates are in ratio of 1:5 used in normal concrete when compared with the compressive strength results that are obtained.

SELWYN BABU J AND MAHENDRAN N (2014)

This paper studied that light weight aggregate place the major role in sustainable concrete. By mixing synthetic light weight aggregates with concrete mixture the light weight concrete is prepared. In the 28th day of concrete mix is less than 2000kg per meter cube. The satisfied requirements for coconut shell aggregate are ASTM C 330. The authors showed the strength of flexural behaviour workability density of concrete containing ¼, ½ , ¾ and 4/5 of metallic element replaced to traditional coarse mixture by volume.

AJAY LONE, ANIKET DESHMUKH (2016)

The coarse aggregate are the main materials of concrete. In authors of this paper discussed about replacing coconut shell for coarse aggregate. 25% and 50% of coarse aggregate replacement prepared by binding constantly along with water in the ratio of 0.45 per all mixes, density, workability and water adsorption. One week, two weeks and four weeks were determined compressive strength, tensile strength and flexural strength.

YOGESH NARAYAN SONAWANE (2013)

In concrete mix the most important ingredient is the coarse aggregate therefore they used coconut shell as main ingredient and found better results. By collecting the test results they proved that using coconut shell is more eco-friendly than other materials. The author aimed to figure out confining strength of concrete By substituting coconut shell for natural coarse mix with replacement of 0, 1/4, 1/2, 1 parts. For each case they prepared 3 samples of

M20 grade mixture in the shape of cubes and authors want to spread perception of using coconut shell as construction material. The total cost for construction will be decreased a lot. They got highest confining strength in control mix i.e. 21 N/mm2 approximately after fourth week, whereas the lowest strength at the same week is noted as 23.00 N/mm2. So whenever light-weight concrete mix is needed the coconut shell is a part of it. Because of the rough surface in coconut shell it is hard to combine it with concrete.

DANIEL YAW OSEI (2013)

In the paper authors used 1:2:4 concrete mixture. 27 cubes were placed and tested various types of strengths were evaluated at 1, 2, 3 and 4 weeks. The concrete is replaced at 20%, 30%, 40%, 50%, and 100%. The results of the review demonstrated that concrete created by replacement of the crushed granite by coconut shell is utilized in Ferro-concrete construction. A possible exists for the employment of coconut shells as replacement of standard combination in each standard Ferro concrete and light weight Ferro-concrete construction. To reduce the usage of environment harmful materials in construction mixture by using coconut shell waste for standard mix which make the mixture eco-friendly. International Journal of Pure and Applied Mathematics Special Issue.

TOMAS U. GANIRON JR (2013)

The author's experimental research covered a wide series of property tests like mechanical property and sieve analysis tests along with the content of specific moisture gravity Test were undertaken in accordance with the ASTM Outcomes showed that by replacing certain amount of coconut shell can satisfy the concrete work mix. When differentiated the normal concrete mixture's strength with the coconut shell included concrete's strength is more.

S.ABIRAMI, K.MUNIYAMMAL (2016)

The authors of this paper discusses about the natural and synthetically properties of concrete materials. By using IS code method the Concrete mix design is done. Feasibleness of raw concrete like compaction and slump cone tests will be done. Various strengths will harden concrete like confining strength of concrete cubes at first and second week and split ductile strength of cylinder at first and second week and flexural prism power at first and second week. To compare the feasibleness and a strength variety for percentage variants of replacement of coarse mixture with coconut shell. Mainly the lightweight concrete will be prepared.

VINOD B R, P.VENKATA KHYATHI (2017)

This has necessitated analysis work into various materials within the construction field. The prices of building materials area unit rising day by day. The coarse aggregates area unit the most ingredients of concrete. During this paper, the employment of coconut shell as a rough combination has been mentioned supported the results obtained from comprehensive review of literature. We tend to all need that our buildings should be robust and may build with the development material of cheap rates. Light weight construction mixture is prepared by using the wastes like panels & block production, internal wall casting, outdoor furniture etc.

PARAG S. KAMBLI, SANDHYA R. MATHAPATI (2014)

The goal of the above paper was to use eco waste in construction materials which reduces the cost for housing. And it also purposes of encouraging house developers and investing these materials in house construction. They used three variants of concrete mixes in three different grades known as M20, M35 and M50 grades with various proportions of natural material. 0%, 10%, 20%, 30% and 40% will be replaced and 7 and 28 days tests will conducted.

CHAPTER-3

COCONUT SHELL ASH BUILDING BRICKS

3.1 Raw Materials Required

3.1.1 Cement:

Cement is the most versatile and most widely used in construction material worldwide. Cement is manufactured through a closely controlled chemical combination of calcium, silicon, aluminium, iron and other ingredients. Common materials used to manufacture cement include limestone, shells, chalk or marl combine with shale ,clay slate, blast furnace slag, silica sand and iron ore. It is a finely milled mineral powder, usually grey in colour. The most important raw materials for the production of cement are limestone, clay and marl. These are extracted from quarries by blasting or by ripping using heavy machinery.

Cement is a binder, a substance used for construction that sets, hardens and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel together. When cement is mixed with water serves as a adhesive to bind sand, gravel, and hard rock, for example cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete.

Types of cements:

- Ordinary Portland cement (OPC) Ordinary Portland cement is the most widely used type of cement, which is suitable for all general concrete construction.
- Portland Pozzolona cement (PPC).
- Rapid Hardening cement.
- Quick setting cement.
- Low Heat cement.
- Sulphates resisting cement.
- Blast Furnace Slag cement.
- High alumina cement.

In this experiment study, ordinary Portland cement is used this Portland cement is most common type of cement in general use around the world as a basic ingredient.

The continuous increase in the price of cement has geared researchers to investigate the viability of some pozzolanic materials as replacement materials, which would be used as partial replacement for cement and lower the cost to cement, so that more people can afford to build their houses.

Figure 3.1.1 Cement

Civilizations as old as from 6500 BC have used non-hydraulic cement in the past. Greeks and Romans developed hydraulic cement afterward (Li 2011). It is the most used construction material these days because of its numerous merits which encircle but are not limited to its malleability, adaptable nature, resistance and workability. Due to the large use of cement in construction, the demand of cement is also increasing with every passing day. The present use of cement is evaluated to be around 12 million tons per year and is yet expanding day by day (Khitab 2020). The production of cement is very hazardous to the environment as it produces heat and an excessive amount of CO_2 (Bheel et al. 2020). Carbon dioxide emissions are a serious environmental problem in cement production (Mangi et al. 2019). It is a well-known fact that the production of one-ton cement exhaust around one ton of carbon dioxide directly into the atmosphere (Mangi et al. 2019). Besides, it is accused of producing cement for 5-7% of carbon dioxide emissions from industrial sources (Bheel et al. 2020). Similarly, the materials required to produce the cement also pollute the environment and cause the depletion of our natural resources (Mangi et al. 2019).

3.1.2 Sand (Fine Aggregate):

Natural River Sand was used which is locally available in Hyderabad region. The specific gravity was found 2.57. Fineness Modulus is also determined using 10mm to 150µm and is found **2.972.** The fineness modulus gives the idea about average size of particles in the fine aggregates. The value 2.972 indicates medium size sand. The details of sieve analysis are presented in **Table 3.1.2,** With sieve analysis data and fineness modulus value, sand is considered as zone II grading sand of **IS: 383 – 1970,** which is considered as good fine aggregate for concrete production. The grading limits of zone II sand for fine aggregates as per IS: 383-1970 is also presented in **Table 3.1.2** for reference only.

Table 3.1.2: Grading limits of Fine Aggregates IS: 383-1970

IS Sieve Designation	Percentage Passing by Weight for			
	Grading-1	Grading-11	Grading-111	Grading-1V
10mm	100	100	100	100
4.75mm	90-100	90-100	90-100	95-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

Sand is an extremely needful material for the construction but this important material must be purchased with all care and vigilance. Sand which is used in the construction purpose must be clean, free from waste stones and impurities. It is important to know what type of sand is beneficial for construction purpose as sand is also classified into three different forms that make it suitable for specific type of construction.

Figure 3.1.2 Sand

Sand is classified as: Fine Sand (0.075 to 0.425 mm), Medium Sand (0.425 to 2 mm) and Coarse Sand (2.0 to4.75 mm). However this classification of sand is further has types of sand in particular and on that basis only they are being incorporated in the construction.

Read out the detailing of the types of sand:

Pit Sand (Coarse sand)

Pit sand is classified under coarse sand which is also called badarpur in common language. This type of coarse sand is procured from deep pits of abundant supply and it is generally in red-orange colour. The coarse grain is sharp, angular and certainly free from salts etc which is mostly employed in concreting.

River Sand

River sand is procured from river streams and banks and is fine in quality unlike pit sand. This type of sand has rounded grains generally in white-grey colour. River sand has many uses in the construction purpose such as plastering.

Sea Sand

As the name suggest, sea sand is taken from seas shores and it is generally in distinct brown colour with fine circular grains. Sea sand is avoided for the purpose construction of concrete structure and in engineering techniques because it contains salt which tends to absorb moisture from atmosphere and brings dampness. Eventually cement also loses its action when mixed with sea sand that is why it is only used for the local purpose instead of structural construction.

There are different standards for the construction purpose which must be checked and considered for the better construction. The requirement according to which sand is chosen should be like:

- For plastering purpose the overall fine sand used must not be less than 1.5 while silt is preferred to not less than 4 percent.
- For brick work fine sand used must not be less than 1.2 to 1.5 and silt is preferred is 4 percent generally.
- Concreting work require coarse sand in modulus of 2.5 to 3.5 with not less than 4 percent silt content.

3.1.3 Coconut shell ash

Coconut Shell Powder is also widely used in production Such as decorative materials, ropes, etc. Due to its low cellulose content, the shell also absorbs less water (Gummadi 2012). This study focus on the study of increased efficiency of coconut shell particles as a natural material for reinforcing epoxy resins towards their Flexural properties. Coconut shells have no economic value, and their disposal is not only expensive but can Ecological problems. Coconut shell is suitable for making carbon black due to its excellent natural structure and low ash quantity. Coconut shell is a waste product obtained from the agricultural industry. This Coconuts shell was burnt under controlled combustion arrangement at 500 °C to 550 °C temperatures for two hours to produce ash. The coconut shell ash was sieved through #200 sieves as shown in Figure 2 and it can be used as a cement replacement material in concrete. The experimental results conducted on CSA were obtained from previous studies as tabulated in Table 3.1.3

TABLE 3.1.3 Physical Properties of Cement and CSA

S.No	Property	Cement	CSA
01	Normal consistency	34%	38%
02	Specific gravity	3.15	1.33
03	Water absorption	----	25%
04	Fineness modulus	5%	8%

Figure 3.1.3 Coconut shell ash (CSA)

3.1.3.1 SETTING TIME OF CSA PASTE

The setting time increase with the rise in content of the CSA. The initial setting time was increased from 74min at 0%CSA to 262min at 10% CSA. The final setting time has been increased from 96min at 0%CSA to 345 min at 10%CSA. However, BS 12 (1978) is recommended that the initial and final setting times do not exceed 45 minutes and 10 hours respectively (Terungwa 2018). The previous report was presented by Arel et al. (2018) that the initial and final setting time was enhanced as the content of CSA increase in the paste. The same trend was followed by Fernando et al. (2017) that the initial and final setting was augmented with the inclusion of CSA in the paste as shown in table 3.1.3.1.

3.1.3.2 POZZOLANIC PROPERTY AND CHEMICAL CHARACTERISTICS

Volcanic ash activity is the most characteristic feature of additional cement materials. It has the capability to consume calcium hydroxide and form calcium silicate hydrate (C-S-H). There are many ways to measure the pozzolanic properties of a material, but the chemical composition of the material can help to understand the pozzolanic potential of the material.

According to ASTM C618, the chemical composition of pozzolanic materials should be about 70%, which contains silicon dioxide, alumina, and iron oxide. As a rule, a chemical analysis of coconut shell ash shows that it contains a major amount of these elements. Therefore, this indicates that volcanic ash is more active. Silica in OPC (commonly called silica) is the main component responsible for the strength of early concrete and mortar. Hence, a large amount of silica in the CSA indicates that it is a cementitious material and can be used as a substitute for OPC. According to the chemical property requirements specified in ASTM C618, CSA can be classified as class N pozzolan. Class N volcanic ash is an unprocessed or calcined natural pozzolan that meets specified requirements and contains a certain diatomite, such as opaque stone and slate, volcanic ash, or pumice, as well as some clay and slate that need to be calcined. The loss of combustion is lower than the standard of 10% for class N volcanic ash. This indicates that the amount of unburned carbon in the CSA is very small. This is an ideal characteristic of N-type volcanic ash because if the percentage of losses during combustion exceeds 10%, this indicates the presence of a large amount of unburned carbon in volcanic ash, which will lead to a decrease the pozzolanic activity (Nagarajan et al. 2014). A decrease in pozzolanic activity can lead to a decrease in concrete strength. On the other hand, the moisture content in CSA exceeds the minimum requirements for volcanic ash of class N, so it is recommended to dry in the oven before using CSA (Adajar et al. 2020). The chemical composition of the binder is shown in Table 03.1.3.2

Table 3.1.3.1. Setting time of CSA paste.

S.No	CSA replacement (%)	Initial setting time (min)	Final setting time (min)
01	30CSA	74	96
02	30CSA	142	239
03	30CSA	262	345
04	30CSA	273	384
05	30CSA	295	458
06	30CSA	327	476
07	30CSA	346	492

Table 3.1.3.2 Chemical composition of CSA and cement

Constituent	OPC (Noor-ul-Amin2010)	CSA(Kumar et al.2017)	CSA (Arel et al. 2018)
SiO2	20.78	37.90	42.50
Al2O3	5.11	24.12	17.70
Fe2O3	3.17	15.48	8.17
CaO	60.89	4.98	4.30
MgO	3	1.89	0.71
Na2O	0.25	0.95	0.93
K2O	0.39	0.83	0.82
P2O5	0.26	0.32	--
SO3	1.71	0.71	0.55
Loss of ignition	2.31	11.94	6.51

3.1.4 Water

Ordinary tap water was used in the production of bricks. water is one of the most important elements in construction but people still ignore quality aspect of this element. The water is required for preparation of mortar, mixing of cement concrete and for curing work etc during construction work. The quality and quantity of water has much effect on the strength of mortar and cement in construction work.

3.1.4.1Quality of Water

The water used for mixing and curing should be clean and free from injurious quantities of alkalis, acid, oils, salt, sugar, organic materials, vegetable growth and other substances that may be deleterious to bricks, stone, concrete or steel. Potable water is generally considered satisfactory for mixing. The P^H value of water should not be less than 6.

3.2 Types of Bricks

A brick is a type of bricks used to build walls, pavements and other elements in masonry construction. Properly, the term brick denotes a bricks composed of dried clay, but is now also used informally to denote other chemically cured construction brickss. Bricks can be joined together using mortar, adhesives or by interlocking them. Bricks are produced in numerous classes, types, materials, and sizes which vary with region and time period, and are produced in bulk quantities.

Bricks are the most vital for construction, and they often play major role in most of the construction.

The following are general types of bricks in present market:

Sun-dried bricks:

Unburnt bricks or sundried bricks are the first and most basic example of bricks. The process of making these bricks lies in the name itself. Not burnt but dried in the sun for hardening, often used in rural areas or temporary constructions. They are not as strong, have reduced fire and water resistance, and hence is best when left to temporary structures in our list for types of bricks used on construction.

Burnt clay bricks:

The most widely used among the types of bricks used in construction, gaining it the name 'common brick.' Used in the construction of important structures such as columns, walls, and the foundation of the building. They come mainly of four types:

First-class bricks (best quality bricks)

Second class bricks (moderate quality)

Third class bricks (poor quality)

Fourth class bricks (over-burnt and in irregular shape)

Concrete Bricks:

Manufactured using concrete with ingredients as cement, sand, and water. They can be manufactured into bricks of all types and sizes. Using concrete bricks over clay bricks is that they can be readily manufactured at a construction site. This can also help in the reduction of the amount of mortar required for the construction itself. Another common and rather popular type of brick used in construction.

Figure 3.2.1 Different type of bricks

Engineering Bricks:

Used for especially for its strength, cold resistance, and fire resistance, is the engineering bricks. Most used for basements, where chemical and water resistance is required more than average. They are also known for their low porosity. The strength option among the types of bricks used in construction.

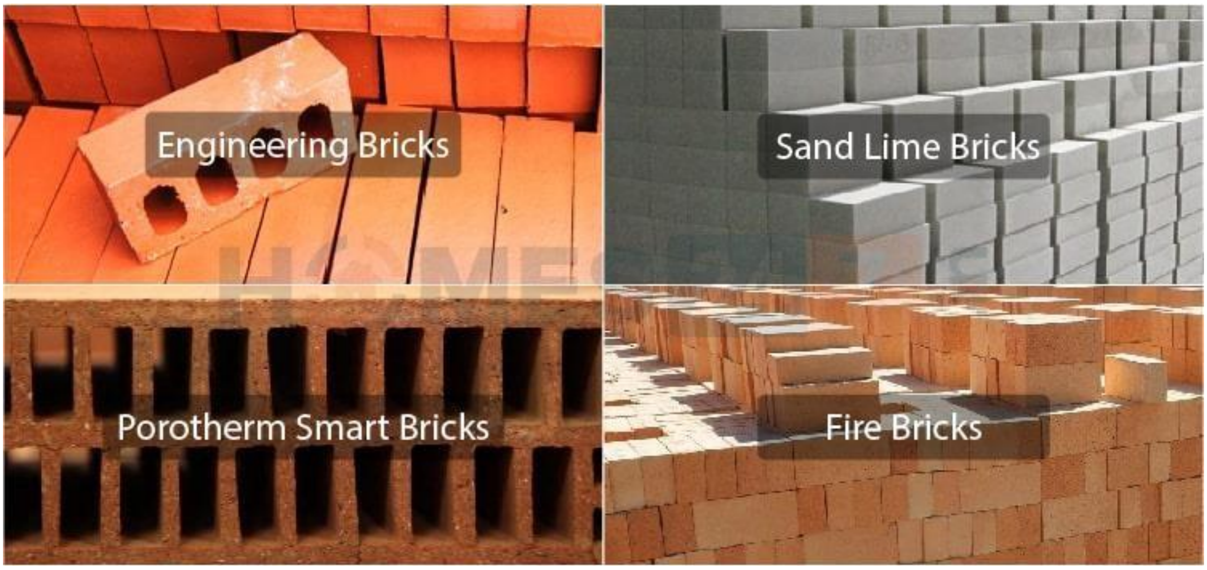


Figure 3.2.2 Different type of bricks

Sand lime or calcium silicate Bricks:

Made using sand and lime, popularly knows as sand-lime bricks. These bricks are used in the construction sector for several purposes and one of the primary types of bricks used in India. Artistic works, including ornamental works in buildings, are incorporate the sand-lime or calcium silicate bricks.

These bricks are chemically-set bricks, which means that the process is completed using heat and pressure elements to accelerate the chemical reaction. They have a smooth finish, acoustic insulation, and have excellent fire resistance are primarily used by artists to make their art shine.

Porotherm Smart Bricks:

Hollow bricks, often referred to as the ‘eco brick,’ are an intelligent way of using natural clay to make hollow bricks. These hollow bricks can either be horizontally or vertically perforated. Perforated means “pierce and make a hole or holes in.”

They are more modern, used in many residential and commercial projects. High strength, thermal insulation, and a 100% eco-friendly nature all for a lower than regular cost make it the best among the different types of bricks used for houses.

Fire Bricks:

Also knows as the refractory bricks. Manufactured from a specially designed earthing process. After it is burned, it can withstand extremely high temperatures through its fire resistance properties. This is all done without affecting the desires, shape, size, and compromising strength. Thus it is one of the common types of bricks used in India, especially in the rural and dry regions.

This is used for the lining of chimney and furnaces where the temperature rates are usually extremely high.

Figure 3.2.3 Different types of bricks

Jhama Bricks:

Jhama Bricks are also known as ‘overburnt bricks” or the ‘vitrified brick as it is fired at a high temperature and for a longer duration of time compared to conventional bricks. The shape is distorted but has a higher absorption capacity, and the strength is considerably higher or equal to a first-class brick. Often used in slab and beam construction using concrete where it does not encounter water normally.

Hollow Bricks:

Around one-third of the weight of the normal bricks, as the name suggests, are hollow inside, these bricks are also called cellular or cavity bricks. These bricks are used extensively for quick construction as they can be laid much quicker than the normal ones. These bricks are also used in partitioning in the construction process.

Fly ash bricks:

Specifically used for masonry, it contains class C or class F fly ash, which is a by-product that we get from burning coal mixed with water, which is then fired at a 1000 degree Celsius. The high amount of calcium oxide makes class C fly ash make it the best among the types of bricks used in construction for pillars, foundation, and walls. Often referred to as "self-cementing" brick.

High Fire Insulation

High Strength

Uniform Sizes for Better Joints and Plaster

Lower Water Penetration.

They do not require soaking before use in construction. Thus fly ash bricks make one of the best types of bricks used in India.

Fly ash bricks can be divided into the following types:

FAL-G (fly ash-lime-gypsum) Bricks:

Fly ash-lime-gypsum bricks/blocks technology has been developed successfully by National Thermal Power Corporation (NTPC), Bhanu International and Ahmadabad Electricity Company (AEC) for manufacturing bricks/blocks which can replace burnt clay bricks as walling material. It is also known as Fly Ash-Lime- Gypsum (FaL-G)bricks. It is not a brand name but it is duct name,christened to the mix for easy identification of its ingredients.

Fal-G bricks and blocks are manufactured without using thermal energy, in contrast to the sintering involved in the production of clay bricks.

Fal-G bricks are made of a mixture of fly ash-lime-gypsum or fly ash-cement-gypsum. In either combination, Fal-G is a hydraulic cement, which means it sets and hardens in the presence of moisture, on the lines of ordinary portland cement, gaining strength progressively over ageing. Nearly 200 tonnes of coal is used to sinter one million clay bricks, a process that generates over 350 tonnes of carbon dioxide (CO2). The production process of World Bank has offered to buy 800,000 tonnes of CO_2

reductions from utilization of Fly ash. Fal-G bricks eliminates harmful emissions of this scale.

Flux Bonded Fly ash Bricks Blocks and tiles:

The process is similar to the one in the conventional industrial fly ash is mixed with less than 10 % plastic clay and a few additives and tiles, bricks or blocks are pressed. These shapes are fired in the range of 900ºC to 1000ºC to make the final product. More than 85% of fly ash is used in the process.

The process is based on the formation of low melting fluxes at the firing temperature, which partly react with the fly ash and form a high temperature reactive glass binder phase. The bricks, tiles and blocks are brick red in colour, but changing the initial composition can make a variety of colours.

Figure 3.2.4.1 Fal- G bricks

Clay- Fly ash Bricks:

Manufacturing process of clay fly ash bricks by manual or extrusion process involves mixing of fly ash (60 %) with clay of moderate plasticity. The green bricks are dried under ambient atmospheric conditions or in shed to equilibrium moisture level of below 3 percent. Dried bricks are fired in traditional brick kilns at 1000º ± 30º C with a soaking period of 5 – 7 hours at maturing temperature. This technology has great potential to reduce not only precious topsoil and consumption of coal in making conventional clay bricks, but also requires minimum charges in existing set up at kiln sites and not very much susceptible to quality of ash.

Fly ash– Sand Lime Bricks:

In presence of moisture, fly ash reacts with lime at ordinary temperature and forms a compound possessing cementitious properties. After reactions between lime and flyash,calcium silicate hydrates are produced which are responsible for the high strength of the compound.

This processes involves homogeneous mixing of raw materials (generally fly ash, sand and lime), moulding of bricks and then curing of the green bricks. Some technologies call for usage of chemical accelerator like gypsum. These processes are almost similar and vary slightly from water curing to steam curing at low pressure or autoclaving at 10-14 kg/cm2.Bricks made by mixing lime and fly ash are, therefore, chemically bonded bricks.

These bricks are suitable for use in masonry just like common burnt clay bricks. These bricks posses adequate crushing strength as a load-bearing member and are lighter in weight than ordinary clay bricks.

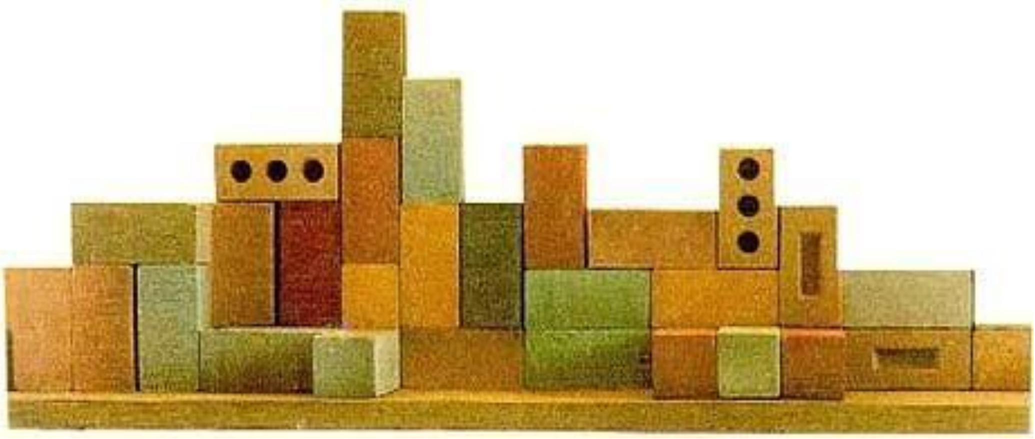


Figure 3.3.4.2 Fly ash– Sand Lime Bricks

Generally, dry fly ash available from power plants meets the properties specified in IS: 3812and is suitable for manufacture of Fly Ash – lime bricks in accordance with the requirements of IS: 12894.

Cold Bonded Lightweight Fly ash Bricks, Blocks and Tiles:

The material can be produced in a variety of building blocks, bricks and tiles, depending onlocal markets and regulations. Keraton consists of cheap and ubiquitous raw materials such as fly ash and / or other waste materials. These materials are mixed and a cold bonding agent is added. The mixed raw material is cast in moulds, after which the moulds are processed in a microwave oven for transportation to the building site.

The products can be applied as a lightweight material in the house building industry and utility building, such as stables, barns, garages, etc. A surface treatment or coating for coloring is possible. Strong points are the ability to use fly ash, the insulation properties and the production flexibility.

Figure 3.3.4.3 Cold Bonded Lightweight Fly ash Bricks

3.4 Proposed system of coconut shell ash bricks

From the research works on the use of coconut shell ash (CSA) as a supplementary cementing material in concrete it is concluded that coconut shell ash can be formed into binding materials.

From replacement of cement by coconut shell ash it was found to be attaining nearer strength as like conventional concrete. Coconut shell burned in high temperature it can be produce coconut shell ash and it can be used for partial replacement of cement. Reduction in the construction cost and light weight cement bricks are produced.

3.5 Properties of materials

Cement

Ordinary Portland cement manufactured in Nigeria as Dangote brand with a specific gravity of 3.14, moisture content of 0.53 % and bulk density of 1158 kg/m3 was used.

Fine aggregates

Clean and air dried river sand was obtained from a local dealer within Zaria city for this research, with a specific gravity of 2.56 moisture content of 7.5% and bulk density of 1505kg/m3 were used. The particle size distribution of the sand indicates that the sand used was classified as zone 1 based on BS 882-2 (1992) grading limits for fine aggregates.

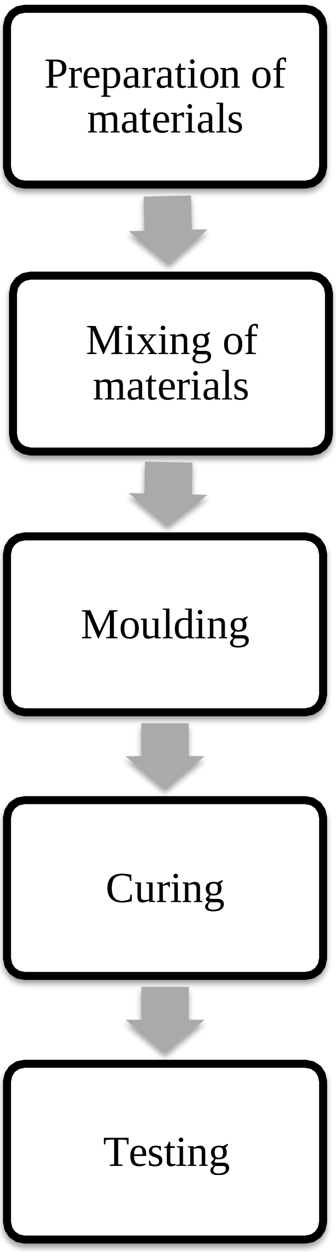
Coconut shell ash (CSA)

The coconut shell ash was obtained by burning the coconut shell to a temperature of 650ºC in an incinerator and controlling the firing at that temperature for about three hours to produce the ash. The ash was collected after cooling, and then sieved through 75µm sieve. The CSA is of specific gravity of 2.35 and moisture content of 1.42%.

CHAPTER -4

METHODOLOGY

Step-wise procedure is as Follows



4.1 Preparation of materials required:

Sand: Locally available river sand is taken and sieved the fine aggregate conforming to requirements of IS 383.

Water: Normal tap water with the PH range between 6 to 8 is used.

Cement: Locally available 53 grade ordinary portland cement conforming to IS 12269 is used.

Coconut shell ash (CSA): Coconut shells from local coconut farmers and vendors are bought and processed as following to obtain coconut shell ash. The coconut shell was sun dried for forty eight hours to remove moisture from it. It was then subjected to uncontrolled combustion using open air burning for three hours and allowed to cool for about 12hours. The burnt ashwas collected and sieved through a IS sieve (75 microns) to get required fineness.

4.2 Mould preparation:

Concrete bricks, hollow (open or closed cavity) or solid shall be referred to by its nominal dimensions. The term nominal means that the dimension includes the thickness of the mortar joint. Actual dimensions(length and depth only) shall be 10 mm short of the nominal dimensions.

The nominal dimensions of concrete bricks shall

be as follows:

Length : 400, 500 or 600 mm

Height : 200 or 100 mm

Width : 50,75, 100, 150,200, 250 or 300 mm.

In addition, bricks shall be manufactured in half lengths of 200, 250 or 300 mm to correspond to the full lengths. Full length and half length U-brickss may also be manufactured for the purposes of band and lintels.

The nominal dimensions of the units are so designed that taking account of the thickness or mortar joints, they will produce wall lengths and heights which will conform to the principles of modular co-ordination.

Bricks of sizes other than those specified in nominal sizes may also be used by mutual agreement between the purchaser and the supplier. In the case of special concrete masonry units such as wall bricks and ornamental bricks, the specified sizes may not necessarily apply.

The variation in the length of the units shall not be more than 5 mm and variation in height and width of units, not more than +3mm.

So, according to these standards we have made moulds with metal with the dimensions as per required brick size of 230mm x 110mm x 70 mm.

4.3 Mixing of materials:

The concrete mix used for bricks shall not be richer than one part by volume of cement to 6 parts by volume of combined aggregates before mixing. In machine-moulded bricks, the web markings on the units as they come from the machine give a good indications to whether the proper consistency of concrete has been used. In addition to the grading of the aggregate and the quantity of the cement, the amount of water required for mix will depend to an extent on the type of machine on which bricks are produced. The amount of water required for mix should be electronically measured and controlled in the mixing drum.

Batching of the ingredients should be done accurately and concrete mixing shall be done in a mixer to achieve homogeneous mix.

Mixing shall be continued until there is a uniform distribution of the materials, and the mass is uniform in colour and consistency.

4.4 Moulding and compaction:

The mix is filled into the moulds after mixing with required amount of water and compacted to remove excess water and to get proper finish.

The bricks should be compacted by vibro-compaction and finished to proper size-without broken edges. After ejection demoulding, the bricks shall be handled carefully to avoid damage. The bIocks shall be protected until they are sufficiently hardened before starting curing.

4.5 Curing:

The blocks hardened in accordance with shall then be cured as per 13.5 of IS 456 or by mist curing. So as to deliver the specified strength of block.

The blocks hardened in accordance with may alternatively be cured by steam. After curing the blocks in accordance with they shall be dried for a period of 4 weeks before being used on the work. In case of curing as per once low pressure steam curing has been done, the blocks shall be dried at ambient temperature for a period of seven days. The blocks shall then be the blocks shall then be stacked with voids horizontal to facilitate through passage of air. It shall be ensured that the blocks have been thoroughly dried and allowed to complete their initial drying shrinkage before supply to the work-site.

4.6 Testing:

Total of 20 samples are produced. Out of the 20 blocks, 6 blocks shall be subjected to the test for water absorption test, 6 blocks to the test for compressive strength, the remaining 8 bricks are for the field tests like efflorescence test, shape test, structure test, colour test, sound test, Impact test, hardness test.

CHAPTER- 5

EXPERIMENTAL TESTS AND RESULTS

Size Test :

The CSA cement bricks have a rectangular plane surface and uniform in size. Hence, these bricks are of good quality in size. If the size of the cement brick is not uniform, then it is not used for construction.

Colour Test:

A good quality brick should have uniform colour throughout the brick. This can be easily identified by observation. If there is colour variation, the bricks are not used in construction. The CSA Cement bricks are good in terms of colour.

Structure Test:

Cement bricks should be homogeneous, compacted and free from holes, lumps etc. Which is known by observing the cross section, by breaking a brick at centre. The CSA cement bricks are good in structure too.

Sound Test:

CSA cement bricks have produced clear metallic sound by striking two bricks, So it is considered as good brick. If the sound is dull, the bricks should be rejected.

Impact Test:

CSA cement bricks are dropped from 1 meter height and the bricks didn't break at all. Hence, CSA cement bricks are good quality bricks.

Hardness Test:

By making a scratch on the brick with nail, and the CSA cement bricks does not have any impression on the surface. So the bricks are of good quality.

If any marks or scratch lines are left over the surface, then these bricks are not good for construction.

Efflorescence Test:

CSA cement bricks have no perceptible deposit of efflorescence. The deposit of salts in this bricks are ignorable and less than 10% of the exposed area. Hence, these bricks are good in terms of efflorescence.

Figure 5.1 Efflorescence test

Water absorption Test:

APPARATUS

The balance used shall be sensitive to within 0.5 percent of the mass of the smallest specimen tested. ThreeThree full-size units shall be used.

PROCEDURE

The test specimens shall be completely immersed in water at room-temperature for 24 h. The specimens shall then be weighed, while suspended by a metal wire and completely submerged in water. They shall be removed from the water and allowed to drain for one minute by placing them on a 10 mm or coarser wire mesh, visible surface water being removed with a damp cloth and immediately weighed. Drying Subsequent to saturation, all specimens shall be dried in a ventilated oven at 100”C to 115°C for not less than 24 h and until two successive weighings at intervals of 2 h show an increment of loss not greater than 0.2 percent of the last previously determined mass of the specimen.

CALCULATION AND REPORT

Water Absorption

Calculate the water absorption as follows:

Water absorption, percent = (A-B)/B x 100

where

A- Weight of wet sample

B- Weight of dry sample

for sample 1 = 2805- 2525.5/2525.5x100

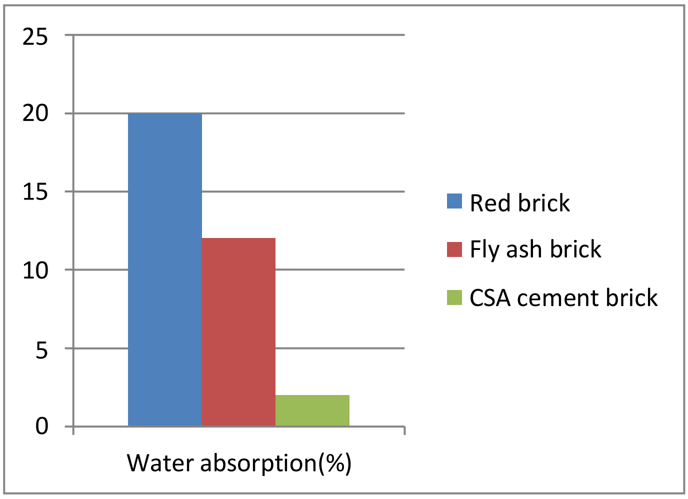
= 279.5/2525.5x100

= 11.06%

Figure 5.2 water absorption test

Table 5.2 Water absorption test:

Specimen	**Replacement of CSA in %**	**Wt of dry sample in grams**	**Wt of wet sample in grams**	**Water absorption (%)**
Sample 1	5	2525.5	2805	11.06
Sample2	5	2584.5	2893	11.93
Sample3	5	2550.3	2845	11.55
Sample 4	10	2411	2721	12.85
Sample 5	10	2485	2794	12.43
Sample 6	10	2395	2715	13.36



5.2.1Water absorption comparison

Compressive strength Test:

Apparatus

A compression testing machine, the compression plate of which shall have a ball seating in the form of portion of a sphere the centre of which coincides with the centre of the plate, shall be used.

Preconditioning: Remove unevenness observed in the bed faces to provide two smooth and parallel faces by grinding. Immerse in water at room temperature for 21 hours. Remove the specimen and drain out any surplus moisture at room temperature. Fill the frog (where provided) and all voids in the bed face flush with cement mortar (1 cement, clean coarse sand of grade 3 mm and down). Store under the damp jute bags for 24 hours followed by immersion in clean water for 3 days. Remove, and wipe out any traces of moisture.

Procedure

Place the specimen with flat faces horizontal, and mortar filled face facing upwards between two 3-ply plywood sheets each of 3 mm thickness and carefully centred between plates of the testing machine. Apply load axially at a uniform rate of 14 N/mm2 (140 kg/cm2) per minute till failure occurs and note the maximum load at failure. The load at failure shall be the maximum load at which the specimen fails to produce any further increase in the indicator reading on the testing machine.

NOTE - In place of plywood sheets plaster of Paris may be used to ensure a uniform surface for application of load

Calculation

The average of results shall be reported.

Compressive strength = Load at failure(N) / loaded surface area(mm^2)

For sample 1:

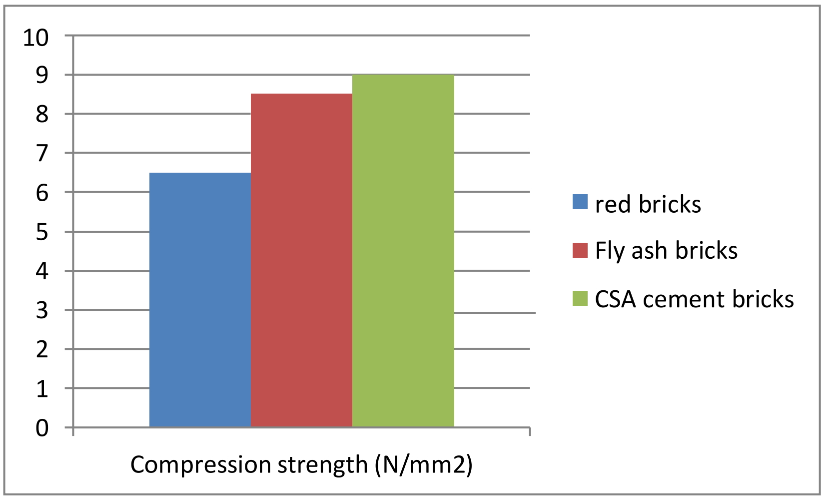
Compressive strength = 205430/25300

= 8.12 N/mm2

Figure 5.3 Compression strength test

Table 5.3 compression strength test:

Specimen	**% of CSA added**	**Load at failure (KN)**	**Loaded area (mm^2)**	**Compressive strength (N/mm^2)**
Sample 1	5	205.43	25300	8.12
Sample 2	5	216.06	25300	8.54
Sample 3	5	211.00	25300	8.34
Sample 4	10	233.51	25300	9.23
Sample 5	10	239.59	25300	9.47
Sample 6	10	243.89	25300	9.64



5.3.1Compression strength comparison

PERFORMANCE EVALUATION

property	**Red brick**	**Fly ash brick**	**CSA brick**
Water absorption in %	20-25	12-16	11-13
Compressive strength in N/mm^2	3-10	7-10	8-10

Since the water absorption in CSA cement bricks is less than red bricks and flyash bricks the CSA cement bricks are more durable.

In terms of compressive strength the CSA bricks are similar to red bricks and flyash bricks

CHAPTER -6

CONCLUSION / FUTURE ENHANCEMENT

- By the field tests like size test, colour test, structure test, sound test, impact test, hardness test & efflorescence test. It is concluded that the produced CSA cement bricks are good quality bricks.
- Water absorption for CSA cement bricks with 5% and 10% of cement replacement by CSA is 11.51% and 12.88% respectively which is less than 20%.
- The avgerage compressive strength for bricks with 5% and 10 % replacement of cement with CSA is 8.33N/mm^2 and 9.44N/mm^2 respectively.
- From this we can conclude that the CSA cement bricks can be used in place of the traditional bricks present in market for construction works.
- Further researching by using various mix proportion combinations with CSA and some other materials like groundnut shell ash, egg shell ash, etc., characteristics of bricks can be improved.

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A Major Project Report

On

SEISMIC ANALYSIS OF RC FRAME STRUCTURE WITH DIFFERENT BRACINGS LOCATED AT GUWAHATI ZONE – V

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

by

Mr.A Vinod Kumar	**-**	**(17K81A0101)**
Mr. K Rohit	**-**	**(18K85A0113)**
Mr.E Jashwanth	**-**	**(17K81A0123)**
Mr.G Venu Rao	**-**	**(17K81A0127)**

Under the Guidance of

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Assistant Professor

DEPARTMENT OF CIVIL ENGINEERING

ST. MARTIN’S ENGINEERING COLLEGE

(An Autonomous Institute)

Dhulapally, Secunderabad – 500 100

JUNE 2021

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Dhulapally, Secunderabad, Telangana (India)-500100

BONAFIDE CERTIFICATE

This is to certify that the project entitled Seismic Analysis Of RC Frame Structure With Different Bracings Located At Guwahati Zone – V, is being submitted by 1.**Mr. K Rohit (18K85A0113) 2. Mr.A Vinod Kumar (17K81A0101) 3. Mr.E Jashwanth (17K81A0123) 4. Mr.G Venu Rao (17K81A0127)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN** Civil Engineering is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

Ms. Rohini Pulluri
Assistant Professor
Department of Civil Engineering

Prof. Sandhya Kiran J K
Head Of the Department
Department of Civil Engineering

Internal Examiner

External Examiner

Place:

Date:

DECLARATION

We, the student of **Bachelor of Technology** in Department of Civil Engineering', session: 2017 – 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled 'Seismic Analysis Of RC Frame Structure With Different Bracings Located At Guwahati Zone – V' is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

Mr. K Rohit (18K85A0113)
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Mr. G Venu Rao (17K81A0127)

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1. Mr. K Rohit
2. Mr. A Vinod Kumar
3. Mr. E Jashwanth
4. Mr. G Venu Rao

ABSTRACT

Structures are highly susceptible to serve damages in earthquake scenario, choosing an appropriate lateral force resisting bracing systems will have a significant effect on performance of the structure. The present study is aimed to evaluating and comparing various types of concentric steel bracings for G+9 storey RC frame building with different configurations.

In this three types of bracing systems are considered i.e. X-Bracing, inverted V bracing and V bracing. The modeling & analysis is carried by using E-Tabs software. The models are compared for different aspects within the structure, such as the maximum storey displacement, storey drift and storey shear, the structure is analyzed for seismic zone V and medium soil condition as per IS 1893:2002 using ETABS software.

Results show that the RC frame structures are more vulnerable to earthquakes. With the provision of different types of bracings, the storey drift and storey displacement gets reduced. Inverted V type of bracing is found to be more efficient in Zones V against lateral seismic loading as they show better performance in terms of strength and stiffness. The storey drift of inverted V braced building is less as compared to the unbraced building and other braced building (X and V braced buildings) thus the overall response of the building decreases. The story shear of inverted V braced building is very high when compared to unbraced building and other braced building (X and V braced buildings) which indicates that stiffness of building has increased.

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CHAPTER 1
INTRODUCTION

1.1 General

An earthquake is a natural phenomenon and it is generated in the earth's crust. Duration of earthquake is normally short. Structures situated in seismic risk areas may be subjected to severe damage in a major earthquake. During earthquake motions, deformations take place across the elements of the load-bearing system. Due to these deformations internal forces develop across the elements of the load-bearing system and cause displacement of the building. Displacement demand varies depending on the stiffness and mass of the building. Buildings with higher stiffness and lower mass have less horizontal displacements demands. The primary objective of all kinds of structural systems used in the building is to transfer gravity loads effectively. Dead load, live load and snow loads are the common loads produced by the effect of gravity. Besides the vertical loads, buildings subjected to horizontal loads caused by wind, blasting or earthquake. Lateral loads can develop high stresses cause vibration. Therefore, it is very important for the structure to have sufficient strength and stiffness to resist lateral loads. Bracing is an effective and economical method of resisting horizontal forces in a framed structure. Braced frame systems are utilized both in RC as well as in steel buildings. Normally, the structure comprises of column and beams whose basic purpose is to transfer gravity load. When bracings are fixed to it, the total set of members forms a vertical cantilever truss like structure to resist the horizontal forces.

Bracing members are utilized in the building as a horizontal load resisting system to improve the stiffness of the frame for seismic forces. Braces can be connected with fixed-ended or pin ended connection. In the case of pin ended connection, it will be subjected to axial forces and it normally fails under compressive load by global buckling. Once the buckling occurs, its strength gets reduced in the succeeding cycles. But there will not be many changes in maximum tensile strength in subsequent cycles. The main advantage of using braces is that they dissipate the energy without damaging the building and also it can be replaced without any difficulty when it gets damaged.

Bracing System is one of the retrofitting techniques and it increase strength and stiffness of existing building against lateral force. Bracing is an effective strategy to enhance the global stiffness and strength of steel frames. It can increase the energy absorption of structures or decrease the demand like displacement, drift imposed by earthquake loads. The bracing system has more plastic deformation before collapse and can absorb more energy during the earthquake. Members in the braced frame made of structural steel and strong in both tension and compression. The beams and columns of the structure to carry vertical loads and bracing carry lateral load. Braces will be subjected to both tension and compression, because lateral loading on a building is reversible, so they are usually designed for the more stringent case of compression.

1.2 Steel Bracings

Steel bracing is a highly efficient and economical method of resisting horizontal forces in a frame structure. Bracing has been used to stabilize laterally the majority of the world's tallest building structures as well as one of the major retrofit measures. Bracing is efficient because the diagonals work in axial stress and therefore call for minimum member sizes in providing stiffness and strength against horizontal shear. A bracing system improves the seismic performance of the frame by increasing its lateral stiffness and capacity. Through the addition of the bracing system, load could be transferred out of the frame and into the braces, bypassing the weak columns while increasing strength. Steel-braced frames are efficient structural systems for buildings subjected to seismic or wind lateral loadings. Therefore, the use of steel-bracing systems for retrofitting reinforced-concrete frames with inadequate lateral resistance is attractive. There are different types of bracing system in common use such as single diagonal bracing, X bracing, V bracing, K bracing, inverted V bracing.The main aim of the present study is to know the effect of bracings on the multistorey RC frames. How the different types of bracings enhance the overall performance of the building and identify the suitable bracing system for resisting the seismic load efficiently. Different types of bracings are

- Based on the way braces are connected to the frame

Concentric bracings increase the lateral stiffness of the frame thus increases the natural frequency and also usually decreases the lateral storey drift. However, increase in the stiffness may attract a larger inertia force due to earthquake. Further, while the bracings decrease the bending moments and shear forces in columns and they increase the axial compression in the columns to which they are connected.In a concentrically braced frame bracing members are connected to beam or column junction.

In an eccentrically braced frame bracing members are connected to separate points on the beam or column. The segment or link present between beam members help in absorbing energy from seismic activity through plastic deformation. Eccentric Bracings improve the lateral stiffness and increase the energy dissipation capacity. In eccentric connection of the braces to beams, the lateral stiffness of the frame depends upon the flexural stiffness.

- Based on the braces configuration

X brace: Bracing where two diagonal braces crosses near mid-length of the bracing members.

Inverted V brace: is that form of chevron bracing that terminates at point on beam from below.

V brace: Bracing where a pair of braces joins at a single point on the beam span.

K brace: Bracing where a pair of braces connected on one side of a column joins at a single point on another leg of column.

Among all types of bracings X, inverted V,V bracings are good.

- Based on the material used in braces

RCC brace: These are the braces which are made up of reinforced cement concrete. The Cross section of concrete brace is similar to RCC beam or column section. These types of braces are strong in compression but are rarely used because of their construction difficulties and also another disadvantage is, these braces cannot be replaced once damaged due to seismic loads and hence it becomes uneconomical.

Steel brace: in Steel braces different types of steel sections can be used such as channel sections, angle sections, I sections or tubular section. These braces usually resist large tension force and fail in buckling. The main advantage of steel braces is it can be replaced after the damage hence making it economical.

1.3 Outline of proposed project work

The present work is aimed to evaluating RC framed building with the following objectives

- Modelling of a G+9 storey RC frame structures with different bracing systems like X bracing, inverted V bracing, V bracing for different configuration.
- The effectiveness of bracings are studied by using different configurations. In each configuration the arrangement of bracing is different.
- Displacement, storey drift, storey shear, time period and base shear of the building is to be studied must be within limits and follow the codal provisions by using response spectrum method.

1.4 Thesis Organization

The project is organized into 5 chapters with following contents.

- The introduction chapter described the need, objectives and importance of study.
- Chapter 2 deals with literature review so as to arrive to a proper issue.
- Chapter 3 described the methodology and modeling adopted in solving the issue.
- Chapter 4 involves the theoretical investigation applied on the structure. Further concludes with analytical modeling of the structures using the software and evaluation of the seismic forces.
- Finally chapter 5 deals with discussions of the results, concludes the thesis with limitations and recommendation of further work which is possible.

CHAPTER-2

LITERATURE REVIEW

2.1 Introduction

This chapter presents a brief review of the recent literature in the form of journals and an official document was performed to study the performance of RC structure with and without bracings. Reinforced concrete building can adequately resist both horizontal and vertical load. Whenever there is requirement for a multi storey building to resist higher value of seismic forces, lateral load resisting system such as Moment resisting frame, In-fill frame, Shear wall, Tube system, Hybrid system, Braced frame. Bracing system should be introduced in a building to know the performance of the building. Properly designed building with Bracing system has shown good performance in past earthquake.

2.2 Seismic Behavior of buildings with Different Bracings

Swetha Sunil et al., (2017) [14]

The main objectives of this paper are to study the seismic response of RC building with different type of bracings such as X, Inclined, V and Inverted V by performing response spectrum analysis. Different heights selected for the study are 6m, 9m, 12m. ETABS 2016 software is used for the study. Compare various parameters like storey drift, storey displacement, base shear time period for different models considered. Identify suitable bracing system for resisting seismic load effectively. To study effect of aspect ratio by performing response spectrum analysis on most effective bracing system After the application of bracing, reduction of displacement increases with increase in aspect ratio. The value of drift not shows much variation with increase in aspect ratio. From the study it was found that X bracing is more effective bracing system compared to other bracings.

Pooja Desai et al., (2017) [11]

In this paper Behavior of concrete and steel X braces with varying storey height is investigated. This paper summarizes the seismic behavior of four structures with 5, 10, 15 and 20 storey’s and plan dimension of 25m x15m. These structures are analyzed using equivalent static load method and response spectrum method in ETABS. Parameters such as base shear, displacement and natural time period were compared and presented in form of graph. It was observed that on adding bracings the seismic response of the structure was improved.

Safvana P et al.,(2017) [13]

In the present study, the seismic study of conventional X brace, zipper brace in RCC structures using ETABS software is investigated. The bracing is provided at each corner. a g+6, g+12 and g+18 story with 6 bay in the x-direction and 3 bay in the y-direction is analyzed using ETABS.

The effectiveness of various types of steel bracing is examined. The effect of the distribution of the steel bracing along the height of the RCC structure on the seismic performance of the rehabilitated building is studied. Provision of conventional X braced, zipper braced and SBS is provided in each stories. The percentage reduction in lateral displacement is found out. It is found that the SBS of steel bracing significantly contributes to the reduction in displacement and story shear compared to conventional X bracings.

Aswathy et al.,(2016) [2]

In this study, the analysis of a reinforced concrete (RC) irregular building (H-Shaped) with different types of bracing (Diagonal, V type, inverted V type, X type, K type) is carried out by using ETABS software. For this purpose response spectrum method is taken into consideration and results are obtained in ETABS.

An attempt is made to find which type of bracing is effective to resist lateral deformation in a multistoried RC framed building by Response Spectrum Analysis. The seismic analysis is carried out taking into consideration that all the buildings are located in zone III as per code. The Storey shears, storey displacement at each storey along with the storey drift are plotted and compared for each model. The mode shapes corresponding to each time period are obtained. using bracings it reduced lateral displacement.

Adithya. M et al.,(2015)[1]

This project is about the efficiency of using different types of bracings and with different steel profiles for bracing members for multi-storey steel frames. ETABS software is used to obtain the design of frames and bracing systems with the least weight and appropriate steel section selection for beams, columns and bracing members from the standard set of steel sections. A three dimensional structure is taken with 4 horizontal bays of width 4 meters, and 20 stories is taken with storey height of 3m. The beams and columns are designed to withstand dead and live load only. Wind load and Earthquake loads are taken by bracings. The bracings are provided only on the peripheral columns. Maximum of 4 bracings are used in a storey for economic purposes. In this study, an attempt has been made to study the effects of various types of bracing systems, its position in the building and cost of the bracing system with respect to minimum drift index and inter storey drift.

Nitin Bhojkar et al., (2015)[10]

In this paper, the seismic analysis of reinforced concrete (RC) buildings with different types of bracing is studied. A G+9 building is analyzed for seismic zone III as per IS 1893: 2002 using STAAD Pro software. The main parameters consider in this paper to compare the seismic analysis of buildings are lateral displacement, story drift, axial force, base shear. It is found that the X type of steel bracing significantly contributes to the structural stiffness and reduces the maximum inter storey drift of the frames. The bracing system improves not only the lateral stiffness and strength capacity but also the displacement capacity of the structure.

Rishi Mishra et al.,(2014)[12]

In this study, seismic analysis of high rise RC building frames have been carried out considering different types of bracing systems. Bracing systems is very efficient and unyielding lateral load resisting system. In proposed problem G+ 10 story building frame is analyzed for different bracing system under seismic loading. STADD-Pro software is used for analysis purpose. The results of various bracing systems (X Bracing, V Bracing, K Bracing, Inverted V Bracing, and Inverted K Bracing) are compared with bare frame model analysis to evaluate the effectiveness of a particular type of bracing system in order to control the lateral displacement and member forces in the frame. It is found that all the bracing systems control the lateral displacement of frame very effectively. However Inverted V bracing is found to be most economical.

Chetan Jaiprakash Chitte et al., (2014)[4]

In this paper, the effect of various types of concentric braces on the behavior of the structure is tried to be evaluated by using pushover analysis which can be used with due achievement of the economy taking care of safety.

The capacity curves for all types of Braces states that the capacity of the structure is increased by applying the braces. By using the braces the capacity of structure to withstand an earthquake can be increased, but due consideration shall be given to the ductility of the structure. When tension or compression brace is used, the capacity as well as ductility nearly remains same, also when X-brace is used it gives the highest capacity but comparatively less ductility. The chevron type of brace gives moderate performance during an earthquake, since the capacity and ductility both are achieved.

Hendramawat et al., (2013)[5]

The aim of this paper is to evaluate the possible improvement of seismic performance of existing reinforced concrete building (the 5th Building of UNS Engineering Faculty) by the use of steel bracing. Three methods of seismic evaluation are employed for the purpose of the study i.e. Nonlinear Static Pushover Displacement Coefficient Method as described in FEMA 356, Improvement of Nonlinear Static Pushover Displacement Coefficient Method as described in FEMA 440 and dynamic time history analysis following the Indonesian Code of Seismic Resistance Building (SNI 03-1726-2002) criteria.

The performance of the existing building could be improved if steel bracings are utilized for seismic retrofitting. It is shown from the nonlinear pushover analysis that target displacements in both directions are reduced by 16%-55% if the proposed steel bracings are used. Furthermore, dynamic time history analysis points out that the story drifts of the retrofitted building are within the limit criteria. Meanwhile, the size of steel bracing elements do not significantly affect the seismic performance of retrofitted building.

A Kadid et al., (2011)[9]

This paper investigates the seismic behavior of RC buildings strengthened with different types of steel braces, X-braced, inverted V braced, ZX braced, and Zipper braced. Static nonlinear pushover analysis has been conducted to estimate the capacity of three story and six story buildings with different brace-frame systems and different cross sections for the braces. It is found that adding braces enhances the global capacity of the buildings in terms of strength, deformation and ductility compared to the case with no bracing, and the X and Zipper bracing systems performed better depending on the type and size of the cross section.

2.3 Conclusion on Literature Review

From the literature review, it was found that large numbers of research works were conducted on seismic behavior of multistoried R.C.C. building with bracing. The following literature surveys for "Analysis of RC frame structure with steel bracings" less number of works are down on RC frame with steel bracings with different configurations. This paper aims to analyze the dynamic characteristics of RC building with different configuration of bracing such as X, inverted V, V bracings.

CHAPTER-3

METHODOLOGY AND MODELING

3.1 Introduction

The study in this thesis is based on linear analysis of RC structures with different types of bracing system. This chapter presents a summary of various parameters defining the computational models, the basic assumptions and the RC frames geometry considered for this study. Accurate modeling of the linear properties of various structural elements is very important in linear analysis.

Response-spectrum analysis (RSA) is a linear-dynamic statistical analysis method which measures the contribution from each natural mode of vibration to indicate the likely maximum seismic response of an essentially elastic structure. Response-spectrum analysis provides insight into dynamic behavior by measuring pseudo-spectral acceleration, velocity, or displacement as a function of structural period for a given time history and level of damping. It is practical to envelope response spectra such that a smooth curve represents the peak response for each realization of structural period. Response-spectrum analysis is useful for design decision-making because it relates structural type-selection to dynamic performance. Structures of shorter period experience greater acceleration, whereas those of longer period experience greater displacement. Structural performance objectives should be taken into account during preliminary design and response-spectrum analysis. RSA provides insight into how damping affects structural response. A family of response curves may be developed with variable levels of damping. As damping increases, response spectra shift downward. The International Building Code (IBC) is based on 5% damping. This accounts for incidental damping from hysteretic behavior, which is not explicitly modeled during RSA.

The present study is to evaluate the behavior of G+9 RC frame structure without bracing and with various bracing like X bracing, inverted V and V bracing by using E-tabs software subjected to earthquake forces in zone V. because the occurrence of earthquakes in this region is frequent compare to another zones II,III,IV. The reinforced concrete structures are analyzed by linear dynamic analysis (Response spectrum Analysis) using ETABS software.

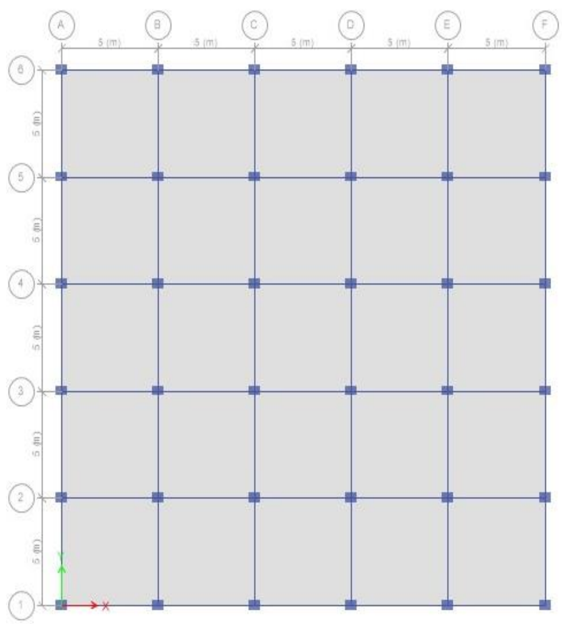
3.2 Modeling

3D analysis has been carried out by using response spectrum method for this study. The seismic analysis of all building is carried by Response Spectrum Method in accordance with IS: 1893 (Part 1):2002. The E-TABS software is used to develop 3D model and to carry out the analysis. The lateral loads to be applied on the buildings are based on the Indian standards. The study is performed for seismic zone V as per IS 456 (Dead load, Live Load) IS 1893:2002 (Earthquake load). The building consists of reinforced concrete. G+9 storied building analyzed with different types of bracing systems like X bracing, inverted V bracing and V bracing. Dynamic response of these buildings, in terms of fundamental time period, storey displacement, drift and storey shear are presented and compared within the considered configuration of with bracing system without bracing,efficient positioning of bracing configuration to be used is suggested.

3.2.1 Geometry

The RCC structure is consist of columns, beams and slab as shown in figure 3.2. The overall dimensions of the structure is 25m x 25m. Column dimensions for G+9 are 450mm x 600mm, beam dimensions are 350mm x 400mm, slab thickness is 125mm.from the code IS 456:2000 beam and column sizes satisfied.

And the figures3.4,3.5,3.6 shows the RC frame with different steel bracings such as X bracing, inverted V bracing, V bracing. The steel bracing size ISHB 450.from the code IS800:2007 the size of the steel bracing are satisfied.



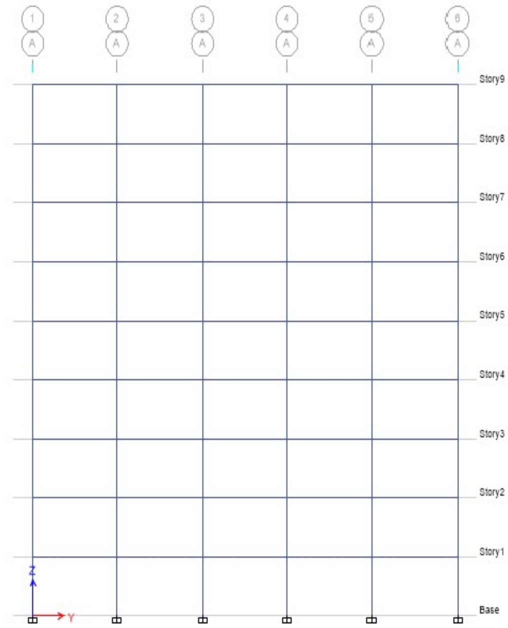


Figure 3.1: Plan of the model Figure Figure 3.2: G+9 RC frame structure elevation

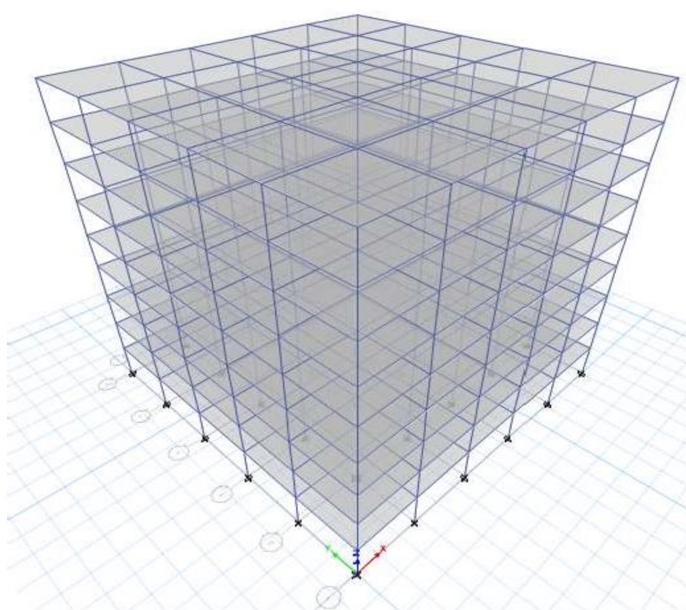
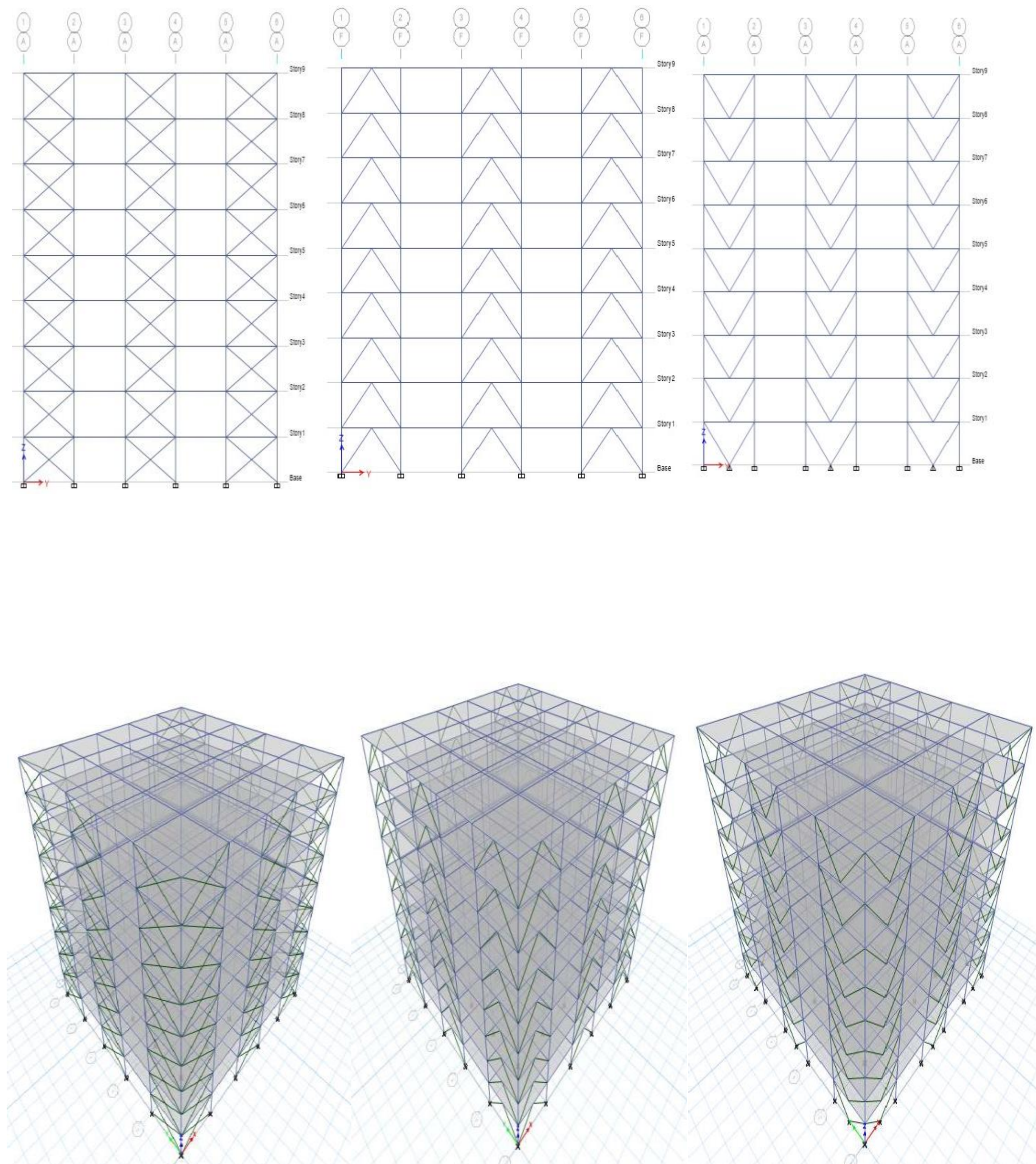


Figure 3.3: 3D view of RC frame structure

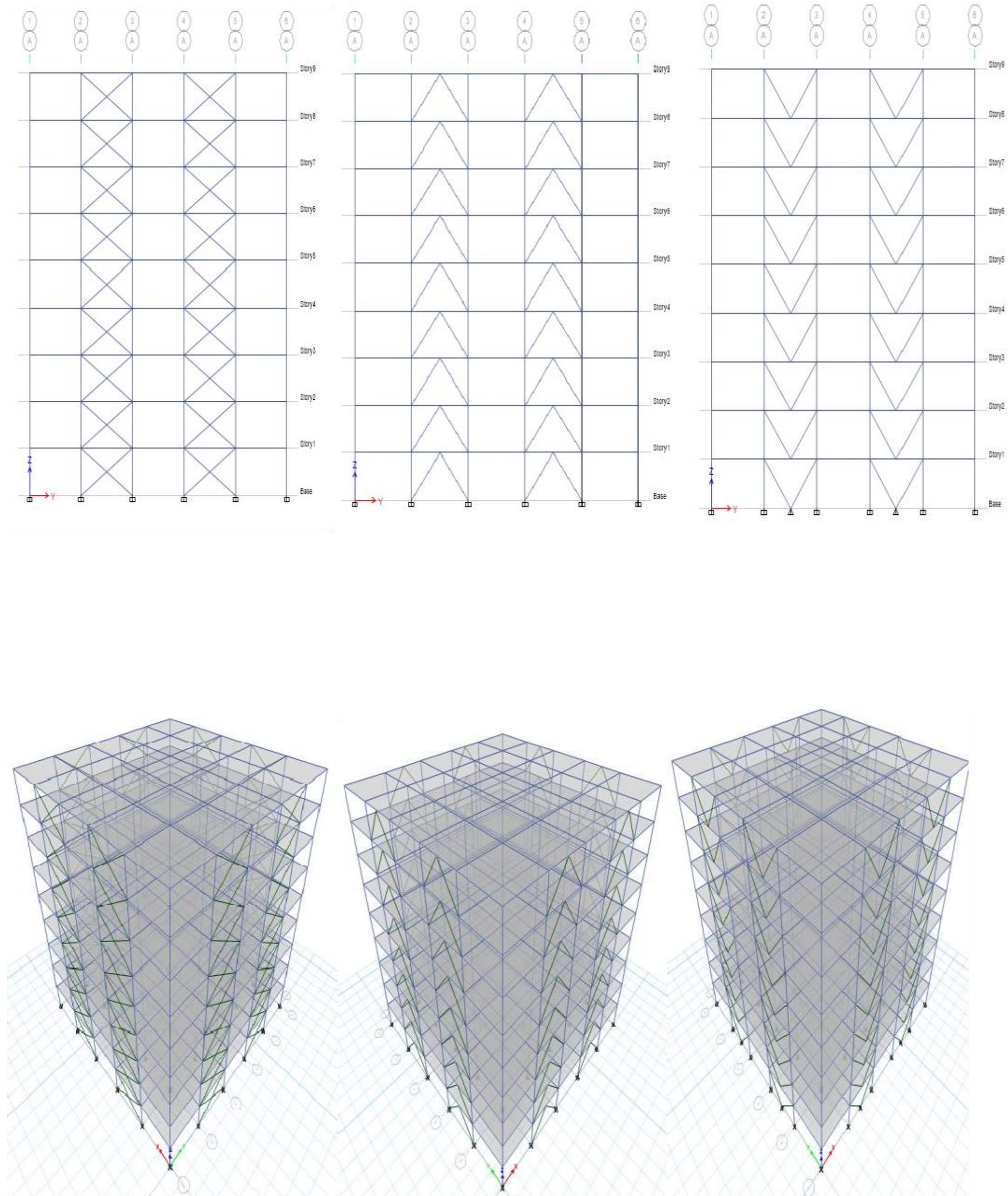


iii **iii**

CONFIGURATION 1

Figure 3.4: RC frame structure with configuration 1

The figure 3.4 shows RC frame with X, Inverted V &V bracings.the arrengement of bracings at two coreners and at middile it consider as a configuration 1.

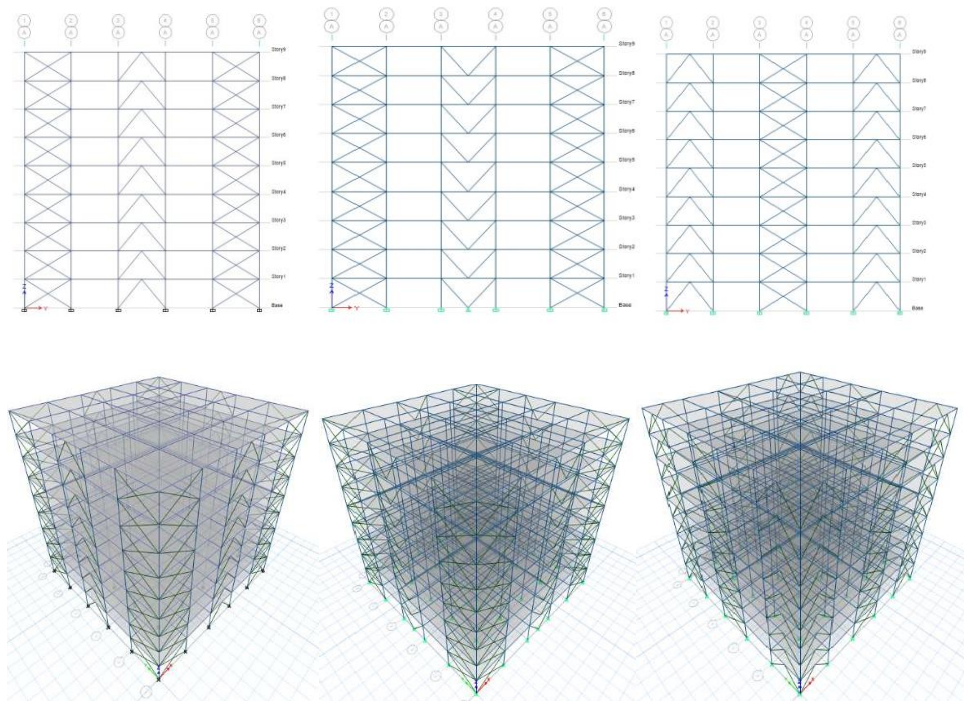


i **ii** **iii**

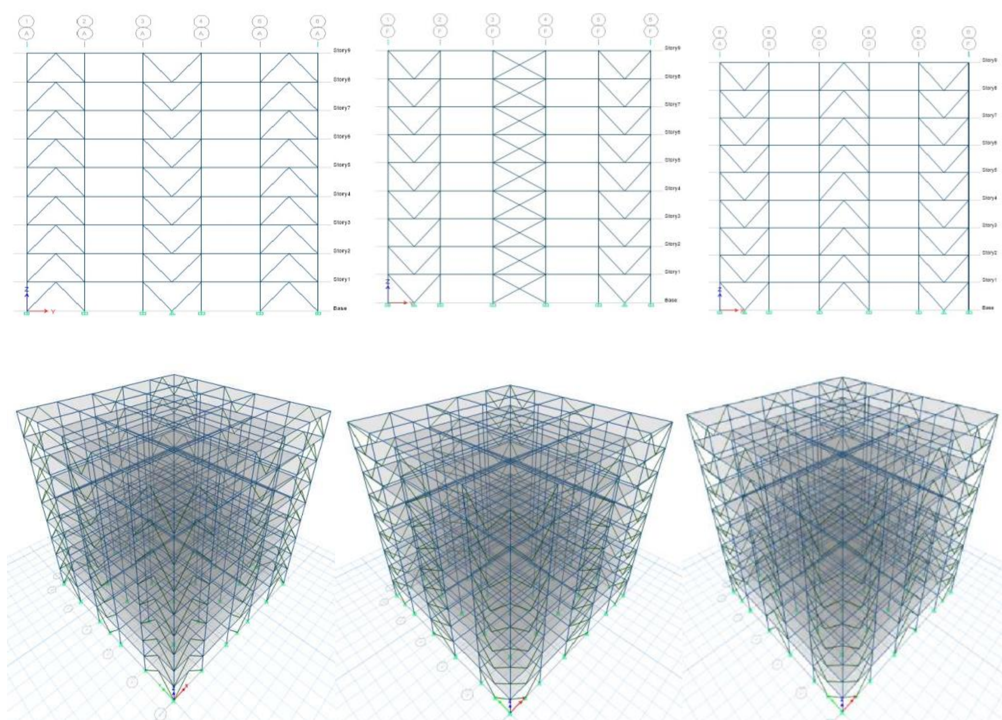
CONFIGURATION 2

Figure 3.5: RC frame structure with configuration 2

The figure 3.5 shows RC frame with X, Inverted V &V bracings.the above arrengement of bracings for RC frame consider as configuration 2.



i **ii** **iii**



iv **v** **vi**

CONFIGURATION 3

Figure 3.6: RC frame structure with configuration 3

The figure 3.6 shows RC frame with X, Inverted V &V bracings.the arrengement of bracings at two coreners and at middile.and in this configuration combination of bracings are arrenged.this arrengement consider as a configuration 3.

3.2.2 Material

The building considered here is specialbuilding having G + 9 storied located in seismic zone V and for earthquake loading, the provisions of the IS: 1893(Part1)2002 is considered. The plan of building is shown in fig. the building is planned to facilitate the basic requirements of special building. The plandimension of the building is 25x25 m. Height of each storey is 3m. The study is carried out on G + 9 storied building plan with below given material properties. The basic loading on the structure and other relevant data is tabulated in table 3.1.

Table 3.1: Section properties

Plan dimensions	25m x25m
Beam dimensions	350mm x400mm
Column dimensions	450mm x600mm
Thickness of slab	125mm
Grade of concrete	M30
Grade of reinforcement	Fe415
Steel bracing size	ISHB450
Live load	$3kN/m^2$
Floor finishes	$1kN/m^2$
Density of reinforced concrete	$25kN/m^3$

Table 3.2: Seismic data

Code	IS 1893:2002
Zone	V
Zone Factor (Z)	0.36
Response Reduction Factor (R)	5
Importance factor (I)	1.5
Soil type	II

Table 3.2 shows seismic data of the structure. The building consider here is special building having G+9 storied located in Zone-V and Response reduction is consider as 5

for special buildings and important factor is 1.5 for educational building are taken from the code provision IS:1893(part-1)-2002[6].

3.2.3 Loading

The loads such as dead load, live load etc., will be acting on the building. For this thesis the loads such as gravity and dynamic loads are only considered to understand the nature of building for these load conditions.

3.3 Static linear analysis

Linear static analysis represents the most basic type of analysis. The term “linear” means that the computed response displacement or stress, for example is linearly related to the applied force. The term “static” means that the forces do not vary with time or, that the time variation is insignificant and can therefore be safely ignored. An example of a static force is a building's dead load, which is comprised of the building's weight plus the weight of offices, equipment, and furniture. This dead load is often expressed in terms of lb/ft^2 or N/m^2. Such loads are often defined using a maximum expected load with some factor of safety applied for conservatism.

In addition to the time invariant dead load described above, another example of a static load is an enforced displacement. For example, in a building part of the foundation may settle somewhat, inducing static loads. Another example of a static load is a steady-state temperature field. The applied temperatures cause thermal expansion which, in turn, causes induced forces.

The static analysis equation is: $[K]\{u\} = \{f\}$ (3.1)

Where K= stiffness and u= displacement

In linear static analysis displacements, strains, stresses and reaction forces under the effect of applied loads are calculated.

3.3.1. Gravity Loads (IS456)

Loads in a structure can be specified as joint load, member load, temperature load and fixed end member load. E-TABS can also generate the self-weight of the structure and use it as uniformly distributed member loads in analysis. Any fraction of this self-weight can also be applied in any desired direction.

3.3.2 Joint loads

Joint loads, both forces and moments, may be applied to any free joint of a structure. These loads act in the global coordinate system of the structure. Positive forces act in the positive coordinate directions. Any number of loads may be applied on a single joint, in which case the loads will be additive on that joint.

3.3.3 Dead loads

All permanent constructions of the structure form the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights. the unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kN/m and 25 kN/m respectively.

3.4 Dynamic analysis

3.4.1 Response Spectrum Method

Response spectrum method of analysis shall be performed using the design spectrum specified, or by a site-specific design spectrum mentioned in the response spectrum method. This approach permits the multiple modes of response of a building to be taken into account (in the frequency domain). This is required in many building codes for all except very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the "harmonics". Computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions i.e. X, Y & Z and then see the effects on the building. Combination methods include the following:

- absolute - peak values are added together
- square root of the sum of the squares (SRSS)

- complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes

The result of a response spectrum analysis using the response spectrum from a ground motion is typically different from that which would be calculated directly from a linear dynamic analysis using that ground motion directly, since phase information is lost in the process of generating the response spectrum. In cases where structures are either too irregular, too tall or of significance to a community in disaster response, the response spectrum approach is no longer appropriate, and more complex analysis is often required, such as non-linear static analysis or dynamic analysis.

3.4.2 Design Lateral Force

The design lateral force shall first be computed for the building as a whole. This design lateral force shall then be distributed to the various floor levels. The overall design seismic force thus obtained at each floor level shall then be distributed to individual lateral load resisting elements depending on the floor diaphragm action.

3.4.3 Design Seismic Base Shear

The total design lateral force or design seismic base shear (V_b) along any principal direction shall be determined by the following expression:

$V_b= A_h \times W$

Where, A_h = horizontal acceleration spectrum W = seismic weight of all the floors

Fundamental Natural Period The approximate fundamental natural period of vibration (T), in seconds, of a moment resisting frame building without brick in the panels may be estimated by the empirical expression: Ta=0.075h0.75 for RC frame building Ta=0.085 h0.75 for steel frame building Where, h = Height of building, in m. This excludes the basement storey's, where basement walls are connected with the ground floor deck or fitted between the building columns. But it includes the basement storey's, when they are not so connected. The approximate fundamental natural period of vibration (T), in seconds, of all other buildings, including moment-resisting frame buildings with brick lintel panels, may be estimated by the empirical Expression:

$$T=.09H/\sqrt{D} \qquad (3.2)$$

Where, h= Height of building, d= Base dimension of the building at the plinth level, in m, along the considered direction of the lateral force.

3.4.4 Distribution of Design Force

Vertical Distribution of Base Shear to Different Floor Level The design base shear (V) shall be distributed along the height of the building as per the following expression:

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2} \qquad (3.3)$$

Q_i = Design lateral force at floor I,

W_i = Seismic weight of floor I,

h_i = Height of floor, 'I' measured from base, and

n = Number of storey's in the building is the number of levels at which the masses are located. Distribution of Horizontal Design Lateral Force to Different Lateral Force Resisting Elements in case of buildings whose floors are capable of providing rigid horizontal diaphragm action, the total shear in any horizontal plane shall be distributed to the various vertical elements of lateral force resisting system, assuming the floors to be infinitely rigid in the horizontal plane. In case of building whose floor diaphragms can not be treated as infinitely rigid in their own plane, the lateral shear at each floor shall be distributed to the vertical elements resisting the lateral forces, considering the in-plane flexibility of the diagram. The total shear in direction of horizontal plane shall be distributed to the various vertical elements of lateral forces resisting system, assuming the floors to be infinitely rigid in the horizontal plane.

3.5 Beam Design

Beams are designed for flexure, shear and torsion. If required the effect of the axial force any be taken into consideration. For all these forces, all active beams loading are pre scanned to identify the critical load cases at different section of the beams. The width of the member shall be not less than 200mm. Also the number shall perfectly have a widthto depth ratio of more than 0.3. The beam consideration is rectangular beam. The bending moment and deflection of the beam will be calculated by considering the different types of loads.

3.5.1 Column Design

- Columns are designed for axial forces and biaxial moments per IS456:2000. Columns are also designed for shear forces. All major criteria for selecting longitudinal and transverse reinforcement as stipulated by IS: 456 :2000 have been taken care of in the column designed of E-TABS. However following clauses have been satisfied to incorporate provision of IS 13929:1993cl 7 the minimum grade of concrete shall preferably be M30.
- Steel reinforcements of grade Fe415 or less only shall be used
- The minimum dimension of column member shall not be less than 200mm. For columns having unsupported length exceeding 4m, the shortest dimension of column shall not be less than 300mm.
- The ratio of the shortest cross-sectional dimension to the perpendicular dimension shall preferably be not less than 0.
- The spacing of hoops shall not exceed half the least lateral dimension of the column, except where special confining reinforcement is provided.
- Special confining reinforcement shall be provided over a length from each joint face, towards mid span, and on either side of any section, where flexural yielding may occur. The length shall not be less than

a) larger lateral dimension of the member at the section where yielding occurs,

b) 1/6 clear span of the member

c) 450mm.

- The spacing of hoops used as special confining reinforcement shall not excced1/4 of minimum but need not be less than 75mm nor more than 100mm.

3.6 Analysis in ETABS

The analysis of the building is carried out using ETABS computer program. The following topics describe some of the important areas in the modeling.

3.6.1 Response spectrum analysis

Response spectrum analysis of the building models is performed in on it apps ETABS. The Latin the lateral load distribution generated by ETABS respond to the seismic zone 2 and the 5% damped response spectrum given in IS: 1893-2002 analysis only one in invariant lateral load pattern was utilized to represent the likely distribution of inertia forces imposed on the frames during an earthquake and the utilized lateral load pattern is described as follows note that the story forces are normalized with the Base shear to have a total Base shear equals to Unity.

3.6.2 Multimodal or SRSS lateral load pattern

The lock pattern considers the effects of higher modes of ivory vibration for long time long period and irregular structures and the lateral force at any story is calculated as square root of sum of Squares SRSS combinations of the load distribution obtained from the modal analysis of the structures.

3.6.3 The analysis of ETABS

1. Modeling
2. Static analysis
3. Response spectrum analysis

3.6.4 Steps involved in Response Spectrum Analysis in ETABS

1. Define the load patterns and add new load of earthquake in X and Y directions. Select type as seismic and select auto lateral load as IS: 1893:2002 and modify lateral load according to our region.

2. Define the function and then select the response spectrum. Add new function and next select the function type as IS: 1893:2002.
3. Define the load cases and add new load case. Enter the load case data response spectrum in X direction; in that we will give load case type as response spectrum. In loads applied, we will add new, in this we select load type as acceleration, direction is U1, function is whatever functions we have mentioned there is Indian standard response spectrum (IS RS) and then enter the scale factor value.
4. **Scale factor:** The response-spectrum scale factor is *I g / R*, where *g* is acceleration due to gravity (386.4 in/sec^2 for kip-in and 9.81 m/sec^2 for kN-m). After analysis, we should review the base shear due to all modes, reported in the Response Spectrum Base Reaction Table. If the dynamic base shear reported is more than 85% of the static base shear, no further action is required. However, if dynamic base shear is less

than 85% of the static base shear, then the scale factor should be adjusted such that the response-spectrum base shear matches 85% of the static base shear. In this case, the new scale factor would be($I\ g\ /\ R$) * (0.85 * static base shear / response-spectrum base shear). Analysis should then be rerun with this scale factor specified in the response-spectrum case.

5. Next add another new load case as response spectrum in y direction and select load case type as response spectrum then change the direction that U_1 to U_2 because in the Y direction now and the function will be Indian standard response spectrum and scale factor is calculated and all the things remains same as before we have given for RS-X. So RS-X an RS-Y have been set then press ok.
6. Define the load combinations as per our requirement.
7. Before doing the response spectrum we should check that our joints are fixed if the joints are not fixed the fix the joints.
8. Next step is assigning, so we will select whole structure and we assign the diaphragm to the shell for that we will assign go to shell then assign diaphragms in that select D1 as diaphragm apply. The diaphragm is assigned to the whole structure of the shells such that that will act as a single mass.
9. Then we will go for analysis, we will check the model first because wehave did this checking of model before so we will check it again such that all the things are safe or not.
10. Check the model if any warning messages have been generated, if no warning messages are generated then the model is said to be safe and read to run for the analysis.
11. Run the analysis, the analysis will be running it will take some time based upon our height of the structure and number of panels taken for the structure to be analyzed.
12. Once the analysis is completed, we can see the deflection, displacements for the dead load on the screen and we can see that there is a button for start animation.
13. Start the animation**,** Check the earthquake x and y direction and we will see whether they are moving in proper direction what we have provided for load cases.
14. Next go to display show tables and then go to the mode period and frequencies for checking the time period and frequency values for each mode.
15. Then go to display to show the store response plots. In this store response plots, we can check for maximum story displacement, maximum story drift, story shear, story

stiffness, overturning moments and we can also export the graphs to excel for print the data.

3.7 Conclusion

In this chapter the methodology, modeling and analysis has been explained. The types of loads are briefly explained. An RC G+9 building is considered and modeled into E-TABS by applying Response spectrum analysis. The analysis procedure of response spectrum analysis is briefly explained. A Nine storied reinforced concrete frame structure of building was taken to analysis. The frame was subjected to design earthquake forces as specified in the IS code for zone V along X and Y directions. Finally, the results obtained have been shown in tabulated forms. The next chapter deals with the results of these structures generated here.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter the analysis carried out on the 3D structures. Finally, the results obtained from the analysis are taken into consideration based on the aim of the research. After getting the results these are compared to draw the final conclusion from it. As it is discussed in the previous chapters that the response spectrum analysis has been carried out, from that the effectiveness of the results on these models is obtained in this chapter. Dynamic analysis may be performed by the Response Spectrum Method.

4.2 Modal analysis

A modal analysis calculates the frequency modes or natural frequencies of a given system, but not necessarily its full-time history response to a given input. The natural frequency of a system is dependent only on the stiffness of the structure and the mass which participates with the structure (including self-weight).

It is useful to know the modal frequencies of a structure as it allows you to ensure that the frequency of any applied periodic loading will not coincide with a modal frequency and hence cause resonance, which leads to large oscillations as shown in below figure 4.1.

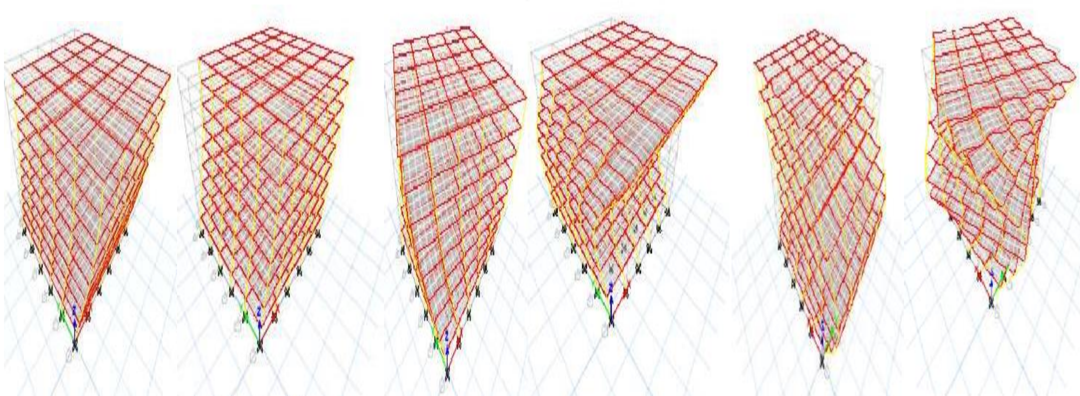
The method is:

1. Find the natural modes (the shape adopted by a structure) and natural frequencies

2. Calculate the response of each mode

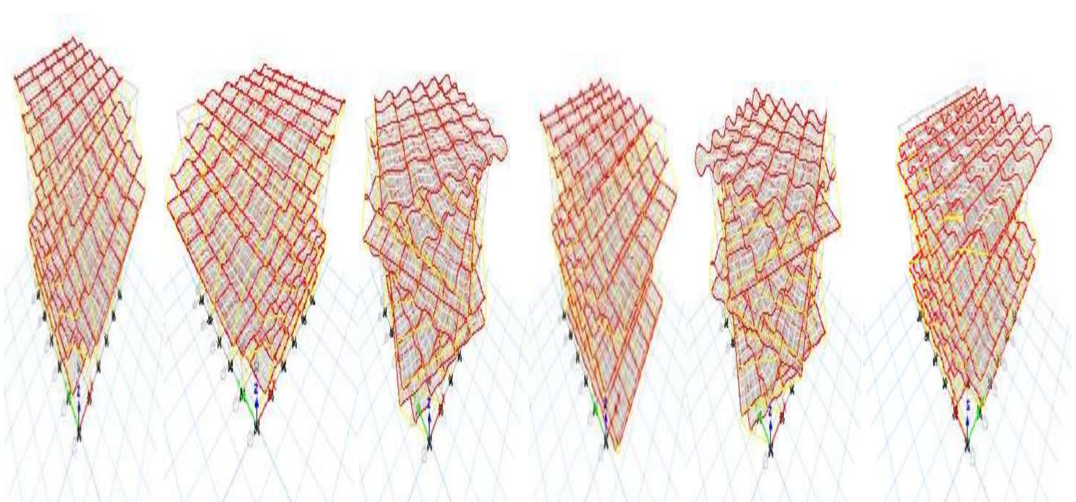
3. Optionally superpose the response of each mode to find the full modal response to a given loading.

4.2.1 MODE SHAPES



Mode shape 1 Mode shape 2 Mode shape3 Mode shape 4 Mode shape 5 Mode shape 6

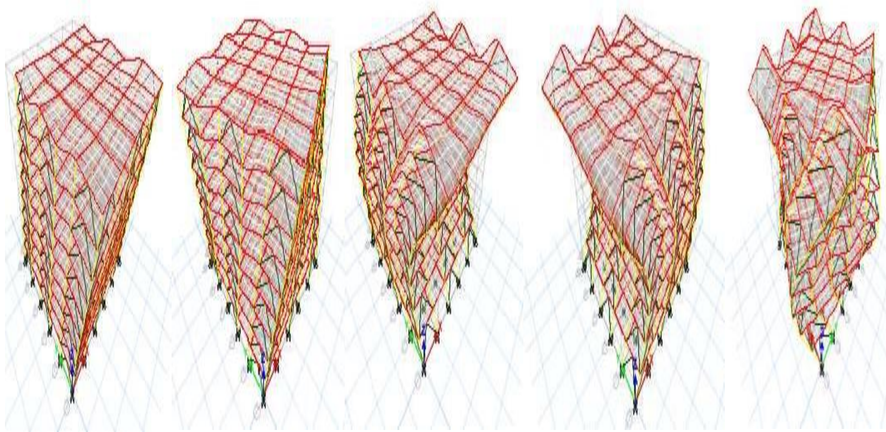
Period 1.576Period 1.468Period 1.411Period 0.507Period 0.463Period 0.45



Mode shape 7 Mode shape 8 Mode shape 9 Mode shape 10 Mode shape 11 Mode shape 12

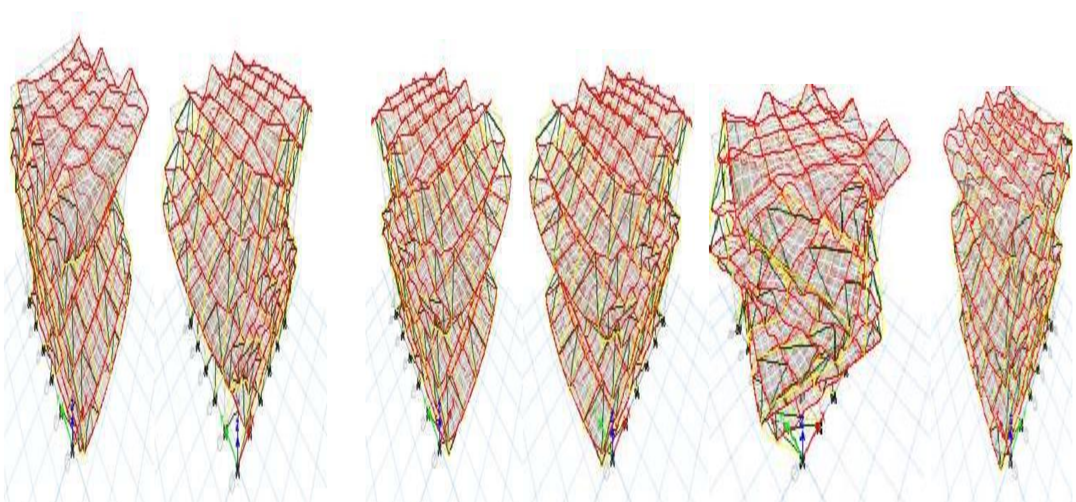
Period 0.286Period 0.253Period 0.25Period 0.19 Period 0.163Period 0.162

Figure 4.1: Mode shapes of RC frame structure



Mode shape 1 Mode shape 2 Mode shape 3 Mode shape 4 Mode shape 5 Mode shape 6

Period 0.815Period 0.801Period 0.519Period 0.253Period 0.247Period 0.163



Mode shape 7 Mode shape8 Mode shape 9 Mode shape 10 Mode shape 11 Mode shape 12

Period 0.137Period 0.133Period 0.098Period 0.093 Period 0.088Period 0.077

Figure 4.2: Mode shapes of RC frame structure with inverted V bracings

The figure 4.1,4.2 shows the modes shapes of RC frame and mode shapes of RC frame structure with inverted V bracings. Maximum time period is 1.576 sec at RC frame without bracings.and minimum is 0.815 sec at INV V bracing in configuration 1. The time period of the structures decreases from mode shape1 to mode shape12. Time Period of the inverted V Braced buildingis less when compared to the unbraced building and other braced building (X and V braced buildings).

4.2.2 Time Period

In any structure the stresses are basically calculated from the net displacement of each and every node in various directions. Once we calculated the displacements, the building will oscillate back-and-forth horizontally and after some time comes back to the original position, these oscillations are periodic. The time taken in seconds for each complete cycle of oscillation (i.e. one complete back-and-forth motion) is the same and is called Fundamental Natural Period T of the building.

Table-4.1: Time period results of RC frame and configuration 1

MODE	RC FRAME (sec)	CONFIGURATION 1		
		X	INV V	V
		(sec)		
1	1.576	0.824	**0.815**	0.892
2	1.468	0.809	0.801	0.872
3	1.411	0.518	0.519	0.569
4	0.507	0.238	0.253	0.256
5	0.463	0.233	0.247	0.25
6	0.45	0.151	0.163	0.164
7	0.286	0.127	0.137	0.138
8	0.253	0.124	0.133	0.134
9	0.25	0.091	0.098	0.098
10	0.19	0.087	0.093	0.094
11	0.163	0.08	0.088	0.088
12	0.162	0.073	0.077	0.077

Table-4.1 shows the time period of the RC frame without bracing and with configuration 1 of bracing system. The time period of the structures decreases from mode shape1 to mode shape12. Time Period of the INV V Braced building is less when compared to the unbraced building and other braced building (X and V braced buildings). Maximum time period is 1.576 sec at RC frame without bracings.and minimum is 0.815 sec at INV V bracing with configuration 1

Table- 4.2: Time period results of RC frame and configuration 2

MODE	RC FRAME (sec)	CONFIGURATION 2		
		X	INV V	V
		(sec)		
1	1.576	0.944	**0.933**	1.011
2	1.468	0.921	0.911	0.982

3	1.411	0.662	0.652	0.718
4	0.507	0.275	0.29	0.294
5	0.463	0.267	0.281	0.284
6	0.45	0.187	0.199	0.202
7	0.286	0.146	0.157	0.157
8	0.253	0.141	0.15	0.151
9	0.25	0.102	0.11	0.11
10	0.19	0.097	0.105	0.106
11	0.163	0.097	0.104	0.104
12	0.162	0.081	0.086	0.086

Table-4.2 shows the time period of the RC frame without bracing and with configuration 2 of bracing system. The time period of the structures decreases from mode shape1 to mode shape12. Time Period of the INV V Braced building is less when compared to the unbraced building and other braced building (X and V braced buildings). Maximum time period is 1.576 sec at RC frame without bracings.and minimum is 0.933 sec at INV V bracing with configuration 2.

Table-4.3: Time period results of RC frame and configuration 3

MODE	RC FRAME (sec)	CONFIGURATION 3					
		X &INVV	X &V	INV V &X	INV V &X	V & X	V &INV V
		(sec)					
1	1.576	0.829	0.844	**0.82**	0.839	0.867	0.862
2	1.468	0.805	0.827	0.805	0.823	0.849	0.845
3	1.411	0.516	0.531	0.521	0.534	0.553	0.55
4	0.507	0.243	0.244	0.248	0.254	0.25	0.255
5	0.463	0.237	0.238	0.242	0.248	0.244	0.249
6	0.45	0.153	0.154	0.159	0.164	0.159	0.163
7	0.286	0.13	0.131	0.133	0.137	0.134	0.138
8	0.253	0.127	0.127	0.13	0.133	0.13	0.133
9	0.25	0.093	0.093	0.095	0.098	0.095	0.098
10	0.19	0.089	0.089	0.091	0.093	0.091	0.094
11	0.163	0.082	0.082	0.085	0.088	0.085	0.088
12	0.162	0.074	0.074	0.075	0.077	0.075	0.077

Table-4.3 shows the time period of the RC frame without bracing and with different configuration of bracing system. Time Period of the INV V & X Braced building is less when compared to the unbraced building and other braced building.Maximum time period is 1.576 sec at RC frame without bracings.and minimum is 0.82 sec at INV V& X bracing with configuration 3.

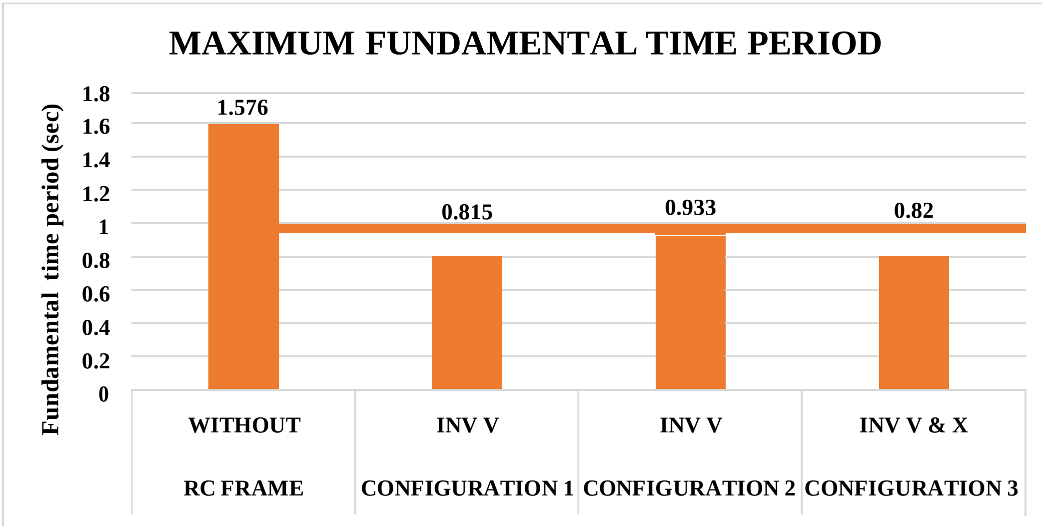


Figure 4.3: Maximum fundamental time period

The time periods of the building without bracing and with different configuration of bracing system. Maximum time period is 1.576 sec at RC frame without bracings.and minimum is 0.815 sec at INV V bracing in configuration 1. The time period of the structures decreases from mode shape1 to mode shape12. Time Period of the INV V Braced building is less when compared to the unbraced building and other braced building (X and V braced buildings). Time period of structure is decreased when bracings providing to the RC frame. Because providing bracings increases the stiffness of the structure. We know that time period of structure is directly proportional to both mass and stiffness as below.

4.3 Response spectrum analysis

An important aspect of earthquake loads exerted on extended structures, or structures founded on several foundations, is the spatial variability of the seismic motion. Hence, a rigorous earthquake resistant design of lifeline structures should account for the spatial character of the seismic input, at least in an approximate way.

For response spectrum analysis G+9 building is considered and located in seismic zone V. For earthquake loading, the provisions of the IS: 1893(Part1)2002 is considered. The zone factor value is 0.36 and soil type is medium soil.

4.4StoreyDisplacement from response spectrum analysis

Storey displacement is displacement with respect to base of the structure.

Table-4.4: Storey displacement results of RC frame and configuration 1

STOREY	RC FRAME (mm)	CONFIGURATION 1		
		X	INV V	V
		(mm)		
9	36.621	23.427	**23.055**	24.655
8	35.01	21.147	20.955	22.426
7	32.516	18.461	18.404	19.759
6	29.125	15.57	15.584	16.841
5	24.92	12.556	12.591	13.75
4	19.988	9.515	9.533	10.587
3	14.445	6.566	6.54	7.451
2	8.55	3.843	3.766	4.466
1	3.017	1.47	1.384	1.727
BASE	0	0	0	0

Table - 4.4 shows that the storey displacement of X, inverted V, V bracings and without bracings with configuration 1. It is observed that Storey displacements are found within the permissible limit as specified by IS: 1893-2002. Storey Displacement of the INV V Braced building is less when compared to the unbraced building and other braced building (X and V braced buildings).Maximum storey displacement is 36.621 mm at RC frame without bracings.and minimum is 23.055 mm at INV V bracing with configuration 1.

Table-4.5: Storey displacement results of RC frame and configuration 2

STOREY	RC FRAME (mm)	CONFIGURATION 2		
		X	INV V	V
		(mm)		
9	36.621	26.035	**25.564**	27.105
8	35.01	23.653	23.4	24.811
7	32.516	20.782	20.688	22.004
6	29.125	17.633	17.632	18.87
5	24.92	14.309	14.345	15.506
4	19.988	10.913	10.946	12.02
3	14.445	7.576	7.572	8.505
2	8.55	4.447	4.384	5.107
1	3.017	1.682	1.605	1.945
BASE	0	0	0	0

Table - 4.5 shows that the storey displacement of X, inverted V, V bracings and without bracings with configuration 2. It is observed that Storey displacements are found within the permissible limit as specified by IS: 1893-2002. Storey Displacement of the INV V Braced building is less when compared to the unbraced building and other braced building (X and V braced buildings).Maximum storey diaplacement is 36.621 mm at RC frame without bracings.and minimum is 25.564 mm at INV V bracing with configuration 2.

Table-4.6: Storey displacement results of RC frame and configuration 3

STOREY	RC FRAME (mm)	CONFIGURATION 3					
		X & INV V	X &V	INV V &X	INV V &V	V & X	V & INV V
		(mm)					
9	36.621	23.266	23.786	**23.215**	23.552	24.235	24.047
8	35.01	21.05	21.524	21.043	21.41	21.98	21.869
7	32.516	18.41	18.845	18.44	18.824	19.3	19.246
6	29.125	15.545	15.947	15.591	15.977	16.384	16.364
5	24.92	12.542	12.912	12.588	12.957	13.313	13.308
4	19.988	9.502	9.844	9.534	9.885	10.184	10.19
3	14.445	6.545	6.856	6.554	6.865	7.121	7.12
2	8.55	3.812	4.069	3.794	4.035	4.239	4.223
1	3.017	1.443	1.549	1.415	1.494	1.627	1.599
BASE	0	0	0	0	0	0	0

Table - 4.6 shows that the storey displacement of combinations of bracings and without bracings with configuration 3. It is observed that Storey displacements are found within the permissible limit as specified by IS: 1893-2002. Storey Displacement of the INV V&X Braced building is less when compared to the unbraced building and other braced building.Maximum storey displacememt is 36.621 mm at RC frame without bracings.and minimum is 23.215 mm at INV V& X bracing with configuration 3.

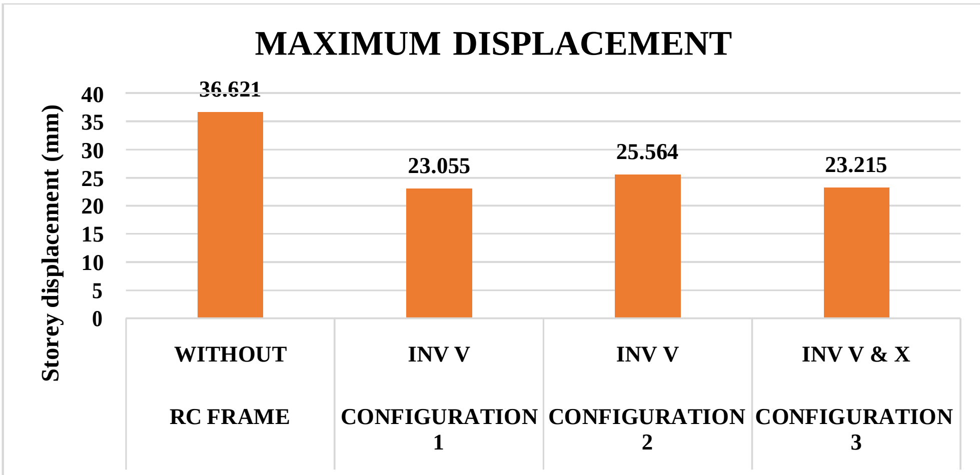


Figure 4.4: Maximum Storey Displacement

The figure 4.4 shows that the Storey Displacement is reduced byproviding bracings to the structure. Storey Displacement of the inverted V bracing with configuration 1 structure is less when compared to the unbraced building and other braced building. maximum storey displacement is 36.621 mm at RC frame without bracing. Minimum storey displacement is 23.055 mm at RC frame with configuration 1 with inverted V bracing.

4.5 Storey Drift from response spectrum analysis

Storey drift is the difference of displacements between two consecutive stories divided by the height of that storey.

Table-4.7: Storey drift results of RC frame and configuration 1

STOREY	RC FRAME (mm)	CONFIGURATION 1		
		X	INV V	V
		(mm)		
9	0.00066	0.00081	0.00075	0.00079
8	0.00099	0.00092	0.00088	0.00091
7	0.00128	0.00099	0.00097	0.001
6	0.00152	0.00103	0.00102	0.00105
5	0.00172	0.00103	0.00104	0.00108
4	0.00189	0.00099	0.00101	0.00106
3	0.00198	0.00093	**0.00091**	0.001
2	0.00185	0.00079	0.0008	0.0009
1	0.00101	0.00049	0.00046	0.00058
BASE	0	0	0	0

Table - 4.7 shows that the storey drift of X, inverted V, V bracings and without bracings with configuration 1. It is observed that Storey drifts are found within the permissible limit as specified by IS: 1893-2002. The storey drift of INV V braced building is less as compared to the unbraced building and other braced building (X and V braced buildings) thus the overall response of the building decreases.Maximum storey drift is 0.001978at RC frame without bracings.and minimum is 0.000912at INV V bracing with configuration 1.

Table-4.8: Storey drift results of RC frame and configuration 2

STOREY	RC FRAME (mm)	CONFIGURATION 2		
		X	INV V	V
		(mm)		
9	0.00066	0.00084	0.00077	0.00081
8	0.00099	0.00099	0.00094	0.00097
7	0.00128	0.00108	0.00106	0.00108
6	0.00152	0.00114	0.00113	0.00116
5	0.00172	0.00115	0.00116	0.00119
4	0.00189	0.00113	0.00114	0.00119
3	0.00198	0.00109	**0.00107**	0.00114
2	0.00185	0.00095	0.00093	0.00104
1	0.00101	0.00056	0.00054	0.00065
BASE	0	0	0	0

Table - 4.8 shows that the storey drift of X, inverted V, V bracings and without bracings with configuration 2. It is observed that Storey drifts are found within the permissible limit as specified by IS: 1893-2002. The storey drift of INV V braced building is less as compared to the unbraced building and other braced building (X and V braced buildings) thus the overall response of the building decreases.Maximum storey drift is 0.001978 at RC frame without bracings.and minimum is 0.00107at INV V bracing with configuration 2.

Table-4.9: Storey drift results of RC frame and configuration 3

STOREY	RC FRAME (mm)	CONFIGURATION 3					
		X & INV V	X &V	INVV &X	INV V &V	V & X	V& INV V
		(mm)					
9	0.00066	0.00079	0.00081	0.00077	0.00077	0.0008	0.00078
8	0.00099	0.0009	0.00092	0.0009	0.00089	0.00092	0.0009
7	0.00128	0.00098	0.00099	0.00098	0.00098	0.001	0.00099
6	0.00152	0.00102	0.00103	0.00103	0.00103	0.00105	0.00104
5	0.00172	0.00103	0.00104	0.00104	0.00105	0.00106	0.00106
4	0.00189	0.001	0.00101	0.00101	0.00103	0.00104	0.00104
3	0.00198	0.00093	0.00094	**0.00093**	0.00096	0.00097	0.00098
2	0.00185	0.00079	0.00082	0.00079	0.00083	0.00086	0.00086
1	0.00101	0.00048	0.00052	0.00047	0.0005	0.00054	0.00053
BASE	0	0	0	0	0	0	0

Table - 4.9 shows that the storey drift of RC frame and RC with configuration 3. It is observed that Storey drifts are found within the permissible limit as specified by IS: 1893-2002. The storey drift of INV V & X braced building is less as compared to the unbraced building and other braced building thus the overall response of the building decreases.Maximum storey drift is 0.001978at RC frame without bracings.and minimum is 0.000926 at INV V&X bracing with configuration 3.

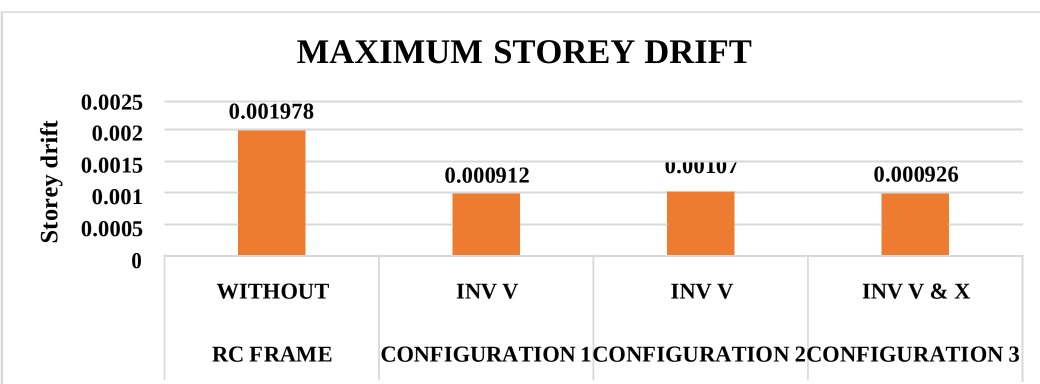


Figure 4.5: Maximum Storey drift

The figure 4.5 shows that the Storey drift is reduced byproviding bracings to the structure. Storey drift of the inverted V bracing with configuration 1 structure is less when compared to the unbraced building and other braced building. maximum storey drift is 0.001978 mm at RC frame without bracing. Minimum storey drift is 0.000912 mm at RC frame with configuration 1 with inverted V bracing.

4.6 Storey Shear from response spectrum analysis

Storey shear is the total load at that particular story.In these the results are compared to draw out some of the conclusions. The story shear values are compared from response spectrum analysis.

Table-4.10: Storey shear results of RC frame and configuration 1

STOREY	RC FRAME (kN)	CONFIGURATION 1		
		X	INV V	V
		(kN)		
9	745.66	1248.20	1244.86	1145.54
8	1297.23	2280.17	2281.23	2089.15
7	1691.67	3071.16	3084.5	2813.7
6	1995.11	3701.57	3728.32	3392.71
5	2245.71	4227.25	4263.27	3877.09
4	2488.44	4681.87	4722.79	4301.15
3	2719.19	5064.99	5104.98	4662.21
2	2920.57	5358.53	5392.10	4940.71
1	3022.60	5503.49	**5540.92**	5080.17

Table - 4.10 shows that the storey shear values of X, V, inverted V bracings and without bracings. It is observed that the story shear of INV V braced building is very high when compared to unbraced building and other braced building (X and V braced buildings) which indicates that stiffness of building has been increased. Minimum storey shear is 3022.60 kN at RC frame without bracing. Maximum storey shear is 5540.92 kN at RC frame with configuration 1 with inverted V bracings.

Table-4.11: Storey shear results of RC frame and configuration 2

STOREY	RC FRAME (kN)	CONFIGURATION 2		
		X	INV V	V
		(kN)		
9	745.66	1111.08	1108.22	1036.26
8	1297.23	2007.00	2011.02	1867.53

7	1691.67	2678.79	2697.83	2490.29
6	1995.11	3209.12	3243.79	2981.76
5	2245.71	3654.09	3699.71	3394.55
4	2488.44	4051.11	4102.59	3767.83
3	2719.19	4396.8	4448.44	4096.97
2	2920.57	4670.22	4716.71	4359.66
1	3022.6	4808.19	**4848.21**	4493.8

Table - 4.11 shows that the storey shear values of X, V, inverted V bracings and without bracings. It is observed that the story shear of INV V braced building is very high when compared to unbraced building and other braced building (X and V braced buildings) which indicates that stiffness of building has been increased.Minimum storey shear is 3022.60 kN at RC frame without bracing. Maximum storey shear is 4848.21 kN at RC frame with configuration 2 with inverted V bracings.

Table-4.12: Storey shear results of RC frame and configuration 3

STOREY	RC FRAME (kN)	CONFIGURATION 3					
		X & INV V	X &V	INV V &X	INV V &V	V & X	V & INV V
		(kN)					
9	745.6604	1248.73	1215.27	1245.56	1211.57	1180.88	1180.35
8	1297.228	2284.15	2219.49	2279.1	2217.00	2154.52	2157.11
7	1691.666	3080.94	2990.07	3076.54	2994.41	2901.28	2910.11
6	1995.108	3717.03	3604.82	3714.49	3617.34	3497.44	3512.65
5	2245.707	4246.7	4117.94	4245.44	4136.19	3995.73	4015.42
4	2488.438	4703.66	4563.28	4702.65	4584.45	4429.99	4452.37
3	2719.194	5087.12	4939.7	5084.7	4959.89	4798.35	4821.15
2	2920.572	5371.09	5228.56	5379.82	5244.13	5081.89	5102.91
1	3022.603	**5521.94**	5371.7	5514.21	5382.51	5223.26	5241.97

Table - 4.12 shows that the storey shear values of RC frame and RC frame with configuration 3. It is observed that the story shear of INV V& X braced building is very high when compared to unbraced building and other braced building which indicates that stiffness of building has been increased.Minimum storey shear is 3022.60 kN at RC frame without bracing. Maximum storey shear is 5521.94 kN at RC frame with configuration 3 with X&INV V bracings.

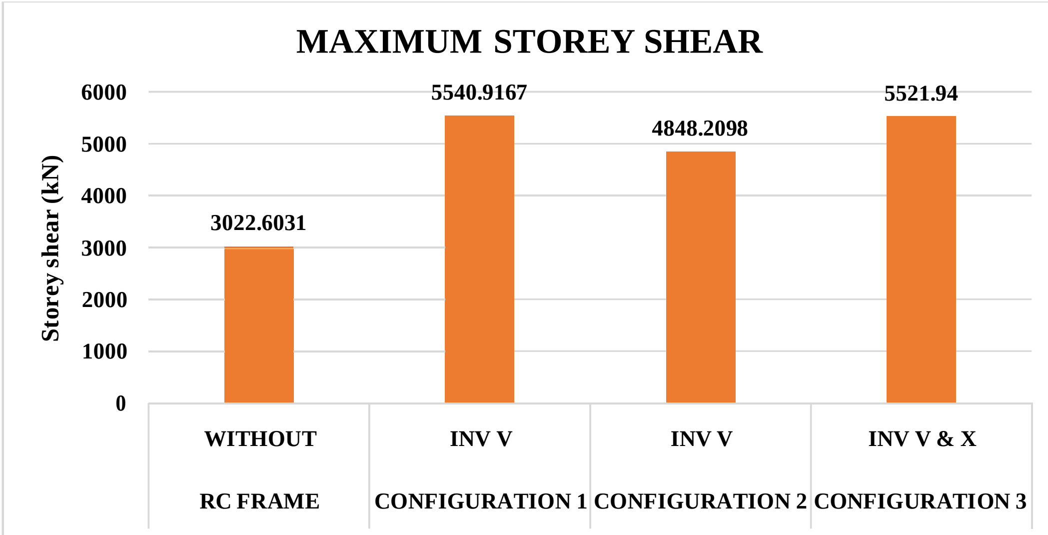


Figure 4.6: Maximum Storey shear

The figure 4.6 shows that the Storey shear is increased byproviding bracings to the structure. Storey shear of the inverted V bracing with configuration 1 structure is less when compared to the unbraced building and other braced building. minimum storey shear is 3022.60 kN at RC frame without bracing. Maximum storey shear is 5540.91 kN at RC frame with configuration 1 with inverted Vbracings.

4.7 Base shear from response spectrum analysis

Base shear is an estimation of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure.

Table-4.13:Base shearresults of RC frame and configurations

TYPES OF FRAMES	BASE SHEAR (kN)
RC FRAME	3734.21
CON 1 WITH X BRACINGS	6417.22
CON 1 WITH INV V BRACINGS	**6912.34**
CON 1 WITH V BRACINGS	6350.11
CON 2 WITH X BRACINGS	6010.27
CON 2 WITH INV V BRACINGS	6060.17
CON 2 WITH V BRACINGS	5617.26
CON 3 WITH X&INV V BRACINGS	6902.39
CON 3 WITH X&V BRACINGS	6714.55
CON 3 WITH INV V&X BRACINGS	6892.72
CON 3 WITH INV V&V BRACINGS	6728.15

CON 3 WITH V&X BRACINGS	6528.98
CON 3 WITH V&INV V BRACINGS	6552.46

Table - 4.13shows that the base shear values of RC frame and RC frame with configurations. It is observed that the base shear of configuration 1 with inverted V braced building is very high when compared to unbraced building and other braced building. Minimum base shear is 3734.21 kN at RC frame without bracing. Maximum base shear is 6912.34 kN at RC frame with configuration 1 with inverted V braced building.

4.8 Conclusion

The present work attempts to study the seismic response and performance level of G+9 storied RC building located in seismic zone - V. In this study all important components of the building that influence the mass, strength, stiffness and deformability of the structure are included in the analytical model to study the behavior of different bracing systems in longitudinal and transverse direction. The deflections at different storey levels and storey drifts are compared by performing response spectrum method. The seismic performance level of the building models are obtained by performing response spectrum analysis. Among different types of bracings RC frame with inverted V bracings giving good results. Because based on their braced members arrangement and load translation along the bracing member. The study leads to the following conclusions.

CHAPTER 5

CONCLUSIONS

5.1 Summary

This 3D model deals with the procedure of analysis within the Etabs 2016 software and obtaining certain results from the analysis. The RC structure has been analyzed and comparative results have been developed using response spectrum analysis. The frame was subjected to design earthquake forces as specified in the IS code for zone V. Using these results the conclusion on research is obtained by subsequent discussion.

5.2 Conclusion

1. Inverted V type of bracing is found to be more efficient in zone against lateral seismic loading as they show better performance in terms of strength and stiffness.
2. Time period of the Inverted V braced building is less when compared to the unbraced building and other braced building.in three configurations the time period of the structure decreased. Among three configurations the configuration 1 with inverted V bracings giving less time period.
3. Storey displacement of the structure with bracing system effectively reduces the lateral displacement up to 45.2% of the structure compared to RC frame without bracing. in three configurations the storey displacement of the structure is less compared to RC frame without bracing. Among three configurations the configuration 1 with inverted V bracings giving less storey displacement.
4. Storey drift reduced 40% when compared to RC frame without bracing. in three configurations the storey drift of the structure less compared to RC frame without bracing. Among three configurations the configuration 1 with inverted V bracings giving less storey drift.
5. Storey shear of structure increased 45.89% compared to RC frame without bracing which indicates that stiffness of building has increased.in three configurations the storey shear of structure increased compared to RC frame without bracing. Among three configurations the configuration 1 with inverted V bracings giving high storey shear.

6. Due to the increase in stiffness, the structure with braces is subjected to large base shear as compared to the RC frame. The base shear of the structure with bracings increased up to 47.44% for RC frame. in three configurations the base shear of structure increased compared to RC frame without bracing. Among three configurations the configuration 1 with inverted V bracings giving high base shear.

5.3 Future Scope

The present study can be further extended by

1. Same study can be done by varying the size of the storey heights.
2. Concrete bracings using higher grade of concrete and steel braces with different sections can be studied.
3. Seismic response for irregular structure can be studied.

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A Major Project Report
On

ANALYSIS OF RC BUILDING FRAME FOR SEISMIC ANALYSIS FOR ZONE-V

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

By

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This is to certify that the project entitled **Analysis of RC Building Frame For Seismic Analysis For Zone-V**, is being submitted by **T. Abhishek (18K85A0104), D. Navaraj (17K81A0119), K. Nikhil (17K81A0135), N. Hemavanth Reddy (16K81A014)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN CIVIL ENGINEERING** is recorded of bonafide work carried out by them. The result embodied in this report has been verified and found satisfactory.

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DECLARATION

We, the students of Bachelor **of Technology** in **Department of Civil Engineering**, of the Academic Year: 2017 - 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project entitled **Analysis of RC Building Frame For Seismic Analysis For Zone-V** is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been carried by taking care of Engineering Ethics. The result embodied in this project report has not been submitted in any university for award of any degree.

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ABSTRACT

The response of building when subjected to seismic excitation can be evaluated in several ways. Structural analysis methods can be mainly divided into four categories Equivalent Static Analysis, Linear dynamic analysis, Nonlinear Static Analysis, Nonlinear dynamic analysis. Equivalent Static Analysis method or linear static analysis, defines a series of forces acting on a building to represent the effect of earthquake ground motion. In this method, the design base shear is computed for the whole building, and it is then distributed along the height of the building. The response spectrum analysis determines the natural frequencies and mode shapes via Eigen value analysis. It is used to estimate the peak response whereas the time history analysis provides a method for obtaining the exact response of a structure as a function of time. The response-history is normally determined using step by step numerical integration of the equation of motion. In nonlinear dynamic analyses, the detailed structural model subjected to a ground-motion record produces estimates of component deformations for each degree of freedom in the model.

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CHAPTER-01

INTRODUCTION

1.1 GENERAL

All over the world, there is a high demand for construction of tall buildings due to increasing urbanization and spiraling population, and earthquakes have the potential for causing the greatest damages to tall structures. Usually, they are modeled as two-dimensional or three-dimensional frame systems using finite beam elements. Since earthquake forces are random in nature and unpredictable, the engineering tools need to be sharpened for analyzing structures under the action of these forces. Analyzing the structure for previous earthquakes of different intensities and checking for multiple criteria at each level has become essential and pivotal these days.

Buildings are defined as structures utilized by the people as shelter for living, working or storage. With rapid growth in population along with the development of industrial and commercial activities rapid urbanization has taken place which has resulted into continuous movement of rural people to metro cities. So it is clear that the horizontal space constraint is reaching an alarming situation for metros. To manage with the situation maximum utilization of space vertically calls for the construction of multistoried buildings in large numbers. Today, tall buildings are a worldwide architectural phenomenon. Many tall buildings are built worldwide, especially in Asian countries, such as China, Korea, Japan, and Malaysia. From a structural engineer's point of view high rise building or multi-storeyed building is one that, by virtue of its height, is affected by lateral forces to an extent that they play an important role in the structural design.

In general, tall multi-storey buildings need to be designed for wind as well as earthquake loads. Governing criteria for carrying out dynamic analyses for earthquake load is different from wind load. According to the provisions of Bureau of Indian Standards for earthquake load, IS 1893(Part 1):2002, height of the structure, seismic zone, vertical and horizontal irregularities, soft and weak storey necessitates dynamic analysis for earthquake load. The contribution of the higher mode effects are included in arriving at the distribution of lateral forces along the height of the building. When wind interacts with a building, both positive and negative pressures occur simultaneously, the building must have sufficient strength to resist the applied loads from these pressures to prevent wind induced building failure.

Structural analysis means determination of the general shape and all the specific dimensions of a particular structure so that it will perform the function for which it is created and will safely withstand the influences which will act on it throughout its useful life. ETABS was used to create the mathematical model of the Burj Khalifa, designed by Skidmore, Owings and Merrill LLP (SOM). The input, output and numerical solution techniques of ETABS are specifically designed to take advantage of the unique physical and numerical characteristics associated with building type structures. ETABS provides both static and dynamic analysis for wide range of gravity, thermal and lateral loads. Dynamic analysis may include seismic response spectrum or accelerogram time history.

The increases in population by which land deficit occurs and to overcome that, high-rise structure is opted. These types of high-rise structure are affected by the natural phenomena. Such as earthquakes are the most dangerous by means of the damage and effect caused to the structural components, , and that they can't be controlled. These natural calamities caused damage structure and interruptions in development of the normal lifecycle. Since it’s a global concern, most of the analysis should be find out and provided with the results to prepare the structure to attain time period. With the technological advancement, man tried combating with these natural phenomena through various ways like developing early warning systems for disasters, adopting new prevention measures, proper relief and rescue measures. But however it's not true for all natural disasters. Hazard maps indicating seismic zones in seismic codes as per (IS 1893:2016) are revised from time to time which results in additional base shear demand on existing buildings. The collapse of a structure may be reduced if the subsequent points are taken into considerations. Majority of the building structures encompass structural elements like beams, Columns, braces, shear walls, and floor slabs. Floor slabs in multi storey buildings, which generally transmit gravity loads to the structural system, are required to transfer lateral inertia forces to the structural system.

- The pattern of failure may be made ductile instead if brittle. If ductility is assured, dissipation of energy produced will show small deterioration.

- Shear should not fail before flexure.

- Columns failure comes after the failure of beams.

 The joints should be hard as compared to the members.

 To perform dynamic analysis of the structure using response spectrum method.

The main parameters to be checked in the seismic analysis of structures are load carrying capacity, ductility, stiffness, damping and mass First, a linear analysis is conducted with dimensioning of all structural elements, ensuring the functionality of the structure after minor earthquakes, and then the behavior of structures during strong earthquakes has to be conducted using nonlinear methods. Dynamic analysis should be performed for symmetrical as well as unsymmetrical buildings. In unsymmetrical building structures the major parameter to be considered is Torque.

1.2 Seismic analysis of structure:

For the determination of seismic responses, it is necessary to carry out seismic analysis of the structure. The analysis can be performed based on external action, the behavior of structural materials, structure and the type of structural model selected. Based on the type of external action and behavior of structure, the analysis can be further classified as:

1) Linear Static Analysis

2) Non-linear Static Analysis

3) Linear Dynamic Analysis

4) Non-linear Dynamic Analysis

1.2.1 Linear Static Analysis

This method is also known as Equivalent Static Analysis method. This procedure does not require dynamic analysis, however, it account for the dynamics of building in an approximate manner. The static method is the simplest one among all the other analysis procedures. It requires less computational efforts and is based on formulas given in the code of practice. First, the design base shear is computed for the entire building and it is then distributed along the height of the building. The lateral forces at each floor levels thus obtained are distributed to individual lateral load resisting elements. The equivalent static analysis procedure involves the following steps:

1) Calculation of the Design Seismic Base Shear, VB

2) Vertical distribution of base shear along the height of the structure

3) Horizontal distribution of the forces across the width and breadth of the structure

4) Determination of the drift and overturning moment

1.2.2) Non-linear Static Analysis

Nonlinear static analysis also known as Pushover Analysis procedure is mainly used to estimate the strength and drift capacity of existing structure and the seismic demand for this structure subjected to selected earthquake. This analysis procedure can be used for checking the adequacy of new structural design as well. The effectiveness of pushover analysis and its computational simplicity brought this analysis procedure in to several seismic guidelines (ATC 40 and FEMA 356) and design codes (Euro code 8 and PCM 3274).

1.2.3) Linear Dynamic Analysis

Response spectrum method is a linear dynamic analysis method. In this method the peak response of structure during an earthquake is obtained directly from the earthquake response, but this is quite accurate for structural design applications. Computer analysis can be used to determine the different modes for a structure. Based on the modal frequency and the modal mass, for each mode a response is read from the design spectrum, and they are then combined to provide an estimate of the total response of the structure using modal combination methods. In this we have to calculate the magnitude of forces in all directions i.e. X, Y & Z and then see the effects on the building.

1.2.4) Non-linear Dynamic Analysis:

Nonlinear dynamic analysis is also referred as Time history analysis. It is an important method for structural seismic analysis especially when the evaluated structural response is nonlinear. To perform this analysis, a representative earthquake time history data is required for a structure being evaluated. Time history analysis is a step-by step analysis procedure of the dynamic response of a structure for a specified loading that may vary with time. Time history analysis is used to determine the seismic response of a structure under dynamic loading for a representative earthquake

1.3 Objectives of the Study

- To study irregularities in structural analysis and design of (G+10) storey's structure as per code (IS 1893:2016).
- To study the behavior of high rise structure without masonry infill if seismic load is applied.
- To Time history analysis subjected to intermediate frequency ground motion for the response of regular buildings and compared to the response spectrum analysis
- Determination of displacements subjected to seismic loading from zone to zone.
- To find out the Shear force and bending moment selecting any one section for various seismic zones.

1.4 Statement of the problem:

ETABS stand for Extended Three Dimensional Analysis of Building Systems. ETABS integrates every aspect of the engineering design process. In the present situations of construction industry, the buildings that are being constructed are gaining significance, in general, those with the best possible outcomes which are referred to members like beams and columns in multi storey's R.C structures. This software mainly used for structures like high-rise buildings, steel and concrete structures. The paper aims to analyze RC building frames by considering seismic loads. The design criteria for analyzing the RC building frames are strength, serviceability and stability. The version of the software used is ETABS 2016.In the present study, we are mainly determining the effects of lateral loads on moments, shear force, axial force, base shear, maximum displacement and tensile forces on structural system are subjected and also comparing the results of seismic zones 2, 3, 4 and 5.

CHAPTER-2

LITERATURE REVIEW

Dr. Sanjay K. Kulkarni.et.al., (2018): This paper presents the seismic load estimation for multistory buildings as per IS: 1893-2002 and IS: 1893-2016 recommendations. The method of analysis and design of multi-storey (G+10) residential building located in zone III, IV. The scope behind presenting this project is to learn relevant Indian standard codes are used for design of various building element such as beam, column, slab, foundation and stair case using a software E-tab under the seismic load and wind load acting the structure. To find out the values in project base shear, time period, maximum story displacement.

Gauri G. Kakpure.et.al., (2017): Reinforced Concrete (RC) building frames are most common types of constructions in urban India. These are subjected to several types of forces during their lifetime, such as static forces due to dead and live loads and dynamic forces due to earthquake. In the present work, two tall buildings (a G+10 and a G+25 structure), presumed to be situated in seismic zone III, are analyzed by using two different methods viz. equivalent static analysis method and response spectrum method, using ETAB 15 software. From analysis results, the parameters like storey drift, storey displacement, Axial Load, Bending Moments are determined for comparative study. Results established the superiority of the Response spectrum method over the Equivalent static analysis method. Storey drift value for G+10 and G+25 are 22 to 25% less respectively, in dynamic analysis than static analysis. All the values are within the limits as per code requirement. As the height of storey increases, the displacement values too gradually increase. Top storey has maximum displacement value in both X-Y directions. For dynamic analysis, storey displacement for G+10 and G+25 buildings are 22 % & 26% less than the corresponding values in static analysis.

E. Pavan Kumar.et.al., (2014): In this journal the parameters considered for analysis are axial force, bending moment and displacement. The plan considered was in square shape of building. To ensure safety against seismic forces of multi-storied building hence, there is need to study of seismic analysis to design earthquake resistance structures. In seismic analysis the response reduction was considered for two cases both Ordinary moment resisting frame and Special moment resisting frame.

B. Rajesh. et.al, (2015): This paper aims towards the static and dynamic analysis of reinforced concrete building with plan irregularity. Four models of G+10 storey building with one regular plan and remaining irregular plan have been taken for the investigation. The analysis of R.C.C. building is carried out with the FE based software ETABS 9.5. Estimation of response such as; lateral forces, base shear, storey drift, storey shear is carried out. The paper also deals with the effect of the variation of the building plan on the structural response building. Dynamic responses under prominent earthquake, related to IS 1893– 2002(part1) Static analysis gives higher values for maximum displacement of the stories in both X and Y direction. The base shear value due to RS analysis and static analysis will be significantly increased at higher stories. The dynamic RS analysis produces storey shear in both directions while the static analysis only produces storey shear in the direction of loading.

G. Guruprasad et al. (2017): Performed a dynamic analysis of G+10 storied RC frame building with L, C & rectangular shape in plan with the help of ETABS software. Comparison has been done by considering the parameters such as story drift, story shear, support reactions, building mode, and section cut force. It has been concluded that maximum value of story shear was observed for L-shape plan than rectangular building and C-shape building. The stories drift values in X direction and Y direction increases for top to bottom story in all three cases. When earthquake load is applied in Y direction, it was found that irregular plan structure can resist baser shear than rectangular plan structure. Regular building and L-shape buildings are giving good results than C-shaped buildings in all aspects.

Praveen Pujar et al. (2017): Analyzed G+9 storied irregular buildings to find their seismic performance with & without shear walls. Shapes of building plan considered for the study were I, L & C. Three models of bare frame &three models with shear walls were considered for the study. The comparison has been done by considering the parameters such as story displacement, story drift and base shear. It has been concluded that L-shape, C-shape structures with Shear walls are having great outcomes in base shear, story drift and displacement. The building with shear wall gives better execution against the seismic tremor when compared with bare frame building.

Mangesh S. Suravase et al. (2017): Performed seismic analysis on G+10 storied R.C frame buildings with different plan shapes such as square, H-shape, L-shape& rectangle with core. Plan area & height of all building models were kept same. Seismic analysis was carried out by pushover analysis method in ETABS software. It has been concluded that the regular building resist earthquake forces longer time and withstand for longer time. Irregular building model shape-H & L is having less resistance to earth quake forces. Irregular building model shape-O is having more resistance to earthquake than H & L shape building.

Sabelli et al. (1999) investigated to identify ground motion and structural features that control the response of concentrically braced frames, and to identify improved design procedures and code provisions. The focus of this paper is on the earthquake response of three and six story concentrically braced frames utilizing buckling-restrained braces. A brief discussion is provided regarding the mechanical properties of such braces and the benefit of their use. Results of detailed nonlinear dynamic analyses are then examined for specific cases as well as statistically for several suites of ground motions to characterize the effect on key response parameters of various structural configurations and proportions.

Mahmoud R. Maher, R. Akbari (2003), carried out the study for the earthquake behaviour factor (R) for steel Xbraced and knee-braced RC buildings. The R factor components including ductility reduction factor and over strength factor are extracted from inelastic pushover analyses of brace-frame systems of different heights and configurations. The effects of some parameters influencing the value of R factor, including the height of the frame, share of bracing system from the applied load and the type of bracing system are investigated. The height of this type of lateral load-resisting system has a profound effect on the R factor, as it directly affects the ductility capacity of the dual system. Finally, based on the findings presented, tentative R values are proposed for steel-braced momentresisting RC frame dual systems for different ductility demands.

P. Jayachandran (2009), carried out the study to enables optimization of initial structural systems for drift and stresses, based on gravity and lateral loads. The design issues are efficiency of systems, rigidity, member depths, balance between sizes of beam and column, bracings, as well as spacing of columns, and girders, and areas and inertias of members. Drift and accelerations should be kept within limits. Good preliminary design and optimization leads to better fabrication and erection costs, and better construction. The cost of systems depends on their structure weight. This depends on efficient initial design. The structural steel weight is shown to be an important parameter for the architects, construction engineers and for fabrication and assembly optimization.

CHAPTER-3
METHODOLOGY

In the present study, analysis of G+10 multi-story building in seismic zone-5 for wind and earthquake forces is carried out.3D model is prepared for G+10 multi-story building using ETABS.

3.1 Methods of analysis of structure:

The seismic analysis should be carried out for the buildings that have lack of resistance to earthquake forces. Seismic analysis will consider seismic effects hence the exact analysis sometimes become building. However for simple regular structures equivalent linear static analysis is sufficient more. This type of analysis will be carried out for regular and high rise buildings and this method will give good results for this type of buildings. Dynamic analysis will be carried out for the building as specified by code IS 1893-2016 (part1). Dynamic analysis will be carried out either by site specific Time history method or Response spectrum method. Following methods are adopted to carry out the analysis procedure.

- Equivalent Static Analysis
- Linear Dynamic Analysis
- Response Spectrum Method
- Time History Analysis
- Pushover Analysis
- Non Linear Static Analysis
- Non Linear Dynamic

3.2 Analysis Loads Acting on Multi-Storey G+10 Building:

Loading on tall buildings is different from low-rise buildings in many ways such as large accumulation of gravity loads on the floors from bottom to top, increased significance of wind loading and greater importance of seismic effects. Thus, multi-storied structures need correct assessment of loads for safe and economical design. Except dead loads, the assessment of loads cannot be done accurately. Live loads can be anticipated approximately from a combination of experience and the previous field observations. Wind and earthquake loads are random in nature and it is difficult to predict them. They are estimated based on a probabilistic approach. The following discussion describes most of the some common types of loads on multi-storied structures.

- Dead loads
- Live loads
- Earthquake loads

In this study, the lateral design forces are determined by the response spectrum method as per the provisions of IS 1893 (Part -1): 2016, for the building models to be considered for the study. The buildings are analyzed by results of the building for different zones for the different load combinations to arrive at a conclusion regarding the importance of carrying out seismic analysis. The present work is expanded to study these effects on our building models by performing lateral load analysis. The present work the seismic effect of different zone on building models which are considered in Zone V.

3.3 Response spectrum method:

Response spectrum analysis is the linear dynamic method which estimates the contribution from each natural mode of vibration to demonstrate the possible maximum response of essentially elastic structure. This method gives the knowledge into dynamic behavior by estimating pseudo spectral acceleration, displacement or velocity as a function of structural period for a given time period and level of damping.

The software takes care of the Eigen value issue of the model and estimate the fundamental natural period values. Thus, the total seismic loads are created and its dispersion along the height of the building corresponding to the mass and stiffness distribution. The modeling and analysis are performed by ETABS 2016.

The response spectrum method is also known as the “modal analysis procedure” and is performed in accordance with the requirements of Clause 7.8.4, IS 1893(Part 1): 2002. The method is based on superposition of modes. Hence, free vibration modes are computed using k) termed as the modal response is obtained for each mode (say kth mode). The number of modes considered is based on a quantity termed as the mass participation factor for each mode. Sufficient number of modes (r) to capture at least 90 percent of the total participating mass of the building (in each of the horizontal directions), should be considered in the analysis. In the present study, 12 modes are considered. The modal responses from all the considered modes are then combined together using either the square root of the sum of the squares (SRSS) method or the complete quadratic combination (CQC) method. The peak response quantities (for example, member forces, displacements, storey forces, storey shears, and base reactions) are combined as per CQC method. The details of data used for the seismic analysis are; zone factor, z=0.16, importance factor, I=1.5, response reduction factor, R=3 and type of soil is soft.

The method is based on superposition of modes. Hence, free vibration modes are computed using k) termed as the modal response, is obtained for each mode (say kth mode). The number of modes considered is based on a quantity termed as the mass participation factor for each mode. Sufficient number of modes (r) to capture at least 90 percent of the total participating mass of the building (in each of the horizontal directions), should be considered in the analysis. In the present study, 12 modes are considered. The modal responses from all the considered modes are then combined together using either the square root of the sum of the squares (SRSS) method or the complete quadratic combination (CQC) method. The peak response quantities (for example, member forces, displacements, storey forces, storey shears, and base reactions) are combined as per CQC method.

In response spectrum method, the design base shear (VB) shall be compared with a base shear (B) calculated using a fundamental period Ta, where Ta, is as per clause no 7.6 of IS 1893(Part 1): 2002. Where VB is less than B, all the response quantities (for example member forces, displacements, storey forces, storey shears and base reactions) need to be multiplied by a factor / VB.

Storey drift is the displacement of one level relative to the other level above or below. Drift is a common phenomenon for high rise and this may hamper the integrity of the structure and cause serious loss of life and properties in case of a major earthquake. As per Clause no. 7.11.1 of IS 1893(Part 1): 2002, the storey drift in any storey due to specified design lateral force with partial load factor of 1.0, shall not exceed.

3.4 Software Requirement:

Existing system: STAAD Pro

1) STAAD or (STAAD Pro) is a structural analysis and design software application originally developed by Research Engineers International in 1997. In late 2005, Research Engineers International was bought by Bentley Systems.

2) STAAD Pro is one of the most widely used structural analysis and design software products worldwide. It supports over 90 international steel, concrete, timber & aluminum design codes.

Advanced system: E tabs (Extended three dimensional analyses)

1) ETABS is advanced software when compared to STAAD Pro.

2) ETABS is an engineering software product that caters to multi-story building analysis and design. Modeling tools and templates, code-based load prescriptions, analysis methods and solution techniques, all coordinate with the grid-like geometry unique to this class of structure.

Modeling tools and templates, code-based load prescriptions, analysis methods and solution techniques, all coordinate with the grid-like geometry unique to this class of structure. Basic or advanced systems under static or dynamic conditions may be evaluated using ETABS. For a sophisticated assessment of seismic performance, modal and direct- integration time-history analyses may couple with P-Delta and Large Displacement effects. Nonlinear links and concentrated PMM or fiber hinges may capture material nonlinearity under monotonic or hysteretic behavior. Intuitive and integrated features make applications of any complexity practical to implement. Interoperability with a series of design and documentation platforms makes ETABS a coordinated and productive tool for designs which range from simple 2D frames to elaborate modern high-rises.

Fundamental to ETABS modeling is the generalization that multi-story buildings typically consist of identical or similar floor plans that repeat in the vertical direction. Modeling features that streamline analytical-model generation, and simulate advanced seismic systems.

For nearly thirty years, the TABS and ETABS series of computer programs have defined the standard for building analysis and design software, and the tradition continues with this latest release of ETABS.

ETABS uses terminology familiar to the building designer such as columns, beams, braces and walls rather than nodes and finite elements.

3.5 Model:

There is a resurgence of construction of high rise structure and ultra-high rise structure around the world. The design of these high rise buildings in seismically active regions varies dramatically from region to region where as rigorous performance-based assessments is required in many countries, including Nepal and China, some other countries do not require anything beyond a traditional design based on force reduction factors. Recent trends in high-rise commercial construction have resulted in a variety of unusual configurations, innovative structural systems, and high performance materials that challenge current design practice.

An RCC framed structure is basically an assembly of slabs, beams, columns and foundation inter-connected to each other as a unit. The load transfer mechanism in these structures is from slabs to beams, from beams to columns, and then ultimately from columns to the foundation, which in turn passes the load to the soil. In this structural analysis study, we have adopted four cases by assuming different shapes for the same structure

Structural design is the primary aspect of civil engineering. The foremost basic in structural engineering is the design of simple basic components and members of a building viz., Slabs, Beams, Columns and Footings The process of structure design involves the following steps: Structural Planning, Calculation of Loads, Analysis of Structure, Member Design, Drawing and Detailing

CHAPTER-4

OVERALL DESIGN

One of the objectives of this model designing is to ensure that the models represent the characteristics of apartment structure. These days, high-rise structure is different in shape, height and functions. This makes each building characteristics different from each other's. There are some standards for each kind of high-rise buildings, such as residential, official, commercials. The seismic design of modern tall buildings, defined as buildings exceeding 170 feet in height, introduces a series of challenges that need to be met through consideration of scientific, engineering, issues specific to the modeling, analysis, and acceptance criteria appropriate for these unique structural systems. There, for model designing, main factors such as floor shape, grid spacing, and floor height and columns and beams are considered.

One building with equal number of storey's, with (G+10) storey having same floor plan of 30 m x 20 m dimensions were considered for this study. The floor plans were divided into 6 x 4 bays in such a way that center to center distance between two grids is 5 meters on both the sides respectively as Plan and elevation & plane shown in Figure. The floor height of the building was assumed as 3.2 meters for all floors and Elevation was shown in Figure. The following two distinct building models are used in the study: high rise building (G+10)

In general, tall multi-storey buildings need to be designed for wind as well as earthquake loads. Governing criteria for carrying out dynamic analyses for earthquake load is different from wind load. According to the provisions of Bureau of Indian Standards for earthquake load, IS 1893(Part 1):2002, height of the structure, seismic zone, vertical and horizontal irregularities, soft and weak storey necessitates dynamic analysis for earthquake load. The contribution of the higher mode effects are included in arriving at the distribution of lateral forces along the height of the building. When wind interacts with a building, both positive and negative pressures occur simultaneously, the building must have sufficient strength to resist the applied loads from these pressures to prevent wind induced building failure.

Load exerted on the building envelope are transferred to the structural system, where in turn they must be transferred through the foundation into the ground, the magnitude of the pressure is a function of the following primary factors: exposed basic wind speed, topography, building height, internal pressure, and building shape.

4.1 Response spectrum analysis

Response spectrum method of analysis shall be performed by using design spectrum specified or by site-specific design spectrum

4.2 Free vibration analysis

Undammed free vibration analysis of the entire building survey performance as per established methods of mechanics using the appropriate masses and Elastic stiffness of the structural system to obtain natural periods and mode shapes of those of its modes of vibration that need to be considered.

4.3 Modes to be considered

The number of modes to be used in the analysis should be such that the total of model masses of almost considered is at least 90% of the total seismic mass find missing mass correction beyond 33%. If modes with natural frequency beyond 33 Hz are to be considered, model combination shall be carried out only for modes update up to 33 Hz. The effect of IMO shall be included by considering missing mass correction following well-established procedures.

4.4 Analysis of building subjected to design forces

The building may be analyzed by accepted principles of mechanics for the design and force is considered as static forces.

The analysis of reinforced concrete structure has been done considering the entire structure as a three dimension model framed structure using STAAD package. Beam and columns are considering as beam elements. The slabs are considered as plate elements. There are 2710 number of joints and 7585 elements in the STAAD analysis model of the structure. The main objective of modeling the whole structure as 3D model is to take into account the behavior of each and every component in space structure environment. The slab is modeled as an element to carry the live load as distributed pressure load. Lift well and staircase walls are modeled as shear wall to resist the lateral loads like wind and earthquake load. Plate elements are used for shear walls.

As per IS 1893(Part 1): 2002, dynamic analysis with time history or response spectrum method need to be performed to obtain the design seismic force, and its distribution to different levels along the height of the building and to the various lateral resisting elements, for the regular buildings those greater than 40 m in height in Zones IV and V, and those greater than 90 m height in zone II and III. The building taken for study has 148.9m in height and it is situated in seismic zone III. Since it is more than 90m height and situated in Zone III, the dynamic analysis is required to be carried out. As Per Clause no 7.8.2 of IS 1893(Part 1): 2002, dynamic analysis may be performed either by time history method or by the response spectrum method. Here, response spectrum method is used for carrying out dynamic analysis.

There are some standards for each kind of high-rise buildings, such as residential, official, commercials. The seismic design of modern tall buildings, defined as buildings exceeding 170 feet in height, introduces a series of challenges that need to be met through consideration of scientific, engineering, issues specific to the modeling, analysis, and acceptance criteria appropriate for these unique structural systems. There, for model designing, main factors such as floor shape, grid spacing, and floor height and column and beam considered.

The building is assumed to be located at different seismic zones and site soil conditions and corresponding base shear is found by seismic coefficient method and response spectrum method using STAAD Pro and the results are given in Table 5. The base shear calculated with response spectrum method (VB) is less than the base shear calculated with seismic coefficient method (B). So, as per as per clause no 7.6 of IS 1893(Part 1): 2002, all the response quantities (member forces, displacements, storey forces, storey shears and base reactions) need to be multiplied by a factor / VB.

It is proposed to design an R.C. frame structure. The principle elements of an R.C. building frame are as follows. (a) Slabs to cover large area. (b) Beams to support slabs and walls. (c) Columns to support beams. (d) Footings to distribute concentrated column loads over a large area of the supporting soil. (a) Design of Slabs: Reinforcement Detailing of Slab using Excel Sheets Developed, Firstly, we checked the continuity of the slab which we want to find detailing, then in developed Excel sheet is opened, We put Lx, Ly length of that slab then Edge continuity condition are chosen, Loads applied on that slab are written below respective cell. Finally, Bar diameter along with their spacing are written down for both (+) and (-) reinforcement.

The function of a foundation or substructure is to safely transfer the loads from the super structure to the ground. Different type of foundation structure like isolated footing, continuous footing, combined footings, slab rafts, piled rafts, and caissons are used for this purpose. Clause 34 of IS 456 deals with limit design of footings.

In the present scenario, a structural engineer cannot afford to generate the results manually as it involves tedious procedures and complicated calculations, which requires considerable time and patience. Thus there is always a need of a simpler alternative like the use of various; Computer Aided Software's which would offer great flexibility and efficiency. In this project, analysis and design of structure was done with the aid of software called ETABS which is quite feasible in using and offers more efficient designs and flexibility.

The modeling of the structure has been done using the structural software ETABS as per the data:

4.5 Description of building

Type of structure: Multi-storey RC frame Structure

· Number of stories: (G+10)

· Ground storey height: 3.6 m

· Intermediate storey height: 3.2 m

· Type of soil: Hard soil

Materials

· Grade of concrete: M25

· Density of concrete: 25kN/m2

· Modulus of elasticity of concrete: 5000√fck

As per IS 456:2000.

Member dimensions in cross sectional area

· Beam Size: 230mm x 500 mm

· Column Size: 230mm x 500 mm

· Slab Thickness: 125 mm

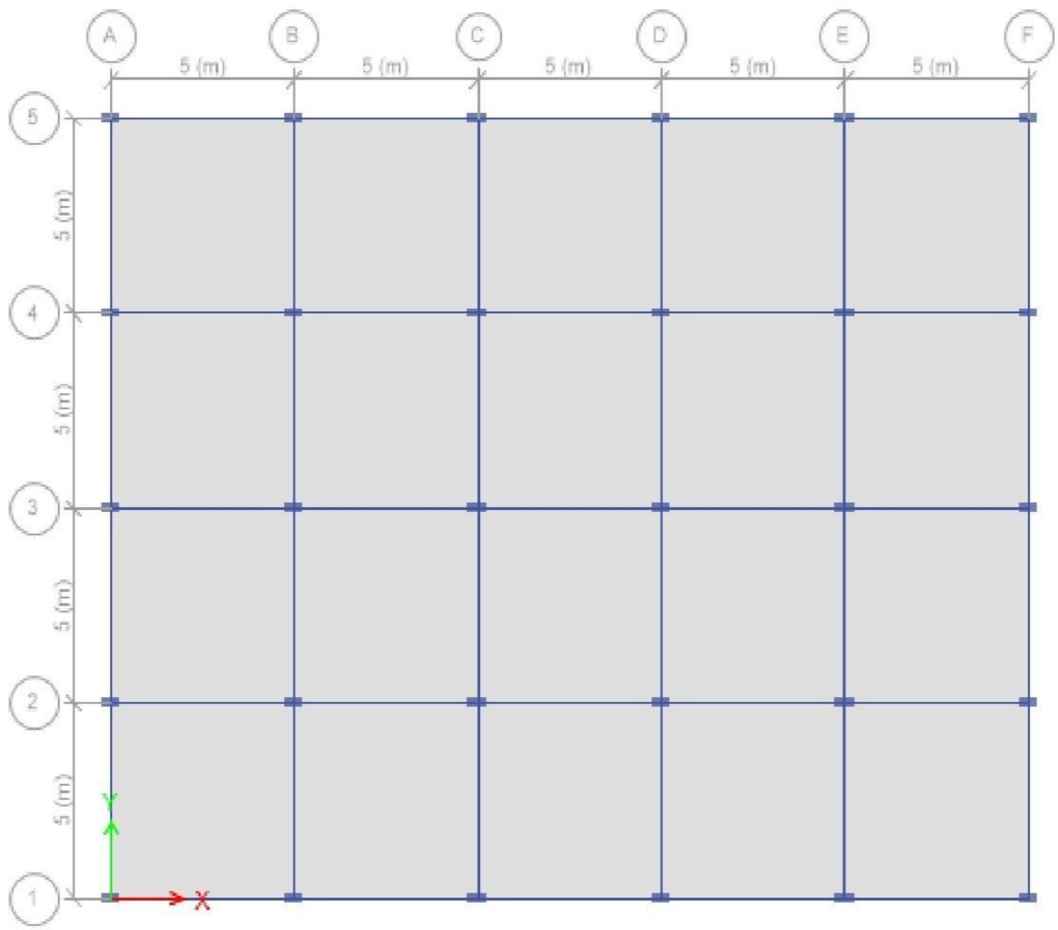

Fig no: 4.5.1-Plan of the building

One building with equal number of storey's, with (G+10) storey having same floor plan of 30 m x 20 m dimensions were considered for this study. The floor plans were divided into 6 x 4 bays in such a way that center to center distance between two grids is 5 meters on both the sides respectively as Plan and elevation & plane shown in Figure. The floor height of the building was assumed as 3.2 meters for all floors and Elevation was shown in Figure. The following two distinct building models are used in the study: high rise building (G+10).

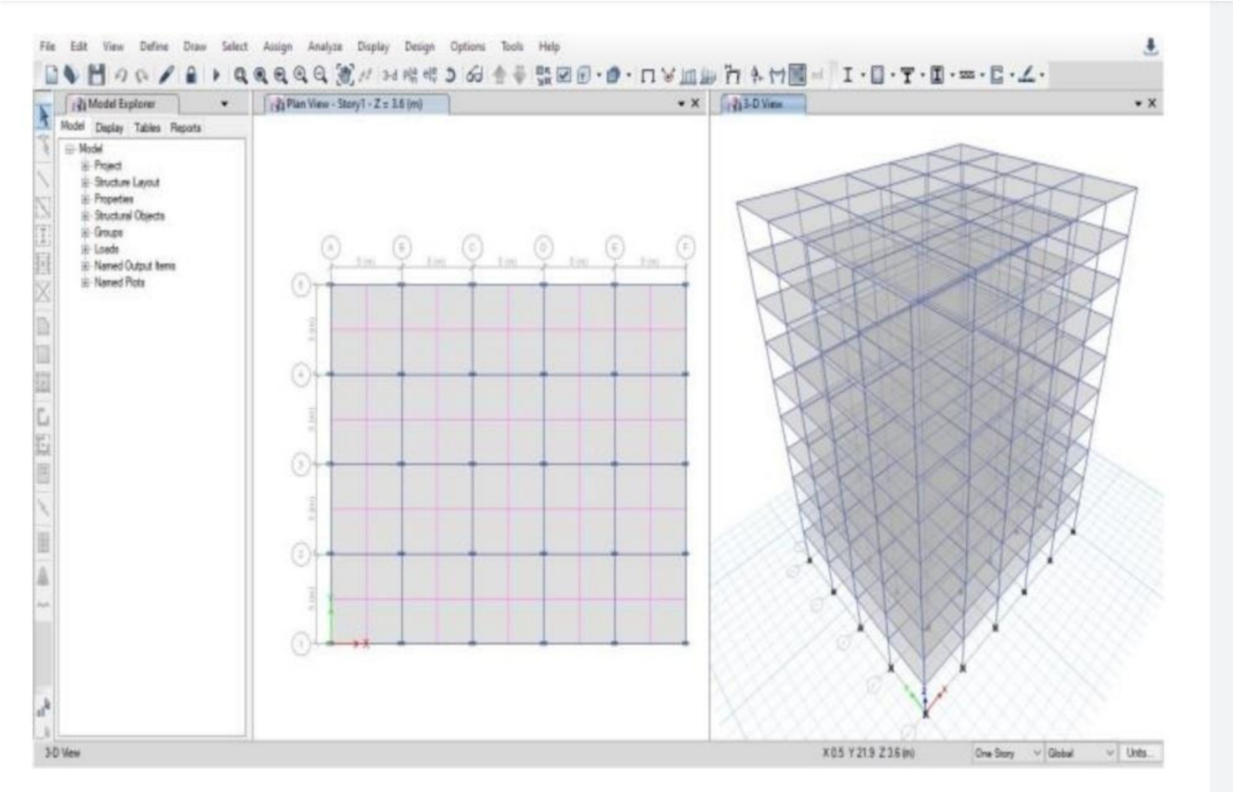

Fig no: 4.5.2-Plan and Elevation of (G+10) Building

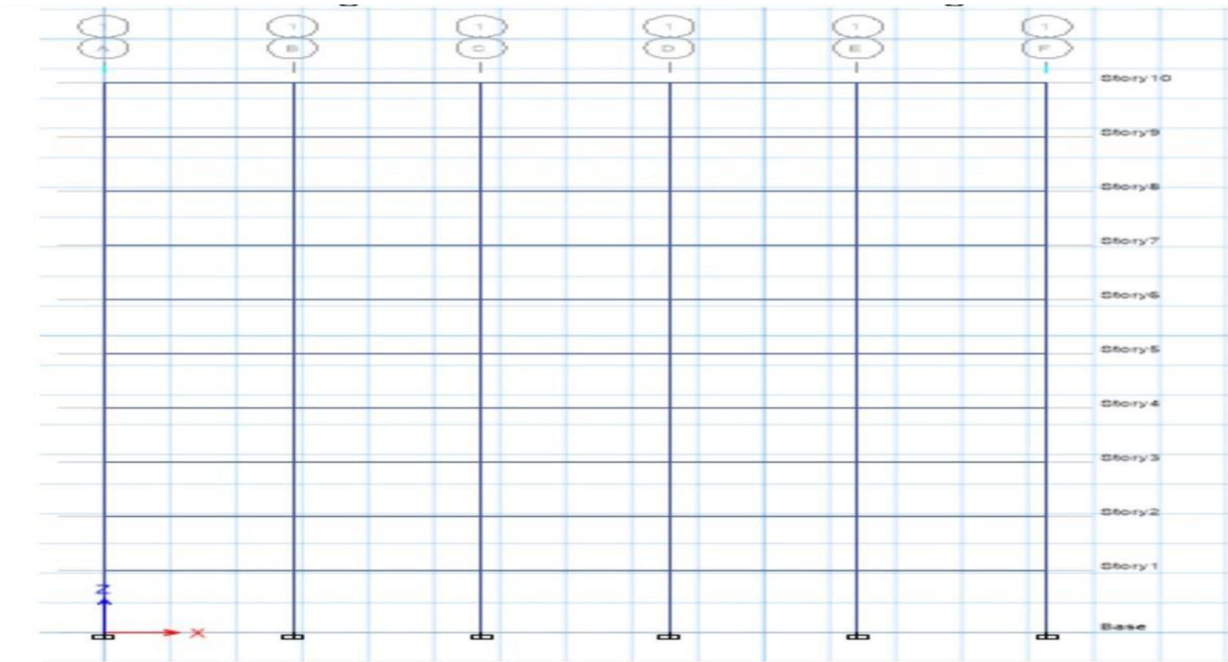

Fig no: 4.5.3-Overall view

4.6 LOAD CALCULATION

1) Dead Load

1) The self wt. of the structural members is taken care in the software.

2) Floor Finish load: 1 KN/m2

2) Live Load

1) Live load on roof: 1.5kN/m2

3) Seismic Load

1) Seismic zone: Zone-V As per IS 1893 (Part 1) 2016
2) Height of Building: 32.4 m
3) Damping ratio: 5% for RC frame structure
4) Seismic zone factor (Z): 0.16,0.24 and 0.36 (Table 2 of IS 1893(Part-1):2016
5) Importance factor (I): 1.0 as per IS 1893(Part-1): 2016
6) Response reduction factor (R): 5.0 as per IS 1893(Part-1): 2016,
7) Foundation Soil type = Type-1(Hard Soil) (As per IS 1893(Part-1): 2016,
8) Design horizontal seismic coefficient (As per IS 1893(Part-1): 2016) For all Models Ah = 0.0267 sec

4) Design Seismic Base Shear:

V B =Ah x W

CHAPTER-5
RESULTS

5.0 GENERAL

For every seismic zone, the software gives six possible seismic load cases and two combination load cases i.e., maximum and minimum. The six possible load cases depend upon the loads acting on the structure their behavior will be analyzed and compared in terms of following parameters

1. Maximum Storey displacement
2. Storey Drift
3. Base Reactions

The comparison of results in terms of the above parameters will be given in terms of graphs and tables. Below discussed in details.

5.1 Maximum Storey Displacement

Storey displacement is defined as the total displacement of any storey with respect to ground and there is maximum permissible limit prescribed in IS codes for buildings. Storey Shear: It is the sum of design lateral forces at all levels above the storey under consideration.

Under the seismic loads as the height of the structure increase the Storey drift, Maximum storey displacement and Storey shear also increases. Rigid frame structure is recommended up to 25 stories. Storey drift, maximum storey displacement and storey shear for the models are within the limit specified by IS-1893:2002 (Part I).

The modeling and analysis of various structural systems were carried out in software. The software was used to model and assess the effectiveness of various structural systems under lateral loadings. Seismic loading was applied to the structures.

Storey	Load case	Direction	Maximum
10	Seismic	X	72.443mm
9	Seismic	X	70.104mm
8	Seismic	X	65.558mm
7	Seismic	X	59.446mm
6	Seismic	X	52.117mm
5	Seismic	X	43.89mm
4	Seismic	X	35.045mm
3	Seismic	X	25.819mm
2	Seismic	X	16.436mm
1	Seismic	X	7.287mm

Table: 5.1.1-Displacement in X direction

Storey	Load case	Direction	Maximum
10	Seismic	Y	40.319mm
9	Seismic	Y	38.96mm
8	Seismic	Y	36.566mm
7	Seismic	Y	33.335mm
6	Seismic	Y	29.461mm
5	Seismic	Y	25.116mm
4	Seismic	Y	20.445mm
3	Seismic	Y	15.57mm
2	Seismic	Y	10.586mm
1	Seismic	Y	5.538mm

Table: 5.1.2-Displacement in Y direction

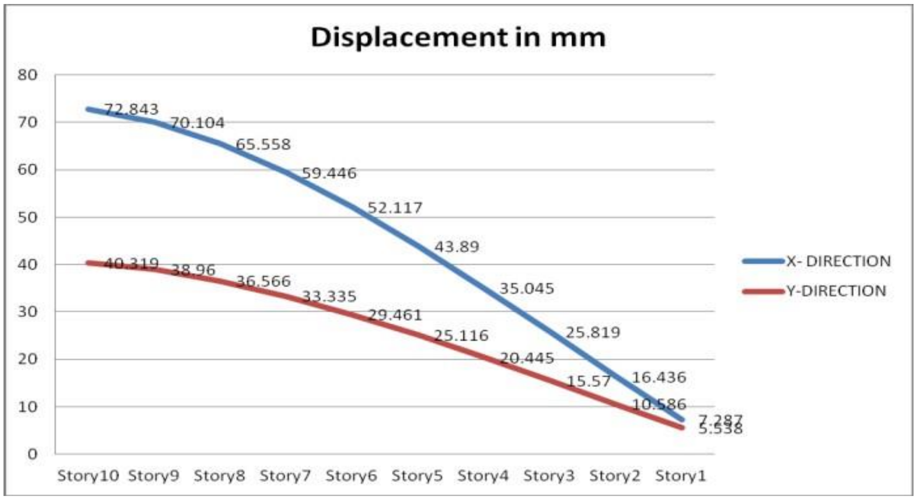

Fig no: 5.1 Displacement X and Y Direction of the structure

5.2 Storey Drift

Storey drift is the lateral displacement of one level relative to the level above or below. Storey drift ratio is the storey drift divided by the storey height

Storey	Load Case	Direction	Maximum
10	Seismic	X	2.74
9	Seismic	X	4.546
8	Seismic	X	6.111
7	Seismic	X	7.329
6	Seismic	X	8.227
5	Seismic	X	8.845
4	Seismic	X	9.227
3	Seismic	X	9.383
2	Seismic	X	9.149
1	Seismic	X	7.287

Table: 5.2.1 Displacement in X direction

Storey	Load Case	Direction	Maximum
10	Seismic	Y	1.359
9	Seismic	Y	2.394
8	Seismic	Y	3.232
7	Seismic	Y	3.874
6	Seismic	Y	4.345
5	Seismic	Y	4.671
4	Seismic	Y	4.875
3	Seismic	Y	4.984
2	Seismic	Y	5.047
1	Seismic	Y	5.538

Table: 5.2.2Displacement in Y direction

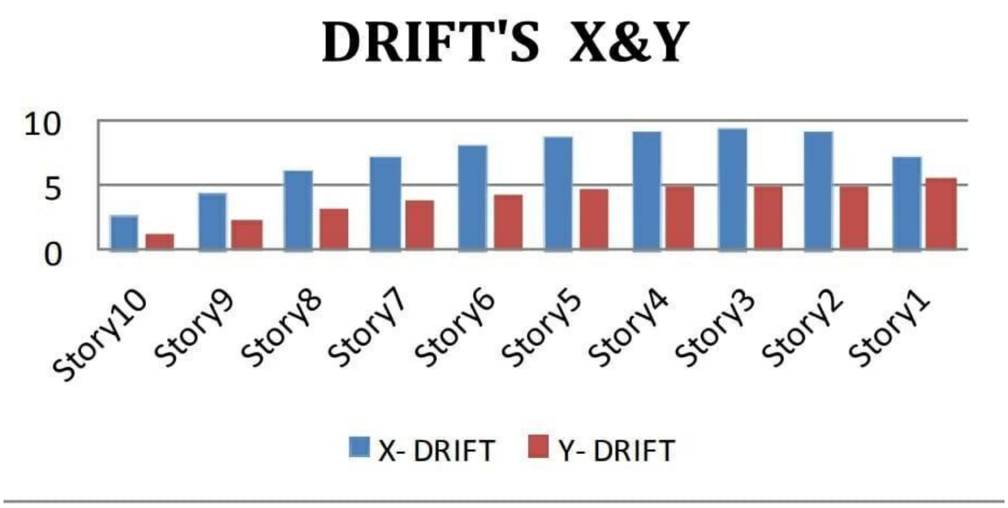

Fig no: 5.2 Comparison of drifts X and Y axis

5.3 Base Reactions

Base reactions are calculated for each mode before modes are combined using the CQC (complete quadratic combination) or SRSS (sum of squares) modal-combination rule.

z Load case	Fx Kn	Fy kn	Fz kn	Mx kn m	My kn m	Mz kn m
Dead	0.0	0.0	24937.8	249378.1	311722.6	0.0
Live	0.0	0.0	7500.0	75000.0	-93750.0	0.0
Floor finish	0.0	0.0	5000.0	50000.0	-62500.0	0.0
EQ-X	-11836.1	0.0	0.0	0.0	-29999.2	11831.3
EQ-Y	0.0	301.4	0.0	7642.3	0.0	-3767.5
RS-X Max	946.8	644.4	0.0	12962.2	19047.8	9599.9
RS-Y Max	354.1	241.0	0.0	4848.1	7124.2	3590.5

Table: 5.3.1 Base Reactions

CHAPTER-6
CONCLUSION

- A high-rise building of (G+10) floors subjected to seismic, wind and live loads were analyzed using ETABS 2017 software.
- The behavior of high-rise building is clearly shown using graphs and lateral displacement.
- The lateral displacements or drifts are more in this zone.
- It is also found that from the base reactions of structure obtained in the zone, the story shear is higher.
- All members were designed using ETABS.
- The members which aren't appropriate will be obtained and suitable sections are recommended by the software.
- Better accuracy of the analysis can be obtained by using ETABS software.

CHAPTER-7

FUTURE ENHANCEMENT

- To analyze the building as per code IS 1893-2016 part I criteria for earthquake resistant structure.
- 2. Reanalyze the frame structure with different seismic zone.
- 3. Building with different lateral stiffness systems.
- 4. The study may further be carried out by providing openings in slabs.
- 5. Development of a city.
- 6. Get economical and efficient lateral stiffness system.
- 7. To deal with energy and environmental challenges

CHAPTER-8

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A Major Project Report

On

GIS AND ITS APPLICATIONS IN FLOOD MANAGEMENT – Tufanganj, Cooch Behar, West Bengal, India

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfilment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

By

Mr. M. Sai Kumar - (18K85A0108)

Ms. S. Sruthilaya - (18K85A0105)

Mr. N. Rahul Reddy - (17K81A0147)

Mr. K. Pavan Nayak - (17K81A0136)

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JUNE 2021

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BONAFIDE CERTIFICATE

This is to certify that the project entitled **"GIS AND IT's APPLICATIONS IN FLOOD MANAGEMENT – Tufanganj, Cooch Behar, West Bengal, India",** is being submitted by **1.Mr. M. Sai Kumar (18K85A0108) 2. Ms. S. Sruthilaya (18K85A0105) 3. Mr. N. Rahul Reddy (17K81A0147) 4. Mr. K. Pavan Nayak (17K81A0136)** in partial fulfilment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN CIVIL ENGINEERING** is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

Signature of Guide

Ms. J. Jasmine
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Department of Civil Engineering

Signature of HOD

Prof. SANDHYA KIRAN J.K.
Head of the Department
Department of Civil Engineering

Internal Examiner

External Examiner

Place:

Date:

DECLARATION

We, the student of **Bachelor of Technology** in Department of 'Civil Engineering', session: 2017 – 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled "**GIS AND IT's APPLICATIONS IN FLOOD MANAGEMENT – Tufanganj, Cooch Behar, West Bengal, India",** is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

Mr. M. Sai Kumar (18K85A0108)
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ABSTRACT

Flood is a natural hazard resulting from extreme geophysical events to create an unexpected threat to human life and property. Flood risk steams from the likelihood that a major hazards event will occur unexpectedly and that it will impact negatively on the people and their welfare. Flood management planning is a very important which helps to rescue the flood affected people to mitigate the problem of flood and to take necessary preventive measures.

As occurrence of floods become frequent in the city Tufangunj, Cooch Behar, West Bengal, India. GIS becomes preferable tool for planners for effective flood management. GIS helps in creating land suitability analysis and flood zone mapping of towns and cities, which, if, incorporated in preparation of master plans can help in flood management in urban India.

The present study attempts to study the impact of floods in the Tufangunj city, Cooch Behar, West Bengal, India. Data used in the present study was, DEM map downloaded from Bhuvan website ISRO. For analysis DEM was generated for the region of the city. DEM was processed for the fill; sink for the using SAGA GIS.

The study describes an efficient & scientific approach with suitable illustrations of map and real time flood inundations. The areas, which are highly flood affected, are delineated. So that, the flood affected people can be rescued from inundation and can be evacuated to different safe places.

Key words: Floods, DEM, SAGA GIS, watershed delineation, Flood management.

TABLE OF CONTENTS

Chapter-1

Introduction

1.1 Overview of project

A flood is an overflow of an expanse of water that submerges land. The EU Floods directive defines a flood as a temporary covering by water of land not normally covered by water. In the sense of "flowing water", the word may also be applied to the inflow of the tide. Flooding may result from the volume of water within a body of water, such as a river or lake, which overflows or breaks levees, with the result that some of the water escapes its usual boundaries. While the size of a lake or other body of water will vary with seasonal changes in precipitation and snow melt, it is not a significant flood unless the water covers land used by man like a village, city or other inhabited area, roads, expanses of farmland, etc.

River and coastal flooding are the most frequently occurring natural disaster and are increasing in occurrence more rapidly than any other disaster. Urbanization and deforestation reduce the capability of the earth to hold excess water. As asphalt- and concrete-covered surfaces expand and open spaces disappear at the edges of metropolitan areas, it takes less rain to flood communities as water running over the pavement collects quickly and easily disrupts storm drain systems. Those areas which are most at risk for floods include low-lying areas, coastal regions, and communities on rivers downstream from dams. Flood waters are extremely dangerous; a mere six inches of swiftly moving water can knock people off their feet. In some places flooding is caused by excessive monsoons, while in others flooding is caused downstream from dams when reservoirs, which normally help to prevent downstream areas of rivers from flooding, are opened due to unusually high levels of rain to prevent the reservoir from overflowing the dam. Dam breaks are also a cause of catastrophic flooding.

West Bengal has 37,660 sq. km flood prone area spread over 111 blocks where the total geographical area of the state is 88,752 sq. km. An analysis of the statistics of flood that occurred during last 41 years (from 1960 - 2000) shows that only on 5 occasions the state has not faced any severe flood. The total devastated area crossed 20,000 sq. km in 4 different years and the flood of medium magnitude i.e. between 2,000 to 10,000 sq. km. occurred on 10 occasions.

Flood is one of the most severe disasters frequently suffered by human and cattle lives which are caused due to cumulative effects of weather events and it is found as the acute environmental hazard of Cooch Behar district of West Bengal. The flood in Cooch Behar threatens the lives and properties of large number of people almost each year. The reasons for floods are excessive rainfall within short duration in small catchment areas and simultaneous melting of newly formed glacier accumulated on eastern Himalaya and continuous heavy rainfall on downstream area of these rivers namely Teesta, Torsa, Jaldhaka, Kaljani and Raidak caused floods. Moreover in the upper courses of river released a huge amount of water in a short period through these rivers caused devastation flood.

The present paper is concerned with the study on the problems of flood of Cooch Behar district. It also includes a detailed discussion on the nature, extent, causes and consequences of floods and here we also discuss the present status of embankments and possible flood prone areas of the catchments for the purpose of analysis of the flood hazards and suggests suitable controlling measures for its revival. Flood simply means inundation of widespread land area with water for a number of days in continuation. Cooch Behar district is a land of many perennial rivers and river basins; it’s also a flood prone area. There are quite a few big rivers namely Teesta, Jaldhaka, Torsa, Kaljani, Raidak etc. and a number of smaller ones Gadadhar, Kaljani, Dharla, Baniadaha, Giridhari, Dudua, Gilandi, BuriTorsa, Sutunga, etc. which have crossed the district. The riversnthis district generally flow from northwest to southeast direction. It is a common experience that every year during rainy season when intensity of rainfall is slightly higher than normal and released unbelievable volume of water through the upstream of

Torsa, Teesta and Jaldhaka rivers, the surrounding area of these rivers remains under water of considerable period of time creating inconvenience to the inhabitants. So, flood has been considered to be the most devastating natural hazard faced by the flood plains of Cooch Behar district. The problem of flood is more complicated to handle in this district because of two particular aspects, such as: (1) enormous bank erosion of these rivers and (2) many embankments are vulnerable condition.

1.1.1 Introduction to GIS:

Geographic information systems, or **GIS**, are computer systems for managing, analysing, and displaying geographic information and data. **GIS** can show many different kinds of data on one map. This enables users to more easily see, analyse, and understand geographic patterns and relationships.

Nowadays, with technology information growth and its spread and effective application in Geometrics skills and sciences, more emphasis is on using non-structure methods based on geographic information system (G.I.S) in flood crisis management. Success in all crisis management stages depends on having updated, accurate and exact information. This information should be collected and arranged logically in terms of descriptive and location information in order to be used perfectly by managers, officials and urban planners in three stages of before, after and during crisis in line with desirable objectives. In this situation, using geographic information system is a key to solve the problem that using computer provides excellent possibilities for collecting, saving, retrieval, processing, analysing and finally producing appropriate visual outputs and including map, table, graph and the like. These systems are able to determine floodplain or flood zoning with high accuracy and speed and spending lower costs for human and financial resources; and they can determine floodway and rivers margin water logging extent by considering flood desired return periods.

GIS helps in creating land suitability analysis and flood zone mapping of towns and cities, which, if, incorporated in preparation of master plans can help in flood management in the flood prone areas. The creation of a computerized GIS database for the flood prone areas and a detailed flood risk assessment and mapping are required to minimize the harmful effects of flood hazard. The study describes an efficient & scientific approach with suitable illustrations of map and real time flood inundations. The areas, which are highly flood affected, are delineated. So that, the flood affected people can be rescued from inundation and can be evacuated to different safe places.

1.2 Causes of Flood

i. Excessive rainfall in river catchments or concentration of runoff from the tributaries and river carrying flows in excess of their capacities.

ii. Backing of water in tributaries at their confluence with the main river.

iii. Synchronization of flood peaks of the main rivers and tributaries.

iv. Landslides causing obstruction to flow and change in the river course.

v. Poor natural drainage.

vi. Cyclone and very intense rainfall.

vii. Intense rainfall when river is flowing full.

The floods of West Bengal have special characteristics. Heavy rainfalls at origin or catchment’s areas of main flooding rivers of this state cause flood, but these areas are mainly lying outside this state. The West Bengal is flooded by water from adjoining states or countries.

Major contributing factors to flood in Northern regions are the run-off because of heavy local rainfall; discharge of upper basin areas and also out fall condition in the neighboring countries. The Mahananda and most of the rivers of Uttar and Dakshin Dinajpur districts get stagnated when the Ganga upstream and downstream of Farakka Barrage rules high there by not allowing draining of flood discharge during that period. Flooding Malda is caused by the rivers Fulhar-Mahananda-and Ganga. The Ganga, forming the southern boundary of the district, brings flood water from eleven states and Nepal. The Fulhar meets the Ganga upstream of Farakka.

The rivers of Bhagirathi-Hoogly basin generate flood because of high rainfall and limited carrying capacity of the river Bhagirathi from Jangipur in Murshidabad to Kalna in Bardwan. In this reach the Bhagirathi has discharge carrying capacity of maximum 1.3 lac. Cusec. But all these rivers if receive rainfall simultaneously in their catchment areas can generate run-off volume of any amount between 4-6 lac. Cusec. In this vast tract of land there is only the Massanjore dam to interfere with the natural flow of flood water.

The basic reason of flood in this zone is the shape of the catchment area, its steep slope from a high level plateau area sloping sharply down to a flat terrain near the outfall and also adverse outfall condition because of its limited intake capacity. This feature is again adversely affected by the tidal condition as is generally noticed in the month of September, when the Hoogly is in high tide condition. Delay in drainage causes more accumulation resulting in spread of flood in the upstream of the river system in the west and beyond Berhampur. Generally part of Murshidabad and Nadia suffer from flood because of three reasons –

1. High intensity rainfall in the basin area of Bhairabi-Jalangi-Sealmari itself,
2. Inflow of flood water from Ganga-Padma at its high spate and
3. Drainage congestion at its outfall because of the high stage of Bhagirathi.

Traditionally, Damodar basin was known to be a curse. The basin of river Damodar has a very special shape and this influences its flood pattern. The river has about 70% of its basin just upstream of Durgapur town. These upper catchments of Jharkhand plateau, above Durgapur, generates heavy run-off during high rainfall and is carried to Durgapur in a short time. From here, this discharge travels through the river, bifurcating at Beguahana. One branch, the lower Damodar with very small capacity, reaches the Hoogly on the west bank. The major discharge passes through the Mundeswari to meet the Rupnarayan. Any major discharge along the downstream of Durgapur Barrage may cause flood depending upon the outfall condition of the Mundeswari at Harinkhola. In Kangsabati river system, the Kangsabati Dam has a limited flood storage capacity which is very nominal. Any major spillway discharge from Kangsabati Dam may cause flood at lower areas downstream of Medinipur town depending on tide and downstream rainfall.

1.3 Occurrence of flood:

Flood Among natural hazards, occurrence of flood ranks first in West Bengal which has become annual festival in the State. Almost all the districts are affected by flood from July to October. But flood is relatively scarce in Darjeeling in North Bengal and Bankura & Purulia in South Bengal. The detail is depicted in the following matrix. According to the Irrigation Department, 37.6 lakhs Ha of West Bengal (42.4% of the total geographical area and 69% of its net cropped area) has been identified as flood prone area; of this 29.8 lakh Ha (i.e., 58% of the flood prone area) is Protected Area. Strong monsoon, rivers and floods are an integral part of Bengal's characteristic ecology that shaped its civilization and culture and at the same time, cause of flood hazard and disasters for the society as a whole.

Flood Among natural hazards, occurrence of flood ranks first in West Bengal which has become annual festival in the State. Almost all the districts are affected by flood from July to October. But flood is relatively scarce in Darjeeling in North Bengal and Bankura & Purulia in South Bengal. The detail is depicted in the following matrix. According to the Irrigation Department, 37.6 lakhs Ha of West Bengal (42.4% of the total geographical area and 69% of its net cropped area) has been identified as flood prone area; of this 29.8 lakh Ha (i.e., 58% of the flood prone area) is Protected Area. Strong monsoon, rivers and floods are an integral part of Bengal's characteristic ecology that shaped its civilization and culture and at the same time, cause of flood hazard and disasters for the society as a whole.

1.4 Problem statement:

- On the basis of field investigation it has been found that flood and its impact are major problem in the study area. The problem under study is to assess the nature, extent and predictable areas of flood of Cooch Behar district and to determine specifically the causative factors of devastation both natural and anthropogenic, in details through data generated from intensive field work, Indian Meteorological Department (IMD) and Disaster Management Office of Cooch Behar.

- Moreover the excessive siltation, accumulation of wastes and huge amount of eroded soil particle are gradually loading the bed of river channels, for which nowadays flood has become a major problem in this area. This research work will deal particularly with one of the current issues of effect of floods as well as different problem of human beings related with severe damages.

1.5 Objectives:

Severe, precise and rational objectives have been chosen for the scientific research of the above mentioned problem of the study area, which are noted below-

- To emphasize the major causes of floods in Tufanganj, Cooch Bihar, West Bengal, India.
- To predict the flood prone areas in Tufanganj, Cooch Bihar, West Bengal, India.
- To delineate the predictable areas of flood using GIS software of Tufanganj, Cooch Bihar, West Bengal, India.
- To evaluate the impact of flood hazard on the socio-economic life of human beings.
- To suggest suitable controlling measures for its revival.

1.6 Scope of the project:

- Our target point in this study is the Flood management by GIS". In first, we learn the use of SAGA GIS and understating the applications of given software. We work on area delineation, Data sources and spatial analysis.
- On flood management part, we analyse and learn to manage and control flood, in accordance with an early warning. Hence, it enables us to control natural disaster and save lives as well as ensure economic safety.
- During a flood event, the responsible authorities need to make decisions on operation of barriers and on evacuation/rescue strategies. Temporary flood protection is sometimes an option and if so it must be decided on quickly.

- It is very important to follow some mitigation measures to prevent future damages.

1.7 Organization of chapter

The dissertation has been divided into five chapters including Introduction. Chapter 1 consists of general introduction, overview of previous literatures are given in chapter 2, study area, components of the Polavaram Project are explained in chapter 3, present irrigation and cropping pattern are presented in chapter 4, chapter 5 consists of conclusion and scope of future work.

Chapter 1 presents the brief introduction about the applications of GIS in Flood Management. The objectives and scope of the study has also been presented and it gives an overview of the project in this chapter.

Chapter 2 presents literature reviews of the previous work of pioneer investigators. This chapter includes previous work already carried out in applications of GIS in Flood Management.

Chapter 3 presents the study area of that is Tufanganj, cooch behar, west Bengal India, also its includes river patterns in this area, flood prone areas.

Chapter 4 represents the methodology used in this study that is SAGA GIS and detail procedure of preparing watershed map, flood map and various maps.

Chapter 5 represents results and discussions of the study and various controlling measures of flood,

Chapter 6 includes the concluding remarks and future scope if the research works.

Previous works carried out by other investigators have been cited in references are provided at the last.

Chapter-2

LITERATURE REVIEW

2.1 LITERATURE REVIEW ON BASE PAPER

Number of studies has been conducted in previous days about the quantification of Food Management in various areas. Various Literature Reviews mentioned that, because of the Excessive rainfall in river catchments or concentration of runoff from the tributaries and river carrying flows in excess of their capacities, Backing of water in tributaries at their confluence with the main river, Synchronization of flood peaks of the main rivers and tributaries, Landslides causing obstruction to flow and change in the river course, Poor natural drainage, Cyclone and very intense rainfall, Intense rainfall when river is flowing full the flood is occurring nowadays. In their studies they mentioned the GIS is an effective tool and also it is and effective for management of floods in flood prone areas. In their papers they mentioned the various controlling measures of floods.

Burrough (1986). In this study his described that GIS provide a wide range of applications in agriculture, geology, natural disaster management, hydrology, weather monitoring, business and service planning, government, logistics and transportation and environmental management

Godschalk et al., (1991), in their paper they mentioned, Flood is a natural calamity and its risk is described in terms of hundred-year flood. One of the main issues in flood management is the ability to prepare a reliable hazard map by identifying those areas having greater flood hazard likelihood. Normally, flood mapping is achieved by overlaying a pre-flood imagery and peak flood imagery in order to demarcate the flooded area.

Coppock et al., (1995), in their paper they entitled, The advancements in the fields of Geographical information science (GIS) and remote sensing (RS) over the last two decades have largely, facilitated the operation of flood risk assessment and mapping. RS and GIS now play a major role in the management of natural hazards, such as flooding, as their occurrence and impact is spatially inherent. First order flood risk management typically involves the generation of flood hazard maps showing areas prone to flooding based on historical flood data. However, in developing nations, historical data that accurately identifies flood extents and frequency can be poorly recorded and subjective, leading to inaccuracies in flood risk zoning and compromising mitigation efforts. Spatial technologies and infrastructure can play an important role in helping to acquire reliable, accurate and repeatedly obtained spatial information on flood events. Moreover, spatial technology like GIS not only provide a way of visualizing the spatial distribution of flood events, but also allows the potential to further analyse and estimate likely damages caused by flooding.

Berz et al., (2001) in their study they entitled that RS and GIS techniques have been reported to be handy in all these stages. With the flood problem expected to escalate due to increasing climate variability and change and increased land use change the ability to provide fast and accurate flood information is/will be critical in order to minimize flood associated damages.

Islam et al., (2001), in their paper they described that, Preparation of the flood risk maps actually depends on the estimated depth of the flood, which is usually derived from numerous hydrological and remotely sensed data. The flood depth is believed to be the most appropriate sign depicting the risk intensity. In identifying the flood depth it is quite imperative to categorize the natural phenomenon of a river flooding such as source flood and non-source flood, which posed significant implications on the GIS model. The source flood is explained as the flood caused mainly by over flow of a river bank, which predominantly affects those areas or settlements close to the river channel, whilst the non-source flood is described as a flood caused by a well dispersed rain storm over a large area.

Sanyal and Lu et al., 2003, in their paper they entitled that , Geographical Information Systems (GIS) is also now being used in several studies to delineate the flood-hazard areas by incorporating meteorological, geomorphological, topographical, land use and demographical data, with an aim to achieve a reduction in the loss of life, disruption and damages caused by floods.

Goodchild et al.,(2006),in their paper they described that, accurate floodplain mapping is one of the most valuable tools for avoiding severe losses from floods (social and economic).

Geographical information system (GIS) is a tool that can be utilized in each progression of the assessment of flood risk for modelling, management of data, and prediction. Currently, GIS is being utilized as a major tool for preparing flood hazard maps in many flood prone and floodplain areas.

Safie et al., (2006), in their paper they conducted a study using GIS for flood hazard mapping in Segamat, Johor Bahru in the Western Malaysia. Data used were originally produced by Directorate of National Mapping Malaysia (JUPEM) such as the topographical map series L7030 at scale 1:50 000 with 20 m contour intervals. Other data such as the geological map, utilities, and land use were as well obtained from Johor Structure Plan Studies 2002. The authors used two different software's; namely, AutoCAD Map 2004 and ArcView 3.1. The data preparation, processing and editing were done using the AutoCAD, which was later converted to GIS format for (2009) simulating flood water of Damansara River, Selangor. In doing the simulation, the focus was on the time of water filling as well as flood volume discharge (m3 /n) over the floodplain. Their result of analysis illustrated that the time travel for the flood water to reach the crest level of 1.23 m is just an hour 30 min. When converted to flood volume is approximately 100 m3 /n covers an area of 107 ha of flood area approximately. Conclusively, the hydrograph shows that the time travel to rise is just 30 min, where it demonstrated the benefit of the incorporation between the GIS tools of the ArcView and XP-SWMM as hydraulic software in developing a flood hazard mapping for urban area in the study area.

Hardmeyer and Spencer (2007), in their paper they used GIS to develop flood hazard maps in Rhode Island indicating zones where the flood is likely to occur and reoccur in an urban area on the island. They report that the GIS map was extremely valuable to town planners and other administrators in viewing the potential flood zones and the likely damages that could occur. This would allow them to recognize priority zones, therefore, improving flood relief arrangement and communication of the data to the general population and different stakeholders.

Adel Omran et al., (2011), used GIS techniques to produce a potential flood hazard map based on geomorphic parameter. In their study area Wadi Dahab Egypt, they used DEM for the morphometric analysis. Then delineation of basin boundaries by identifying the ridge lines(water divide) between sub basins.

Gomaa M Dawood (2011),in their paper they described that, Combination of the hydraulic series data within a spatial interface, such as GIS and RS can be sued as key elements for the graphical visualations of the flood plains. Gomaa M Dawood Flood estimating was done, DEM was generated and soil, Land Cover, geological maps were overlaid.With these initial parameters, morphometric parameters were calculated using GISSoftware.

Chapter-3

STUDY AREA

3.1 Location map of study area

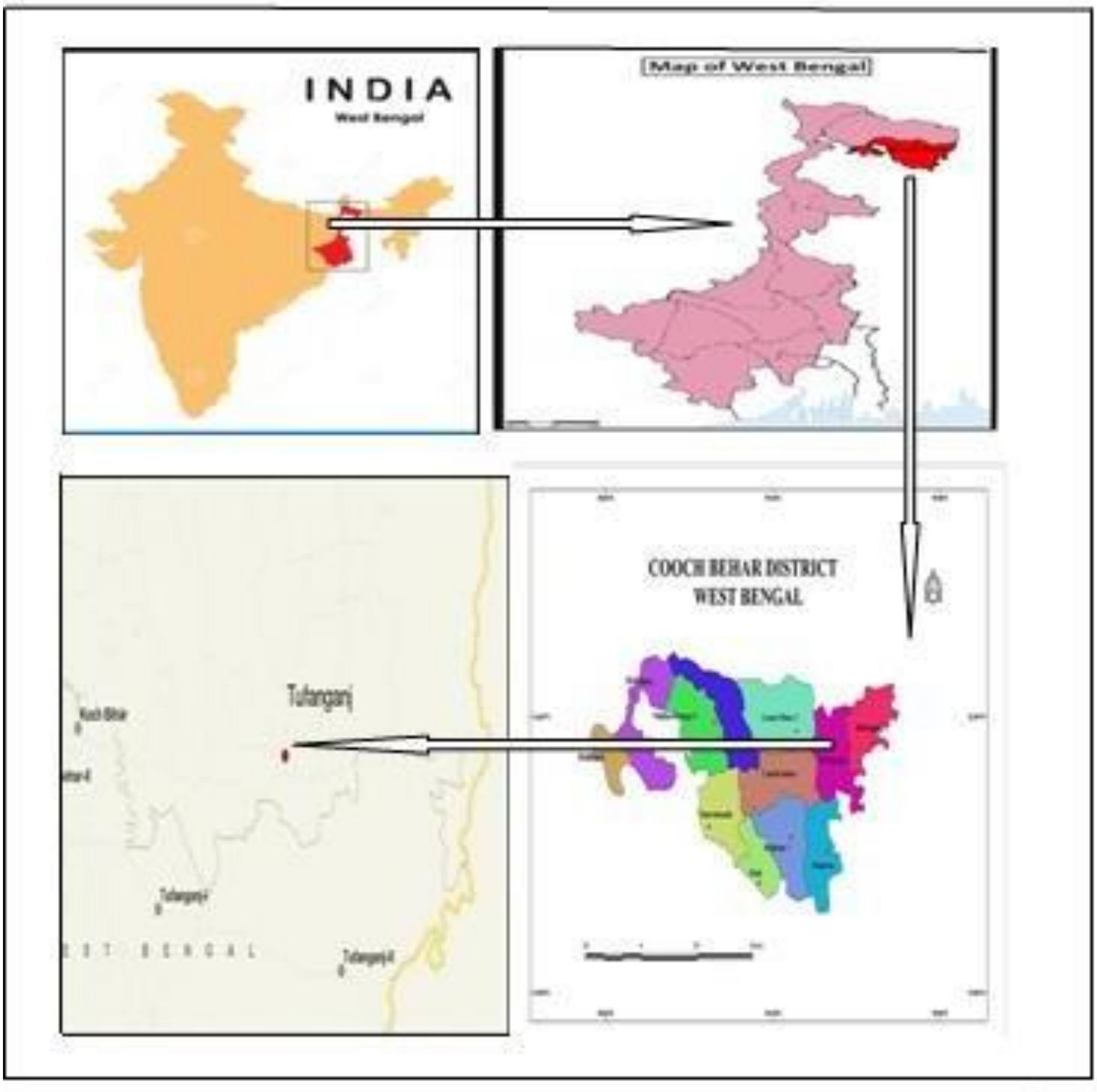


Figure: 3.1 Location map of study area

The Cooch Behar district of West Bengal has been selected for this research study. The study area is bounded by 25º 57´ 4´´ North to 26º 32´ 20´´ North Latitudes and 88º 47´ 40´´ East to 88º 54´ 35´´ East Longitude (Figure 1). The Cooch Behar district covering an area of 3387 sq. km is divided into 5 sub-divisions namely Cooch Behar Sadar, Dinhata, Mathabhanga, Tufanganj and Mekhliganj. This area represents a zone of transition between Duars (Tarai) land and Bangladesh, and displays the typical characteristics of the formation of cut-offs (Bils), ox-bow lakes, paleo channels and streams which are mostly perennial of nature and flow in their full capacity in rainy season. This area has been formed by sediment depositedby the Tista, Jaldhaka and Torsa rivers.

Tufanganj is a city and a municipality of Cooch Behar district in the Indian state of West Bengal. It is the headquarters of the Tufanganj subdivision. Tufanganj municipality was established in 1983 on the river bank of RAIDAK. It is the most important part of west Bengal state in India.it has many significant. Bangladesh and Assam border is 12k.m far from this municipality.N.H 31 passing through into this area. It is one of the most important sub-division of cooch behar district of west bengal.tufanganj municipality is 22k.m far from cooch behar town.

3.2 Torsa river flood at Tufanganj

Figure: 3.2 Torsa River Flood Affected Area

Flood simply means inundation of widespread land area with water for a number of days in continuation.

Cooch Behar district is a land of many perennial rivers and river basins; it's also a flood prone area. There are quite a few big rivers namely Teesta, Jaldhaka, Torsa, Kaljani, Raidak etc. and a number of smaller ones Gadadhar, Kaljani, Dharla, Baniadaha, Giridhari, Dudua, Gilandi, BuriTorsa, Sutunga, etc. which have crossed the district. The riversin this district generally flow from northwest to southeast direction. It is a common experiencethat every year during rainy season when intensity of rainfall is slightly higher than normal and released unbelievable volume of water through the upstream of Torsa, Teesta and Jaldhaka rivers, the surrounding area of these rivers remains under water of considerable period of time creating inconvenience to the inhabitants. So, flood has been considered to be the most devastating natural hazard faced by the flood plains of Cooch Behar district. The problem of flood is more complicated to handle in this district because of two particular aspects, such as: (1) enormous bank erosion of these rivers and (2) many embankments are vulnerable condition.

3.3 River System In West Bengal

The Ganga-Padma river artery divides the state in two parts, north and south. Being a part of Ganga-Bhrammhaputra-Meghna basin, North Bengal is extremely flood prone. The rivers Teesta, Torsa, Jaldhaka, Raidak-I, Raidak-II and their numerous tributaries belonging to the Brammhaputra basin and flowing through a part of Darjeeling, Jalpaiguri and Coochbehar originate in the Himalayas of Sikkim and Bhutan and flows south-east to Bangladesh. A part of Darjeeling and the districts of Uttar Dinajpur, Dakshin Dinajpur and Malda are drained through the rivers of Mahananda, Dauk, Tangon, Nagar, Atreyee, Punarbhaba and their tributaries. These are part of Ganga basin. Except the Mahananda, all other rivers originate in the plain of West Bengal and Bangladesh and join the Ganga-Padma at downstream of Farakka in Bangladesh. The Mahananda emerges from the Nepal Himalayas. Malda through which the river Ganga Flows receives its flood water from about eleven states and batters by the run-off flow generated from these vast areas. In central and southern part of this state, there are certain distinctive features of drainage condition which gives rise to flood situation. Basin-wise there are a number of rivers on the right bank of the Bhagirathi-Hoogly. These are Pagla-Bansloi, the Dwarka-Bramhani, the Mayurakshi-Babla-Uttarasan, the Bakreswar-Kuye and also the Ajoy. They emerge from the Jharkhand Plateau an flow southeast to meet Bhagirathi-Hoogly. These rivers drain an area of 17,684 km. spread over the State Jharkhand and Birbhum, western part of Murshidabad and Burdwan.

Originating from Ganga-Padma, the Bhairab-Jalangi-Sealmari system of rivers drain the eastern part of Murshidabad and meet the Bhagirathi at Swarupnagar in Nadia. Nadia is drained partly by Jalangi and partly by the Churni which is a part of Mathabhanga-Churni-Ichamati system, taking off from Ganga-Padma flowing southwest, to meet Bhagirathi on the east bank at Ranaghat. The other part viz. the Ichamati flows east through Bangladesh enters the district of Uttar 24 Paraganas, flows in the south direction to fall into the tidal creek of the Raimangal. Part of Howrah and Uttar and Dakshin 24 Paraganas are drained mainly by the Hoogly and its tidal creeks and other internal drainage canals. Burdwan, Howrah and Hoogly districts are mainly drained by Damodar and Bhagirathi-Hoogly Rivers. In the Damodar-Barakar basin system, the rivers originate at Chotanagpur plateau and flow down the plains of West Bengal to meet Bhagirathi. The Ajoy forms the border between Birbhum and Burdwan. Purulia and Bankura are drained by the rivers of Kangsabati, Kumari, Shilabati, Keleghai, Dwarakeswar and their tributaries. The Keleghai also drains Paschim Medinipur and a part of Purba Medinipur. These rivers originate from the western highland of the state and flow in southeast direction to form the tidal rivers of the Rupnarayan and the Haldi to meet the Hoogly on the west bank. The Rupnarayan forms the boundary between Hoogly and Purba Medinipur. A part of Purba Medinipur is drained by the river Subarnarekha originating from the Jharkhand Plateau and flowing in southwest direction to meet the Bay of Bengal in Orissa

3.4 River Catchments and its Flood affected area in the Cooch Behar district

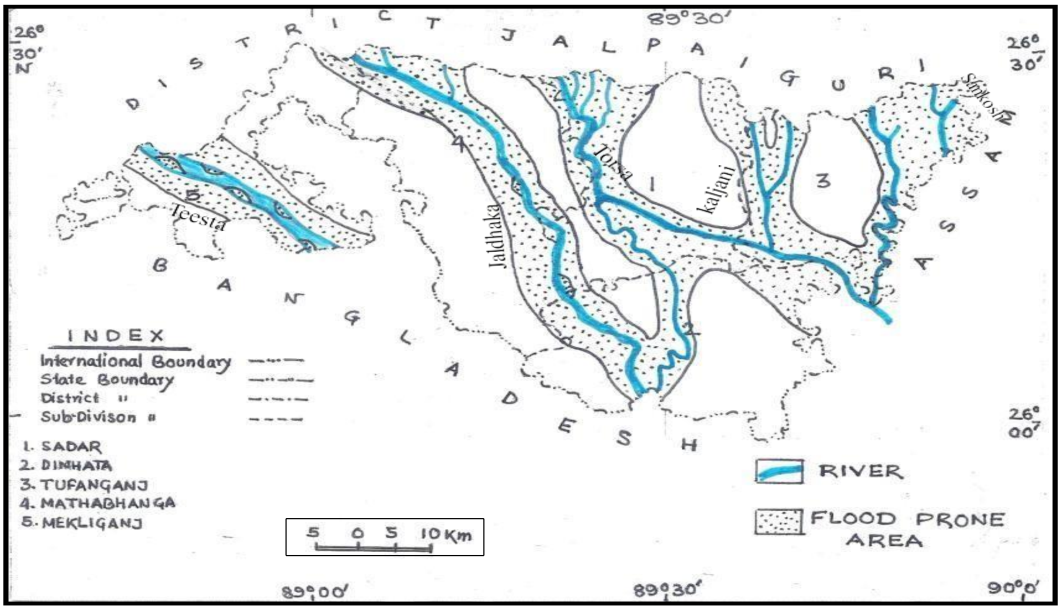


Figure: 3.3 Flood affected area in Cooch Behar

Major Rivers	Block likely to be affected by Flood
Teesta	Mekliganj and Haldibari
Jaldhaka/ Mansai	Mathabhanga-I& II, Dinhata- I and Sitai
Torsa	Cooch Behar-I and II, Tufanganj municipality
Kaljani	Cooch Behar-I and II, Tufanganj- I and Dinhata-II
Raidak-I	Tufanganj- I
Raidak- II	Tufanganj- II
Sankosh	Tufanganj- II

Table: 3.1 Flood affected area of Cooch Behar by various rivers

Source: Cooch Behar Irrigation Division (2013), Govt. of West Bengal.

Name of the block	Name of the River	Bank	Length of damage portion(in meter)	Affected embankments
Cooch Behar- I,II and Tufanganj Municipality	Torsa	LB	1300	PurbaGuriahati- Lankabar, Hanskhowa,RajarhatGhierhari Embankments
Cooch Behar - I	Mansai	LB	900	Chhederjhar-Sibpur, Hardev-Chhederjhar area in PutimariFuleshwari G. P. and BairatiJagatjilly embankments
Mathabhanga-II	Torsa	RB	500	Khopaduli
Mathabhanga-II	Mansai	LB	1200	Dewanbose embankment
Mathabhanga-II	Dharala	RB	200	panaguri embankment
Mathabhanga-I	Mansai	RB	100	Bhangamore- Chatkhaterbari Embankment
Tufanganj- I	Kaljani	RB	700	Katierkuthi, Chhatowa and Shouldhukri Embankments
Tufanganj- I	Torsa	LB	450	Chilakhana Bandar and Panishala
Tufanganj- II	Raidak-I & II	RB	600	MahishKuchi Spur and Manindrasetu
Tufanganj- I	Torsa	LB	450	Santoshpur and Gadadharembankments
Sitai	Mansai	RB	200	Adabariembankment
Mathabhanga-II	Dudua	RB	200	Uttar Doribose

Table:3.2 flood affected blocks of Cooch Behar by various rivers

Source: Cooch Behar Irrigation Division (2013), Govt. of West Bengal.

Chapter-4

METHODOLOGY

4.1 Introduction to GIS:

GIS is a computerized system that is used to capture, store, retrieve, analyze, and display spatial data.

GIS is very effective in identifying the components of the flood management. GIS shows the spatial distribution of the actual view of flood phenomenon. GIS is used to measure the location of flooded areas and provide a measurable estimation of the land and infrastructures affected by the floods.

4.1.1 Application of GIS

As to be noted, water resource assessment and management are inherently geographical activities requiring the handling of multiple forms of spatial data. Various combinations of geographic information systems and simulation models will be required to improve our knowledge in these areas. GISs offer powerful new tools for the collection, storage, management, and display of map related information, whereas simulation models can provide decision-makers with interactive analysis tools for understanding the physical system and judging how management actions might affect that system (National Research Council 1999).

The water resource applications of GIS will also need to be multifaceted. Many of the problems involve interactions between the hydrosphere, atmosphere, lithosphere, and biosphere. The solutions must serve competing groups of users, with many of the important hydrologic processes having local, regional, national, and global dimensions. Moreover, it is sometimes difficult to translate research outcomes into policy and management strategies because much of the fundamental hydrologic research is conducted at specific sites or on small plots. Conversely, many of the policy and management strategies are focused on watersheds and/ or administrative jurisdictions. The immediate challenges in the water resource domain are:

• To identify ways in which GIS can facilitate more effective and/ or more efficient water resource management;

• To develop GIS-based methods that address specific water resource challenges and problems; and

• To train the next generation of water resource scientists, engineers, and policy analysts to sustain the continued evolution and appropriate use of GIS-based water resource applications.

4.1.2 GIS data, their management and delivery

The management of water resources requires a wide range of spatial data, from hydrography and water distribution and collection systems, representing the status of water resources, to phenomena influencing the quality and movement of water such as terrain, climate, soils, and land use. GIS has enabled government agencies and private organizations to extend the delivery of their data from numerical tables to maps and to support various forms of spatial searches for relevant data. A good example of the latter is the Environmental Protection Agency "Surf Your Watershed " site, which allows the user to obtain water quality data in the form of maps and tables (see http://www.epa.gov/surf/ for details).

4.1.3 Digital elevation models

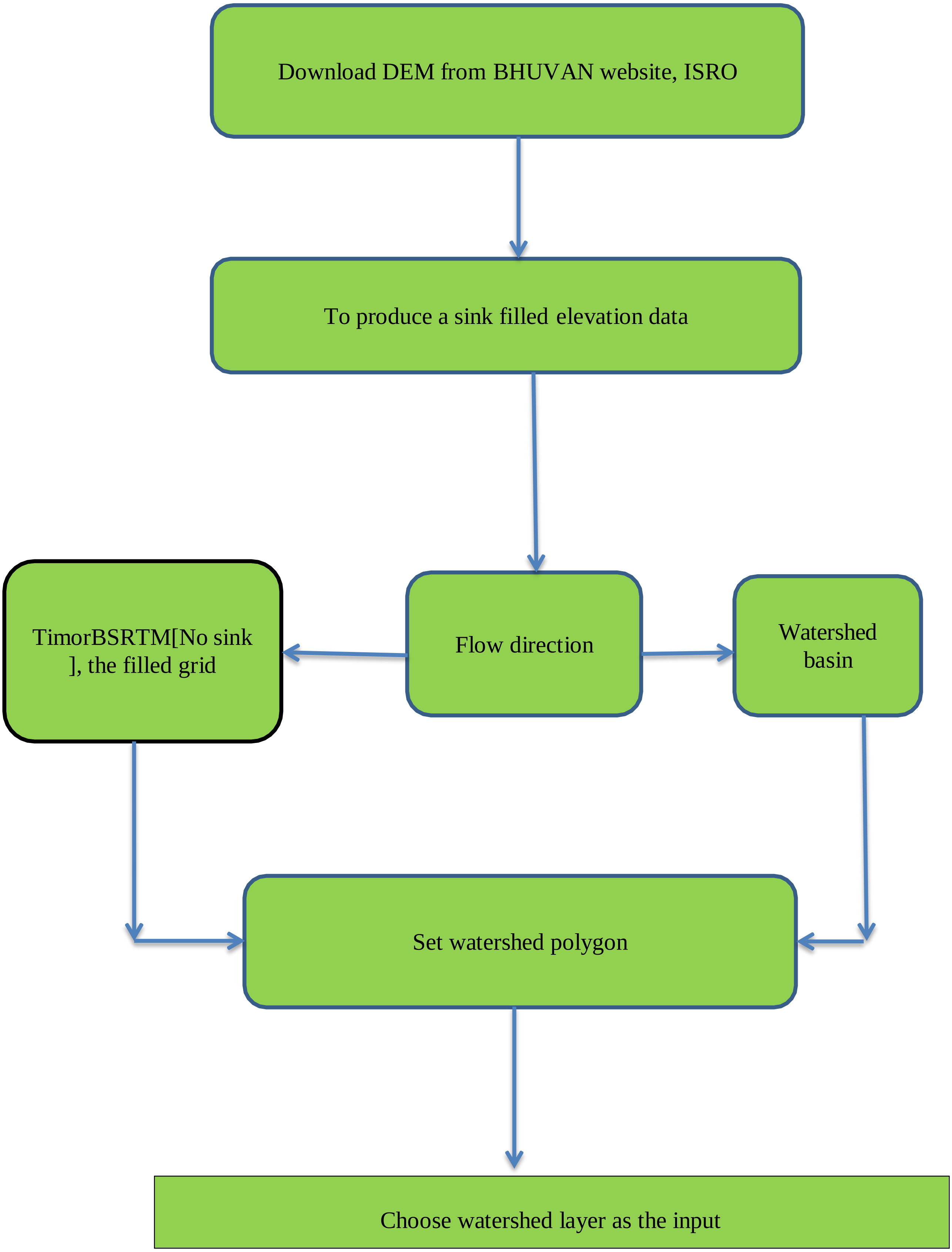
Topographic information cast in the form of digital elevation models (DEMs) has had a profound impact on water resource applications of GIS by stimulating the research and development of distributed hydrologic and nonpoint source pollution models and their linkage to GIS.

4.1.4 SAGA GIS:

System for Automated Geoscientific Analyses (**SAGA GIS**) is a geographic information system (**GIS**) computer program, **used to** edit spatial data.

GIS Database Design SAGA GIS software is used to display the spatial data and attribute data that has been set up using the data needed to establish potential areas of flooding area. Catchment areas should be produced before the process of determining the potential flood areas.

4.2 Design and development data in this study include the process as described below



Select larger catchment

Cut DEM layer

Choose the grid system

Prepared catchment

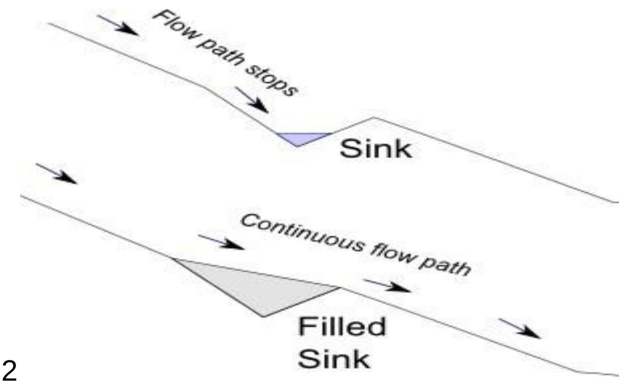
Further analysis: Terrain analysis includes slope map, reclassify slope map, analytical hill shading map, aspect map, analytical hill shade, flow accumulation map, flow direction

Figure: 4.1 Flowchart of methodology

Figure: 4.1 Flowchart of methodology

4.2.1 Pre-processing and catchment delineation:

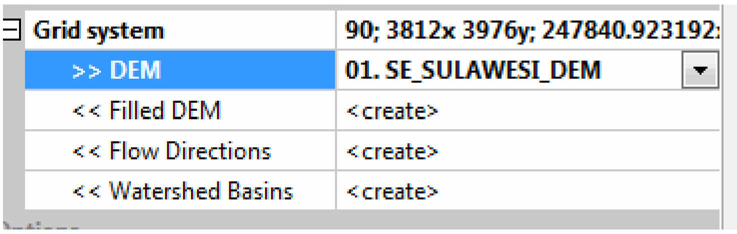
Pre-processing – Sink Fill



In order to produce hydrological flow models we need to produce an elevation data-set free of 'Sinks' or depressions that would capture the flow of water. The figure to the right is an example of a model with a 'Sink' and the same surface after 'Sinks' are filled and overland flow is continuous.

To produce a sink filled elevation data use the Module: *Terrain Analysis>Pre-processing>Fill Sinks (Wang Liu)*.

Add the Timor Barat DEM as the input. The output includes a filled DEM and watershed basins (DAS).



To produce a sink filled elevation data use the Module: *Terrain Analysis>Pre-processing>Fill Sinks (Wang Liu)*.

Choose the grid system and the DEM grid.

The 'Fill sinks' module produces three new layers:

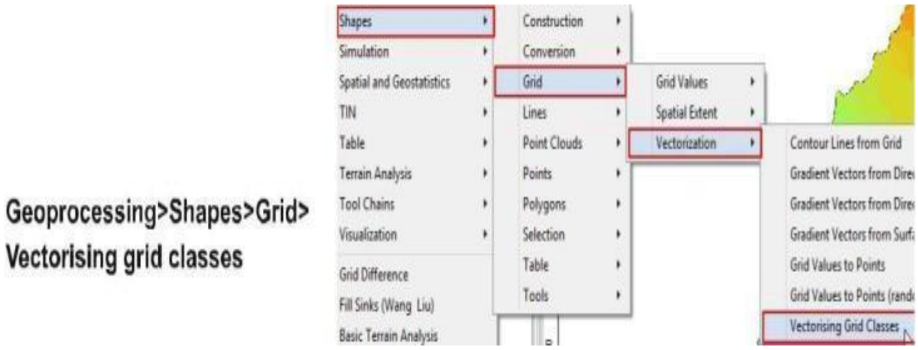
1. "TimorB_SRTM [no sinks]" , the sink filled grid
2. "Flow directions" the direction of water flow through each cell
3. Watershed basins" or catchments.

Double click on the layer Watershed basins (DAS) so see it in the map.

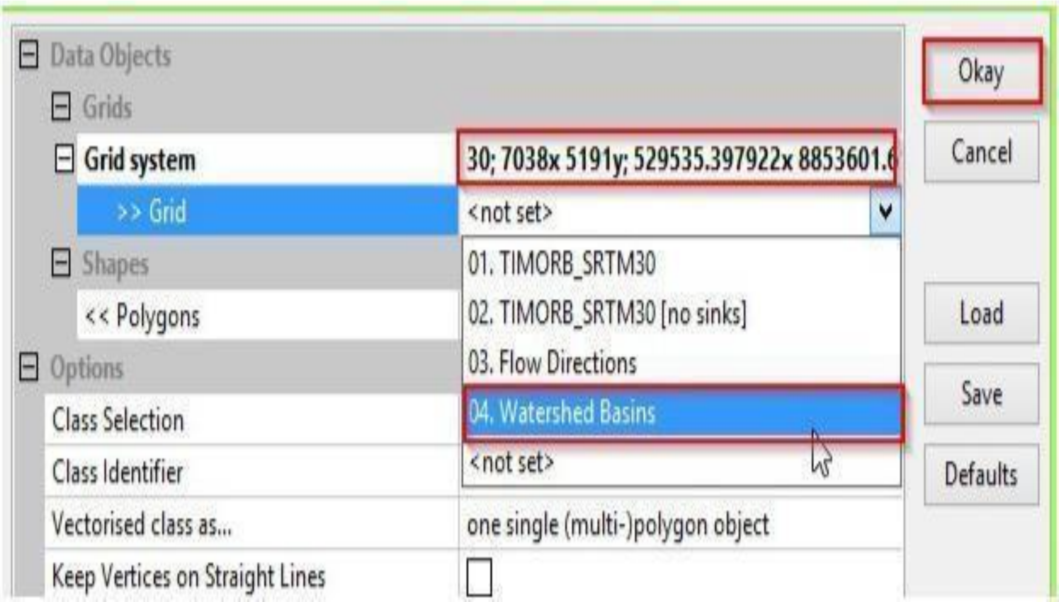
We will conduct further analysis on just one catchment delineated by the fill sink tool. To

clip our data to one catchment we must first convert our raster watershed data-set to

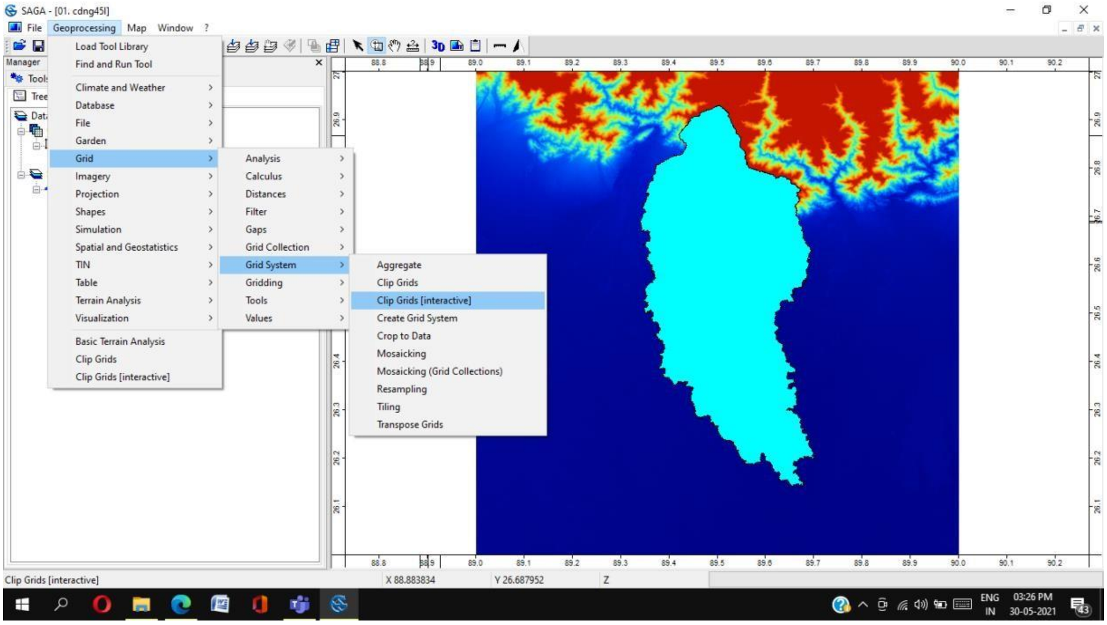
watershed polygons. To do this we use the Vectorising grid classes tool as shown here:



Choose the watershed layer as the input.



Once the process is complete display the new shape file watershed basin layer and select one of the larger catchments with your cursor tool.



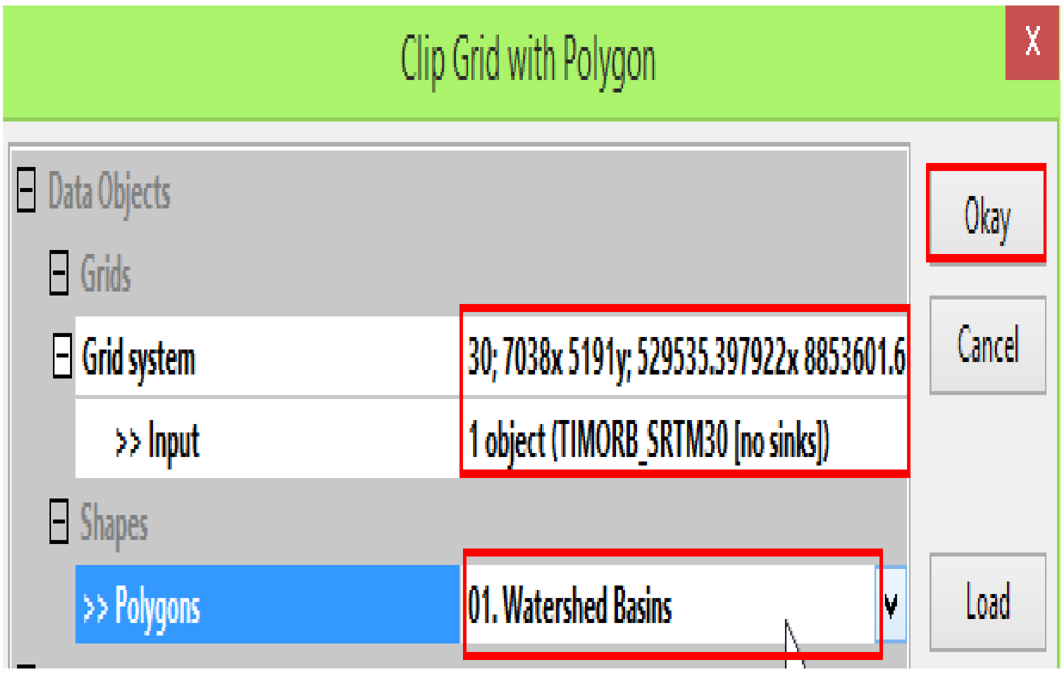
Cut the DEM layer using the selected catchment.

Use: **Geoprocessing>Shapes>Grid>Spatial Extent>Clip grid with polygon**

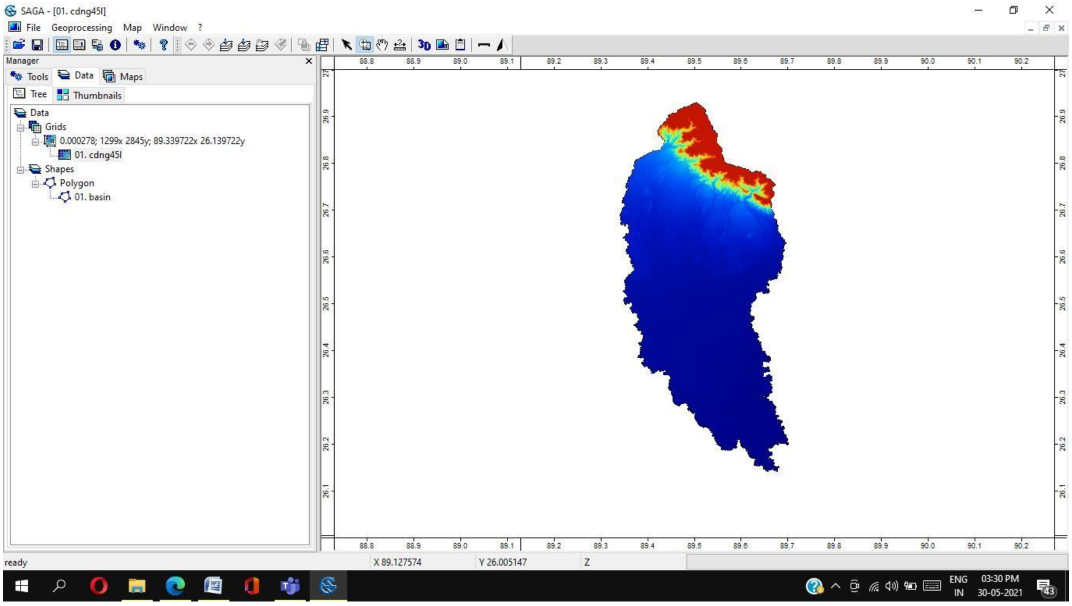
1. Choose the Grid system

2. Select just the DEM as the input layer

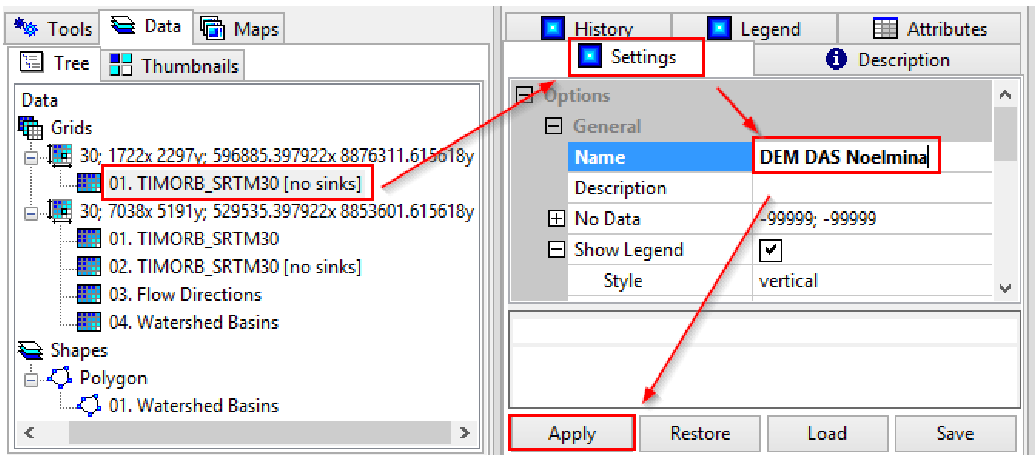
3. Double click **Input>DEM TimorB_SRTM [no sinks]**



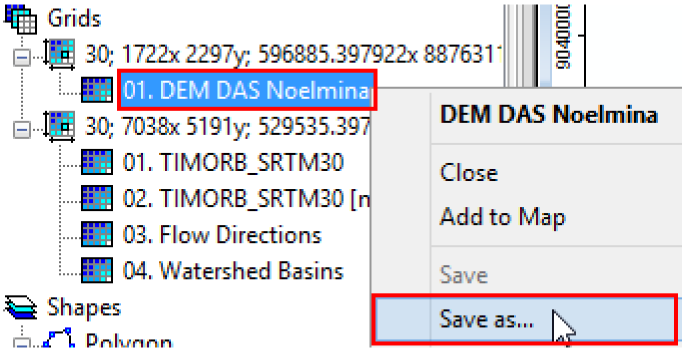
You will notice a new grid system with smaller extents has been made. This is the clipped grid. Double click on the new grid to display it over the Watershed shape file..



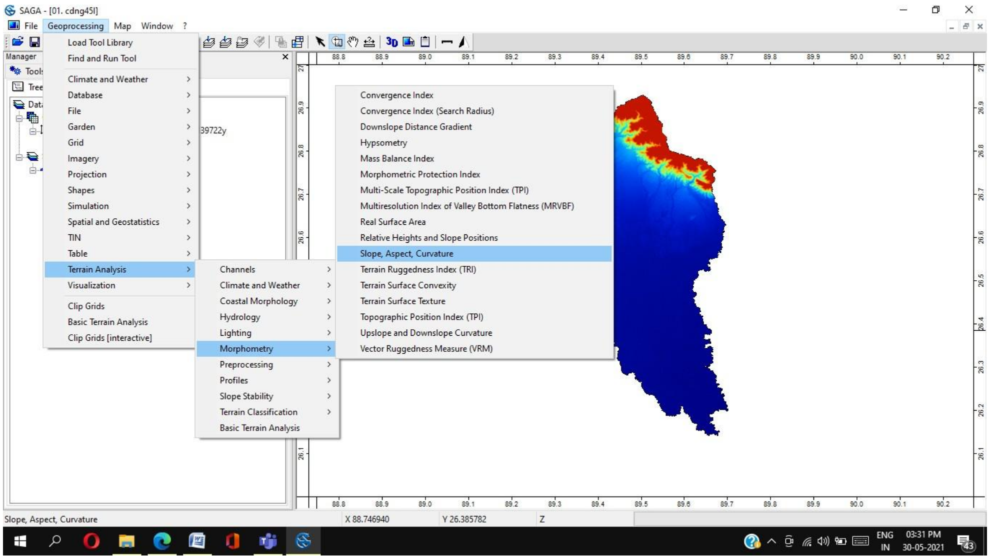
Although it is a new Grid it has taken the name of the old grid. In order to avoid confusion change the name of the new grid in the settings tab. In the example shown here we have called it DEM DAS Noelmina. ‘DAS’ is the Indonesian name for a catchment and Noelmina is the name of the catchment clipped in the example shown.



By right clicking in on the new grid layer it is possible to save it. It will be default save as a SAGA Grid format (.srgd).



Now we have prepared our catchment we can conduct some more further analysis.



Chapter -5

RESULTS AND DISCUSSIONS

5.1 Slope Map:

A map indicating the topography of an area along with an analysis of topographic features as they have influenced and may continue to influence land development. A slope map is a topographic map showing changes in elevation on a highly detailed level. Architects, landscape designers, and water control planners use a slope map to evaluate a particular site. Detailed data are required to generate one of these maps. The concept of slope is important in economics because it is used to measure the rate at which changes are taking place. ... Slope shows both steepness and direction. With positive slope the line moves upward when going from left to right. With negative slope the line moves down when going from left to right.

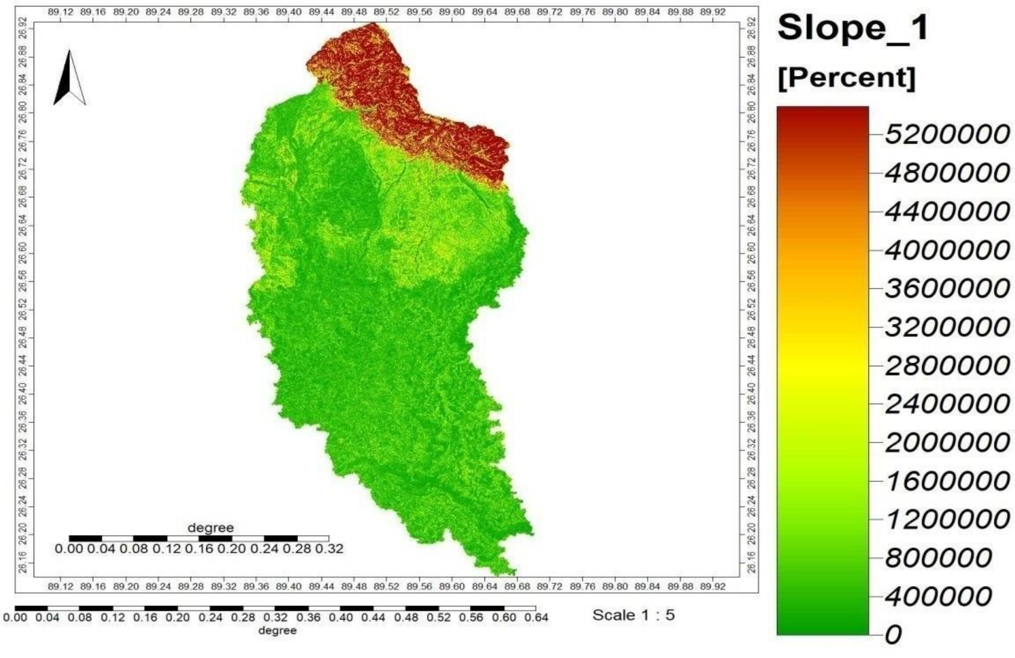


Figure: 5.1 Slope Map

5.2 Cdng Map

The concept of slope is important in economics because it is used to measure the rate at which changes are taking place..... Slope shows both steepness and direction. With positive slope the line moves upward when going from left to right. With negative slope the line moves down when going from left to right. The concept of slope is important in economics because it is used to measure the rate at which changes are taking place .....Slope shows both steepness and direction. With positive slope the line moves upward when going from left to right. With negative slope the line moves down when going from left to right.

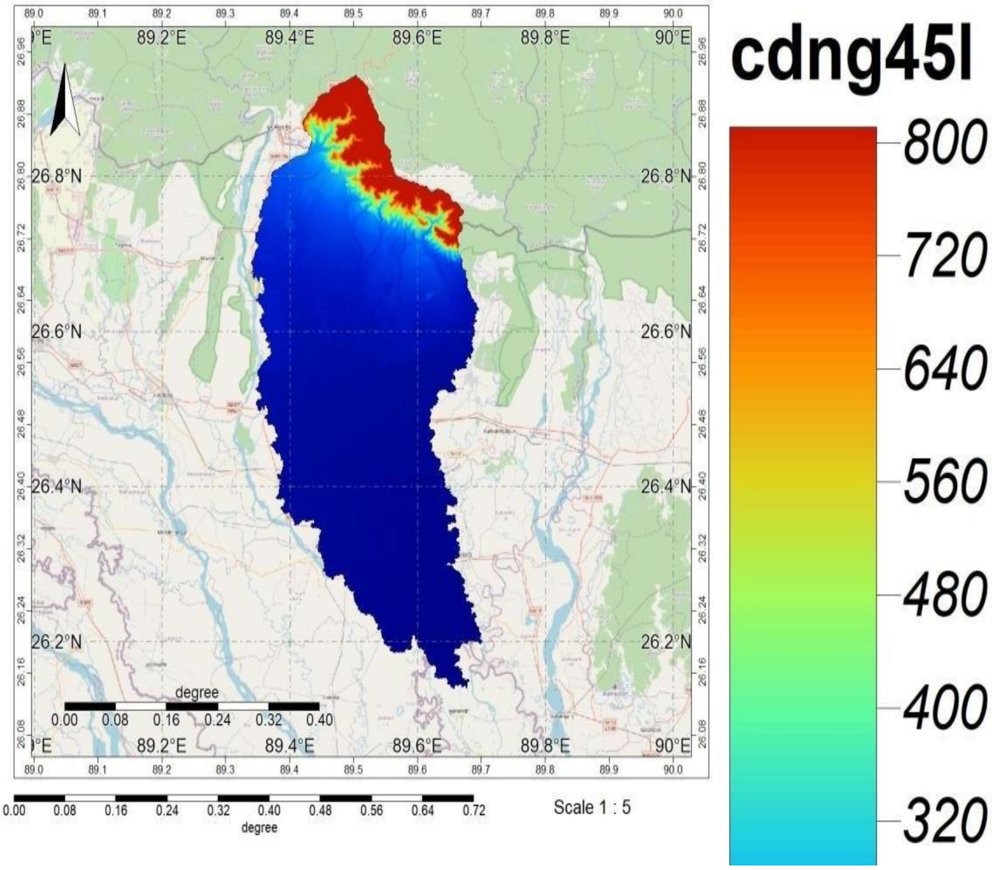


Fig: 5.2 Cdng Map

5.3 Analytical hill-shade map

Analytical hill-shading Home. The representation of topographic relief with the method of hill-shading, is based on simulating the effect of natural light on earth's surface, under some necessary assumptions and simplifications that make the result usable for cartographic purposes.

Hill-shading is a technique for creating relief maps, showing the topographical shape of hills and mountains using shading (levels of gray) on a map, just to indicate relative slopes, mountain ridges, not absolute height.

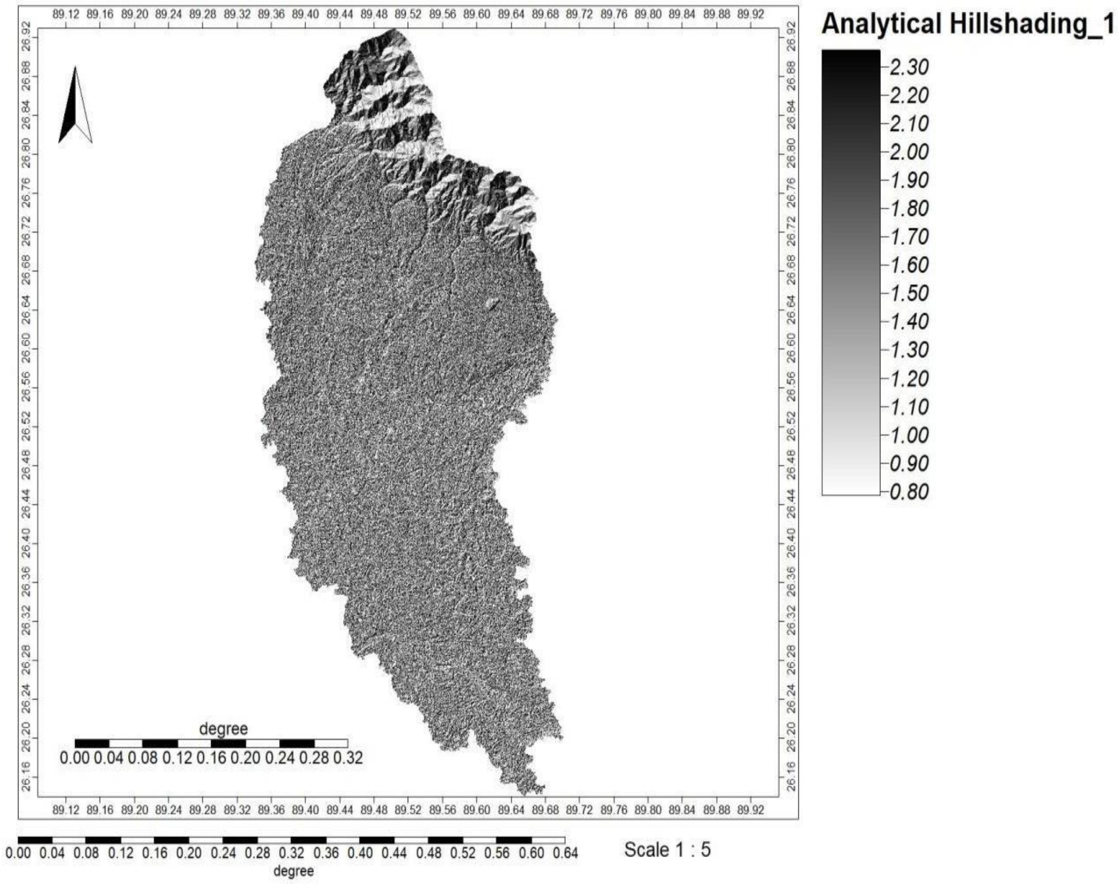


Fig: 5.3 Analytical Hill-shading map

5.4 Channel network

Channel mapping is a method that goes beyond listing the ways customers are contacted by a company to explore what a company's brand value means to a particular customer. A channel is a communication medium, the path that data takes from source to destination. A channel can be comprised of so many different things: wires, free space, and entire networks. Signals can be routed from one type of network to another network with completely different characteristics.

Essentially then, a river network is a two-dimensional representation of the three-dimensional landscape morphology, not necessarily (although frequently) related with the actual river flowing on that landscape in reality.

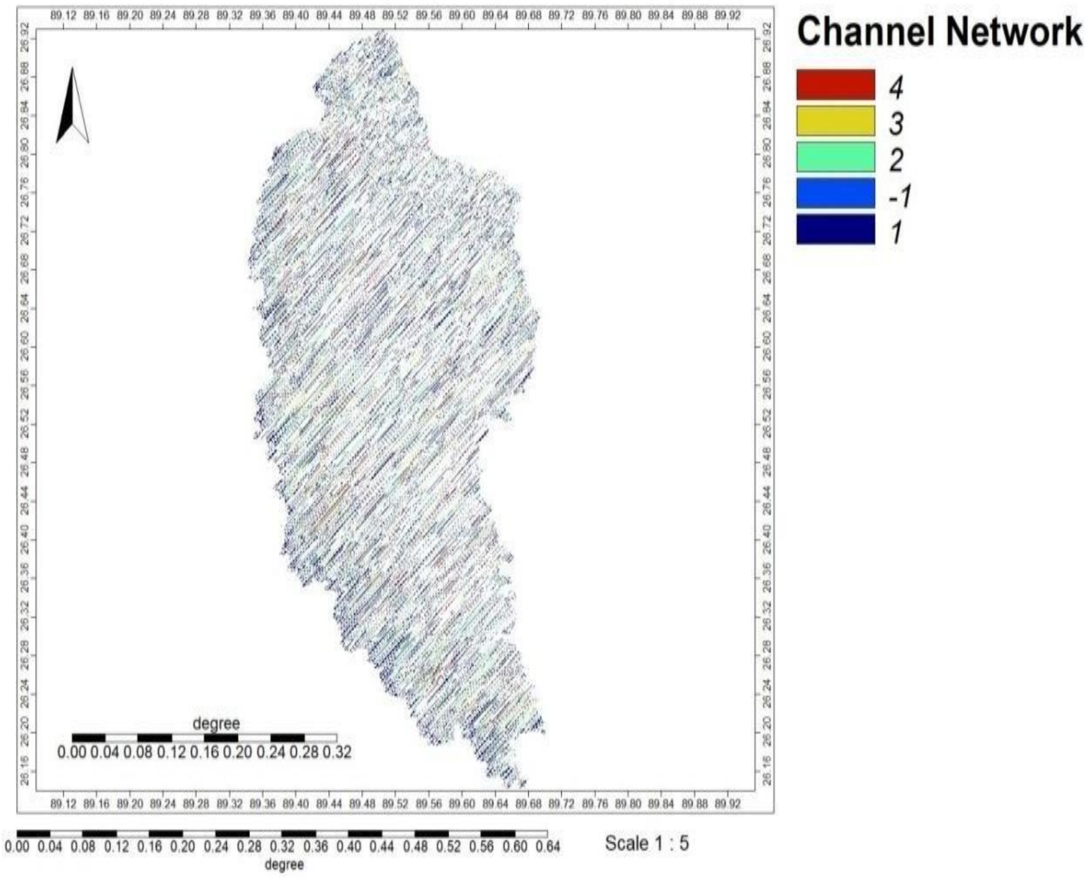


Fig: 5.4 Channel Network

5.5 Slope reclassified map

Reclassification is the process of reassigning one or more values in a raster dataset to new output values. The Reclassify tool is available in the Spatial Analyst extension in both ArcMap and Arc-GIS.

To ou drew (after converting it to feet). Multiply the resulting number by 100 to get a percentage value equal to the percent slope of the hill.

Curvature m calculates a percent slope, simply divide the elevation change in feet by the distance of the line yap:

A curvature map is a texture that stores the convexity/concavity of the mesh. Also called Concavity, Convexity, Pits & Peaks, Worn Edge. A Cavity map is different, it stores ambient occlusion which is limited to small crevices only. Curvature maps are basically greyscale representations of the convex/concave areas on the surface of a mesh. So in the map(depending where you bake it) convex areas will show lighter shades of grey and concave will show darker. The map can be derived from both the geometry itself (per-vertex), or the normal map(per-pixel)

Surface curvature is a topographic attribute that describes the convexity/concavity of a terrain surface. Curvature calculation is based on second derivatives; the rate of change of a first derivative such as slope gradient or slope direction (aspect), usually in a particular direction . The two curvature measures most frequently used are the profile and the plan curvature. The profile curvature (PRC) describe the rate of change of slope along a flow line and can be related to acceleration/deceleration of gravitational flow, while the plan curvature (PLC) describe the rate of change of aspect and is associated with flow convergence/divergence. Since PLC can take extremely large values where the gradient is small, a better measure for topographic convergence is the tangential curvature (TAC), which is the curvature in an inclined plane perpendicular to the direction of flow and the surface

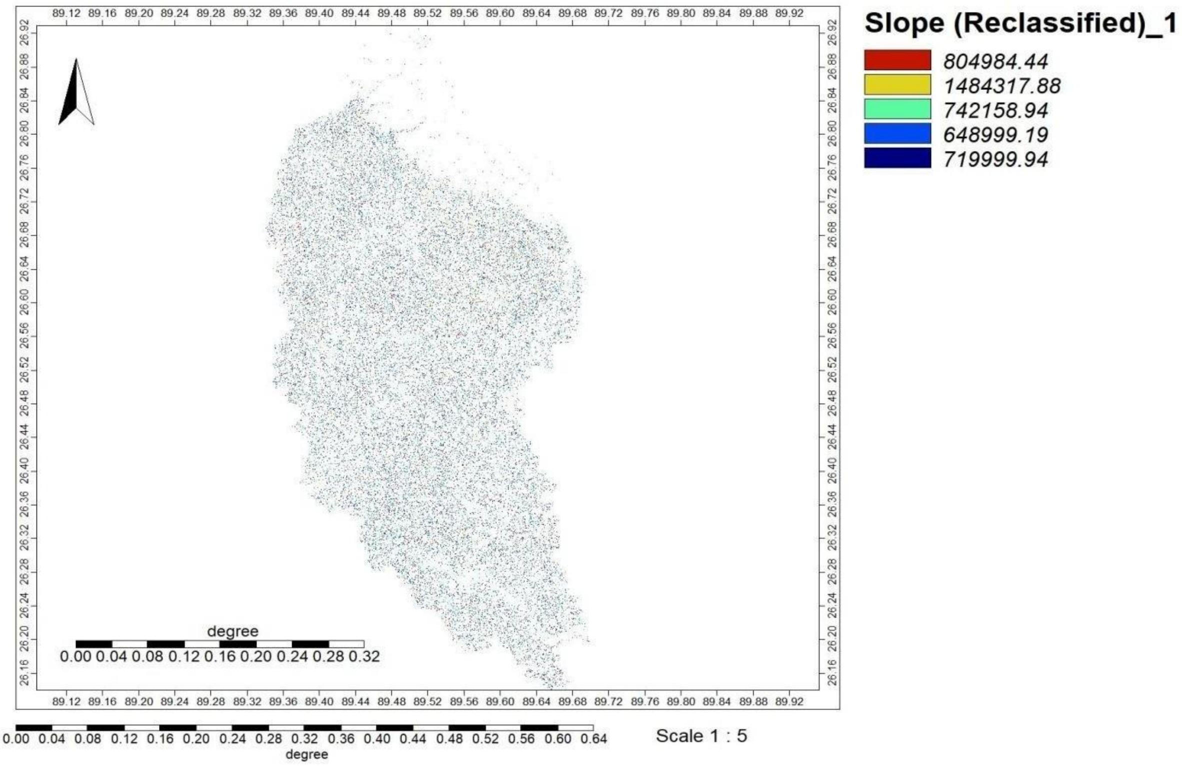


Figure: 5.5 Slope Reclassified Map

5.6 Curvature map

The curvature map is formulated for a discrete mesh, but the same concept can be applied to an analytic surface, where the curve values for discrete increments would be replaced by a continuous function on the surface. We have presented the curvature map, a new method for comparing local shape based on surface curvature. It has been applied as a 1-D method on N-ring neighborhoods and as a 1-D or 2-D method on Geodesic fans. Point curvature (0- D) methods do a poor job of distinguishing between local regions. Curvature maps demonstrate improved capability to discriminate shape as compared to these 0-D methods. Determining how far out to go when comparing local.

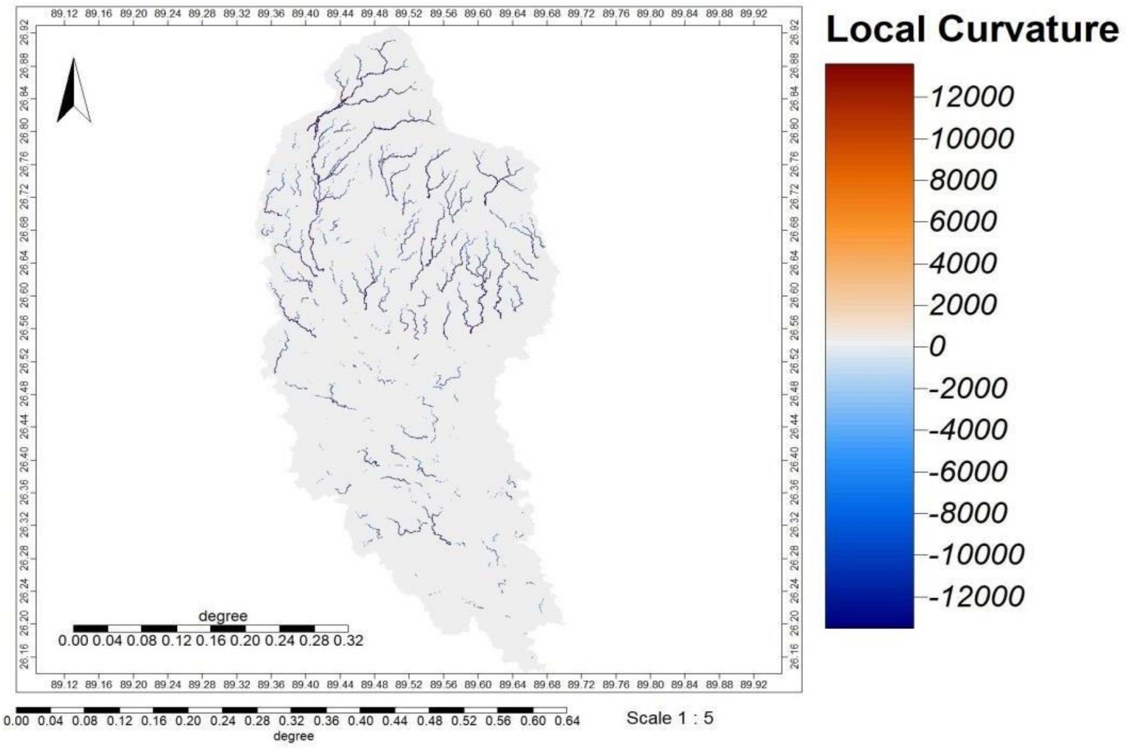


Figure: 5.6.1 Local Curvature Map

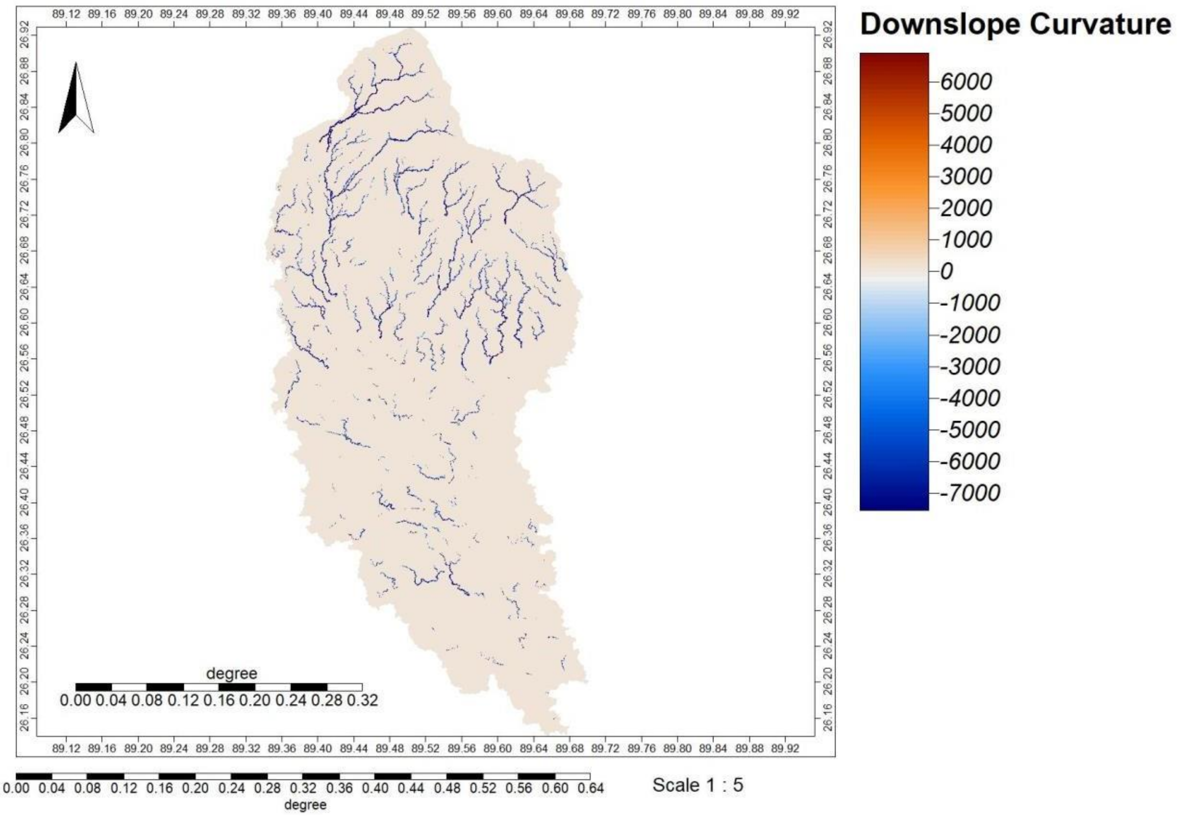


Fig: 5.6.2 Down slope Curvature

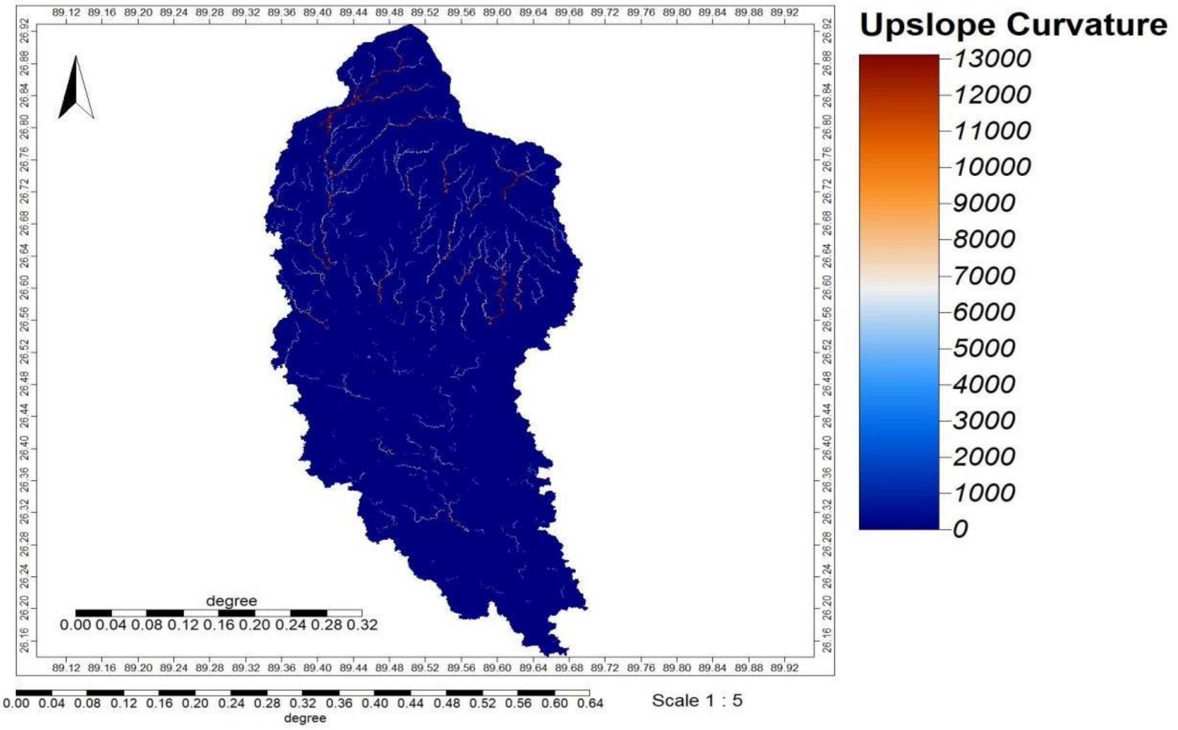


Figure: 5.6.3 upslope curvature map

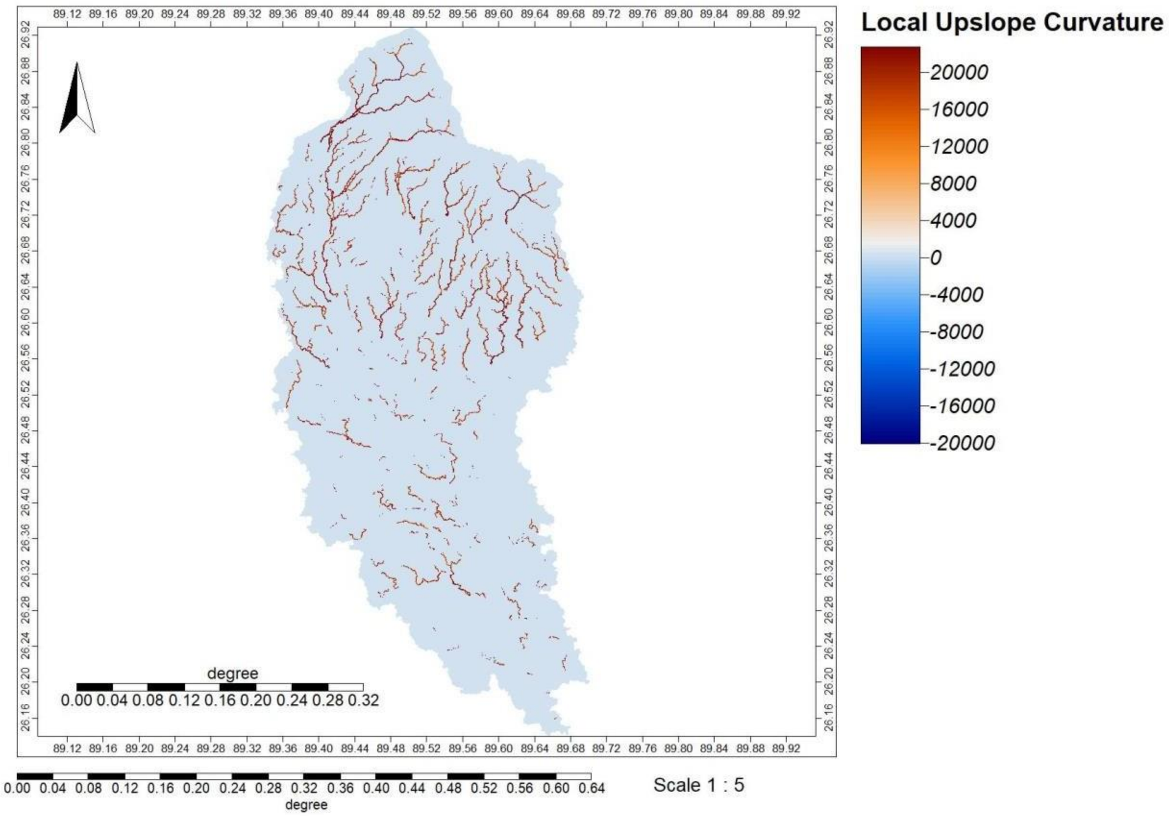


Figure: 5.6.4 local upslope curvature

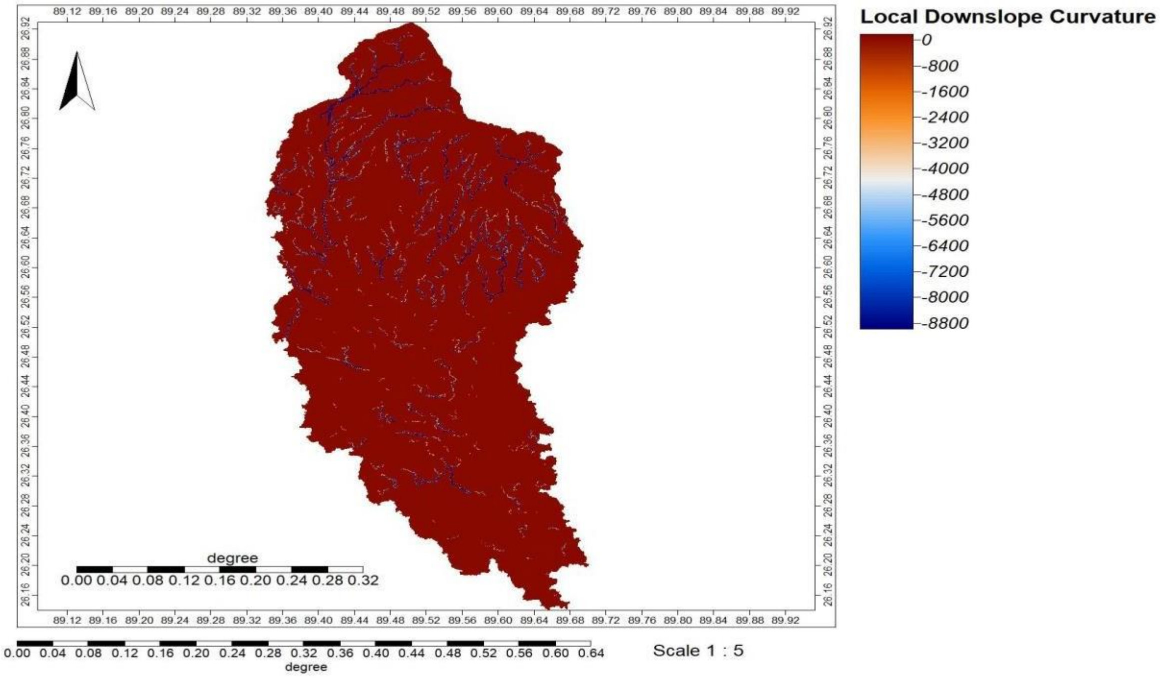


Figure: 5.6.5 Local downslope Curvature map

5.7 Flow accumulation map

The Flow Accumulation tool calculates accumulated flow as the accumulated weight of all cells flowing into each downslope cell in the output raster Cells with a high flow accumulation are areas of concentrated flow and may be used to identify stream channels.

Flow Accumulation. In the process of simulating runoffs, the flow accumulation is created by calculating the flow direction. To each cell, the flow accumulation is determined by how many cells that flows through that cell; if the flow accumulation value is greater, the area will be easier to form a runoff.

The Flow Accumulation tool calculates accumulated flow as the accumulated weight of all cells flowing into each downslope cell in the output raster. If no weight raster is provided, a weight of 1 is applied to each cell, and the value of cells in the output raster is the number of cells that flow into each cell.

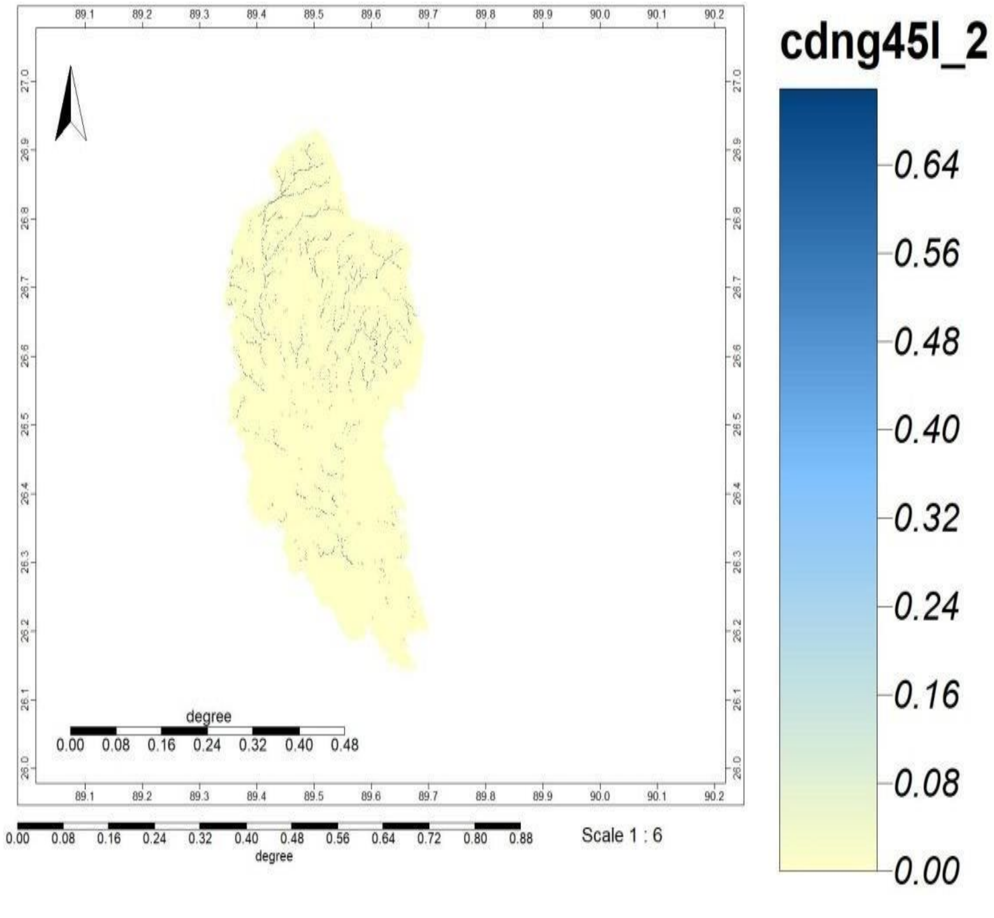


Figure: 5.7 Flow Accumulation Map

5.8 Flow direction map

Flow direction determines which direction water will flow in a given cell. Based on the direction of the steepest descent in each cell, we measure flow direction. Also, the z-value difference and slope are calculated between neighboring cells. Measure the longitudinal strain at two points along the path of the pipe. The flow direction will be from highest to lowest strain. Measures shear stress. Measure lateral strain like longitudinal strain, associated with fluid pressure. Hydrologists use flow direction maps to help model how surface runoff contributes to flooding. They also use it for a lot more. Flow direction calculates the direction water will flow using slope from neighboring cells. ... On a cell-by-cell basis, we explore which direction water travels using a pour-point model.

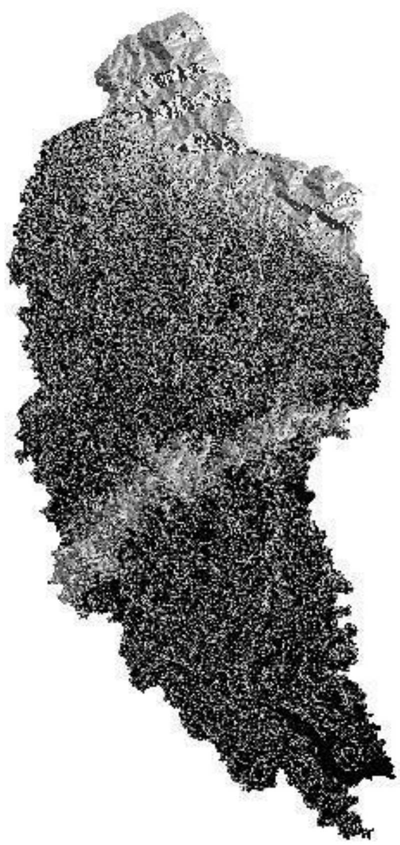


Figure: 5.8 Flow direction map

5.9 Rain fall data of Torsa at Cooch Behar

year	River Torsa at Cooch Bihar D.L/Y-42.07M E.D.L/R-42.68	
	Highest Gauge Rainfall In Metre	Date
2002	42.38	24/7/02
2003	42.54	1/7/03
2004	41.75	8/7/04
2005	42.18	19/07/05
2006	42.36	28/6/06
2007	42.62	7/9/07
2008	41.90	29/08/08
2009	42.02	20/8/09
2010	42.34	21/7/10
2011	41.28	10/7/11
2012	41.88	15/7/12
2013	42.68	21/8/13
2014	41.80	15/7/14

Table 5.1 Rain fall data of Torsa at Cooch Behar

5.10 Flood map:

Flood Map application does not show current or historic flood level but it shows all the area below set elevation."

- Flood Map may be useful to some extent for flood risk assessment or in flood management, flood control etc.

- Flood Map may help to provide flood alert/flood warning if flood water level at certain point is rising.

- Flood Map can help to locate places at higher levels to escape from floods or in flood rescue/flood relief operation.

- It can also provide floodplain map and flood line map for streams and rivers.

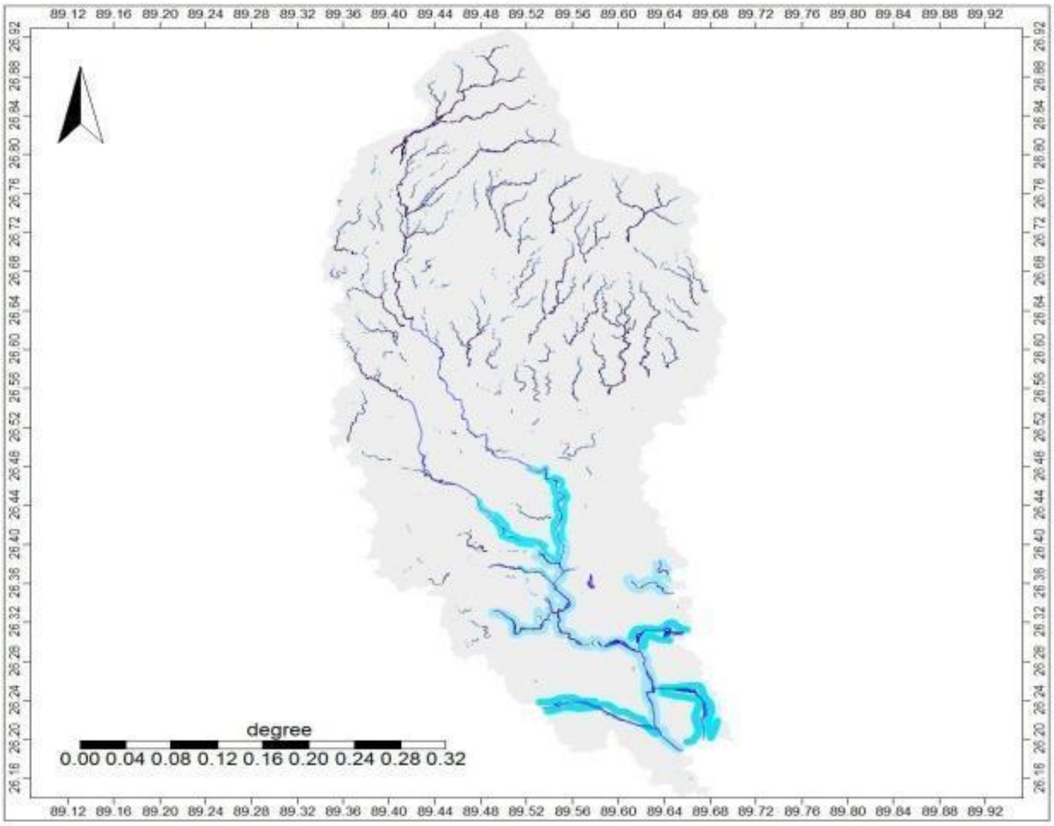


Figure: 5.10 Flood Map

5.11 Discussion:

From the above discussion it is clear that the flood has great impact on people's livelihood along with these rivers. In view of the ever-increasing problem of flood hazard in Cooch Behar district, local residents as well as the illiterate people must be made conscious of the possible dangers that they are inviting due to their careless dealing with nature. Natural occurrence such as flash flood cannot be completely stopped from happening but its frequency can be reduced through the success of full management planning and commitment from the policy planners. Keeping in view the intensity of the problems, it is the high time that people from all walks of life should sit jointly to take required precautionary measures.

5.12 Controlling Measures

It is very important to follow some mitigation measures to prevent future damages. Lookingat the previous floods, the Central and State governments took planned steps to control the floods at Cooch Behar. Through a number of measures have already been taken by the government, such as embankment has made, revetment concept has also been introduced. Butstill the situation is not under control. Huge damage has done at the downstream of rivers dueto high rate of scouring mainly in rainy season or at the time of high water level. The flood plain areas of these rivers in the subdivisions of Cooch Behar district are more prone and vulnerable to floods. Proper step should be initiated to control further flood in the flood plain areas. There are several steps to control or minimize the menace of floods, which are as follows-

- Flood forecasting is crucial and very helpful for taking timely action to prevent loss ofmany lives and moveable properties.

- The channels of Teesta, Jaldhaka and Torsa rivers more prone to flood improved by deepening and widening.

- Flood forecasting is crucial and very helpful for taking timely action to prevent loss of many lives and moveable properties.

- The channels of Teesta, Jaldhaka and Torsa rivers more prone to flood improved by deepening and widening.

- Defenses such as levees, bunds, reservoirs, and weirs are used to prevent rivers from bursting their banks

- Legislative measures are taken to restrict the construction of residential units and other economic activities in the flood prone areas. Under legislative commitment, constructions are not allowed in flood plain.

- Reduction of surface run-off is one of the very effective methods of flood hazard management. This can be done by large scale afforestation in the upper catchment area of the rivers. Run-off reduction helps in reducing soil erosion which leads to reduced streams sediment load and helps in maintaining the capacity, competency anddischarge of these rivers.

- Floods can be controlled by construction of dams. Dams has the capacity of holding huge amount of water during flood and also help in reducing peak water level of river channels.

- Construction of additional dykes and embankment along the river. Construction of embankment is still considered to be one of the very successful devices against inundation of the inhabited areas and agricultural land areas.

- The volume of water during flood period of a river may be reduced through a series ofengineering techniques such as, construction of flood control storage reservoirs.

- People involvement through education and consciousness among the potential victimsare also proposed as a mitigation measure for reducing flood damage.

Chapter-6

CONCLUSION AND FUTURE ENHANCEMENT

6.1 Conclusion

- It has being observed that the flood event of the TUFANGANJ will be highly affected the population of citizens under the flood impact.

- It can be seen that the flood maps which are obtained using SAGA GIS indicates flood affected zones of the area.

- It can be observed that the slope obtained from GIS software indicates different classes of slopes.

- It can be seen that, the flow direction map, flow accumulation map which are obtained from the software indicates the occurrence of flood in the area.

- This analysis has helped to pinpoint the importance management of flood in flood prone areas through SAGA GIS, and helps in carry out suitable mitigation measures to control the flood.

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- This analysis has helped to pinpoint the importance management of flood in flood prone areas through SAGA GIS, and helps in carry out suitable mitigation measures to control the flood.

- Tufanganj area, Cooch Bihar, West Bengal, India highly is affected by flood almost every year. In this area almost all parts the city was affected by flood.GIS is ideally suited for various floodplain analysis and management. Extensive use of these technologies have great prospect in creating long-term database on flood proneness and relief management.

- This study shows a simple and cost effective way to use geographical information system for creating flood management plan from the available data base. It is acknowledged that accuracy of the key information, past records of flooding, depends upon the scale of the map that represents them. Although flooding is a natural phenomenon we cannot completely stop it but we can minimize its adverse effects by better planning & management system.

- Clearly, identifying pattern of the flood will help to prevent it and reduce more damage by taking necessary steps in time. In addition, it is also important to calculate the loss. Since flood problem is very common to this region, it should grab some more attention.

6.2 Future Enhancement

- Further study on flood management of any area with different scale, and geometrical conditions has to be carried out in order to provide more data for effective management of flood events and to carry out effective methods of mitigation of flood in order to reduce or control flood.

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J. Jasmine , M. Sai Kumar, S. Sruthilaya, N. Rahul Redd, K. Pavan Nayak , "GIS and It's Applications In Flood Management-Tufanganj, Cooch Behar, West Bengal, India ", International Conference on Computing for Sustainable Development in Civil Engineering (ICCSDC 2021), St. Martin's Engineering College, Secunderabad, 24 & 25th June, 2021.

A Major Project Report

On

SUPPLICATION OF OIL PALM BOILER CLINKER AGGREGATES IN THE PRODUCTION OF STRUCTURAL LIGHT WEIGHT CONCRETE

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

by

Mr. T. Akhil - (18K85A0120)

Ms. B. Sathvika - (17K81A0170)

Ms. N. Jyothi - (17K81A0192)

Mr. K. Anjaiah - (18K85A0119)

Under The Guidance of

Mr. M. Rajasekhar

Assitant Professor

DEPARTMENT OF CIVIL ENGINEERING

ST. MARTIN'S ENGINEERING COLLEGE

(An Autonomous Institute)

Dhulapally, Secunderabad – 500 100

JUNE 2021

BONAFIDE CERTIFICATE

This is to certify that the project entitled **"SUPPLICATION OF OIL PALM BOILER CLINKER AGGREGATES IN THE PRODUCTION OF STRUCTURAL LIGHT WEIGHT CONCRETE"**, is being submitted by **Mr. T. AKHIL (18K85A0120), N. JYOTHI (17K81A0192), B. SATHVIKA (17K81A0170), K. ANJAIAH (18K85A0119**) in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN CIVIL ENGINEERING** is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

Signature of guide

Mr. M. Rajasekhar.
(Assistant professor)
Department of Civil engineering

Signature of head of the department

Ms. Sandhya Kiran .J.K
(Head of the department)
Department of civil engineering

Internal Examiner

External Examiner

Place:

Date:

DECLARATION

We, the student of **Bachelor of Technology** in Department of Civil Engineering, session: 2017 – 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled "**SUPPLICATION OF OIL PALM BOILER CLINKER AGGREGATES IN THE PRODUCTION OF STRUCTURAL LIGHT WEIGHT CONCRETE**" is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

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ABSTRACT

Industrial waste has many functional and economic benefits when used as a building material for environmentally friendly structures. Oil-palm-boiler clinker is a waste product produced by burning solid waste during the extraction of palm oil. The material is concrete. This experimental investigation summarizes the research done over the last two decades on the use of oil-palm-boiler-clinker as a lightweight aggregate in structural lightweight aggregate concrete. The compression, Split and Flexural strength of oil-palm-boiler clinker concrete are discussed. In this investigation M20 grade is used and coarse aggregate was replaced by 0%, 20% and 40% percentages of OPBC. The compressive strength of lightweight concrete could be greatly improved by partially replacing it with oil palm boiler clinker. This report also identifies research gaps in order to investigate advanced lightweight concrete based on financial and environmental design considerations. Density plays a key role in the construction of any structure. Normal weigh concrete has a density of 2400_2500 kg/M3, whenever the structure wants to construct in seismic zones density of the concrete is the major problem.one has to make the concrete with low density and with structural properties same as normal weight concrete.

Keywords: Oil palm boiler clinker, Light weight concrete, Density, Compression strength.

CHAPTER-1
INTRODUCTION

1.1 General

The benefits of using structural lightweight concrete in construction industry, particularly in high rise buildings, over normal weight concrete are numerous. Due to the limited resources for natural and artificial lightweight aggregates, the alternative sources for lightweight aggregates should be discovered from industrial wastes. Most of the palm oil processing plants dispose of the clinker in them by using them as a cover for the potholes on the roads within the vicinity of the plantation areas. Rather than utilizing those for some purpose that could harm the environment.There were many experimental works conducted to improve the property of the concrete by putting new materials, whether it is natural material or recycled materials or synthetic materials in the concrete mix. A large number of agricultural wastes were disposed in most of tropical countries especially in Asia for countries like Thailand, Philippines and Malaysia. This has necessitated research into alternative materials of construction.Oil-palm-boiler clinker (OPBC) are solid wastes from palm oil industry is a perfect option for the replacement and to save the environment. Oil-palm-boiler clinker (OPBC) is an agricultural solid waste from the incineration process of solid wastes in palm oil industry. The OPBC that is highly porous and lightweight in nature is suitable to be used as a lightweight aggregate. Palm oil clinker (POC) is a waste by-product gathered after the complete incineration process of oil palm shell and fiber. Physically they are porous, grey in color, irregular in shape and much lighter.

Lightweight concrete, similar to normal weight concrete, is a mixture of water, Portland cement or Ordinary Portland Cement (OPC), and aggregate. Light-weight aggregate concrete uses a variety of aggregates with lower density than normal weight concrete. LWA can be divided into two categories.

- Those occurring naturally and are ready to use only with mechanical treatment, i.e., crushing and sieving.
- Those produced by thermal treatment from either naturally occurring materials or from industrial by-products, waste materials, etc.

In this study, oil palm boiler clinkers is used as light weight aggregate Production of lightweight concrete is a technology aimed at reducing dead load on structures and to reduce the overall cost of the structure. Nearly all LWACs are fire resistant. In addition, depending up-on the densities and strength, the concrete can be easily cut, nailed, drilled, and chiselled with ordinary wood working tools. The use of agricultural waste as aggregates can provide an alternative to conventional methods for production of lightweight aggregates. Structural concrete with densities from 1000 to 2000 kg/m3 can be prepared. Compressive strength up to 80MPa can be achieved.FIG.1 shows the sample of OPBC.

Structural lightweight concrete is an important and versatile material in modern construction. It has many advantages of dead load reduction, high thermal insulation. If floors and walls are made up of light weight concrete, it leads to economy of structure. It also lowers power consumption for extreme climatic condition due to possessing property of low thermal conductivity. The use of lightweight concrete is gaining wide acceptance in building construction, obviously due to the considerable reduction in mass. Reduction in weight by the use of light weight aggregate is preferred especially for structures built in seismic zones. Reduced dead load by using lightweight aggregate results in reduction of earthquake damages to structures. The cement content is a prominent factor in the physical/mechanical and durability properties of lightweight aggregate concretes.

Nowadays lightweight concrete is commonly used in precast and pre-stressed components. Lightweight concrete offers design flexibility and substantial cost savings by providing less dead load, improves seismic structural response, better fire rating, decreased storey height, smaller size structural members, lower foundation cost, and less reinforcing steel. The highly porous microstructure of lightweight aggregate gives it low density and better insulation and make that the concrete made with lightweight concrete exhibit lower thermal conductivity than that of normal weight concrete. Therefore, lightweight concrete provides more efficient fire protection than dense aggregate as it is less liable to spalling and has a higher thermal insulation.

Lightweight concrete plays an important role in structural engineering and its use is steadily increasing. It is defined as a type of concrete which includes an expanding agent in that it increases the volume of mixture. And mainly it is lighter than conventional concrete with dry density of 300kg/m^3 up to 1840kg/m^3. The reduction in weight by use of lightweight concrete will be advantageous, especially for building structures.

Structural lightweight concrete has an in-place density (unit weight) on the order of 1440 to 1840 kg/m^3 compared to normal weight concrete with a density in the range of 2240 to 2400 kg/m^3. For structural applications the concrete strength should be greater than 17 Mpa. The concrete mixture is made with a lightweight coarse aggregate. In some cases, a portion or the entire fine aggregate may be a lightweight product. There are other classes of non-structural lightweight concretes with lower density made with other aggregate materials and higher air voids in the cement paste matrix, such as in cellular concrete. These are typically used for their insulation properties. The above properties focus on structural lightweight concrete.

Lightweight concrete is defined as a concrete that has a density, after oven drying, that isn't larger than 2000 kg/m3, total or partially produced with porous structure aggregate. Nowadays, the use of lightweight concrete is increasing, not only for structural applications, but also for other purposes, such as rehabilitation or pavement filling. The application of lightweight concrete on pavements is increasing, mainly due to the lower self-weight compared to the ordinary concrete, making possible the decrease of loading in the structure. However, one of the major problems that concrete has is the time that it takes to dry out, meaning, the time that the water takes to come out of the concrete, delaying the coating and causing anomalies on this one. Since, the drying process is slow, it is necessary to know the water content that is acceptable in the concrete so there isn't any problem when a coating, that is sensitive to humidity, is applied. This dissertation has the aim of knowing the water content of concrete, throughout time, in order to estimate how long it does take to dry depending on the lightweight aggregate used.

1.2 Objectives

- To develop Light weight concrete and To determine whether the oil palm boiler clinker concrete can be used as a structural concrete or not.
- To test the durability property of oil palm boiler clinker light weight concrete based on water absorption test.
- To study the properties of OPBCC and compare it with the properties of conventional concrete of similar grade (M20).
- To determine optimum content of OPBC as a substitute of coarse aggregate in concrete.

- To determine the compression strength of the light weight concrete having density below 1800kg\m^3
- To study the effect of various replacements (0%, 20%, 40%) of natural aggregates by OPBC on 7, 21 and 28 days compressive strength.

1.3 Background of the Study

In many developed countries, due to the increasing cost of raw materials and the continuous reduction of natural resources, the use of waste materials is a potential alternative in the construction industry. This will have the double advantage of reduction in the cost of construction material and also as a means of disposal of waste. It can be used as building materials of high quality and can be used in construction in the near future.

Recycling or use of solid waste generated from most agricultural and manufacturing industries is very profitable. The anxiety about enormous waste production, resource preservation, and material cost has focused attention for the reuse of solid waste. Material recovery from the conversion of agricultural wastes and industrial wastes into useful materials has not only environmental gains, but may also preserve natural resources. It is desirable that a study on the use of various types of solid waste effective has received greater attention in the last few decades.

The palm oil industry in Malaysia accounts for more than half of the total world production of palm oil and is expected to rise again as a result of the increase in global demand for vegetable oil. However, it is also a main contributor to the pollution problems in the country, covering 2.6 million tons of annual production of solid waste in the form of oil palm boiler clinker (OPBC) (M.N. Amiruddin, 1998). Contributing to the many 2 environmental problems associated with diverse ecosystem (Tomas U. Ganiron Jr, 2013).

OPS are hard endocarp surrounding the palm kernel. Wide availability of resources is still not used commercially. The practice of burning waste disposal in the industry is usually done in a way that is not under control and many contribute to environmental pollution.

OPS are light and naturally-sized, they are best suited to replace the aggregate in concrete construction. Become hard and organic origin, they will not contaminate or leach to produce toxic substances when they are bound in a matrix of concrete. OPS concrete can be potentially used in concrete applications that require low medium strength such as path and infill panel for floorings and walls. The use of oil palm shell will cause lighter concrete because of the low density (Mannan, M. A and Ganaphaty, C, 2002).

One of the suggestions in the forefront has been the sourcing, development and use of alternative, non-conventional local construction materials including the possibility of using some agricultural wastes and residues as construction materials. As the natural fibres are agriculture waste, manufacturing natural product is, therefore, an economic and interesting option. Palm oil shows diversity in size, weight, shape and colour, depending on genetic diversity and maturity of the nut at harvest (Ohler, 1999).

1.4 Problem Statement

The concrete industry nowadays is the largest consumer of natural resources due to it's widely usage in civil engineering structures. Its annually consumption of materials is as 2.282 billion tonnes of cement, 10-12 billion tonnes of stones and rocks together and 1 billion tonne of mixing water. Due to huge amount of concrete production, it has a significant effect on the social, economic and environmental problems. The best alternative to achieve an environmentally friendly and sustainability in concrete industry is to use waste and by-product materials instead of raw materials in concrete mixtures, which can contribute to a better quality of life for all mankind. The development of the industry intensified today has brought a lot of revenue and the rest of the industry such as oil palm boiler clinkers. The rest of the industry should be dealt with a perfect or original use the rest of the waste material this by generating a new product. Oil palm boiler clinker (OPBC) are an alternative waste materials found in tropical regime countries and can be used as aggregate in concretes. OPBC is a crushed porous stone which is produced by burning of agricultural solid wastes in the boiler combustion process in oil palm mills. Therefore, it is expected that by using of OPBC the engineering properties of resulted concrete are improved. Therefore, the objective of this paper was to produce a new type of lightweight aggregate concrete using a blended coarse lightweight aggregate by incorporating OPBC in concrete mixture.

Additionally, this natural raw material resources increasingly limited means of disposal is the need to have other alternatives to make natural material waste to useful materials. One way is by using the Palm boiler clinkers to replace the coarse aggregate in concrete.

However, the test needs to be done in advance against the concrete to make sure it went through the concrete specifications has been defined in terms of strength and long-term durability. Example, desert sand generally not suitable to use for construction because the wind erosion of sand in the desert results in smooth and desert the next problem is noise pollution from the quarry of sound emitted as a result of fragmentation of rocks to produce aggregate. With the availability of replacement of natural ingredients such as palm oil boiler clinkers, then the use of the aggregate can be reduced and can reduce breakage of rocks on a hill and necessarily will reduce noise noisy as a result of bombs breaking and machinery used.

1.5 Scope of Study

Scope of this study focus on the influence of using oil palm boiler clinkers as partial replacement of coarse aggregate in concrete production. This study is also focusing on the characteristics of concrete grade M20 using Oil Palm boiler clinkers as coarse aggregate in concrete material at a different percentage replacement 0%, 20% and 40% of the coarse aggregate volume. It also focuses on mechanical properties and durability properties of oil palm boiler clinkers in the concrete production. Studies using the cube size 150mm x 150mm x 150mm. The study carried out for comparison with normal concrete made in terms of strength, workability, and mode of failure M20. The concrete mix was using Composite Portland cement. The cube test and compression, split and flexural test for concrete were tested within the range of 7, 21 and 28 days according to the curing period.

1.6 Types of Lightweight Concrete Based on Density and Strength

- Low density concrete
- Moderate strength concrete
- Structural concrete

1.6.1 Low Density Concrete

These are employing chiefly for insulation purposes. With low unit weight, seldom exceeding 800 kg/m^3, heat insulation value is high. Compressive strength is low, regarding from about 0.69 to 6.89 N/mm^2.

1.6.2 Moderate Density Concrete

The use of these concrete requires a fair degree of compressive strength, and thus they fall about midway between the structural and low density concrete. These are sometimes designed as ‘fill’ concrete. Compressive strength is approximately 6.89 to 17.24 N/mm² and insulation values are intermediate.

1.6.3 Structural Concrete

Concrete with full structural efficiency contain aggregates which fall on the other end of the scale and which are generally made with expanded shale, clay, slates, slag, and fly-ash. Minimum compressive strength is 17.24 N/mm².Most structural LWC are capable of producing concrete with compressive strength in excess of 34.47 N/mm².Since the unit weight of structural LWC are considerably greater than those of low density concrete, insulation efficiency is lower. However, thermal insulation values for structural LWC are substantially better than Normal weight concrete.

1.7 Uses of Lightweight Concrete

- Screeds and thickening for general purposes especially when such screeds or thickening and weight to floors roofs and other structural members.
- Screeds and walls where timber has to be attached by nailing.
- Casting structural steel to protect it’s against fire and corrosion or as a covering for architectural purposes.
- Heat insulation on roofs.
- Insulating water pipes.
- Construction of partition walls and panel walls in frame structures.
- Fixing bricks to receive nails from joinery, principally in domestic or domestic type construction.
- General insulation of walls.
- Surface rendered for external walls of small houses.
- It is also being used for reinforced concrete.

1.8 Advantages of Lightweight Concrete

- Reduced dead load of wet concrete allows longer span to be poured un-propped. This save both labour and circle time for each floor.

- Reduction of dead load, faster building rates and lower haulage and handling costs. The eight of the building in term of the loads transmitted by the foundations is an important factor in design, particular for the case of tall buildings.
- The use of LWC has sometimes made it possible to proceed with the design which otherwise would have been abandoned because of excessive weight. In frame structures, considerable savings in cost can be brought about by using LWC for the construction floors, partition and external cladding.
- Most building materials such as clay bricks the haulage load is limited not by volume but by weight. With suitable design containers much larger volumes of LWC can haul economically.
- A less obvious but nonetheless important characteristics of LWC is its relatively low thermal conductivity, a property which improves with decreasing density in recent years, with the increasing cost and scarcity of energy sources, more attention has been given the formerly to the need for reducing fuel consumption while maintaining, and indeed improving, comfort conditions buildings. The point is illustrated by fact that a 125 mm thick solid wall of aerated concrete will give thermal insulation about four times greater than that of a 230 mm clay brick wall.

1.9 Application of lightweight concrete

The primary use of light weight concrete is to reduce the dead load of the concrete structure, which then allows the structural designer to reduce the size of the column, footing and other load bearing elements. Structural lightweight concrete mixture can be designed to achieve similar strength as normal weight concrete. The same is true for the other mechanical and durability performance requirements. Structural lightweight concrete provides a more efficient strength to weight ratio in structural elements. Lightweight Concrete is used when structural concerns require. Lightweight Concrete is ideal for roof deck repairs, stair pan fill, elevated floor slabs or overlays on existing floor decks. It can also be used for appliance platforms, curbs, down spout gutters, balconies, floors, fish ponds, walls, setting posts, castings, steps, or virtually any job that would normally be done with standard weight concrete. Use it where ease in lifting and carrying is important. Lightweight Concrete also offers slower temperature transfer rates than standard weight concrete, resulting in improved insulation factors.

Nowadays with the advancement of technology, lightweight concrete expands its uses, for example, in the form of perlite with its outstanding insulating characteristics. It is widely used as loose-fill insulation in masonry construction where it enhances fire ratings, reduces noise transmission, does not rot and termite resistant. It is also used for vessels, roof decks and other applications.

The use of high strength, high performance lightweight concrete (HSLWC) can result in longer span lengths and lighter weight girders. Previous research at the Georgia Institute of Technology (Georgia Tech) showed that HSLWC bridge girders can be constructed with 10,000 psi (69 MPa) compressive strength concrete with a very low permeability, while achieving up to a 20% decrease in shipping weight.

CHAPTER - II

LITERATURE REVIEW

1. Omar.w. et.al. (2001): As the aggregates were decreasing rapidly, clinker was explored as a suitable material to replace aggregate in Hot Mix Asphalt. Palm oil clinker can be found easily in our country as Malaysia is the largest manufacturer of palm oil products. Malaysia is holding the main production for world palm oil production as 51%, 62% for the world exports and 30% for the oils and fats exportation. Combustions of shell and fibre from the palm oil create clinkers as waste material which will be thrown away from mill .The significant usage of clinker as the artificial lightweight aggregate in HMA in road pavement will benefit us from the aspect of waste management from palm oil mill and minimize the demand on natural aggregate in the road construction industry.

2. Payam Shafigh, Hilmi Bin Mahmud: Have explained about "Structural lightweight aggregate concrete using two types of waste from the palm oil industry as aggregate". Huge quantities of raw materials are used in making concrete. Due to the limitations of natural materials the use of waste and by-product materials in concrete can eliminate the negative impact of concrete on the environment. To produce a cleaner and greener concrete two waste materials from the palm oil industry were used as coarse and fine aggregates. For this purpose normal sand was replaced with oil-palm-boiler clinker (OPBC) sand from 0 to 50% in oil palm shell (OPS) lightweight aggregate concrete. Properties, including workability, different types of density, compressive strength in different curing regimes, splitting tensile and flexural strengths, stress–strain curve, modulus of elasticity, water absorption and drying shrinkage strain of green lightweight concretes, were measured and discussed. The results showed that it is possible to produce environmentally-friendly structural lightweight concrete by incorporating high volume waste lightweight aggregates from the palm oil industry

3. Kim Hung Moa, U. Johnson Alengarama(2015): Have explained that for concrete with similar compressive strength, the OPSC had slightly lower splitting tensile strength compared to NWC while the modulus of elasticity was about 25% of that for the corresponding NWC. The initial water absorption and sorptivity of the OPSC were lower compared to the corresponding NWC. Similar shape of the bond stress-slip curve was observed for both OPSC and NWC bonded with steel bar. However, the bond strength was about 2 times higher in the case of OPSC. Both OPSC and NWC beams exhibited similar flexural failure mode and also had similar ultimate moment. The primary crack spacing was smaller for the OPSC due to better bonding between OPSC and steel bar. These findings indicate that in terms of the mechanical, permeation as well as the structural properties, the OPSC incorporating GGBS and manufactured sand could potentially be utilized as actual construction material.

4. Muhammad Aslam & Mohd Zamin Jumaat (2017): Have explained about the "Mechanical and engineering properties of high strength lightweight aggregate concrete using blended coarse lightweight aggregates". From test results, the following conclusion can be drawn. Due to the round shape of OPBC aggregates, incorporation of this aggregate in OPS concrete improves workability of the concrete. Due to an OPBC grain is about 42% heavier than an OPS grain, inclusion of OPBC in OPS concrete increased the density of concrete. However, the density of OPS-OPBC concrete was still in the acceptable range for structural lightweight aggregate concretes. The substitution of 50% OPS with OPBC in OPS concrete the compressive, splitting tensile and flexural strengths significantly improved. By this substitution, grade 35 concrete with the oven dry density of about 1800 kg/m3 was transferred to grade 50 concrete with the oven dry density of about 1950 kg/m3. The modulus of elasticity of grade 35 OPS concrete is very low compared to normal concrete and structural lightweight aggregate concrete at the same compressive strength. However, the incorporation of OPBC in OPS concrete significantly enhanced this property. The modulus of elasticity of OPS-OPBC concrete is in the normal range of structural concretes. The initial and final water absorption of OPS-OPBC concrete is significantly less than OPS concrete. Based on water absorption, this concrete is considered as good quality concrete. The drying shrinkage of OPS and OPS-OPBC concretes is similar at early ages. However, OPS-OPBC concrete showed significantly lower drying shrinkage compared to OPS concrete after one month. The ACI-209R has conservative estimation for OPS-OPBC concrete.

5. Muhammad Aslam, Payam Shafighand (2015): Have experimental investigation and concluded that it is possible to produce a structural lightweight aggregate concrete by incorporating two types of waste materials. The OPS coarse aggregate was replaced (by volume) up to 40% of the OPBC coarse aggregate. At the same mix proportions, the substitution of the OPBC in OPS concrete significantly increased the compressive strength of the concrete. Although, the density of the OPBC concrete is slightly higher than the OPS concrete, but it is in the acceptable range of the structural lightweight concretes. However, the efficiency factor of the OPBC lightweight concrete is significantly greater than OPS concrete. In addition, it was also found that the internal curing process in the OPBC concrete might be better than the OPS concrete, so by incorporating the OPBC aggregates in the OPS concrete it significantly improves the quality of the structural lightweight concrete. By incorporating of OPBC in OPS concrete, the lightweight concrete not only can be a low cost construction material but it can be also called as a green high strength lightweight concrete.

6. Mohd Zamin Jumaat (2016): Have investigated “The engineering properties of a lightweight concrete containing both of these aggregates”. 50% (by volume) of OPS was replaced with OPBC in an OPS lightweight concrete. It is concluded that, grade 35 concrete with the oven dry density of about 1800 kg/m3 was transferred to grade 50 concrete with the oven dry density of about 1950 kg/m3. The initial and final water absorption of OPS-OPBC concrete is significantly less than OPS concrete. The modulus of elasticity of OPS-OPBC concrete is in the normal range of structural concretes. The initial and final water absorption of OPS-OPBC concrete is significantly less than OPS concrete. Based on water absorption, this concrete is considered as good quality concrete. The drying shrinkage of OPS and OPS-OPBC concretes is similar at early ages.

7. Jegathish Kanadasan and Hashim Abdul Razak (2015): Have discussed about “The fresh, hardened and microstructure properties were evaluated throughout the study”. Despite replacing cement at 50%, POC powder specimens managed to produce almost 70% of the strength when compared to control specimens. Besides that, POC powder samples managed to achieve 60% structural efficiency of that of normal mortar. These satisfactory results indicate suitability of using POC powder for mass concreting works. The carbon emission was lowered by 52% when POC powder is used.

8. Kamolchanol Kueaket, Danupon Tonnayopas (2021): They have examined the compressive strength and the durability performance of the green mortar mixtures, Palm oil boiler clinker (POBC) was used as a substitution material for natural fine aggregate. An ordinary Portland cement was partially replaced by rice husk ash (RHA) and calcium bentonite (CB) in the proportion of 10%, 20%, and 30% by weight of cement. The compressive strength, water absorption, porosity, durability against sulphuric acid and sodium sulphate solutions, and microstructures of the POBC mortar mixtures were evaluated at the curing age of 7, 28, and 56 days. The results obtained are the compressive strength, the water absorption, the porosity, and the durability characteristic of POBC mortar incorporating rice husk ash and calcium bentonite were improved by long-term curing.

9. Chai Lee (2020): Have investigated about "The use of OPBC as coarse aggregate in a grade 40 conventional concrete when normal coarse aggregate was fully substituted (by volume) with this porous and lightweight aggregate". Test results showed that full substitution of normal coarse aggregate with OPBC reduced workability, compressive strength and density of the concrete. However, OPBC concrete has still good workability for casting and also practical favourable 28-day compressive strength. Water absorption test results revealed that OPBC concrete could be considered as good quality concrete in term of durability property.

10. Arunima V R (2016): He worked on "Experimental Study on the Properties of Hardened Concrete Using Palm Oil Clinker as Replacement Material for Fine Aggregate". Study revealed the effect of using Palm Oil Clinker as a replacement material for fine aggregate on the mechanical properties of structural concrete. Natural river sand is the most preferred choice as a fine aggregate material. In this study, fine aggregate is replaced with palm oil clinker by 5%, 10% 15%, 20% and 25% by weight and compared with the control mix prepared without palm oil clinker. When comparing the 28th day average compressive strength of the 20% palm oil clinker concrete mix to the control mix, the compressive strength of the 20% palm oil clinker concrete mix increased by 44%. When comparing the 20 percent palm oil clinker concrete mix to the control mix, the 28-day average split tensile strength shows a 20% increase in split tensile strength. When compared to the control mix, the 28-day average flexural tensile strength of the 20 percent palm oil clinker concrete mix shows a 92 percent increase in flexural tensile strength. The optimal level osf palm oil clinker replacement was found to be 20%, with results superior to the control mix. A decrease in concrete strength was observed above a replacement level of 20% fine aggregate with palm oil clinker.

11. Kamolchanol Kueaket, Danupon Tonnayopas (2018): Have explained about the "ENHANCED PROPERTIES OF PALM OIL BOILER CLINKER CONCRETE WITH SANG YOD RICE HUSK ASH". Laboratory experiments of this investigation are to reclaim palm oil boiler clinker (POBC) as coarse aggregate for concrete and partially replaced Portland cement type 1 with Sang Yod rice husk ash (SYRHA) in proportion of 10%, 20% and 30wt.%. POBC is known as normal-weight aggregate and was available as coarse aggregate on concrete developed for other construction applications except heavy duty and pavement wearing surfaces, according to experimental results from this report. SYRHA's chemical composition complied with the requirements for artificial pozzolans in burnt products. Setting time, paste hydration heat, and bulk density of POBC concrete are all reduced. In terms of improved POBC concrete, 10% SYRHA replacement of OPC significantly improved early strength and decreased water absorption of POBC concrete, while 20% SYRHA replacement of OPC offered satisfactory strength for the long term of the 28-day concrete curing ages.

12. M. Adaway (2015): Have studied the variation of compressive strength on using recycled glass as replacement material for fine aggregate in structural concrete. Recycled glass was introduced into the concrete mix at different levels of replacement such as 0%, 15%, 20%, 25%, 30% and 40% of fine aggregate in concrete. An increase in compressive strength was observed for the mixes containing recycled glass as compared to normal concrete. Maximum strength development was observed at 30% partial replacement of fine aggregate by recycled glass.

13. Sumeet (2015): Have conducted experiments to study the strength and durability of concrete with partial replacement of fine aggregate by pond ash .Pond ash obtained as the by-product of thermal industry was introduced into the concrete mix at different levels of replacement such as 0%, 10%, 20%, 30% and 40% of fine aggregate in concrete. An increase in compressive strength, flexural strength and split tensile strength was observed for the mixes containing pond ash compared to the conventional concrete specimens. The maximum strength was observed at 30% partial replacement of fine aggregate by pond ash. The study concludes that the use of pond ash is suitable for construction industries and is also environmental friendly. Bashar S. Mohammed et al. [3] conducted a durability test known as rapid chloride permeability test on concrete specimens incorporating palm oil clinker. The specimens were prepared by fully replacing the fine and coarse aggregate using palm oil clinker aggregates. All the strength test results indicated the feasibility of using palm oil clinker in light weight aggregate concrete. Rapid chloride permeability test was conducted at 7day, 28day and 90 day. A high value of chloride ion penetration was observed at 7 day and 28 day whereas moderate value was observed at 90 day.

14. F .A. Oluto (2015): Have studied the behaviour of concrete slab incorporating sawdust and palm kernel as replacement material for fine and coarse aggregate respectively .The study revealed the production of light weight concrete slabs at a lower replacement value of 25% sawdust and palm kernel shell. Divakar.Y et al. [5] studied the use of granite fines as a replacement material for fine aggregate. Replacement of fine aggregate was carried out in five proportions such as 5%, 15%, 25%, 35%, and 50%. Compressive strength test, split tensile strength test and flexural strength test were conducted and the overall increase in the strength was observed for 35% replacement level of fine aggregate using granite fines.

15. K. Muthuwamy et al. (2013): Have explained about the use of crushed palm oil shell as a replacement material for fine aggregate in concrete. Crushed palm oil shell was introduced in the concrete specimens as partial sand replacement material ranging from 0%, 25%, 50%, 75% and 100%. As the crushed palm oil shell replacement level increased, the compressive strength and density decreased. The study revealed the optimum percentage that can be adopted for structural concrete was around 25% of crushed palm oil shell.

16. Chai Lee, Jin (2016): Utilizing waste material in the construction industry is an effective way to protect the environment and minimize construction cost. Oil-palm-boiler clinker (OPBC) is a waste material obtained by the burning off solid wastes of the palm oil industry during the process of palm oil extraction. This study presents an investigation on the use of OPBC as coarse aggregate in a grade 40 conventional concrete when normal coarse aggregate was fully substituted (by volume) with this porous and lightweight aggregate. Workability of concrete was assessed based on slump test. The development of compressive strength up to 56 days as well as initial and final water absorption were measured. Test results showed that full substitution of normal coarse aggregate with

OPBC reduced workability, compressive strength and density of the concrete. However, OPBC concrete has still good workability for casting and also practical favourable 28-day compressive strength. Water absorption test results revealed that OPBC concrete could be considered as good quality concrete in term of durability property.

17. Bashar S. Mohammed (2014): Have discussed about the experimental program on the flexural behaviour of reinforced concrete beams produced from palm oil clinker (POC) aggregates. POC is obtained from by-product of palm oil milling. Utilisation of POC in concrete production not only solves the problem of disposal of this solid waste but also helps to conserve natural resources. An experimental work was conducted involving eight under-reinforced beams with varying reinforcement ratios (0.34–2.21%) which were fabricated and tested. The data presented include the deflection characteristics, cracking behaviour and ductility indices. It was found that although palm oil clinker concrete (POCC) has a low modulus of elasticity, the test results revealed that the deflection of singly reinforced POCC beams, with reinforcement ratio less than 0.524, under the design service load is acceptable as the span-deflection ratios range between 250 and 257 and these values are within the allowable limit provided by BS 8110. In addition, the results reported in this paper indicate that the BS8110 based design equations can be used for the prediction of the flexural capacity of POCC beams with reinforcement ratio up to 2.23%.

18. Shafigh et al. (2014): Have studied by using 100% oil palm shell OPS as the coarse aggregate and the natural fine material is replaced with oil palm boiler clinker (OPBC) for a certain percentage. For the M mix proportion, 100% natural sand are used and compressive strength obtained from the mix is 37MPa. The compressive strength of M recorded is identical as M25. M25 mix proportion used 100% OPS as coarse aggregates and replaced25% of natural sand with OPBC as fine aggregates. For M12.5 sample used 12.50% OPBC replacing the sand in fine aggregates but there is 2.70% reduction of compressive strength for M12. The decreasing values of compressive strength approximately 12.50% are detected for M37.5 and M50 as the replacement of OPBC increased.

19. <u>Rezuwan Kamaruddin</u> (2016): Have investigated about the "Oil Palm Clinker Potentiality for Producing Lightweight Concrete: Compressive Strength, Tensile and Modulus of Elasticity Analysis". Research has been conducted to explore the potentiality usage of oil palm clinker as fine and coarse lightweight aggregates at Universiti Pertanian Malaysia. Mixtures of oil palm clinker concretes were designed, prepared and tested. Mechanical properties of a good mixture of tensile strength, compressive strength, modulus of elasticity, creep and shrinkage were satisfied the standard engineering codes of practices. Oil palm clicker concrete was found lighter than conventional concrete, which usually weighs between 2240 and 2400 kg m^{-3}.The means of compressive and tensile strengths were found 30.79 and 3.34 N mm^{-2} respectively. In addition, the mean of modulus of elasticity was 13.024 $kNmm^{-2}$. Therefore, he concluded that oil palm clinker aggregate and concrete are recommended to be used in lightweight reinforced concrete structures.

20. Ibrahim Abdulrazak Al-Ani, Wan Hamidon (2020): Have explained about the "Development of Lightweight Concrete Using Industrial Waste Palm Oil Clinker". The utilisation of palm oil clinker (POC), a solid waste generated from palm oil industry is proposed to replace natural aggregate in this research to reduce the demand for natural aggregates. One mix of ordinary concrete as control concrete; while four mix proportions of oil palm clinker concrete were obtained by replacing 25%, 50%, 75%, and 100% of gravel and sand of control concrete with coarse and fine oil palm clinker respectively by volume, with same cement content and water cement ratio.

By the results of partially replacement of normal aggregate with the oil palm clinker, it is concluded that the 25% replacement of normal aggregate with the palm oil clinker has improved the strength and durability. Furthermore, the replacement of normal aggregate with the palm oil aggregate of more than 25% results in a strength reduction. Regarding the full replacement of normal aggregate with the palm oil aggregate it is noticed that when the water cement ratio increases, the strength (including the compressive strength, flexural and splitting strength) will be increased. According to ACI classification of lightweight concrete only the 100% replacement can achieve the definition of lightweight concrete since its density is less than 1,900 kg/m3 and the strength is larger than 17 MPa. Eventually, the relationship between the water cement ratio and the 28 days compressive strength has been established.

21. Neville A.M, et al (1995): Usage of clinkers also will minimize the cost of the road construction due to the rate of palm oil clinker is cheaper than the natural aggregate.

22. Bashar S. Mohammed, Mohammed A. (2011): Have discussed about the "Analytical and experimental studies on composite slabs utilising palm oil clinker concrete". From the outcome of this work, they concluded that, for all the composite slabs, the maximum strain in the concrete was not achieved and the strain of the profiled steel sheeting did not reach the yield point. This confirms that the composite slabs did not reach the maximum bending strength and they failed in shear-bond. The partial composite action between the concrete and the steel started after the loss of the chemical bonding and could be identified by the sound of propping; formation of the first crack and the beginning of end slip. The inner strain had a complex behaviour due the presence of new neutral axis after loss of the composite action between concrete and steel. The loss of composite action in short shear spans occurs in higher loads than the long shear spans. The sudden increase in mid-span deflection occurred after the loss of the composite action between the concrete and the steel. Conventional concrete slabs had lower deflection compared to the POCC slabs due to its higher elasticity. All the composite slabs were considered to have ductile behaviour since the maximum applied load exceeded the load causing 0.5 mm end slip by 10%. The structural behaviour and the shear-bond strength of the POCC composite slabs are satisfactory. This implies that POC can be adequately used in the construction of composite slabs.

23. Swamy R.H & Lambert G.H (1984) studied above the light weight aggregate and proved that the thermal efficiency is very more to the light weight concrete and the load carrying capacity of the light weight concrete is same as the normal concrete by using some mineral and chemical admixtures.

24. G. Balamurugan (2015): Have studied the effect of using quarry dust as replacement material for fine aggregate. The work was carried out to study the variation in the strength of concrete when replacing sand by quarry dust from 0% to 100% in steps of 10%. Split tensile strength and flexural strength test was conducted at 28 day. The result indicated that quarry dust can be effectively used in concrete mixtures as a substitute for natural river sand at 50% replacement with additional strength than control mix.

CHAPTER - III

MATERIALS & METHODOLOGY

3.1 Materials

3.1.1 Cement

Cement is the most common binder which allows to make structures, and used in construction that sets, hardens and adheres to other materials, binding them together. Cement starts to set when mixed with water which causes a series of hydration chemical reactions. The constituents slowly hydrate and the mineral hydrates solidify; the interlocking of the hydrates gives cement its strength. Contrary to popular perceptions, hydraulic cements do not set by drying out, proper curing requires maintaining the appropriate moisture content during the curing process. If hydraulic cements dry out during curing, the resulting product can be significantly weakened.

Cement is seldom used solely, but is used to bind sand (fine aggregate) and gravel (coarse aggregate) together. Cement is used with fine aggregate to produce mortar for masonry, or with sand and gravel aggregates to produce concrete. Portland cement is by far the most common type of cement in general use around the world. This cement is made by heating limestone (calcium carbonate) with other materials to 1450 °C in a kiln, in a process known as calcination, whereby a molecule of carbon dioxide is liberated from the calcium carbonate to form calcium oxide, or quicklime, which then chemically combines with the other materials that have been included in the mix to form calcium silicates and other cementitious compounds. The resulting hard substance, called 'clinker', is then ground with a small amount of gypsum into a powder to make 'Ordinary Portland Cement'(OPC), the most commonly used type of cement (often referred to as OPC). Portland cement is a basic ingredient of concrete, mortar and most no specialty grout. The most common use for Portland cement is in the production of concrete. The cement used is Ordinary Portland Cement (OPC) of 53 grade without any lumps. The physical properties of cement are tested in the laboratory as per IS: 12269-1999 code and the results are tabulated in the Table3.4.

Figure - 3.1: Cement

3.1.2 Fine Aggregate

Locally available river sand confirming to IS: 383-1970 was used as the fine aggregate in the concrete preparation. Aggregate is the granular material used to produce concrete or mortar and when the particles of the granular material are so fine that they pass through a 4.75mm sieve, it is called fine aggregate. It is widely used in the construction industry to increase the volume of concrete, thus it is a cost saving material and you should know everything about the fine aggregate size, its density and grading zone to find the best material. Fine aggregate is the essential ingredient in concrete that consists of natural sand or crushed stone. The quality and fine aggregate density strongly influence the hardened properties of the concrete. The concrete or mortar mixture can be made more durable, stronger and cheaper if you made the selection of fine aggregate on basis of grading zone, particle shape and surface texture, abrasion and skid resistance and absorption and surface moisture. Fine aggregates are the structural filler that occupies most of the volume of the concrete mix formulas.

Figure - 3.2: Fine Aggregate

3.1.3 Coarse Aggregate

Coarse aggregate of nominal size 12 mm, obtained from the local quarry confirming to IS: 383:1970 was used. The properties of coarse aggregate are shown in Table-3.5.

Basically, aggregates are used as an economical option to lower down the cost of concrete usage. In simpler words, we can say that these are the fillers used in concrete mix. The majority of construction applications use different coarse aggregate size, but it is essential to keep the characteristics in mind to get uniform and strong output. The proper definition of coarse aggregate depicts that it is the important constituent of concrete and used to give body to the concrete mix while reducing the shrinkage. In lots of construction applications, you can see coarse aggregates are performing an integral role, for instance, as a granular base under a slab and as a component in a mixture, such as asphalt or concrete mixtures. Coarse aggregates are generally categorized as per their shape and size. Depending on the shape they can be round, irregular, angular, flaky, and elongated. From normal strength to high strength concrete, coarse aggregates can be used between the sizes 5 mm to 256 mm.

Figure - 3.3: Coarse Aggregate

3.1.4 Oil Palm Boiler Clinker Aggregate

Oil-palm-boiler clinker (OPBC) is an agricultural solid waste sourced from the palm oil industry in tropical regions. POBC samples were obtained from a palm oil facility in from eluru, West Godavari district for this study. It was made from the combustion of palm fibres, seeds, and shells as a boiler fuel following the oil extraction process. After cooling down, this combustion process will take 6-12 hours at temperatures ranging from 700 to 1200 °C. Because of quick cooling, the POBC is 90% greenish grey, 5%-

10% black, and 1% pinkish brown in colour, sintered, vesicular texture with unidirectional and disconnected porosity (bubble-shaped regions), uneven form, brittle edges, and exposed in huge lumps within 95-70 cm. . The POBC was cleaned and air-dried for one week before being crushed to a size of less than 12.5 mm.

Figure - 3.4: Coarse Aggregate

3.1.5 Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Clean potable water conforming to IS: 456 – 2000 was used for the preparation of concrete mixture. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. In practice, very often great control on properties of cement and aggregate is exercised, but the control on the quality of water is often neglected. Since quality of water affects the strength, it is necessary for us to go into the purity and quality of water. If water is fit for drinking it is fit for making concrete. This does not appear to be a true statement for all conditions. Some waters containing a small amount of sugar would be suitable for drinking but not for mixing concrete and conversely water suitable for making concrete may not necessarily be fit for drinking. Some specifications require that if the water is not obtained from source that has proved satisfactory, the strength of concrete or mortar made with questionable water should be compared with similar concrete made with pure water. Some specifications also made accept water for making concrete if the pH of water lies between 6 and 8 and the water is free from organic matter.

3.2 Tests on Cement

The following tests are performed in the concrete technology laboratory to determine the properties of cement and the results are shown in the Table 3.1

- Normal consistency test
- Fineness of cement

- Specific gravity of cement
- Initial and final setting time
- Soundness of cement

3.2.1. Normal consistency test:

Take 250gm of cement and weight carefully and add 20% water in it. Care should be taken that mixing time is not less than 3min and gauging shall be counted from the time of adding water. Fill the paste in the mould. The excess paste to trim off and vibration are given to remove air bubbles. Fix the 10mm dia. plunger in the moving rod and bring down in touch with the paste. Release the plunger. Repeat the procedure till it penetrate 33-34mm from the top & note down the water percentage.

Observations and Calculations:

Table - 3.1 Normal Consistency

Cement	% of Water added	Penetration
250 grams	27 X (250/100)	33
	28 X (250/100)	25
	29 X (250/100)	15
	30 X (250/100)	10
	31 X (250/100)	7

Result: The percentage of water for normal consistency for the given sample of Cement is 31.67%.

3.2.2. Fineness of Cement:

Weigh approximately 300g of cement to the nearest 0.01g and place it on the sieve. Agitate the sieve by swirling, planetary and linear movements, until no more fine material passes through it. Weigh the residue and express its mass as a percentage w1, of the quantity first placed on the sieve to the nearest 0.3 percent. Gently brush all the fine material off the base of the sieve. Repeat the whole procedure using a fresh 300g sample to obtain w2. Then calculate R as the mean of w1 and w2 as a percentage, expressed to the nearest 0.1 percent. When the results differ by more than 1 percent absolute, carry out a third sieving and calculate the mean of the three values.

<u>Observation and Calculations:</u>

Fineness of cement = W1+W2+W3/ avg x10= weight retain on sieve/total weight

Table - 3.2 Fineness of Cement

S. No	**Weight of cement (grams)**	**Weight of residue formed (grams)**	**Fineness of cement (%)**
1	300	20	6.67
2	300	30	5.29
3	300	30	7.0

Fineness of Cement= (5.29+6.67+7.0)/3 = 6.32%

Result: The finesse of cement is 6.32%, which is less than 10%.

3.2.3. Specific gravity of cement:

Object: To determine the specific gravity of cement using Le Chatelier Flask or Specific Gravity Bottle.

Apparatus:

- Le Chatelier Flask or Specific Gravity Bottle-100ml gm.
- Balance capable of weighing accurately 0.1gm.

Procedure:

- Weigh a clean and dry Le Chatelier Flask or Specific Gravity Bottle with its stopper (W1).
- Place a sample of cement up to half of the flask (about 50 gm.) and weigh with its stopper (W2).
- Add kerosene (polar liquid) to cement in flask till it is about half full.

- Mix thoroughly with glass rod to remove entrapped air. Continue stirring and add more kerosene till it is flush with the graduated mark.
- Dry the outside and weigh (W3). Entrapped air may be removed by vacuum pump.
- Clean it refills with clean kerosene flush with the graduated mark wipe dry the outside and weigh (W4).

Calculations

Where W1 =weight of empty flask = 120 gm

W2=weight of flask + cement = 220 gm.

W3=weight of flask + cement + kerosene = 510 gm.

W4=weight of flask + kerosene = 442 gm.

Specific Gravity = (W2-W1)/ [(W2-W1) - (W3-W4)]

= (220-120)/ [(220-120) - (510-442)]

= 100/32

= 3.142

= 3.14

Result: The Specific Gravity of cement is **3.14**

3.2.4. Initial and final setting time:

Take about 500gms of cement. Add water of standard consistency. To make cement paste. To make the surface of the cement paste is till smooth and Level. The whole assembly kept in vicat's apparatus.

Bring the needle in the rod gently near the surface of the test block and release it quickly allowing it to penetrate into the block and note the time. Repeat the procedure till the needle fails to penetrate into the test block by 5mm to 7mm from the bottom of the mould. Generally, the initial setting time of cement is not less than 30min.

Observation:

1. Quantity of cement = 250 grams.
2. Water for standard Consistency = 31.67%

Observation Table:

Table - 3.3 Initial and Final Setting Time

Cement	**Percent of water Added**	**Time (sec)**	**Penetration (mm)**
250 grams	0.85 x 31% of weight of cement	5	0
		10	0
		15	0
		20	0
		25	3
		30	5
		35	6
		40	10

Result:

(a) The initial setting time of the cement sample is found to be 44 minutes (b) The final setting time of the cement sample is found to be 600 Minutes

3.2.5. Soundness of Cement:

1. Before Performing the test, calculate the standard consistency of cement to find out the water required to obtain the normal consistency (P).

2. Now add 0.78 times of water to the cement to give a paste of standard consistency (0.78P).

3. Lightly apply oil to the Le-chatelier mould and place it on a glass plate.

4. Now pour the cement paste into mould and close the mould using lightly oiled glass plate and to avoid misplacement place a weight on it.

5. Then submerge the whole assembly for 24Hrs in water bath at a temperature of 27C
6. Remove the entire apparatus from water and then calculate the distance separating two indicator points using measuring scale and note it as L1.

7. Again, submerge the whole assembly in a water bath at a temperature of boiling point for 3hours.

8. After completion of 3hours remove the assembly from the bath and measure the distance between two indicator points and note it as L2.

Calculations:

Soundness/expansion of cement = L_2-L_1

- L_1=Measurement taken after 24 hours of immersion in water at a temp. of 27 $\pm 2^0$ C =12 mm
- L_2=Measurement taken after 3 hours of immersion in water at boiling temperature =18 mm

Result: Soundness of Cement = **6 mm**

Table –3.4: Test results of cement

S. No.	Parameter	Result
1	Normal consistency test	31%
2	Fineness of cement	6.32%
3	Specific gravity of cement	3.14
4	Initial setting time	44 min

5	Final setting time	600 min
6	Soundness of cement	6 mm

3.3 Tests on Aggregates

The following tests are performed in the concrete technology laboratory to determine the properties of fine aggregate, coarse aggregate, oil palm boiler clinker aggregate and the results are shown in Table-3.5.

- Specific gravity of fine aggregate
- Specific gravity of coarse aggregate
- Specific gravity of oil palm boiler clinker aggregate
- Water absorption test for oil palm boiler clinker
- Bulk unit weight of oil palm boiler clinker
- Fineness modulus of oil palm boiler clinker
- Los Angeles abrasion test (oil palm boiler clinker)
- Aggregate impact test (oil palm boiler clinker)
- Aggregate crushing strength test (oil palm boiler clinker)

Table - 3.5: Test results of aggregates

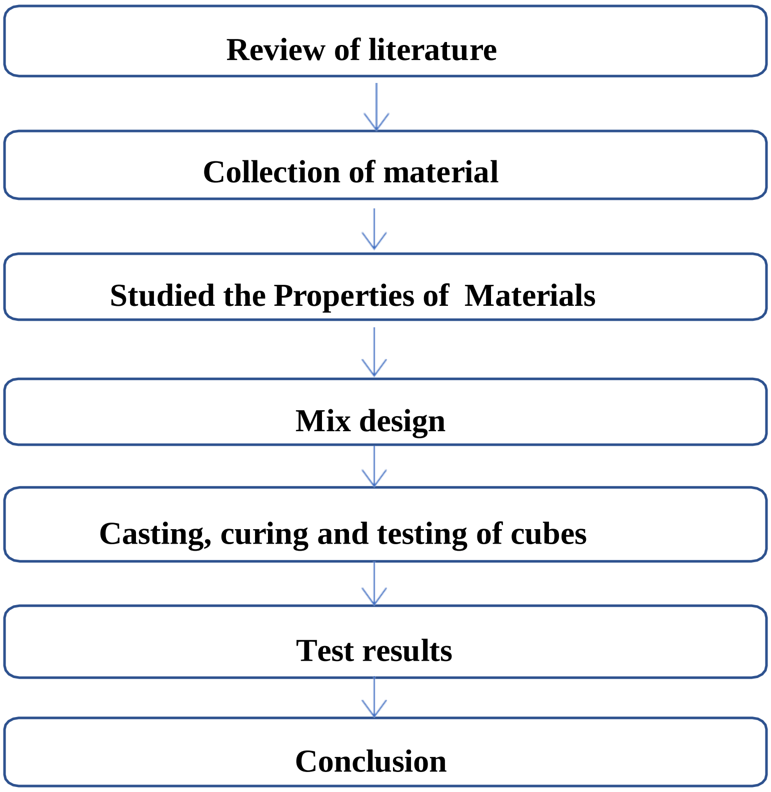
S. No.	Parameter	Result
1	Specific gravity of fine aggregate	2.68
2	Specific gravity of coarse aggregate	2.66
3	Specific gravity of oil palm boiler clinker aggregate	1.6

4	Water absorption of oil palm boiler clinker	28%
5	Bulk unit weight of oil palm boiler clinker	672.56 kg/m^3
6	Fineness modulus of oil palm boiler clinker	6.08
7	Los Angeles abrasion value (oil palm boiler clinker)	4.90%
8	Aggregate impact value (oil palm boiler clinker)	7.51%
9	Aggregate crushing value (oil palm boiler clinker)	8.00%

3.4 Methodology

Literature reviews related to the Oil palm boiler clinker (OPBC) were collected and based on the literature survey preliminary works were performed. Works like collection of OPBC was performed. Materials required for concrete such as coarse aggregate, fine aggregate, cement were collected. Basic tests were conducted on fine aggregate, coarse aggregate, cement, Oil palm boiler clinker, to check their suitability concrete making. The properties of fine and coarse aggregates sieve analysis of fine and coarse aggregates, tests on cement are found out. The Study aims to investigate the strength related properties of concrete of M20 grade. The proportions of ingredients of the control concrete of grade M20 had determined by mix design as per IS code. Moulds were prepared to cast he specimen. Mould of size 150mm*150mm*150mm and cylinder mould 150mm*300mm and prism mould 100*100*500 were cast with desired of partially replacement (0%, 20% and 40%) of coarse aggregate. Casted Samples were tested after 7days, 21days and 28 days of curing Compressive strength was performed using casted concrete. Results were obtained and conclusion was arrived.

3.4.1 Flow chart representing the methodology



3.5 Mix Design

The mix design procedure adopted to obtain M20 grade concrete is in accordance with IS: 10262 - 2009.Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. The mix proportion obtained for normal M20 grade concrete is 1: 1.72: 2.83 with a water-cement ratio of 0.50.

3.5.1 Mix proportions

Coarse aggregate was partially replaced by oil palm shell aggregate in the range of varying 0%, 20% and 40%. And the mix proportions have been recommended based on trial mixes. In the present study, M20 grade with design mix as per IS: 456-2000 was used. Concrete mix proportion by weight for one cubic meter and water cement ratio of 0.50. Gives the mix used for study.

Table - 3.6: Mix Proportions for conventional concrete

W/C Ratio	Cement	Fine Aggregate	Coarse Aggregate
0.50	394.32 kg/m^3	680.16 kg/m^3	1118.15 kg/m^3
	1	1.72	2.83

Table - 3.7: Mix proportion of different % of OPBC aggregate.

Mix Designation	OPBC %	Cement in kg/m^3	Fine Aggregate in kg/m^3	Coarse Aggregate(kg/m^3)	OPBC in kg/m^3
M_0	0%	394.32	680.16	1118.15	0
M_1	20%	394.32	680.16	894.52	134.51
M_2	40%	394.32	680.16	670.89	269.02

Table - 3.8: Mix proportions for light weight concrete.

Mix Designation	Description	Proportion [C: FA: CA: PA]
M_0	Control concrete of M20 grade	1 : 1.72 : 2.83 : 0
M_1	20% OPBC aggregate + 80% coarse aggregate	1 : 1.72 : 2.26 : 0.34

M_2	40% OPBC aggregate + 60% coarse aggregate	1 : 1.72 : 1.70 : 0.68

3.6 Experimental Procedure

In the present experimental investigation oil palm boiler clinker (OPBC) aggregate has been used as partial replacement of coarse aggregate in concrete mixes. On replacing coarse aggregate with different percentage of oil palm boiler clinker (OPBC) aggregate of 0%, 20% and 40%. The compressive strength is studied at different ages of concrete cured in normal water.

3.7 Batching

Batching is the process in which the quantity or proportion of materials like cement aggregates and water, etc. are measured on the basis of either weigh or volume to prepare the concrete mix. Proper Batching improves the workability of concrete by reducing the segregation or bleeding in concrete. In this study the process of weigh batching is adopted.

The process of measuring ingredients or materials to prepare concrete mix is known as batching of concrete. Batching can be done by two methods, volume batching and weight batching. Batching should be done properly to get quality concrete mix.

3.7.1 Methods of Batching Concrete

i. Volume Batching

- In volume batching, materials are measured on the basis of volume. It is less precise method of batching
- Measurement boxes or gauge boxes of known volume are used to measure materials.
- Cement is taken in the form of bags, where volume of one bag of cement (50 kg) is taken as 35 litres.
- Volume of Gauge box used is made equal to the volume of one bag of cement which is 35 litres.
- Gauge boxes are generally deeper and contains narrow top surface and they are made of timber or steel or iron.

- Volumes of different sized fine aggregate and coarse aggregate are measured individually by these gauge boxes.
- Water is measured using water meter or water cans of known volume are used.

ii. Weigh Batching

- In this method, Materials are measured on the basis of weight. It is accurate method of batching.
- Weigh batchers or other types of weighing equipment are used to measure weight of materials.
- Cement, fine aggregate, coarse aggregate and water are taken by weighing.
- Weigh batchers used are available in two types namely mechanical weigh batcher and electronic weigh batchers.
- In mechanical weigh batchers, weights are measured using spring and dial gauge arrangement and it is widely used equipment in weigh batching.
- In electronic weigh batchers, electronic scales and load cells supported by hoppers are used to measure the weight of ingredients of concrete.
- Weigh batchers available are may be Manual or semi-automatic or fully automatic. Manual type is used for small concrete production job while other two types are used for large concrete production.
- In case of semi-automatic weigh batching, aggregate container gates are lifted manually and it is automatically closed after reaching required quantity in the weighing machine.
- In fully automatic weigh batcher, all the process will be done automatically. The benefit of this type equipment is, it also measures the moisture content present in the aggregate and corrects the required quantity of water-cement with respect to moisture content of aggregates.

3.8 Mixing

Mixing is done according to the mix design of M20 grade. Calculated amount of cement, fine aggregate, coarse aggregate, oil palm shell, are first mixed in a tray with a trowel. The object of mixing is to coat the surface of all aggregate particles with Cement paste and to blend all the ingredients of concrete into a uniform mass. Though mixing of the materials is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency. In this study the process of hand mixing was adopted.

3.9 Casting

The specimens are casted in the ratio of 0%, 20%, 40% replacement of oil palm boiler clinker aggregate respectively with each ratio comprising of 6 cubes and 6 cylinders and 6 prisms. A total of 18 cubes and 18 cylinders and 18 prisms were casted. After the casting process, the cubes, prisms and cylinders were kept for 24 hours and de-moulded, and they were cured for 7 days, 21 days and 28 days.

Table - 3.9: Details of specimens

S. No.	Properties Studied	Specimen	Specimen Size(mm)
1	Compressive strength	cube	150 X 150 X 150
2	Split tensile strength	cylinder	300 height & 150diameter
3	Flexural strength	prism	500 X 100 X 100



Cube **Cylinder** **Prism**

Figure - 3.5: Standard specimens

3.9.1 Procedure for Casting Cubes

Clean the cube mould properly with a cloth and apply a coat of firm oil on the inner surfaces of the mould. No excess oil should be visible on the inner surfaces. Fix the nuts & bolts tightly with base plate and side plates, no gaps should be seen within the parts of cube mould. It is necessary that the cube mould should be placed on a clean, level & firm surface for filling the concrete in it.

Concrete for specimen should be collected from three or four random mixes according to the preferred mix design of M20 grade. Place the concrete mix into the mould in each layer of maximum 50 mm thick. Level off the top with the steel float & clean any concrete from around the mould and leave the mould undisturbed for 24 hours. Give number & casting date of the specimens on the top surface after 30 minutes. Remove the cube from the mould after 24 hours. The specimen should be put straight into a tank of clean water. The specimen should be fully submerged under water. After 7 and 28 days, send the specimen to the testing laboratory to determine the compressive strength of concrete.

3.9.2 Procedure for Casting Cylinders

Clean the Cylinder mould properly with a piece of cloth and apply a coat of firm oil on the inner surface of mould. No excess oil should be visible on inner surface. Fix the nuts & bolts tightly with base plate and no gaps should be within the parts of cylinder mould. It is necessary that the cylinder mould should be placed on a clean, level & firm surface. Concrete for specimen should be collected from three or four random mixes. Place concrete into the mould in each layer of maximum 50 mm thick. Level off the top with the steel float & clean any concrete from around the mould and leave the mould undisturbed for 24 hours.

Give number & casting date of the specimens on the top surface after 30 minutes. After 24 hours the specimen should be taken out from the mould and put it straight into a tank of clean water. The specimen should be fully submerged under water. After 7, 21 and 28 days, send the specimen to the testing laboratory to determine the tensile strength of concrete. Minimum three specimens are made at a time on site. The average test result is taken to determine the tensile strength of concrete.

Figure-3.6: casting of cylinder

3.9.3 Procedure for casting prism

Clean the prism mould properly with a cloth and apply a coat of firm oil on the inner surfaces of the mould. No excess oil should be visible on the inner surfaces. Fix the nuts & bolts tightly with base plate and side plates, no gaps should be seen within the parts of prism mould. It is necessary that the mould should be placed on a clean, level & firm surface for filling the concrete in it. Concrete for specimen should be collected from three or four random mixes according to the preferred mix design of M20 grade. Place the concrete mix into the mould in three layers and then perform the compaction process by using mechanical vibrator. Level off the top with the steel float & clean any concrete from around the mould and leave the mould undisturbed for 24 hours.

Give number & casting date of the specimens on the top surface after 30 minutes. Remove the prism from the mould after 24 hours. The specimen should be put straight into a tank of clean water. The specimen should be fully submerged under water. After 7, 21 and 28 days, send the specimen to the testing

Laboratory to determine the Flexural Strength of concrete.

Figure 3.7: Casting of prisms

Table - 3.10: Number of specimens casted.

S.NO	Mix Designation	No. of. cubes		No. of. Cylinders		No. of. prisms	
		7 days	28 days	7 days	28 days	7 days	28 days
1	Nominal Concrete	3	3	3	3	3	3
2	20%Replacement with OPBC	3	3	3	3	3	3
5	40%Replacement with OPBC	3	3	3	3	3	3
	Total specimens	9	9	9	9	9	9

3.10 Curing

The specimens shall be removed from the moulds at the end of 24 hours and immersed in clean water till the 7, 21 and 28-days age of testing. The specimens shall be tested in the saturated and surface dry condition. For the true representation of actual strength of concrete in the structure, extra specimens shall be cast, stored and cured as per the identical conditions of that structure, and tested at required age.

Figure - 3.8: Curing of Specimen.

3.11 Workability

Workability is a property of raw or fresh concrete mixture. In simple words, workability means the ease of placement and workable concrete means the concrete which can be placed and can be compacted easily without any segregation. Workability is a vital property of concrete and related with compaction as well as strength. The desired workability is not same for all types of concrete. More workability is required for a thin inaccessible section or heavily reinforced section rather than a mass concrete body. Hence, we can’t set a standard workability for all casting works. Aggregates influence the workability of the concrete by the amount of aggregate, the relative proportions of fine and coarse aggregate, and the different aggregate properties. Generally, workability is determined by different methods, but mainly the slump cone test is used in site.

3.11.1 Slump cone test

Slump Test is used to determine the consistency of concrete mix of given proportions. Scope and significance unsupported fresh concrete flows to the sides and a sinking in height takes place. This vertical settlement is known as slump. In this test fresh concrete is filled into a mould of specified shape and dimensions, and the settlement or slump is measured when supporting mould is removed. Slump increases as water-content is increased. The slump cone test is done for each mix and results are taken.

Procedure:

- The internal surface of the mould is thoroughly cleaned and applied with a light coat of oil.
- The mould is placed on a smooth, horizontal, rigid and non-absorbent surface.
- The mould is then filled in four layers with freshly mixed concrete, each approximately to one-fourth of the height of the mould.
- Each layer is tamped 25 times by the rounded end of the tamping rod (strokes are distributed evenly over the cross section).
- After the top layer is tampered, the concrete is struck off the level with a trowel.
- The mould is removed from the concrete immediately by raising it slowly in the vertical direction.

- The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured.
- This difference in height in mm is the slump of the concrete.

Figure - 3.9: Slump testing

3.12 Testing of specimens

The cured specimens are taken from the curing tank and placed outside until it gets dried. Later, the entire specimens which include 18 cubes and 18 cylinders were tested in the compression testing machine for 7 days, 21 days and 28 days. The tests conducted are;

- Compression test
- Split tensile test
- Flexural strength test

3.12.1 Compression test:

The cubes of standard size 150x150x150 mm are used to find the compressive strength of concrete. The load at the failure is noted down and compressive strength was calculated. Load at the failure divided by area of specimen gives the compressive strength of the concrete. Compressive strength is the maximum stress a material can sustain under pushing, crushing force. It is determined by the shattering fracture of the material under these forces. The compressive strength is the ratio of the maximum load to the surface area of the concrete cube. Three cubes were tested for each mix ratio and the average of three specimens is taken as the compressive strength it was tested by compression testing machine of capacity 2000 KN. The light weight concrete was tested for compressive strength at the age of 7 day, 21 day and 28 day. The specimens were subjected to a compressive force at the rate of 140KN per minute. Fig shows the concrete cube under test and the concrete cube specimens, respectively. The maximum load at failure was taken. The average compressive strength of concrete specimens was calculated by using the following equation.

$$\text{compressive strength} = \frac{\text{ultimate compressive load}}{\text{cross sectional area of specimen}}$$

Figure - 3.10: Compression testing machine

Figure – 3.11: Testing of cube

3.12.2 Split tensile test:

Concrete cylinders of size 150 mm diameter and 300mm length were cast with oil palm boiler clinker aggregate as partial replacement of coarse aggregate. During casting, the cylinders were mechanically vibrated using a table vibrator. After 24 hours, the specimens were de-moulded and subjected to curing for 7 days, 21 days &28 days in portable water. After curing, the cylindrical specimens were tested for split tensile strength using compression testing machine of 2000kN capacity. The ultimate load was taken and the average split tensile strength was calculated using the equation.

- Split tensile strength = $2P/\pi DL$ (Mpa) Where:

P = Failure load

D = Diameter of the cylinder

L = Length of the cylinder

The split tensile strength test was carried out as per IS 5819: 1999. Cylindrical concrete specimens 150 mm in diameter and 300 mm in height were cast. The specimens were tested for split tensile strength using universal testing machine at the age of 7, 21 and 28 days.

Figure - 3.12: Testing of cylinder specimen.

3.12.3 Flexure Test:

Flexure tests are generally used to determine the flexural modulus or flexural strength of a material. A flexure test is more affordable than a tensile test and test results are slightly different. The beam is laid horizontally over two points of contact (lower support span) and then a force is applied to the top of the material through one points of contact (upper loading span) till the sample failed. The force at failure is taken and tabulated.

PROCEDURE

Prepare the test specimen by filling the concrete into the mould in 3 layers of approximately equal thickness. Tamp each layer 35 times using the tamping bar as specified above. Tamping should be distributed uniformly over the entire cross section of the beam mould and throughout the depth of each layer.

- Clean the bearing surfaces of the supporting and loading rollers, and remove any loose sand or other material from the surfaces of the specimen where they are to make contact with the rollers.
- Circular rollers manufactured out of steel having cross section with diameter 38 mm will be used for providing support and loading points to the specimens. The length of the rollers shall be at least 10 mm more than the width of the test specimen. A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes. The distance between the outer rollers (i.e. span) shall be 3d and the distance between the inner rollers shall be d. The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic.
- The specimen stored in water shall be tested immediately on removal from water; whilst they are still wet. The test specimen shall be placed in the machine correctly centred with the longitudinal axis of the specimen at right angles to the rollers. For moulded specimens, the mould filling direction shall be normal to the direction of loading.
- The load shall be applied at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens.

Fig ure -3.13: Testing of flexural strength

CHAPTER-IV

RESULTS AND DISCUSSIONS

4.1 General

In this chapter, compressive strength and density of concrete at various concrete mixes is discussed. And results were compared, checked for compressive strength.

4.2 Workability test results

4.2.1 Slump results

For each mix we have conducted the slump test and results are shown in Table No-4.1. The slump value directly proportional to workability, as slump value increases then the workability also increased. Generally, slumps are classified in to three types they are,

- **Collapse slump**: In this slump the concrete collapses completely.
- **Shear slump**: In this slump the top portion of the concrete shears off and slips sideways.
- **True slump**: In this slump the concrete simply subsides, keeping more or less to shape.

Table - 4.1: slump cone results

Mix (percentage of replacement with oil palm boiler clinker)	Slump value(mm)
0%	101
20%	90
40%	95

Table – 4.2: slump ranges

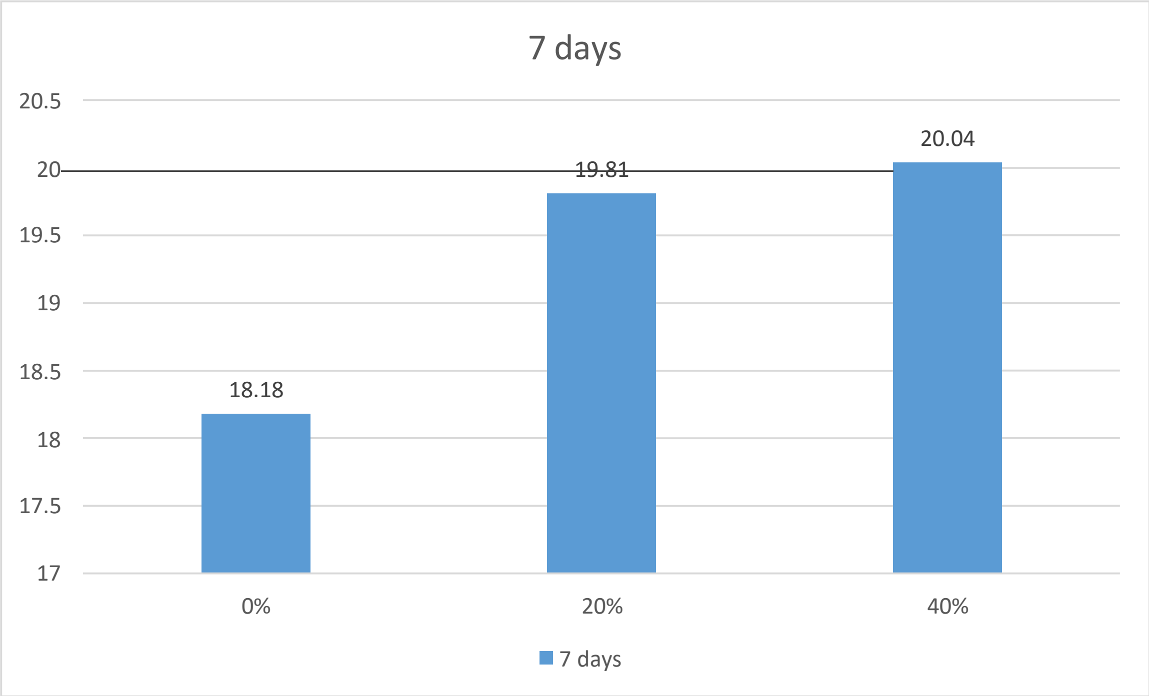
Slump Range	Workability
10-50mm	Low workability
50-100mm	Medium workability
Above 100mm	High workability

4.3 Compressive strength results

The compressive strengths of the casted specimens were determined by the compressive test machine and are tabulated as follows:

Table -4.3: compressive strength results for 7 days

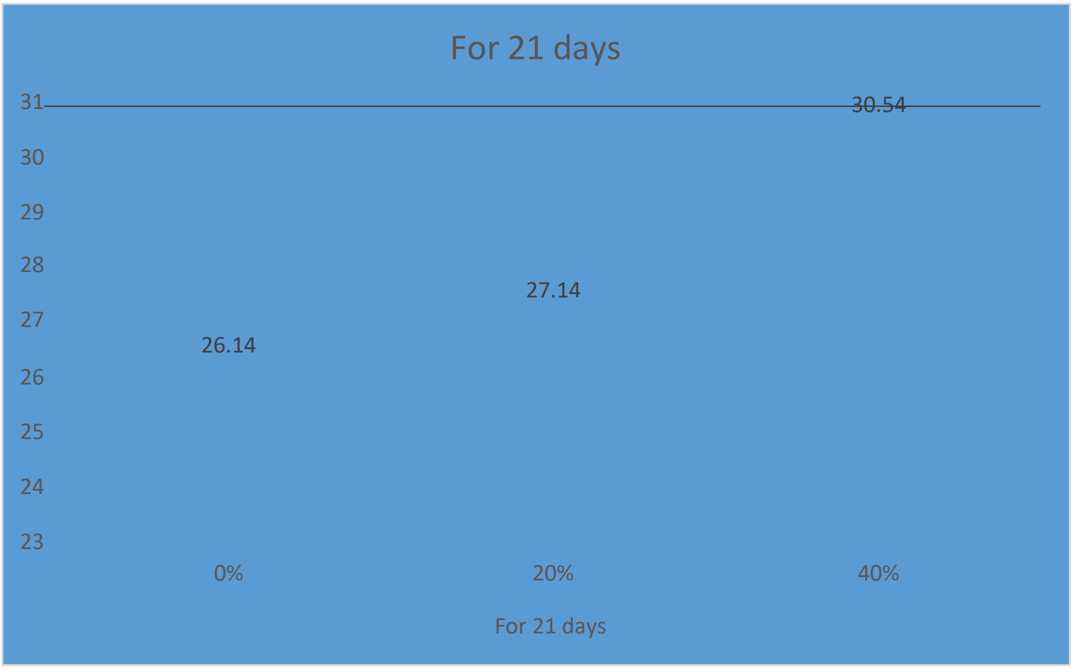
S. NO.	Percentage of Replacement	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1	0% (conventional concrete)	18.06	18.18
		19.08	
		17.40	
2	20%	19.60	19.81
		20.01	
		19.83	
3	40%	20.84	20.04
		19.95	
		19.92	



Graph 4.3.1: Showing comparison of compressive strength results for 7 days.

Table - 4.4: compressive strength results for 21 days.

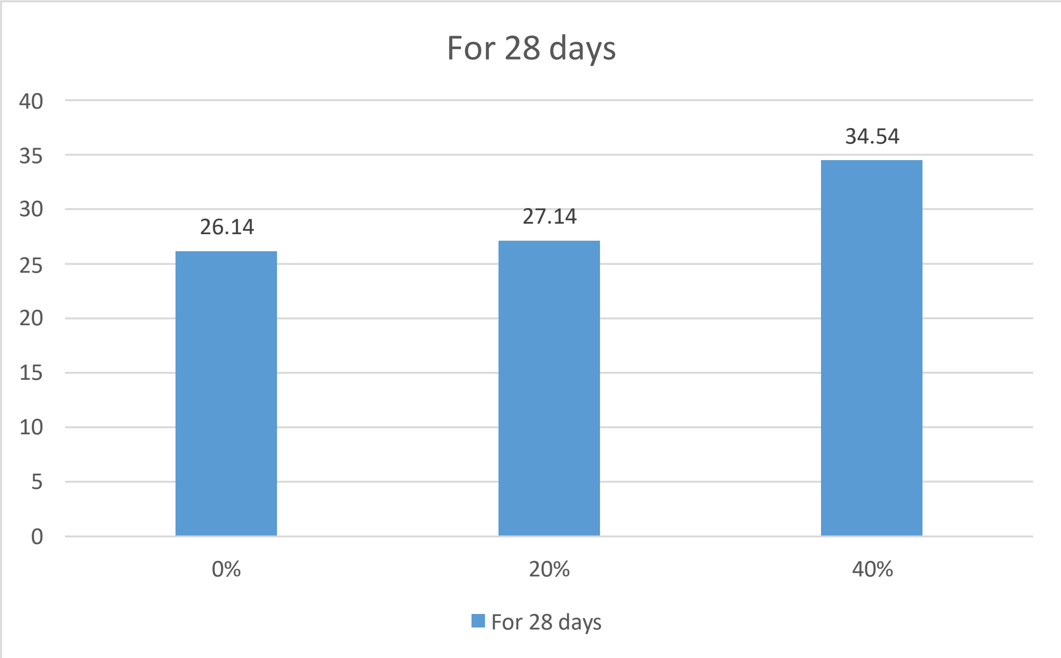
S. NO.	Percentage of Replacement	Compressive Strength (N/mm ^{2})	Average Compressive Strength (N/mm ^{2})
1	0% (conventional concrete)	26.34	26.14
		25.78	
		26.32	
2	20%	27.74	27.14
		26.95	
		26.73	
3	40%	30.94	30.54
		27.85	
		28.95	



Graph 4.3.2: Showing comparison of compressive strength results for 21 days.

Table - 4.5: compressive strength results for 28 days.

S. NO.	Percentage of Replacement	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1	0% (conventional concrete)	26.24	26.14
		25.95	
		26.23	
2	20%	27.74	27.14
		26.95	
		26.73	
3	40%	33.94	34.50
		32.85	
		34.95	



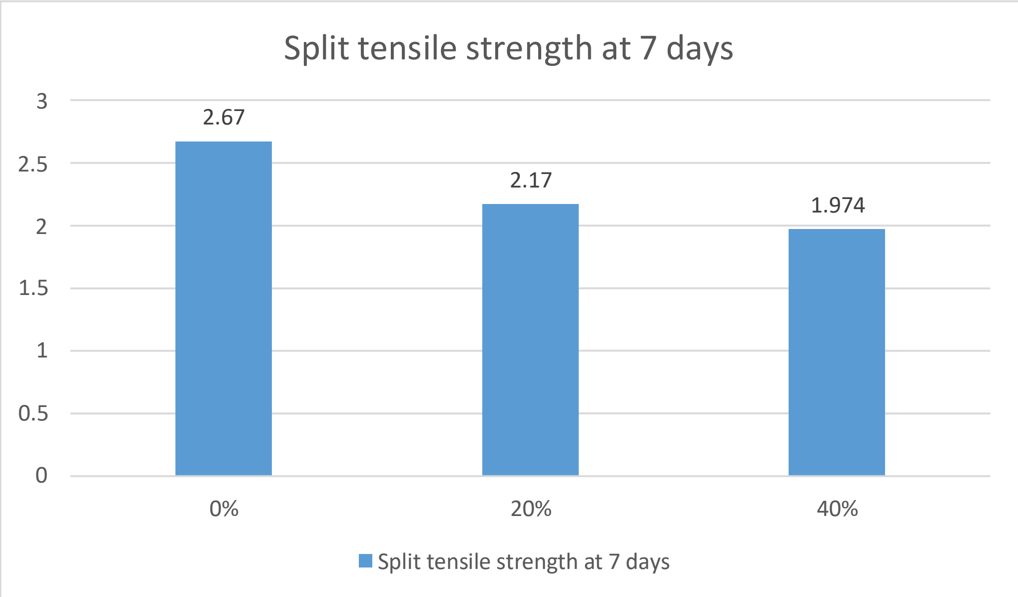
Graph 4.3.2: Showing comparison of compressive strength results for 28 days.

4.4 Split tensile strength results

The split tensile strength of the casted specimens was determined. And results are tabulated as follows:

Table – 4.6: Tensile strength results for 7 days

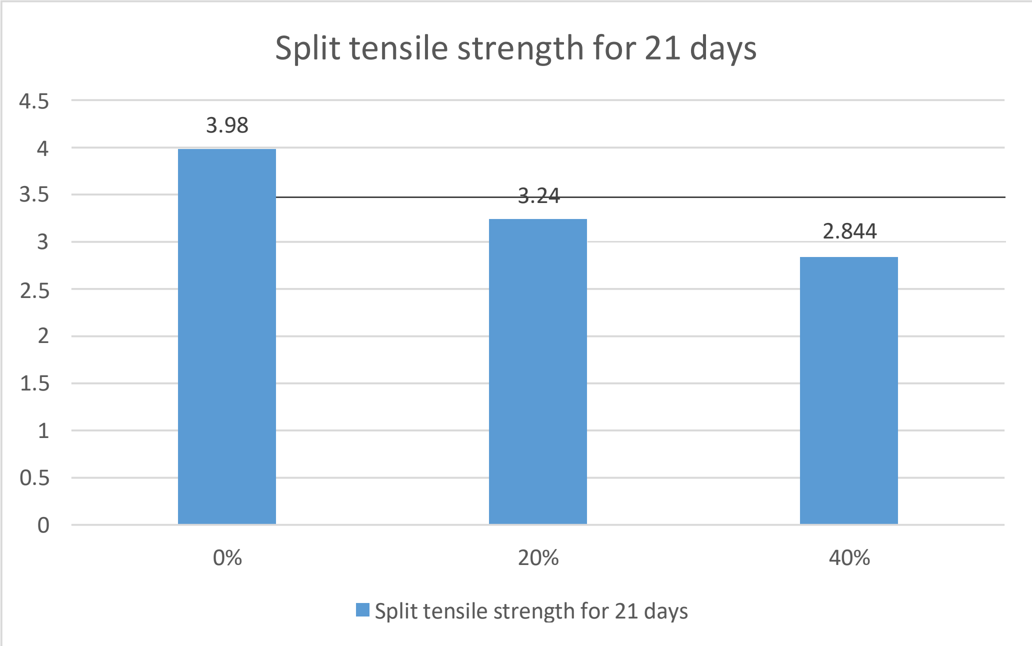
S. NO.	Percentage of Replacement	Split Tensile Strength (N/mm^2)	Average Split Tensile Strength (N/mm^2)
1	0% (conventional concrete)	2.89	2.67
		2.62	
		2.50	
2	20%	2.23	2.17
		2.50	
		1.79	
3	40%	1.72	1.97
		2.24	
		1.95	



Graph 4.4.1: Showing comparison of Split tensile strength results for 7 days.

Table – 4.7: Tensile strength results for 21 days

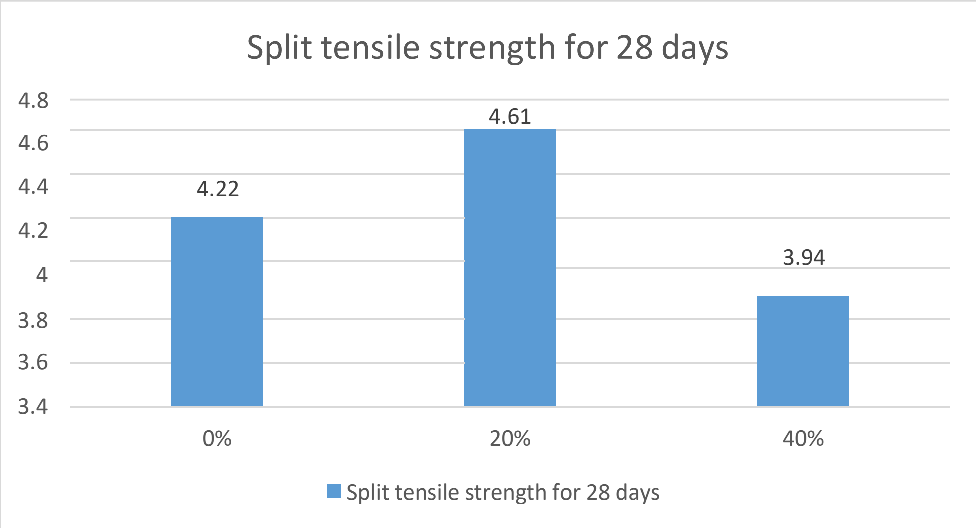
S. NO.	Percentage of Replacement	Split Tensile Strength (N/mm^2)	Average Split Tensile Strength (N/mm^2)
1	0% (conventional concrete)	2.98	3.98
		3.26	
		2.99	
2	20%	3.32	3.24
		3.66	
		2.90	
3	40%	3.56	2.84
		3.26	
		3.67	



Graph 4.4.2: Showing comparison of Split tensile strength results for 21 days.

Table – 4.8: Tensile strength result for 28 days

S. NO.	**Percentage of Replacement**	**Split Tensile Strength (N/mm^2)**	**Average Split Tensile Strength (N/mm^2)**
1	0% (conventional concrete)	4.42	4.22
		3.62	
		4.64	
2	20%	4.20	4.61
		4.93	
		4.70	
3	40%	4.16	3.92
		3.78	
		3.82	



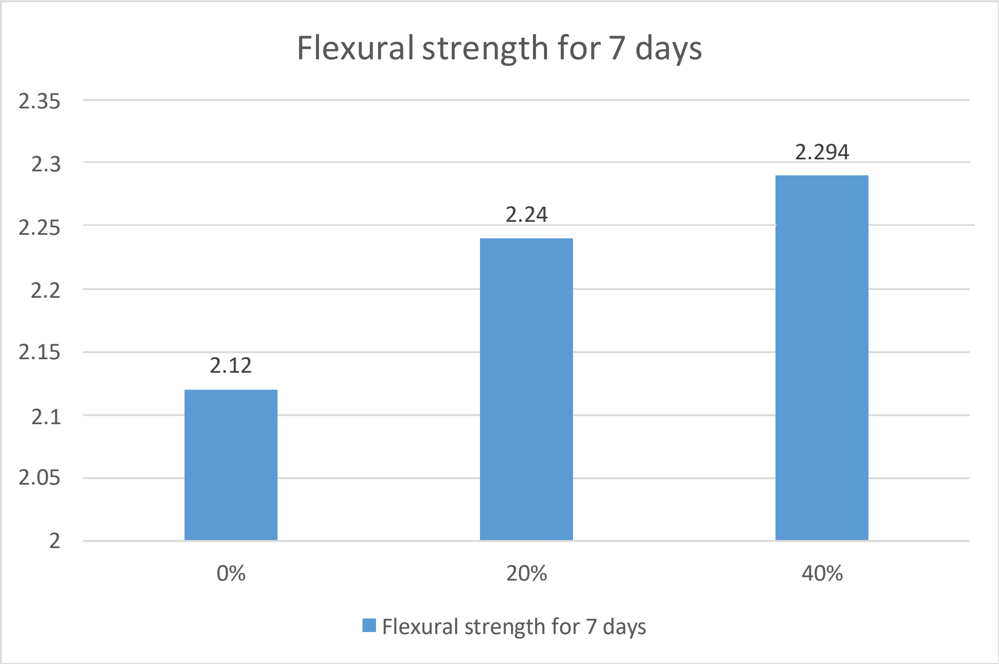
Graph 4.4.3: Showing comparison of split tensile strength results for 28 days.

4.5 flexural strength results

The flexural strength of the casted specimens was determined. And results are tabulated as follows:

Table – 4.9: flexural strength results for 7 days

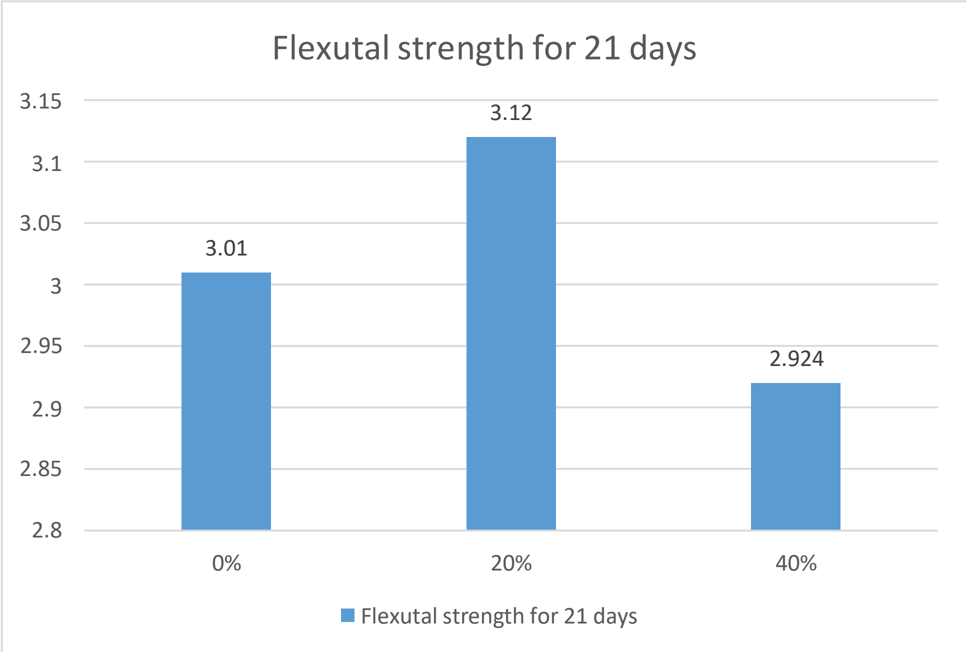
S. NO.	Percentage of Replacement	flexural Strength (N/mm^2)	Average flexural Strength (N/mm^2)
1	0% (conventional concrete)	1.96	2.12
		2.25	
		2.16	
2	20%	1.88	2.24
		2.50	
		2.35	
3	40%	2.18	2.29
		2.46	
		2.25	



Graph – 4.5.1 showing comparison of flexural strength result for 7 days

Table – 4.10: flexural strength results for 21 days

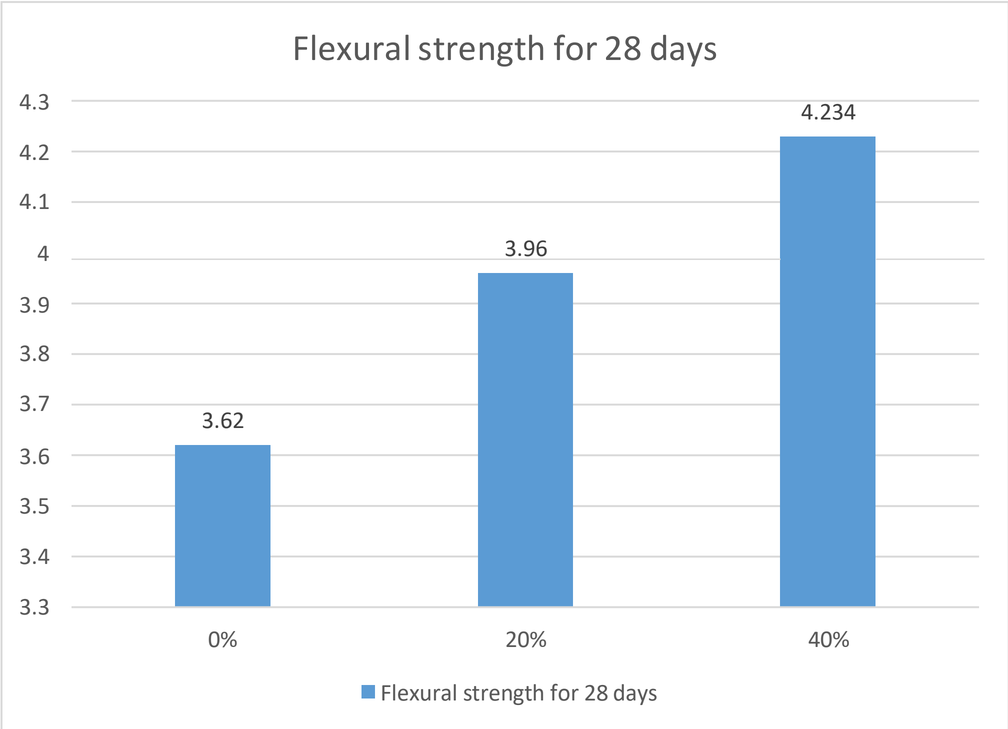
S. NO.	Percentage of Replacement	flexural Strength (N/mm^2)	Average flexural Strength (N/mm^2)
1	0% (conventional concrete)	1.69	3.01
		2.52	
		2.28	
2	20%	1.66	3.12
		2.97	
		2.47	
3	40%	2.26	2.92
		2.47	
		2.75	



Graph – 4.5.2 Showing comparison of flexural strength result for 21 days

Table – 4.11: flexural strength results for 28 days

S. NO.	Percentage of Replacement	flexural Strength (N/mm^2)	Average flexural Strength (N/mm^2)
1	0% (conventional concrete)	3.45	3.62
		3.92	
		3.50	
2	20%	3.81	3.96
		4.28	
		3.80	
3	40%	4.42	4.23
		3.91	
		4.38	

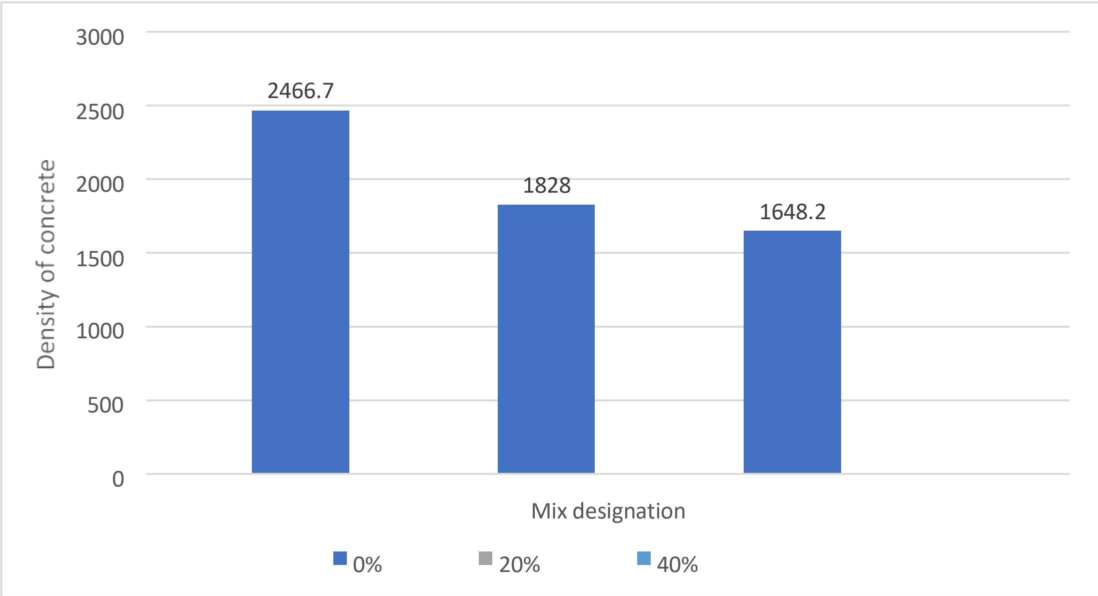


Graph – 4.5.3 showing comparison of flexural strength result for 28 days

4.6 Density of Concrete

Table – 4.12: density of concrete at various mix designations

S. No.	Mix Designation	Density of Concrete (Kg/m^3)
1	M_0 (0% REPLACEMENT)	2466.7
2	M_1 (20% REPLACEMENT)	1828.0
3	M_2 (40% REPLACEMENT)	1648.2



Graph - 4.6.1: Showing the comparison of density for each mix

CHAPTER - V

CONCLUSION

The concluding remarks are obtained from the comparative study of strength using different percentage of replacements with OPBC.

Based on the above results the following conclusions may be drawn.

- It has been reported that concrete containing LWA can achieve 80 - 92% of the 28-day compressive strength at 7-day age.
- With the increase in percentage of replacement of standard coarse aggregate with OPBC aggregates, the slump value of fresh concrete was decreased. However, the slump value remained within the appropriate range for LWC.
- The OPBC concrete absorbed more water than the control conventional concrete. OPBC concrete, on the other hand, is considered high quality concrete based on initial and final water absorptions.
- It could be inferred that the porous nature of OPBC aggregates with a lower bulk density has had a direct impact on the OPBC concrete's lower mass per volume.
- From the results we can conclude that 20% replacement sample is considered as partial LWC because its density is more than 2000kg/m^3 and 40% replacement sample is the ideal % of OPBCC, it gives density below 2000kg/m^3 and compressive, split and flexural strength results are promising. So this sample can be considered as Structural LWC
- Generally, OPBC aggregate was founded to be a good replacer of coarse aggregate in concrete production from strength and workability point of view and according to recycle of waste material.
- However, the strength of the concrete is depending on the two variables i.e. amount of OPBC and curing period

CHAPTER - VI

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A Major Project Report
On

EXPERIMENTAL STUDY ON PRECAST COMPOUND WALL MANUFACTUED FROM PLASTIC WASTE

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

by

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JUNE 2021

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BONAFIDE CERTIFICATE

This is to certify that the project entitled "**Experimental Study on Precast Compound Wall Manufactured From Plastic Waste**", is being submitted by **Mr. D. Vikram Reddy (17K81A0173), Ms. D. Niharika (17K81A0176), Mr. J. Nagesh (17K81A0184) and Mr. V. Mouli SaiKiran (18K85A0132)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN CIVIL ENGINEERING** is recorded of bonafide work carried out by them. The result embodied in this report have been verify and found satisfactory.

Signature of Guide

Mrs. K. SNEHALATA
Assistant Professor,
Department of Civil Engineering

Signature of HOD

Prof. SANDHYA KIRAN J.K.
Head of the Department
Department of Civil Engineering

Internal Examiner

External Examiner

Place:

Date:

DECLARATION

We, the student of **Bachelor of Technology** in Department of Civil Engineering, session: 2017 – 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled "Experimental Study On Precast Compound Walls Manufactured From Plastic Waste" is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

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ABSTRACT

The aim of this project is to replace cement with plastic waste in compound wall and to reduce the cost of compound wall when compared to that of convention concrete compound wall. At present nearly 56 lakhs tones of plastic waste is produced in India per year. The degradation rate of plastic waste is also a very slow process. Hence the project is helpful in reducing plastic waste in a useful way. In this project we have used plastic waste in different proportions with quarry dust, coarse aggregate and ceramic waste. The plastic compound wall were prepared and tested and the results were discussed Plastic waste used in this work was brought from the surrounding areas. Currently about 56 lakh tones of plastic waste dumped in India in a year. The dumped waste pollutes the surrounding environment. As the result it affects both human beings and animals in direct and indirect ways. Hence it is necessary to dispose the plastic waste properly as per the regulations provided by our government. The replacement of plastic waste for cement provides potential environmental as well as economic benefits. With the view to investigate the behaviour of quarry rock dust, recycled plastic, production ofplastic compound wall from the solid waste a critical review of literature was taken up from the observations of test results, PET can be reused with 50% of fine aggregate 50% coarse aggregate in Plastic precast compound wall. The physical and mechanical properties of materials used in Plastic precast compound wall were investigated. For thetest 3 cubes cube were cast for measuring Compressive strength. The recycled plastic and aggregate are used in various proportions mix designs and check there stability.

Keywords: *compressive strength, plastic waste, PET, recycled plastic*

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CHAPTER- 1
INTRODUCTION

1.1 OVER VIEW OF THE PROJECT

Plastic is a very common material that is now widely used by everybody in the world. Plastic plays a predominant role in reusable in this era, as it is compact and light in weight. Common plastic items that are used are covers, bottles, and food packages. The great problem with plastic is its decomposition. Plastic is made of polymer chemicals and they are non-biodegradable. This means that plastic will not decompose when it is placed in earth. Though plastic is very useful material that is flexible, robust and rigid they become waste after their use and they pollute the air and land. Recycling is processing use waste materials into new products to prevent waste of potentially useful materials. The increase in the popularity of using eco-friendly, low cost and lightweight construction materials inbuilding industry has brought about the need to investigate how this can be achieved by benefiting to the environment as well as maintaining the material requirements and their standards. From the advantages of plastic recycling procedure is used. For the production of plastic bricks is an optimal method for controlling the problem by decomposition of plastic waste and also it costs economical for the production of building materials. In this study, plastic waste from factories will be used to incorporate with cement and sand to produce sand bricks. The bricks will then be tested to study the compressive strength, efflorescence and water absorption. In the recent past research, the replacement and addition have been done with the direct inclusion of polyethylene, polyethylene terephthalate (PET) bottles in shredded form, chemically treated polyethylene-fibre, PET in small particles form by replacing natural coarse aggregate. Most of replacements have been done by volume calculation, and showed the decreased in compressive strength as the increased plastic waste. In this study, recycled plastic waste have been introduced in the form of crushed. The replacement of plastic waste material has been done by weight. Paver block paving is versatile, aesthetically attractive, functional, and cost effective and requires little or no maintenance if correctly manufactured and laid. Most concrete block paving constructed in India also has performed satisfactorily but two main areas of concern are occasional failure due to excessive surface wear, and variability in the strength of block. Natural resources are depleting worldwide at the same time the generated wastes from the industry and residential area are increasing substantially. The sustainable development for construction involves the use of Non- conventional and innovative materials, and recycling of waste materials in order to compensate the lack of natural resources and to find alternative ways conserving the environment. Plastic waste used in this work was brought from the surrounding areas. Currently about 56 lakh tonnes of plastic waste dumped in India in a year. The dumped waste pollutes the surrounding environment. As the result it affects both human beings and animals in direct and indirect ways. Hence it necessary to dispose the plastic waste properly as per the regulations provided by our government. The replacement of plastic waste for cement provides potential environmental as well as economic benefits.With the view to investigate the behaviour of quarry rock dust, recycled plastic, production of plastic paver block from the solid waste a critical review of literature was taken up. An attempt was made by Nivetha C et.al[1] to reuse the solid waste quarry dust fly-ash and PET with an aim not to lose the strength far from original Paver blocks. From the observations of test results, PET can be reused with 50% of quarry dust and 25 % of fly-ash in Plastic Paver block. The physical and mechanical properties of materials used in Plastic Paver block were investigated. For the test 6 cubes cube were cast for measuring Compressive strength. Satish Parihar et.al[2] used recycled plastic aggregate in various proportions in concrete mix and check there stability. Amount of waste plastic being accumulated in 21st centuries has created big challenges for their disposal, thus obliging the authorities to invest in felicitating the use of waste plastic coarse aggregate in a concrete is fundamental to the booming construction industry. Three replacement levels of 10 %, 20%, 30 by weight of aggregates were used for the preparation of the concrete. Poonam Sharma[3] et. al. discussed about cement concrete paver blocks for rural roads. Presently, different types of waste materials and industrial byproducts such as recycled concrete aggregate, glass, ceramic, fly ash, slag, etc., are being used with and without natural aggregates and ordinary Portland Cement (OPC), not only in traditional construction but also in digital construction like 3D printing. It has been shown that the properties of these materials are suitable to produce new concrete up to a certain limit. Therefore, numerous studies have been conducted to find the optimum content of these materials in concrete, which does not negatively influence the engineering properties of concrete. Waste materials such as plastics and glass, which present possible environmental hazards and are often landfilled, are often used in concrete for different applications. Globally, the use of plastics had seen an astronomical increase since 1920, when it was first developed for industrial use. The many advantages of plastics have caused the increase in its production by plastic industries. Compared to other materials such as glass and metal, plastics have lower cost, a higher strength-to-weight ratio, are more durable (resistant to deterioration), easy to work and shape, and have a low density. Some staggering statistics have shown that in 2013, 299 million tons of plastic were produced globally, exceeding the estimated consumption for 2015 by about 2 million tons. However, waste plastics are generally a threat to the global environment. While the production of plastics in its varied forms cannot be halted, recycling may be a solution to the threat waste plastics pose to the environment.Again, the recycling of all sorts of waste materials is sustainable and conserves natural resources. Millions of tons of plastic waste are generated all around the world, and they frequently find their way into rivers, coast, beaches, and the land. Only about 25% of plastic waste is recycled around the world. Recovery and recycling of plastics remain insufficient, and millions of tons end up in landfills and oceans every year. This percentage of recycled plastic can be increased by transforming waste plastic into products Sustainability 2018, 10, x FOR PEER REVIEW 2 of 26 plastics in its varied forms cannot be halted, recycling may be a solution to the threat waste plastics pose to the environment. Recycling of various types of organic and inorganic waste such as construction, electronics, and agricultural waste, among others, has drawn much attention due to the increasing cost of dumping the waste and decreasing space in landfills. Again, the recycling of all sorts of waste materials is sustainable and conserves natural resources. Millions of tons of plastic waste are generated all around the world, and they frequently find their way into rivers, coast, beaches, and the land. Only about 25% of plastic waste is recycled around the world. Recovery and recycling of plastics remain insufficient, and millions of tons end up in landfills and oceans every year. This percentage of recycled plastic can be increased by transforming waste plastic into products suitable for housing and construction. Figure 1 illustrates the cumulative amount of plastic waste generation and disposal from 1950 up to 2015 and the projected amount by 2050. Up to 2015, only about 16% of the waste generated was recycled. It is projected that by 2050, up to 33% of the waste generated will be recycled. Even if this projection comes true, the amount of unrecycled waste will still leave much to be desired.

Figure: 1.1 Non biodegradable plastic

1.1.1 PRESENT SCENARIO OF WASTE GENERATION IN INDIA

Growth of population has increased our urbanization as a result rising standard of living due to technological innovations have contributed to an increase both in the quantity and variety of solid wastes generated by industrial, agricultural activities, mining and domestic. Globally the estimated quantity of wastes generation was 12 billion tones in the year2002 of which 11 billion tones were industrial wastes and 1.6 billion tones were municipal solid wastes (MSW). About 19 billion tons of solid wastes are expected to be generated annually by the year 2020.Annually, Asia alone generates 4.4billion tons of solid wastes and MS comprise 795 million tons of which about 48 (6%) MT are generated in India. MSW generation in India, is expected to reach 300 Million tones and land requirement for disposal of this waste would be 169.6 km2 as against which only 20.2 km2 were occupied in 1997 for management of 48 Million tones. As it is studied that apart from municipal wastes, the organic wastes from agricultural sources alone contribute more than 350million tons per year. However, it is reported that about 600 million tons of wastes have been generated in India from agricultural sources alone. The Quantity of wastes generated from agricultural sources are sugarcane baggage, paddy and wheat straw and husk, wastes of vegetables, food products, tea, oil production, wooden mill waste, coconut husk, jute fibre, groundnut shell, cotton stalk etc. In the industrial sector inorganic solid waste could are coal combustion residues, bauxite red mud, tailings from aluminium, iron, copper and zinc primary extraction processes. Generation of all these inorganic industrial wastes in India is estimated to be 290 million Tons per annum. In India,4.5 million tons of hazardous wastes are being generated annually during different industrial process like electro plating, various metal extraction processes, galvanizing, refinery, petrochemical industries, pharmaceutical and pesticide industries. In most cases, waste plastics have been used in concrete either as fine or coarse aggregate. Although utilization of this type of waste in concrete is beneficial from an environmental point of view, its engineering (e.g., mechanical and thermal) properties are essentially different from natural aggregates (Table 1). It is also worth noting that the properties of recycled waste plastic concrete depend on the pre-treatment given to the waste plastic. The bond strength of plastic aggregates and the cement paste could be significantly influenced by the treatment.

1.1.2 ECO PRECAST WALLS:

An **Eco Pavement blocks** is a plastic bottle packed with used plastic to a set density. They serve as reusable building blocks. Eco bricks can be used to produce various items, including furniture, garden walls and other structures. Eco bricks are produced primarily as a means of managing consumed plastic by sequestering it and containing it safely, by terminally reducing the net surface area of the packed plastic to effectively secure the plastic from degrading into toxins and microplastics. Eco bricking is a both an individual and collaborative endeavour. The Eco bricking movement promotes the personal Eco bricking process as a means to raise awareness of the consequences of consumption and the dangers of plastic. It also promotes the collaborative process as a means to encourage communities to take collective responsibility for their used plastic and to use it to produce a useful product. To enable the production of Eco bricks at minimal environmental cost, the Global Eco brick Alliance promotes low-technology methods that do not require capital, fuel, electricity, or specialized equipment. Typically, producers use a wood or bamboo stick to manually pack plastic into the plastic bottle. Any size of transparent polyethylene terephthalate (PET) plastic bottle can be used to make an Eco bricks. The bottle and the packed plastic are clean and dry to prevent the growth of bacteria. Plastic is cut or ripped into small pieces then packed little by little, alternating between adding the plastic and compacting it, layer by layer. The bottle is rotated with each press to ensure the plastic is evenly compacted throughout the bottle. This helps prevent voids and that the packing reaches the requisite solidity needed for a building block applications. Completed Eco bricks are packed solid enough that they can bear the weight of a person without deforming—a density range between 0.33g/ml and 0.7g/ml. Maximizing density minimizes the flammability of the Eco brick while increasing its durability and re-usability. Utilization of recycled waste plastics in concrete as a partial aggregate replacement has a clear effect on the properties of the material. Therefore, if this material is to be used in concrete in large quantities, it is important to know the relationship between the addition of recycled waste plastics and the engineering properties. This review provides a basis for understanding this relationship. A thorough search of peer-reviewed literature was undertaken to find studies in which recycled plastic has been used for the production of concrete. Major search engines (ScienceDirect, Google Scholar) were used. The focus was on recent literature, i.e., published after 2010, relevant to current developments in the field. Articles from reputable journalsdealing with building materials on the one hand and sustainable development and recycling on the other hand were extracted. Note that the number of citations of individual articles was not used as a selection criterion; instead, articles were selected based on their relevance to (parts of) this review. After collecting the relevant articles, we then categorized into those dealing with fresh, mechanical, and durability properties of concrete. Thereafter, each property was reviewed from the different publications, and a position statement was arrived at by these authors. Where differences or similarities exist, these were discussed extensively. The purpose of the paper is to present clearly, from experimental results, the performance of concrete containing recycled waste plastic regarding the fresh, mechanical, and durability properties. Therefore, this paper can be used as a valuable source of data for researchers for their future studies since it critically summarizes the recent findings on the use of waste plastics in concrete

1.1.3 HISTORY

Eco bricking plastic waste into bottles is a method for dealing with waste that has popped up organically around the world. Various simultaneous pioneers have helped shape the global around movement and refine the technology. Susana Heisse an environmental activist around Lake Atitlan in Guatemala in 2004. Alvaro Molina began on the island of Ometepe in 2003. The technique builds upon the bottle building techniques developed by German architect Andreas Froese (using sand filled Polyethylene terephthalate (PET) bottles) in South America in 2000.In 2010, in the Northern Philippines, Russell Maier and Irene Baking developed a curriculum guide of simplified and recommended practices to help local schools integrate Eco bricks into their curriculum. Applying the ancestral ecological principles of the Igorot's for building rice terraces, they integrated Cradle-to cradle principles into Eco bricks methodology: ensuring that Eco bricks can reused at the end of the construction they are used in. Through the Department of Education, the guide was distributed to 1700 schools in 2014.

The open source development of Eco brick best practices and innovations that emerged from the Filipino movement became the genesis for the Global Eco brick Alliance as founded by Russell Maier, Joseph Stodge and Candice Mostert. The Global Eco brick Alliance continues to develop and maintain the conceptual and technological infrastructure of the global Eco brick movement as an Earth Enterprise.

Movements in South Africa began in 2012, when Joseph Stodge brought the concept to Grey ton, throwing an annual Trash to Treasure festival at the local dumpsite with South African, Candice Mostert, who started local school projects under Grey ton transition town building with the bricks made by the community. The movement has since grown in South Africa, with organizations like Waste-ED, founded by Candice Mostert, who works both in Zambia and Cape Towns surrounds to educate people about plastic and its value, and the architect Ian Demises as the Eco brick Exchange. Concrete is the most widely used man made construction material in the world and its second only to water as the most utilized substance in the planet. Seeking aggregates for concrete and to dispose of the plastic waste is the present concern. Today sustainability has got top priority in construction industry. In the present study the recycled plastics were used to prepare the coarse aggregates thereby providing a sustainable option to deal with the plastic waste. There are many recycling plants across the world, but as plastics are recycled they lose their strength with the number of recycling. So these plastics will end up as earth fill. In this circumstance instead of recycling it repeatedly, if it is utilized to prepare aggregates for concrete, it will be a boon to the construction industry. Most of the failures in concrete structures occur due to the failure of concrete by crushing of aggregates.

Plastic Coarse Aggregates which have low crushing values will not be crushed as easily as the stone aggregates. These aggregates are also lighter in weight compared to stone aggregates. Since a complete substitution for Normal Coarse Aggregate is not found feasible, a partial substitution with various percentage of Plastic Coarse Aggregate is done. Volumetric substitution was employed in this investigation. Hence in the present study, it is aimed at concrete mix with partial replacement of coarse aggregate by LDPE granules (0%, 10%, 20%, and 30%).This mix in the form of cubes and cylinders were subjected to compression and split tension to ascertain the behaviour and strength parameter.

1.1.4 20TH CENTURY PLASTIC DEVELOPMENT

Petroleum-derived energy has enabled the growth of the global economy over the last hundred years. The widespread adoption of fossil fuels has enabled transportation and material technologies to develop. However, in the refinement of crude oil, 4-13% cannot be processed into high value, high energy fuels. This by-product is useful as a feedstock for the ultra-cheap production of plastic polymers. Since 1950 an estimated 8,300 million metric tons (Mt) of virgin plastics have been produced worldwide; 9% of which had been recycled, 12% were incinerated and 79% have accumulated in landfills or the natural environment. Plastic associates products based have been considered as the world most consumer packaging solution. However, substantial quantities of plastic consumption have led to exponential increase of plastic derived waste. Recycling of plastic waste as valued added product such as concrete appears as one of promising solution for alternative use of plastic waste. This paper summarized recent progress on the development of concrete mixture which incorporates plastic wastes as partial aggregate replacement during concrete manufacturing. A collection of data from previous studies that have been researched which employed plastic waste in concrete mixtures were evaluated and conclusions are drawn based on the laboratory results of all the mentioned research papers studied Plastics have become an essential part of our modern lifestyle, and the global plastic production has increased immensely during the past 50 years. This has contributed greatly to the production of plastic-related waste. Reuse of waste and recycled plastic materials in concrete mix as an environmental friendly construction material has drawn attention of researchers in recent times, and a large number of studies reporting the behavior of concrete containing waste and recycled plastic materials have been published. This paper summarizes the current published literature until 2015, discussing the material properties and recycling methods of plastic and the influence of plastic materials on the properties of concrete. To provide a comprehensive review, a total of 84 studies were considered, and they were classified into sub categories based on whether they dealt with concrete containing plastic aggregates or plastic fibers. Furthermore, the morphology of concrete containing plastic materials is described in this paper to explain the influence of plastic aggregates and plastic fibers on the properties of concrete. The properties of concretes containing virgin plastic materials were also reviewed to establish their similarities and differences with concrete containing recycled plastics

1.1.5 PETROLEUM PROJECTIONS

According to the American Chemistry Council, since 2010 $186bn dollars is being invested in 318 new projects to fuel a 40% increase in plastic production over the nextdecade.] If current production and waste management trends continue, roughly 12,000 Mt of plastic waste will be in landfills or in the natural environment by 2050.[9] In addition, by2030, COemissions from the production, processing and disposal of plastic could reach 1.34 gigatons per year—equivalent to the emissions released by more than 295 new 500-megawatt coal-fired power plants.

1.1.6 PLASTIC POLLUTION AND CONTAMINATION

A tremendous amount of plastic waste litters our planet every year, and its cost is huge. According to the United Nations Environment Programme (UNEP) 2014 Yearbook, plastic contamination threatens marine life, tourism, fisheries and businesses and the overall natural capital cost for plastic waste is $75 billion each year. Increasing scientific documentation is demonstrating many dangers arising from plastic degradation. When plastic enters the biosphere it releases toxins, fragments into microplastics and emits greenhouse gases that interfere with ecological cycles.When plastic is burned or incinerated, toxic gases like dioxins, furans, and polychlorinated biphenyls are released into the atmosphere. Photo-oxidative degradation caused by exposure toultravoilet (UV) radiation and physical abrasion fragments plastic debris into smaller and smaller particles, known as microplastics.The degradation process corresponds directly to the amount of surface area of the plastic that is exposed as well as the length of time of exposure to UV rays. The majority of non-recyclable single use plastics are sheets and films with large surface areas and are highly susceptible to photodegrading. The photo degradation process also emits greenhouse gases, methane and ethylene.

Microplastics can have possible direct Eco toxicological impacts, accumulate in food chains and cause economic damage because of food safety concerns. Burned and incinerated plastics have been shown to release dioxins and other chemicals that are harmful to human health.

1.1.7 RURAL COMMUNITY IMPACT

In countries and communities without access to industrial recycling or incineration, plastic has accumulated in streets, ditches, and beaches. Without large scale options for managing plastic households and communities have been powerless to manage their own plastic, other than dangers and intoxicating low-temperature incineration, water, and land loose dumping.

1.1.8 FAILURE OF INDUSTRIAL RECYCLING

Between, 1950 and 2017 an estimated 8,300 million metric tons (Mt) of virgin plastics have been produced worldwide; only 9% were recycled, the rest have been dumped or burned.As of the early 2000s most industrial recycling was occurring in China where the majority of G7 countries were exporting their waste plastic.The processing of this plastic, in particular the dumping and incineration of unrecyclable, caused significant pollution in China.As of January 1, 2018, China banned plastic imports in its National Sword program. Since then, globally, more plastics are now ending up in landfills, incinerators, or likely littering the environment as rising costs to haul away recyclable materials increasingly render the practice unprofitable. The displaced plastic exports from Europe and America has been largely diverted to Indonesia, Turkey, India, Malaysia, and Vietnam] where lacking environmental regulations have resulted in wholesale air, water and earth pollution around processing plants.Critics observe that industrial recycling relies on the energy intensive export of plastic to other locations, that industrial recycling isn't a circular (processes turn a high grade plastic into a lower, less-recyclable form), and that recycling enables the unquestioned continuation of plastic consumption

1.1.9 ECO BUIDING APPLICATIONS

Eco bricks can be connected using tire bands, silicone, cob, and cement to build furniture, gardens, structures and more. Eco bricks are being used in different ways around the world. Ideally, Eco brick constructions use cradle to cradle design methods of combining the bottles—ensuring that the Eco bricks can be extricated without compromise to the bottle at the end of the construction's life span.It is useful to differentiate between short-term Eco brick and long term Eco brick applications

1.1.10 SHORT-TERM APPLICATIONS

Eco bricks can be combined together using tire bands or inner-tube-bands as short-term, non-permanent attachment methods to create applications that last months to several years. As short-term applications are not usually covered, such constructions are typically for indoor use, in order to prevent UV photodegrading of the bottles. Short-term applications range from:

- **Eco brick Milstein Modules:** Hexagon and triangle modules that are used for sitting, but can be combined together to form one or two level horizontal surfaces. Applicationsinclude tables, beds, stages, etc
- **Eco brick Dieleman Modules:** A geometric configuration of 16 Eco bricks that enables a stackable LEGO module. These modules can be stacked horizontally and vertically indefinitely. Applications include indoor playgrounds, temporary stalls, sheds, and circular structure
- **Eco brick Open Spaces:** A combination of hundreds of Milstein and Dieleman legomodules that enable the creation of interactive social spaces.

1.1.11 LONG-TERM APPLICATIONS

Eco bricks can be used with Earth building techniques to create structures that can last years or decades (it is not uncommon for traditional earth constructions to last centuries).In this way, earth mixes are used in between horizontally laid Eco bricks as mortar. Eco bricks can also used vertically and with traditional construction techniques in the Pura Vida Atlas style of building. Both methods are careful to avoid the complete covering of Eco bricks with cement which upon the end of the construction results in the destruction of Eco bricks upon extrication Examples of long-term Eco brick applications include:

- **Raised gardens:** Eco bricks are laid horizontal and completely covered
- **Raised benches:** Two or three levels of horizontally laid Eco bricks to make seats and benches
- **Food Forest Play Parks:** A combination of raised beds and benches to make a public green space, ideally filled with edible plants.
- **Walls:** Eco bricks can be laid horizontal with earth mortar to build vertical walls. The walls can between standing posts and beams or as a circular standing structure.

Alternatively, the pura vida method, uses chicken wire between posts to make walls from enclosed vertically standing Eco bricks.

1.2 OBJECTIVE

- The main objective of this review is to determine the suitability of waste voltaic bottles and polyethylene bags in the development of plastic precast compound wall for construction.

- To reduce the plastic waste.
- To use plastic waste material in construction methodology.
- To reduce the environmental and ecological challenge associated with plastic.
- To find alternatives of basic materials which are used in construction of plastic precast compound wall.
- To compare the compressive strength of Recycled Plastics used as Coarse Aggregate for Constructional Concrete with the Conventional concrete.
- To know its applications in construction industry.
- To reduce the pressure on naturally available materials by replacing it with recycled plastic aggregate
- Compare the physical characteristics of natural aggregate with Plastic recycled aggregate.
- To study the behavior of fresh and hardened concrete reinforced with plastic waste coarse aggregate.
- To study it’s behaviour in construction of pavements and roads.
- To produce lightweight polymer concrete for multi-purpose use.

1.3 SCOPE OF PROJECT WORK

According to our research the major source of pollution in India is waste plastic. Growth of population, increasing urbanization, rising standards of living due to technological innovations have contributed to an increase both in the quantity and variety of solid wastes generated by industrial, mining, domestic and agricultural activities. Globally The estimated quantity of wastes generation was 56 million tones in the year. To find the possibilities of reducing the amount of waste plastic as it will create an eco-friendly environment as well as it used in construction of plastic precast compound wall.

1.4 PROBLEM STATEMENT

Solid waste management is the most pressing environmental challenge faced by urban and rural areas of India. India, with population exceeding 134 crores, is one of the largest producers of solid waste. There is rapid growth in the population and the increase in population comes with increase in waste generation. India generates around 62 million tons of solid waste annually, out of which only 20-30% is collected. The waste are disposed in open spaces, road sides and within residential buildings. Sorting plastic waste and using it in construction will reduce waste accumulation to a great extent. There are construction stages that does not require normal concrete or heavy load and alternatively lightweight can be used on the building or structure. The contineous rise in solid plastics waste and cost of building materials over the years in India and the world at large, forced researchers to look for ways of addressing the problem. Plastics waste which is one of the non-bio-gradable materials as stated earlier causes a lot of environmental pollution, and there is the need to find solution to such menace.

It was reported that recycling of waste materials can be economical and as a consequence reduces pollution and contamination. The problem with cement concrete are in terms of low tensile strength, permeability to liquids, corrosion of reinforcement, prone to biological or chemical attack, poor freeze/thaw resistances. Research and Development has a new dimension in the use of affordable local building materials in addressing the concrete drawbacks, such as the use of waste plastics and other admixtures forimproving the performance of concretes. Research has been carried out in advanced countries, on the use of waste plastic materials in concrete, but only few were reported in India. The study also evaluates differences in compressive strength and density based on variable addition of granulated waste plastic in the cement based composite respectively.

CHAPTER 2
LITERATURE REVIEW

Youcef Ghernouti et al. 1 The study present the partial replacement of fine aggregate in concrete by using plastic fine aggregate obtained from the crushing of waste plastic bags. Plastic bags waste was heated followed by cooling of liquid waste which was then cooled and crushed to obtained plastic sand having finesse modulus of 4.7. Fine aggregate in the mix proportion of concrete was replaced with plastic bag waste sand at 10%, 20%, 30% and 40% whereas other concrete materials remain same for all four mixes. In fresh properties of concrete it was observed from the results of slump test that with increase of waste content workability of 3 PK Mehta "Concrete Microstructure, properties and Materials" third edition, chapter1.

Raghatate Atul M.2 The paper is based on experimental results of concrete sample casted with use of plastic bags pieces to study the compressive and split tensile strength. He used concrete mix by using Ordinary Portland Cement, Natural River sand as fine aggregate and crushed granite stones as coarse aggregate, portable water free from impurities and containing varying percentage of waste plastic bags (0%, 0.2%, 0.4%, 0.6% 0.8% and 1.0%). Compressive strength of concrete specimen is affected by the addition of plastic bags and with increasing percentage of plastic bag pieces compressive strength goes on decreasing (20% decrease in compressive strength with 1% of addition of plastic bag pieces). On other hand increase in tensile strength of concrete was observed by adding up to 0.8% of plastic bag pieces in the concrete mix afterward it start decreasing when adding more than 0.8% of plastic bags pieces. He concluded that utility of plastic bags pieces can be used for possible increase in split tensile strength. This is just a basic study on use of plastic bags in concrete. More emphasis was required by varying the shape and sizes of plastic bags to be use in concrete mixes.

Praveen Mathew et al. [2013]3 They have investigated the suitability of recycled plastic as partial replacement to coarse aggregate in concrete mix to study effect on compressive strength, modulus of elasticity, split tensile strength and flexural strength properties of concrete. Coarse aggregate from plastic was obtained by heating the plastic pieces at required temperature and crushed to required size of aggregate after cooling. Their experimental results shown that plastic aggregate have low crushing (2.0 as compare to 28 for Natural aggregate), low specific gravity(0.9 as compare to 2.74 for Natural aggregate), and density value(0.81 as compare to

3.14 for Natural aggregate), as compare to Natural coarse aggregate. Their test results were based on 20% substitution of natural coarse aggregate with plastic aggregate. Increase in workability was reported when slump test for sample was carried out. Volumetric substitution of natural aggregate with plastic aggregate was selected best in comparison with grade substitution. At 400 centigrade temperature Plastic coarse aggregate shown considerable decrease in strength as compare to normal concrete. An increase of 28% was observed in compressive strength but decrease in split tensile strength and modulus of elasticity was observed. They recommended that with use of suitable admixture @0.4% by weight of cement will improve the bonding between matrix and plastic aggregate; however they demand more research to address the tensile behavior of concrete prepared with 20% plastic aggregate.

R L Ramesh et al. 4 They have used waste plastic of low density poly ethylene as replacement to coarse aggregate to determine its viable application in construction industry and to study the behavior of fresh and harden concrete properties. Different concrete mix were prepared with varying proportions (0%, 20%, 30% & 40%) of recycle plastic aggregate obtained by heat treatment of plastic waste (160-200 centigrade) in plastic granular recycling machine. A concrete mix design with 1: 1.5: 3 proportions was used having 0.5 water/cement ratio having varying proportion of plastic aggregate as replacement of crushed stone. Proper mixing was ensured and homogeneous mixture was prepared. A clear reduction in compressive strength was reported with increase in percentage of replacing plastic aggregate with crushed aggregate at 7, 14 and 28 days of casted cubes (80% strength achieved by replacing waste plastic up to 30%). The research highlights the potential application of plastic aggregate in light weight aggregate. Their research was narrowed down to compressive strength of concrete with no emphasis given to flexural properties of concrete. They suggest future research scope on plastic aggregate with regard to its split tensile strength to ascertain its tensile behavior and its durability aspects for beams and columns.

Zainab Z. Ismail et al. [2007]5 they have conducted comprehensive study based on large number of experiments and tests in order to determine the feasibility of reusing plastic sand as partial replacement of fine aggregate in concrete. They conducted tests on concrete samples for dry/fresh density, slump, compressive and flexural strength and finally toughness indices on room temperature They have collected waste plastic from plastic manufacture plant consist of 80% polyethylene and 20% polystyrene which was crushed (varying length of 0.15-12mm and width of 0.15-4mm). Concrete mix were produce with ordinary Portland cement, fine aggregate (natural sand of 4.74mm maximum size), coarse aggregate (max size below 20mm) and addition of 10%, 15% and 20% of plastic waste as sand replacement. Their test results indicate sharp decrease in slump with increasing the percentage of plastic, this decrease was attributed to the presence of angular and non uniform plastic particles. In spite of low slump however, the mixture was observed with good workability and declared suitable for application. Their tests also revealed the decrease in fresh and dry density with increasing the plastic waste ratio; however increase was reported in dry density with time at all curing ages. Decrease in compressive and flexural strength was observed by increasing the waste plastic ratio which can be related to decrease in adhesive strength between plastic waste particles with cement. However, load-deflection curve of concrete containing plastic waste showed the arrest of propagation of micro cracks which shows its application in places where high toughness is required. The study has shown good workability in spite of low slump but w/c content kept constant in all samples. They should have reduced the water content in order to improve the strength when workability was not an issue.

P. Suganthy et al.[2013]6 This study investigate the application of pulverized fine crushed plastic (produce from melting and crushing of high density polyethylene) as replacement of fine aggregate in concrete with varying known percentages. Their main focus was on optimum replacement of natural sand by pulverized plastic sand. Five concrete mixes were produced from specified concrete materials having replacement of fine aggregate (sand) by 0, 25, 50, 75 and 100% respectively to study the test graph results of various concrete properties. The results showed increase in water/cement ratio with increase replacement of sand with plastic particles to achieve desired 90mm concrete slump. They have also observed from the results that gradual decrease in strength of concrete specimen for plastic replacement up to 25% but afterward the decrease in strength israpid which shows suitable replacement up to 25% of sand with plastic pulverized sand. They have also concluded after testing of specimen (having different proportion of plastic replacement) for Ultimate and yield strength that both strength decreases with increase replacement of sand with pulverized plastic particles. Their study lacks detailed testing of properties of concrete because only compressive strength and w/c ratio tests will not be sufficient to study the matrix as a whole to be suitable for construction. No efforts were made to explore the use of admixtures in controlling of compressive strength reduction in a mix containing pulverized plastics.

Khilesh Sarwe.[2014]7 This study presents the results of addition of waste plastics along with steel fibres with an objective to seek maximum use of waste plastic in concrete. Two different categories of mix were casted in cubes (150mm x 150mm x 150mm), one with varying percentages of plastic wastes (0.2%, 0.4%, 0.6%, 0.8% and 1% weight of cement) and another mix of plastics waste/steel fibers (0.2/0.1, 0.4/0.2, 0.6/0.3, 0.8/0.4 and 1/0.5 % by weight of cement) to study the compressive strength at 7 and 28 days strength. The combine mix of plastic waste and steel fibers has shown more strength as compare to concrete mix prep only with plastic waste. He has reached to conclusion that a plastic waste of 0.6% weight of cement when used with steel fiber of 0.3 % (weight of cement) has shown the maximum compressive strength. This study has really focused on addressing the issue of reduced compressive strength with addition of plastic waste. Steel fibers when used along with plastic wastes will affect all the properties of concrete but the researcher only focused on compressive strength property which is insufficient to give clear picture of concrete behavior.

A Bhogayata et al. [2012]8 they have studied the environment friendly disposal of shredded plastic bags in concrete mix to be use in construction industry which have dire need for alternative material to be use in lieu of conventional materials. Different test results were analyzed after testing on 48 x concrete cubes(150mm x 150mm x150mm) prepared from varying percentage of polyethylene fibers (0.3, 0.6, and 0.9 to 1.2% of volume of concrete) with conventional concrete material to prepare mixes. Two type of plastic bag fibers were used, one cut manually (60mm x 3mm) and another shredded into a very fine random palettes. Cubes were tested for 7&28 days compressive strength and compaction. They concluded that good workability was shown by the mix added with shredded fibers due to its uniform and higher aspect ratio evenly sprayed in the mix. Addition of plastics up to 0.6% is considered suitable after which reduction in compressive strength and compaction is seen affected. They observed that strength loss was less in concrete having shredded fibers of plastic as compare to hand cut macro fibers. Their research focus was only on comparative study of compressive strength but no work was carries out on other concrete properties like tensile strength, modulus of elasticity and density of concrete.

M. Elzafraney et al. [2005]9 this study has incorporated use of recycled plastic aggregate in concrete material for a building to work out its performance with regards to thermal attributes and efficient energy performance in comparison with normal aggregate concrete. The plastic content concrete was prepared from refined high recycled plastics to meet various requirement of building construction like strength, workability and finish ability etc. Both buildings were subject to long and short term monitoring in order to determine their energy efficiencies and level of comfort. It was observed that recycled plastic concrete building having good insulation used 8% less energy in comparison of normal concrete; however saving in energy was more profound in cold climate in building with lower insulation. They recommended that efficiency of energy can further be increase if recycle plastic of high thermal capacity is used. They have suggested the use of recycle plastic aggregate concrete being economical and light weights are having high resistance to heat. The author should also incorporate the comparison of both buildings with regards to durability and strength.

Pramod S. Patil.et al. [2007]10 This study presents the use of plastic recycled aggregate as replacement of coarse aggregate for production of concrete. They used forty eight specimen and six beams/cylinders casted from variable plastic percentages (0, 10, 20, 30, 40 and 50%) used as replacement of coarse aggregate in concrete mixes. They have conducted various tests and observed decrease in density of concrete with increase percentage of replacement of aggregate with recycle plastic concrete. They also reported decrease in compressive strength for 7 and 28 days with increase in percentage of replacement of coarse aggregate with recycle plastic aggregate. They have recommended feasibility of replacing 20 % will satisfy the permissible limits of strength. Again these researchers limited their research to only compressive strength property and no work was carried out to study the other important properties of concrete. Their research also lacks use of various admixtures in concrete to cater for the loss in strength.

A. Kamaruddin et al.(2000) : "Potential use of Plastic Waste as Construction Materials: Recent Progress and Future Prospect" Plastic associates products based have been considered as the world most consumer packaging solution. However, substantial quantities of plastic consumption have led to exponential increase of plastic derived waste. Recycling of plastic waste as valued added product such as concrete appears as one of promising solution for alternative use of plastic waste. This paper summarized recent progress on the development of concrete mixture which incorporates plastic wastes as partial aggregate replacement during concrete manufacturing. A collection of data from previous studies that have been researched which employed plastic waste in concrete mixtures were evaluated and conclusions are drawn based on the laboratory results of all the mentioned research papers studied.

K.S.Rebeiz andA.P.Craft(2000): "Plasticwastemanagementin construction: technological and institutionalissues" The main objective of a solid waste management system is to effectively safeguard the public health, safety, and welfare. The various options involved in a waste management process are landfilling, incineration, and recycling wastes into useful products. Plastics recycling, in particular, would not be successful unless the proper infrastructure to collect the waste is being set, the technology to economically reprocess the waste into new products is available, and the establishment of markets for the cost-effective use of recycled products are developed. The development of new construction materials using recycled plastics is important to both the construction and the plastics recycling industries. Extensive research investigated the use of resins based on recycled poly (ethylene terephthalate) (PET) plastic waste for the production of a high performance composite material, namely polyester concrete (PC). Resins using recycled PET offer the possibility of a lower source cost of materials for forming good quality PC. PC products also allow the long-term disposal of PET waste, an important advantage in recycling applications. 16 |P a g e Evaluation of use of Plastic Waste in Construction.

OriyomiM.Okeyinka etal.(2001): "AReviewonRecycledUseofSolid Wastes in Building Materials" Large quantities of solid wastes being generated worldwide from sources such as household, domestic, industrial, commercial and construction demolition activities, leads to environmental concerns. Utilization of these wastes in making building construction materials can reduce the magnitude of the associated problems. When these waste products are used in place of other conventional materials, natural resources and energy are preserved and expensive and/or potentially harmful waste disposal is avoided. Recycling which is regarded as the third most preferred waste disposal option, with its numerous environmental benefits, stand as a viable option to offset the environmental impact associated with the construction industry.This paper reviews the results of laboratory tests and important research findings, and the potential of using these wastes in building construction materials with focus on sustainable development. Research gaps, which includes; the need to develop standard mix design for solid waste based building materials; the need to develop energy efficient method of processing solid waste use in concrete; the need to study the actual behavior or performance of such building materials in practical application and the limited real life application of such building materials have also been identified. A research is being proposed to develop an environmentally friendly, lightweight building block from recycled waste paper, without the use of cement, and with properties suitable for use as walling unit. This proposed research intends to incorporate, laboratory experimentation and modeling to address the identified research gaps.

Ahmed Trimbakwala (2003): "PlasticRoads UseofWaste Plastic inRoad Construction" India has a road network of over 5,472,144 kilo-metres (3,400,233 mi) as on 31 March 2015, the second largest road network in the world. The plastic wastes can be used in road construction and the field tests withstood the stress and proved that plastic wastes used after proper processing as an additive would enhance the life of the roads and also solve environmental problems. Plastic use in road construction is not new. It is already in use as PVC or HDPE pipe mat crossings built by cabling together PVC (polyvinyl chloride) or HDPE (high-density poly-ethylene) pipes to form plastic mats. Waste plastic is ground and made into powder; 3 to 4 % plastic is mixed with the bitumen. The durability of the roads laid out with shredded plastic waste is much more compared with roads with asphalt with the ordinary mix. The use of the innovative technology not only strengthened the road construction but also increased the road life as well as will help to improve the environment and also creating a source of income. 17 |P a g e Evaluation of use of Plastic Waste inConstruction

Azmat Shaikh, Nabeel Khan, Faisal Shah, Devendra Shukla, Gaurav Kale (2003): "Use of Plastic Waste in Road Construction" Plastic waste is one such resource, a major component of solid waste which is abundantly available and disposed of without proper treatment. There has been an exponential growth in municipal plastic waste disposal especially in urban areas which deteriorates the beauty of the landscape. Plastic was found to be an effective binder for bitumen mixes used in flexible pavements. This efficient method helps the pavements to resist higher temperature by minimizing the formation of cracks and reducing rainwater infiltration which otherwise leads to the development of potholes. These pavements have shown improved crushing and abrasion values and reduced water seepage.Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes. Bituminous Concrete (BC) is a composite material mostly used in construction projects like road surfacing, airports, parking lots etc. It consists of asphalt or bitumen (used as a binder) and mineral aggregate which is mixed together & laid down in layers then compacted. Now a day, the steady increment in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature put us in a demanding situation to think of some alternatives for the improvisation of the pavement characteristics and quality by applying some necessary modifications which shall satisfy both the strength as well as economic aspects. Also considering the environmental approach, due to excessive use of polythenes in the day to day business, the pollution to the environment is enormous. Since the polythenes are not biodegradable, the need of the current hour is to use the waste polyethene in some beneficial purposes.

Mohammed Jalaluddin (2003): "Use of Plastic Waste in Civil Constructions and Innovative Decorative Material (Eco- Friendly)" The project elucidates about the use of plastic in civil construction. The components used include everything from plastic screws and hangers to bigger plastic parts that are used in decoration, electric wiring, flooring, wall covering and waterproofing. Plastic use in road construction that have shown same hope in terms of using plastic waste in road construction. i.e. plastic roads. Plastic roads mainly use plastic carry bags, disposable cups and PET bottles that are collected from garbage dumps as important ingredients of the construction materials. By using plastic waste as modifier, we can reduce the quantity of cement and sand by their weight, hence decreasing the overall cost of construction. At 5% optimum modifier content, strength of modified concrete we found to see the times greater than the plain cement concrete. Using plastic poisons our food chain under the plastic affects human health. By the disposable plastics is the main source of plastic. For these plastic pollution is not only the ocean also in desert. Plastic will increase the melting point of the bitumen. Rain water will not seep through because of the plastic in the tar. So, this technology will result in lesser road repairs. 18 |P a g e Evaluation of use of Plastic Waste inConstruction

Mojtaba et al. (2006) : "Using plastic instead of bricks in Buildings" Concluded that reusing the plastic bottles as the building materials can have substantial effects on saving the building embodied energy by using them instead of bricks in walls and reducing the CO2 emission in manufacturing the cement by reducing the percentage of cement used. It is counted as one of the foundation's green project and has caught the attention of the architecture and construction industry. Generally the bottle houses are bioclimatic in design, which means that when it is cold outside is warm inside and when it is warm it is cold inside. Constructing a house by plastic bottles used for the walls, joist ceiling and concrete column offers us 45% diminution in the final cost. Separation of various components of cost shows that the use of local manpower in making bottle panels can lead to cost reduction up to 75% compared to building the walls using the brick and concrete block.

Shilpi et al. (2006) : "Plastic PET bottles use in bottle brick technique" Concluded that by utilizing PET bottles in construction recycled materials, thermal comfort can be achieved in very low cost housing, benefit in residents for those who cannot afford to buy and operate heating and cooling systems. Plastic is non biodegradable, toxic, highly resistant to heat and electricity (best insulator) and not recyclable in true sense, plastic PET bottles use in bottle brick technique. This gives relief for the poor people of India to provide cheap and best houses for living .

Puttaraj et al. (2006) : "Use of waste plastic in plastic-soil brick" This research paper examined that efficient usage of waste plastic in plastic-soil bricks has resulted in effective usage of plastic waste and thereby can solve the problem of safe disposal of plastics, also avoids its widespread littering and the utilization of quarry waste has reduced to some extent the problem of its disposal. Plastics are produced from the oil that is considered as non-renewable resource. Because plastic has the insolubility about 300 years in the nature, it is considered as a sustainable waste and environmental pollutant. So reusing or recycling of it can be effectual in mitigation of environmental impacts relating to it. It has been proven that the use of plastic bottles as innovative materials for building can be a proper solution for replacement of conventional materials .

Pratima et al. (2008): "Solution to plastic pollution problems in landfills" Plastic bottles wall have been less costly as compare to bricks and also they provide greater strength than bricks. The PET bottles that are not recycled end up in landfills or as litter, and they take approximately 1000 years to biodegrade. This has resulted in plastic pollution problems in landfills, water ways and on the roadside, and this problem continues to grow along with the plastic bottle industry.

CHAPTER- 3
MATERIALS AND METHODOLOGY

3.1 Plastic:

3.1.1 Introduction and Properties :

Plastic is a material consisting of any of a wide range of synthetic or semi-synthetic organics that are malleable and can be moulded into solid objects of diverse shapes. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural. Plasticity is the general property of all materials that are able to irreversibly deform without breaking, but this occurs to such a degree with this class of mouldable polymers that their name is an emphasis on this ability. Due to their relatively low cost, ease of manufacture, versatility, and imperviousness to water, plastics are used in an enormous and expanding range of products, from paper clips to spaceships. They have already displaced many traditional materials, such as wood, stone, horn and bone, leather, paper, metal, glass, and ceramic, in most of their former uses. In developed countries, about a third of plastic is used in packaging and another third in buildings such as piping used in plumbing or vinyl siding. Other uses include automobiles (up to 20% plastic), furniture, and toys. In the developing world, the ratios may be different - for example, reportedly 42% of India's consumption is used in packaging. Plastics have many uses in the medical field as well, to include polymer implants, however the field of plastic surgery is not named for use of plastic material, but rather the more generic meaning of the word plasticity in regards to the reshaping of flesh.

Figure 3.1.1 : plastic waste

3.1.2 Categories of Plastic:

- Polyester (PES) – Fibres, textiles.
- Polyethylene terephthalate (PET) – Carbonated drinks bottles, peanut butter jars,plastic film, microwavable packaging.
- Polyethylene (PE) – Wide range of inexpensive uses including supermarket bags,plastic bottles.
- High-density polyethylene (HDPE) – Detergent bottles, milk jugs, and moulded plastic cases.
- Polyvinyl chloride (PVC) – Plumbing pipes and guttering, shower curtains, window frames, flooring.
- Polyvinylidene chloride (PVDC) (Saran) – Food packaging.
- Low-density polyethylene (LDPE) – Outdoor furniture, siding, floor tiles, shower curtains, clamshell packaging.
- Polypropylene (PP) – Bottle caps, drinking straws, yogurt containers, appliances, car fenders (bumpers), plastic pressure pipe systems.
- Polystyrene (PS) – Packaging foam/"peanuts", food containers, plastic tableware, disposable cups, plates, cutlery, CD and cassette boxes.

- High impact polystyrene (HIPS) -: Refrigerator liners, food packaging, and vending cups. Polyamides (PA) (Nylons) – Fibres, toothbrush bristles, tubing, fishing line,
- low strength machine parts: under-the-hood car engine parts or gun frames. Acrylonitrile butadiene styrene (ABS) – Electronic equipment cases (e.g., computer monitors, printers, keyboards), drainage pipe
- Polyethylene/Acrylonitrile Butadiene Styrene (PE/ABS) – A slippery blend of PE and ABS used in low-duty dry bearings.
- Polycarbonate (PC) – Compact discs, eyeglasses, riot shields, security windows,traffic lights, lenses.
- Polycarbonate/Acrylonitrile Butadiene Styrene (PC/ABS) – A blend of PC and ABSthat creates a stronger plastic.Used in car interior and exterior parts, and mobile phone bodies.
- Polyurethanes (PU) – Cushioning foams, thermal insulation foams, surface coatings, printing rollers (Currently 6th or 7th most commonly used plastic material, forinstance the most commonly used plastic in cars).

3.1.3 Health hazard:

Pure plastics have low toxicity due to their insolubility in water and because they are biochemically inert, due to a large molecular weight. Plastic products contain a variety of additives, some of which can be toxic. For example, plasticizers like adipates and phthalates are often added to brittle plastics like polyvinyl chloride to make them pliable enough for use in food packaging, toys, and many other items. Traces of these compounds can leach out of the product. Owing to concerns over the effects of such leachates, the European Union has restricted the use of DEHP (di-2-ethylhexyl phthalate) and other phthalates in some applications, and the United States has limited the use of DEHP, DPB, BBP, DINP, DIDP, and DnOP in children's toys and child care articles with the Consumer Product Safety Improvement Act. Some compounds leaching from polystyrene food containers have been proposed to interfere with hormone functions and are suspected human carcinogens. Other chemicals of potential concern include alkylphenols.

Whereas the finished plastic may be non-toxic, the monomers used in the manufacture ofthe parent polymers may be toxic. In some cases, small amounts of those chemicals canremain trapped in the product unless suitable processing is employed. For example, theWorld Health Organization's International Agency for Research on Cancer (IARC) has recognized vinylchloride, the precursor to PVC, as a human carcinogen. Some polymers may also decompose into the monomers or other toxic substances when heated. In 2011, it was reported that "almost all plastic products" sampled released chemicals with estrogenic activity, although the researchers identified plastics which did not leach chemicals with estrogenic activity.

Most plastics are durable and degrade very slowly; the very chemical bonds that make them so durable tend to make them resistant to most natural processes of degradation. However, microbial species and communities capable of degrading plastics are discovered from time to time, and some show promise as being useful for bio remediating certain classes of plastic waste. Since the 1950s, one billion tons of plastic have been discarded and some of that material might persist for centuries or much longer, as is demonstrated by the persistence of natural materials such as amber.

Serious environmental threats from plastic have been suggested in the light of the increasing presence of micro plastics in the marine food chain along with many highly toxic chemical pollutants that accumulate in plastics. They also accumulate in larger fragmented pieces of plastic called nurdles. In the 1960s the latter were observed in the guts of sea birds and since then have been found in increasing concentration. In 2009, it was estimated that 10% of modern waste was plastics, although estimates vary according to region. Meanwhile, 50-80% of debris in marine areas is plastic. Before the ban on the use of CFCs in extrusion of polystyrene (and in general use, except in life-critical fire suppression systems; see Montreal Protocol), the production of polystyrene contributed to the depletion of the ozone layer, but current extrusion processes use non-CFCs.

3.1.4 Climate change:

The effect of plastics on global warming is mixed. Plastics are generally made from petroleum. If the plastic is incinerated, it increases carbon emissions; if it is placed in a landfill, it becomes a carbon sink although biodegradable plastics have caused methane emissions. Due to the lightness of plastic versus glass or metal, plastic may reduce energy consumption. For example, packaging beverages in PET plastic rather than glass or metal is estimated to save 52% in transportation energy.

3.1.5 Recycling :

Thermoplastics can be re-melted and reused, and thermoset plastics can be ground up and used as filler, although the purity of the material tends to degrade with each reuse cycle. There are methods by which plastics can be broken back down to a feedstock state. The greatest challenge to the recycling of plastics is the difficulty of automating the sorting of plastic wastes, making it labour-intensive. Typically, workers sort the plastic by looking at the resin identification code, although common containers like soda bottles can be sorted from memory. Typically, the caps for PETE bottles are made from a different kind of plastic which is not recyclable, which presents additional problems to the automated sorting process. Other recyclable materials such as metals are easier to process mechanically. However, new processes of mechanical sorting are being developed to increase capacity and efficiency of plastic recycling. While containers are usually made from a single type and colour of plastic, making them relatively easy to be sorted, a consumer product like a cellular phone may have many small parts consisting of over a dozen different types and colours of plastics. In such cases, the resources it would take to separate the plastics far exceed their value and the item is discarded. However, developments are taking place in the field of active disassembly, which may result in more consumer product components being re-used or recycled. Recycling certain types of plastics can be unprofitable, as well. For example, polystyrene is rarely recycled because it is usually not cost effective. These unrecycled wastes are typically disposed of in landfills, incinerated or used to produce electricity at waste-to energy plants.

3.2 Aggregates: Fine Aggregates:

3.2.1 Introduction Fine aggregate :

(Sand) is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e. a soil containing more than 85% sand-sized particles (by mass). The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or $SiO2$), usually in the form of quartz. The second most common type of sand is calcium carbonate, for example aragonite, which has mostly been created, over the past half billion years, by various forms of life, like coral and shellfish. It is, for example, the primary form of sand apparent in areas where reefs have dominated the ecosystem for millions of years like the Caribbean .

Figure 3.2.1: Fine Aggregate

3.2..2 Composition:

In terms of particle size as used by geologists, sand particles range in diameter from 0.0625 mm (or 1»16 mm) to 2 mm. An individual particle in this range size is termed a sand grain. Sand grains are between gravel (with particles ranging from 2 mm up to 64 mm) and silt (particles smaller than 0.0625 mm down to 0.004 mm). The size specification between sand and gravel has remained constant for more than a century, but particle diameters as small as 0.02 mm were considered sand under the Albert Atterberg standard in use during the early 20th century. A 1953 engineering standard published by the American Association of State Highway and Transportation Officials set the minimum sand size at 0.074 mm. A 1938 specification of the United States Department of Agriculture was 0.05 mm. Sand feels gritty when rubbed between the fingers (silt, by comparison, feels like flour).

ISO 14688 grades sands as fine, medium and coarse with ranges 0.063 mm to 0.2 mm to 0.63 mm to 2.0 mm. In the United States, sand is commonly divided into five sub-categories based on size: very fine sand (1»16 – 1»8 mm diameter), fine sand (1»8 mm – 1»4 mm), medium sand

(1»4 mm – 1»2 mm), coarse sand (1»2 mm – 1 mm), and very coarse sand (1 mm – 2 mm). These sizes are based on the Krumbein phi scale, where size in Φ = -log2D; D being the particle size in mm. On this scale, for sand the value of Φ varies from −1 to +4, with the divisions between subcategories at whole numbers. The most common constituent of sand, in inland continental settings and non-tropical coastal settings, is silica (silicon dioxide, or SiO2), usually in the form of quartz, which, because of its chemical inertness and considerable hardness, is the most common mineral resistant to weathering. The composition of mineral sand is highly variable, depending on the local rock sources and conditions. The bright white sands found in tropical and subtropical coastal settings are eroded limestone and may contain coral and shell fragments in addition to other organic or organically derived fragmental material, suggesting sand formation depends on living organisms, too. The gypsum sand dunes of the White Sands National Monument in New Mexico are famous for their bright, white colour. Arkose is a sand or sandstone with considerable feldspar content, derived from weathering and erosion of a (usually nearby) granitic rock outcrop. Some sands contain magnetite, chlorite, glauconite or gypsum. Sands rich in magnetite are dark to black in colour, as are sands derived from volcanic basalts and obsidian. Chlorite-glauconite bearing sands are typically green in colour, as are sands derived from basaltic (lava) with a high olivine content. Many sands, especially those found extensively in Southern Europe, have iron impurities within the quartz crystals of the sand, giving a deep yellow colour. Sand deposits in some areas contain garnets and other resistant minerals, including some small gemstones.

3.2..3 Study :

The study of individual grains can reveal much historical information as to the origin and kind of transport of the grain. Quartz sand that is recently weathered from granite or gneiss quartz crystals will be angular. It is called Grus in geology or sharp sand in the building trade where it is preferred for concrete, and in gardening where it is used as a soil amendment to loosen clay soils. Sand that is transported long distances by water or wind will be rounded, with characteristic abrasion patterns on the grain surface. Desert sand is typically rounded.

3.2.4 Uses Agriculture:

- Sandy soils are ideal for crops such as watermelons, peaches and peanuts, and their excellent drainage characteristics make them suitable for intensive dairy farming.
- Aquaria: Sand makes a low cost aquarium base material which some believe is better than gravel for home use. It is also a necessity for saltwater reef tanks, which emulate environments composed largely of aragonite sand broken down from coral and shellfish.

- Artificial reefs: Geotextile bagged sand can serve as the foundation for new reefs.
- Artificial islands in the Persian Gulf for instance.
- Beach nourishment: Governments move sand to beaches where tides, storms or deliberate changes to the shoreline erode the original sand.
- Brick: Manufacturing plants add sand to a mixture of clay and other materials for manufacturing bricks.
- Cob: Coarse sand makes up as much as 75% of cob.
- Mortar: Sand is mixed with masonry cement or Portland cement and lime to be used in masonry construction.
- Concrete: Sand is often a principal component of this critical construction material.
- Hydraulic Fracturing: A drilling technique for natural gas, which uses rounded silica sand as a "proppant", a material to hold open cracks that are caused by the hydraulic fracturing process.
- Glass: Sand is the principal component in common glass. Landscaping: Sand makes small hills and slopes (for example, in golf courses).
- Paint: Mixing sand with paint produces a textured finish for walls and ceilings or nonslip floor surfaces.
- Railroads: Engine drivers and rail transit operators use sand to improve the traction of wheels on the rails.
- Recreation. Playing with sand is a favourite beach time activity. One of the most beloved uses of sand is to make sometimes intricate, sometimes simple structures known as sand castles. Such structures are well known for their impermanence. Sand is also used in children's play.
- Special play areas enclosing a significant area of sand, known as sandboxes, are common on many public playgrounds, and even at some single family homes
- Roads: Sand improves traction (and thus traffic safety) in icy or snowy conditions. Sand animation: Performance artists draw images in sand. Makers of animated films use the same term to describe their use of sand on frontlit or backlit glass.
- Sand casting: Casters moisten or oil molding sand, also known as foundry sand and then shape it into moulds into which they pour molten material. This type of sand must be able to withstand high temperatures and pressure, allow gases to escape, have a uniform, small grain size and be non-reactive with metals.
- Sand castles: Shaping sand into castles or other miniature buildings is a popular beach activity.

- Sandbags: These protect against floods and gunfire. The inexpensive bags are easy to transport when empty, and unskilled volunteers can quickly fill them with local sand in emergencies.

3.3 Aggregates: Coarse Aggregates:

3.3.1 Introduction:

Construction aggregate (coarse aggregate), or simply “aggregate”, is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. Aggregates are the most mined materials in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material. Due to the relatively high hydraulic conductivity value as compared to most soils, aggregates are widely used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and road side edge drains.

Aggregates are also used as base material under foundations, roads, and railroads. In other words, aggregates are used as a stable foundation or road/rail base with predictable, uniform properties (e.g. to help prevent differential settling under the road or building), or as a lowcost extender that binds with more expensive cement or asphalt to form concrete. Preferred bituminous aggregate sizes for road construction are given in EN 13043 as d/D (where the range shows the smallest and largest square mesh grating that the particles can pass). The same classification sizing is used for larger armour stone sizes in EN 13383, EN 12620 for concrete aggregate, EN 13242 for base layers of road construction and EN 13450 for railway ballast.

The American Society for Testing and Materials publishes an exhaustive listing of specifications including ASTM D 692 and ASTM D 1073 for various construction aggregate products, which,by their individual design, are suitable for specific construction purposes. These products include specific types of coarse and fine aggregate designed for such uses as additives to asphalt and concrete mixes, as well as other construction uses. State transportation departments further refine aggregate material specifications in order to tailor aggregate use to the needs and available supply in their particular locations. Sources for these basic materials can be grouped into three main areas: Mining of mineral aggregate deposits, including sand, gravel, and stone; use of waste slag from the manufacture of iron and steel; and recycling of concrete, which is itself chiefly manufactured from mineral aggregates. In addition, there are some (minor) materials that are used as specialty lightweight aggregates: clay, pumice, perlite, and vermiculite.

Figure 3.3.1: Coarse Aggregate

3.3.2 History:

People have used sand and stone for foundations for thousands of years. Significant refinement of the production and use of aggregate occurred during the Roman Empire, which used aggregate to build its vast network of roads and aqueducts. The invention of concrete, which was essential to architecture utilizing arches, created an immediate, permanent demand for construction aggregates.

3.3.3 Modern production:

The advent of modern blasting methods enabled the development of quarries, which are now used throughout the world, wherever competent bedrock deposits of aggregate quality exist. In many places, good limestone, granite, marble or other quality stone bedrock deposits do not exist. In these areas, natural sand and gravel are mined for use as aggregate. Where neither stone, nor sand and gravel, are available, construction demand is usually satisfied by shipping in aggregate by rail, barge or truck. Additionally, demand for aggregates can be partially satisfied through the use of slag and recycled concrete. However, the available tonnages and lesser quality of these materials prevent them from being a viable replacement for mined aggregates on a large scale. Large stone quarry and sand and gravel operations exist near virtually all population centers. These are capital intensive operations, utilizing large earth-moving equipment, belt conveyors, and machines specifically designed for crushing and separating various sizes of aggregate, to create distinct product stockpiles.

3.3.4 Recycled materials for aggregates:

The largest-volume of recycled material used as construction aggregate is blast furnace and steel furnace slag. Blast furnace slag is either air-cooled (slow cooling in the open) or granulated (formed by quenching molten slag in water to form sand-sized glass-like particles). If the granulated blast furnace slag accesses free lime during hydration, it develops strong hydraulic cementitious properties and can partly substitute for Portland cement in concrete. Steel furnace slag is also air-cooled. In 2006, according to the USGS, air-cooled blast furnace slag sold or used in the U.S. was 4.3 million tonnes valued at $49 million, granulated blast furnace slag sold or used in the U.S. was 3.2.2 million tonnes valued at $318 million, and steel furnace slag sold or used in the U.S. was 4.4.7 million tonnes valued at $40 million. Air-cooled blast furnace slag sales in 2006 were for use in road bases and surfaces (41%), asphaltic concrete (13%), readymixed concrete (16%), and the balance for other uses. Granulated blast furnace slag sales in 2006 were for use in cementitious materials (94%), and the balance for other uses. Steel furnace slag sales in 2006 were for use in road bases and surfaces (51%), asphaltic concrete (12%), for fill (18%), and the balance for other uses.

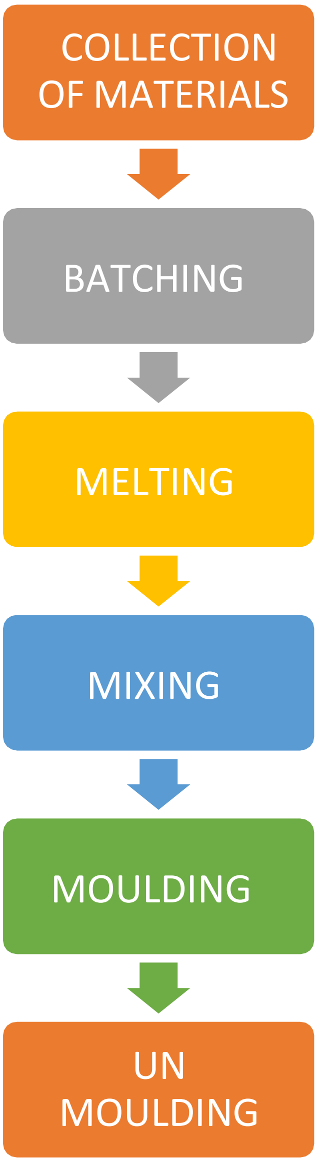
Glass aggregate, a mix of colours crushed to a small size, is substituted for many construction and utility projects in place of pea gravel or crushed rock, often saving municipalities like the City of Tumwater, Washington Public Works, thousands of dollars (depending on the size of the project). Glass aggregate is not sharp to handle. In many cases, the state Department of Transportation has specifications for use, size and percentage of quantity for use. Common applications are as pipe bedding—placed around sewer, storm water or drinking water pipes to transfer weight from the surface and protect the pipe. Another common use would be as fill to bring the level of a concrete floor even with a foundation. Use of glass aggregate helps close the loop in glass recycling in many places where glass cannot be smelted into new glass. Aggregates themselves can be recycled as aggregates. Unlike deposits of sand and gravel or stone suitable for crushing into aggregate, which can be anywhere and may require overburden removal and/or blasting, “deposits” of recyclable aggregate tend to be concentrated near urban areas, and production from them cannot be raised or lowered to meet demand for aggregates.

Supply of recycled aggregate depends on physical decay of structures and their demolition. The recycling plant can be fixed or mobile; the smaller capacity mobile plant works best for asphalt-aggregate recycling. The material being recycled is usually highly variable in quality and properties. Many aggregate products of various types are often recycled for other industrial purposes. In Bay City, Michigan, for example, a recycle program exists for contractors and their own unused products. These piles are composed of unused mixed concrete, block, brick, gravel, pea stone, and other used materials. Composed of several alternating piles that grow to hundreds of feet in height and diameter. These piles are then crushed to provide gravel for roads and driveways, among other purposes. This program has huge economic and environmental benefits to the local and surrounding area. Contractors save on disposal costs and less aggregate is buried or piled and abandoned. According to the USGS in 2006, 2.9 million tonnes of Portland cement concrete (including aggregate) worth $21.9 million was recycled, and 1.6 million tonnes of asphalt concrete (including aggregate) worth $11.8 million was recycled, both by crushed stone operations. Much more of both materials are recycled by construction and demolition firms not in the USGS survey. For sand and gravel, the USGS survey for 2006 showed that 3.2.7 million tonnes of cement concrete valued at $32.0 million was recycled, and 3.4.17 million tonnes of asphalt concrete valued at $43.3.1 million was recycled.

Again, more of both materials are recycled by construction and demolition firms not in this USGS survey. The Construction Materials Recycling Association indicates that there are 325 million tonnes of recoverable construction and demolition materials produced annually. Many geosynthetic aggregates are also made from recycled materials. Being polymer based, recyclable plastics can be reused in the production of these new age of aggregates.

Steps involved in making of plastic precast comound wall

- Collection of Materials.
- Batching.
- Melting.
- Mixing.
- Moulding
- Unmoulding.



Flowchart of plastic precast compound wall manufacturing process

MIX DESIGN

GRADE	MIX RATIO
M1	1:1:2
M2	1:1.5:2
M3	1:2:3
M4	1:1.5:3

Table 1: Various Mix Ratios Considered

- **COLLECTION OF PLASTIC MATERIALS**

The plastic material should be collected from the factories waste and hospital waste and industries waste and also food packages and plastic bottles this will come under the LDPE plastic type.

- **BATCHING OF PLASTIC**

Measurement of materials for making brick is called batching. After collection of materials we separate the types of plastic and remove any other waste presented in the collected material and check that any water content in in sample collected ten proceed for burning.

- **MELTING OF WASTE PLASTIC**

After completion batching the plastic waste were taken for burning in which the plastic bags are drop one by one into the container and allowed to melt. These would be done in closed vessel because to prevent the toxic gases released into atmosphere. These will be at the temperature of 90-110 degrees centigrade.

- **MIXING OF WASTE PLASTIC WITH SAND**

Mixing of materials is essential for the production of uniform and strength for wall. The mixing has to be ensure that the mass becomes homogeneous, uniform in colour and consistency.

Generally, there are two types of mixing, Hand mixing and mechanical mixing. In this project, we adopted hand mixing. until the entire plastic content required for making plastic wall of one mix proportion is added into it. then these plastic liquids thoroughly mixed by using trowel before it hardens. The mixture has very short setting bags are turned to molten state; the river sand is added to it. The sand added is mixed time. Hence mixing process should not consume more time.

- **MOULDING**

After completion of proper mixing we place mix into required mould. In these projects we use the plastic precast compound wall sizes (250X30X5cm). after 2 hours remove from the mould and then done for use.

- **UNMOULDING**

After completion of moulding, we have to wait for 15 min for the settling and cooling of the plastic precast compound wall. Now we can remove from the mould.

CHAPTER 4

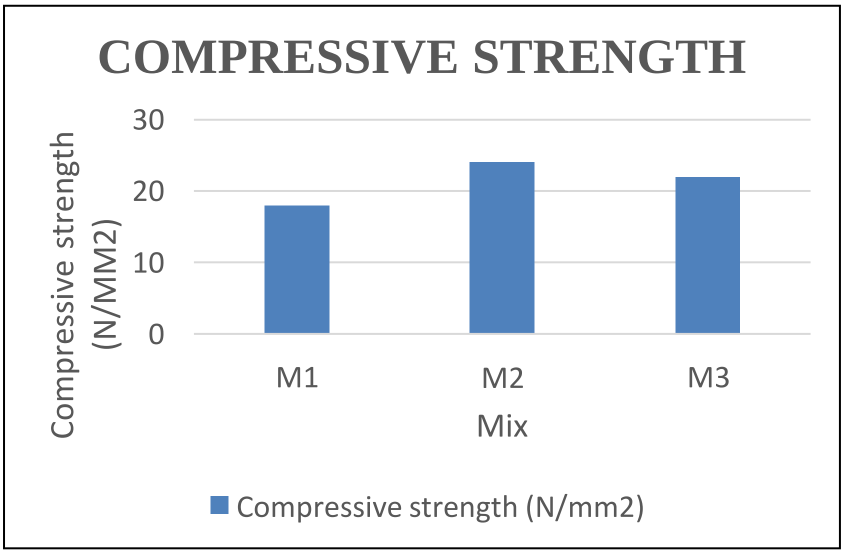
RESULTS AND DISCUSSION

COMPRESSIVE STRENGTH

The tests on Compressive strength of the specimen brick shall be calculated for 5 different ratio specimens using the formula as follows,
Compressive strength = load/area

MIX DESIGNATION	PLASTIC FINE AND COARSE AGGREGATE RATIO	COMPRESSIVE STRENGTH(N/MM^2)
M1	1:1:2	18 N/MM^2
M2	1:1.5:2	24 N/MM^2
M3	1:2:3	22 N/MM^2

Table II. COMPRESSIVE STRENGTH



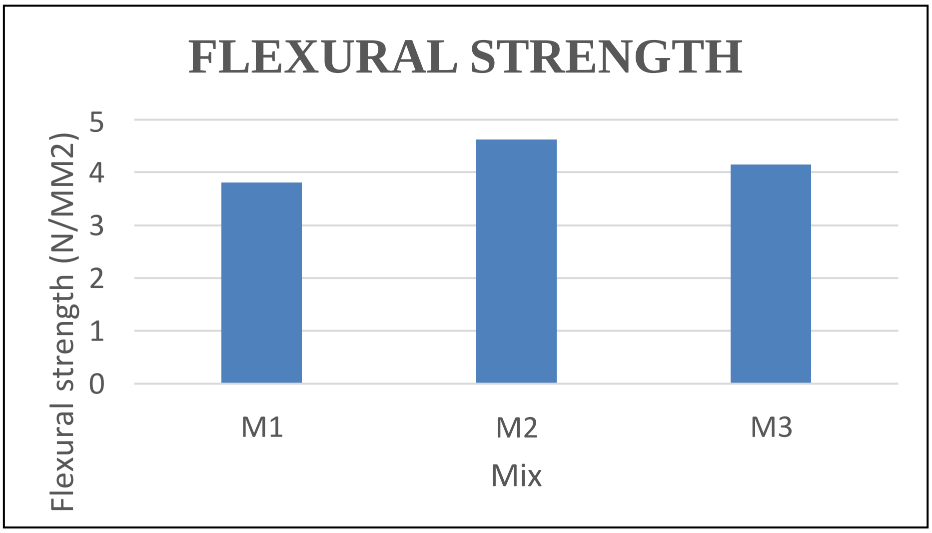
GRAPH OF COMPRESSIVE STRENGTH

FLEXURE TEST

Flexure test is more affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applies to the top of the material through either one or two points of contact (upper loading span) until the sample fails.

Mix Design	Plastic Fine & Course Aggregate Ratio	Flexure Strength (N/mm^2)
M1	1:1:2	3.8 N/mm^2
M2	1:1.5:2	4.62 N/mm^2
M3	1:2:3	4.24 N/mm^2

TABLE III: FLEXURE TEST



GRAPH OF FLEXURE TEST

OVEN TEST RESULT

SPECIMEN	TEMPERATURE IN (°C)°	REMARK
M1	50	No change
	100	No change
	170	Melts
M2	50	No change
	100	No change
	170	Melts
M3	50	No change
	100	No change
	170	Melts

Table IV. OVEN TEST RESULT

SOUNDNESS TEST

This sound is carried any of the two bricks. If the two bricks are not broken after striking with each other and a clear ringing sound is produced, then it means that the bricks are sufficiently sound.

COST ANALYSIS:

Cost analysis of plastic precast compound wall for 1:1:2 ratio for 250x30x5cms mould

Required plastic 12 kg = Rs.120/-
Required sand 12 kg = Rs.24/-
Required coarse aggregate 24 kg = Rs.24/-
Steel required 3 kg (Fe500) = Rs.120/-

288/-
Weight of wall slide = 12 kg+12 kg+24 kg+3 kg = 51 kg
Mould size = (250x30x5) cm
= 2.5x0.3x0.05
Volume = 0.0375 m^3

Density of precast compound wall = 51/0.0375 = 1360 kg/m^3

CHAPTER -5

CONCLUSIONS & ENHANCEMENT

5.1 CONCLUSION

The experimental results have shown the use of waste plastic material in making concrete/mortar can provide an alternative solution to minimize the environmental impact due to unscientific disposal of waste plastic.

The following conclusions were drawn:

- Waste plastic, which is available everywhere, may be put to an effective use in precast compound walls.
- Plastic precast compound walls can help reduce the environmental pollution, thereby makingthe environment clean and healthy.
- Plastic precast compound walls reduce the usage of cement in making of pavement blocks.
- Plastic precast compound walls give an alternative option of pavement to the customers onaffordable rates.
- Water absorption of plastic pavement blocks is zero percent.
- Compressive strength of Plastic precast compound walls is $24N/mm^2$ at the compressive load of 96KN.
- Flexure strength of Plastic precast compound walls is $4.62N/mm^2$.

a) A variety of plastic waste has been used in many ways in Plastic precast compound walls. The compressive strength of the Plastic precast compound walls produced comply the standard outlined, which is more than the acceptable range outlined.

b) A suitable proportion between plastic waste and other materials used need to be optimized to meet the standard outlined for manufacturing of Plastic precast compound walls. Further research and development is needed to improve the quality and durability of Plastic precast compound walls.

We conclude that the Plastic precast compound walls are useful for the construction industry when we compare with normal precast compound walls.

- The waste plastic used for experiments is of LDPE (Low Density Poly Ethylene), 5-7mm size and specific gravity of waste plastic is found to be 0.92.
- The mechanical properties of the test concrete did not display any notable differences depending on the color of the plastic waste.

- This research also has potential application for the production of lightweight concrete, for minimizing the amount of polymer wastes in landfills, and the creation of decorative, attractive landscaping products.

Advantages and Disadvantages :

Advantages:

- A better workability is achieved for plastic reinforced concrete in comparison to the conventional one.
- Considerable reduction in the weight results in the formation of light weight concrete. Behaviour of concrete by partial replacement of coarse aggregate with recycled plastic granules Dept. of Civil Engineering, TOCE, BANGALORE .
- Recycled plastic in the construction purpose can set a benchmark by utilizing the non-biodegradable waste and eventually minimizing the environmental pollution.

Disadvantages:

- Strength achieved for the plastic replaced concrete is slightly less than the conventional concrete but can be improved by the use of admixtures.
- Cost of plastic is high in the place where we need to buy from the dealers and hence the cost of construction also increases.
- There is no proper bonding of plastic materials in the matrix unless admixtures are Used.
- Plastics may be degraded under the action of direct sunlight which reducestheir mechanical strength.
- Many plastics are flammable unless treated. High embodied energy content.

5.2 FUTURE ENHANCEMENT

- The present research can be extended to The test can be carried out for different grades of concrete.
- The use of admixtures in the test can be performed to get improved strength.
- Experimental study has to be conducted for other varieties of plastics like HDPE, PP, PET etc.
- The durability of such a concrete has to be tested for beams and columns with varying proportions of waste plastic at different ages.

- The use of waste plastics in concrete is relatively a new development in the world of concrete technology and lot of research must go in before this material is actively used in concrete construction.
- The use of plastics in concrete lowered the strength of resultant concrete, therefore, the research must be oriented towards ternary systems that helps in overcoming this drawback of use of plastics in concrete.
- Estimation of the types, quantity and useful components present in the waste plastic materials in the city and surrounding areas.
- Methodology for collection and sorting out the useful components of the plastic waste.
- Carrying out further laboratory investigations, construction of some test tracks and field studies on the performance of concrete using the modified concrete.
- Working out relative economics of using the modified concrete mixes in road construction works, considering the improved performance and increased service lifeof the pavement.
- Preparation of specifications and standards for the construction industry.
- The studies can be further extended by addition of admixtures to make the concrete not to alter its strength considerably even with the addition of more percentage of plasticwaste.
- Durability studies can be conducted so as to study its properties in the long run. Tensile strength can be studied where concrete needs more tensile capacity.

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- To be communicated

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A Major Project Report
On

STRENGTH AND DURABILITY STUDY OF CONCRETE USING FOUNDRY WASTE SAND

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

by

A. SHIVANAND	**-**	**(17K81A0163)**
G. ABHISHEK	**-**	**(17K81A0180)**
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DEPARTMENT OF CIVIL ENGINEERING

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JUNE 2021

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Dhulapally, Secunderabad, Telangana (India)-500100

BONAFIDE CERTIFICATE

This is to certify that the project entitled **Strength and Durability Study of Concrete Using Foundry Waste Sand**, is being submitted by **A. Shivanand (17K81A0163), G. Abhishek (17K81A0180), Abdul Bari (17K81A0161), CH. RAM KUMAR (17K81A0172)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN CIVIL ENGINEERING** is recorded of bonafide work carried out by them. The result embodied in this report has been verified and found satisfactory.

Signature of Guide

Mr. V. HEMASEKHAR REDDY
M TECH
Assistant Professor,
Department of Mechanical Engineering

Signature of HOD

Mrs. J.K. SANDHYA KIRAN
Professor& Head of the Department
Department of Mechanical Engineering

Internal Examiner

External Examiner

Place:

Date:

DECLARATION

We, the students of **Bachelor of Technology** in **Department of Civil Engineering**, of the Academic Year: 2017 - 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project entitled **Strength and Durability Study of Concrete Using Foundry Waste Sand** is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been carried by taking care of Engineering Ethics. The result embodied in this project report has not been submitted in any university for award of any degree.

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ABSTRACT

Due to ever increasing quantities of waste materials and industrial by-products, solid waste management is the prime concern in the world. Scarcity of land-filling space and because of its ever increasing cost, recycling and utilization of industrial by-products and waste materials has become an attractive proposition to disposal. There are several types of industrial by-products and waste materials. The utilization of such materials in concrete not only makes it economical, but also helps in reducing disposal concerns. One such industrial by-product is Waste Foundry Sand (WFS). WFS is major byproduct of metal casting industry and successfully used as a land filling material for many years. But use of waste foundry sand (WFS) for land filling is becoming a problem due to rapid increase in disposal cost. In an effort to use the WFS in construction materials, research has being carried out for its possible utilization in making concrete as partial replacement of fine aggregate. In India, approximately 1.71 million tons of waste foundry sand and in Punjab region, approximately 0.17 million tons of waste foundry is produced yearly. In the present work, experimental investigation were performed such as compressive strength, split tensile strength, flexural strength of concrete for M25 grade of concrete by the replacement of foundry waste sand in place of fine aggregate. Curing is chosen was 28 days. The innovative use of used foundry sand in concrete formulation as a fine aggregate replacement material is one such alternative to traditional concrete. The fine aggregate will be replaced by used foundry sand accordingly in the range of 10%, 20%, 30% & 40% by weight for different grades of concrete. Foundry sand is a by-product of ferrous and non-ferrous metal. The present study gives the information about the civil engineering applications of foundry sand, which is technically sound and environmentally safe. Tests are performed for compressive strength, split tensile strength and flexural strength for all replacement level of foundry sand for 7 and 28 days curing period .The end result for 20% alternative of waste foundry sand suggest that the concrete produced is an economical sustainable and high strength concrete for the following tests conducted.

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CHAPTER-1

INTRODUCTION

1.1 OVERVIEW OF THE PROJECT

Concrete is the most useful material used in the construction field. The main focus of research in the field of concrete is an industrial waste (Foundry sand) and construction waste in ordinary concrete. Due to ever increasing quantities of waste materials and industrial by-products, solid waste management is the prime concern in the world. Scarcity of land-filling space and because of its ever increasing cost, recycling and utilization of industrial by-products and waste materials has become an attractive proposition to disposal. There are several types of industrial by-products and waste materials. The utilization of such materials in concrete not only makes it economical, but also helps in reducing disposal concerns. One such industrial by-product is waste foundry sand. Foundries successfully recycle and reuse the sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed as waste foundry sand. Metal casting industries which produce by-product as ferrous and non-ferrous metal casting and which cause environmental problems due to its improper disposal. This gives an idea about the utilization and various improvements in the field of Industrial Waste (Foundry Sand). Physical properties, chemical properties, and mechanical properties are reviewed. The results obtained from various research works that the concrete achieves its maximum strength at 28 days and is durable when partially replaced by foundry sand to fine aggregates.

Foundry sand (FS) waste creates a serious solid waste management problem worldwide due to the high volumes produced, necessitating alternatives to landfilling. A possible route is its use in concrete; however, the current consensus is that FS can only be used for modest sand replacements, based mostly on evidence on concrete with clay-bound FS (greensand). Conversely, this study assessed salient properties of structural concrete with chemically bound FS (polymeric resin binder), for which there is very little information. Concrete mixes were prepared in which FS replaced regular concrete sand partially or fully. The results showed that unlike green sand, the tested chemically bound FS could replace regular concrete sand fully, giving highly workable mixes with good mechanical properties (compressive, splitting and flexural strengths) similar to those of mixes with regular concrete sand; the effect of FS content on these properties was not statistically significant. Durability in terms of water absorption, carbonation and alkali-silica reaction tests was not adversely affected. The possibility of using high contents of this type of FS in concrete (as opposed to greensand) gives promise for an additional outlet route for large quantities of this waste material with clear economic and environmental benefits.

1.2 STATEMENT OF THE PROBLEM

Indian foundries produce approximately 1.71 million tons of waste foundry sand each year. The considerable disposal expense has made the current practice of WFS disposal in landfills less favorable. Besides the financial burden to the foundries, landfilling WFS also makes them liable for future environmental costs, remediation problems and regulation restrict ions. This issue is increasingly addressed by alternate options of reusing WFS beneficially. Mostly natural sand material. Its properties are similar to the properties of natural or manufactured sand. Thus it can normally be used as a replacement of sand. Beneficial reuses of WFS span a variety of applications related to infrastructure engineering and rehabilitation works. Some of the researchers have reported the possible use of waste foundry sand in different civil engineering applications. These alternate applications offer cost savings for both foundries and user industries and an environmental benefits at the local and national level.

1.3 AIM AND OBJECTIVES OF THE STUDY

To economize the cost of construction without compromising with quality. To investigate the utilization of Used Foundry Sand as Fine aggregate and influence of WFS on the Strength on concrete made with different replacement levels. To check the effect of Used Foundry Sand on properties of fresh concrete & compressive strength, split tensile strength and flexural strength. To check the suitability of Used Foundry Sand as an alternative construction material.

1.4 SCOPE OF THE STUDY

The present work concerns the investigation of WFS utilization effect on concretes. The aims are to establish the amount of used foundry sand that can be added in the mixture without too heavy penalizations, principally in terms of workability, mechanical performances (i.e. compressive strength and tensile strength). This research was conducted to investigate the performance of fresh and hardened concrete containing waste foundry sands as a replacement of fine aggregate. A control concrete mix was proportioned to achieve a 7-days and 28-day compressive strength, split tensile and flexural strength. Other concrete mixes were proportioned to replace 10% and 20%, 30% & 40% of regular concrete sand with used foundry sand by weight.

1.5 HARDWARE REQUIREMENTS

***COMPRESSIVE STRENGTH TEST**

Compressive strength of concrete was carried out on Compression Testing Machine. Five cubes of each batch were subjected to this test. A comparative study was made on properties of concrete after percentage replacement of fine aggregate by waste foundry sand in the range of 0%, 10%, 20%, 30% and 40%.

Cube specimens of size 150mm were cast for compressive strength as per Indian standard specifications BIS: 516-1959. After casting, all tests specimens were finished with steel trowel. Immediately after finishing, the specimens were covered with sheets to minimize the moisture loss from them. Specimens were demoulded after 24-hours and then cured in water at approximately room temperature till testing. Compressive strength tests for cubes were carried out at 7, 28 days. All the specimens were tested in an automated CTM.

***SPLIT TENSILE TEST**

The tensile strength of concrete is approximately 10% of its compressive strength. After curing of 7 and 28 days the specimens were tested for splitting tensile strength using a calibrated compression testing machine.

The splitting tensile strength is well known indirect test used for determining the tensile strength of concrete. Tensile strength is one of the most important fundamental properties of concrete. An accurate prediction of tensile strength of concrete will help in mitigating cracking problems, improve shear strength prediction and minimize the failure of concrete in tension due to inadequate methods of tensile strength prediction. The splitting tensile strength was determined at the age of 7, 2 days on cylinders 150 mm x 300 mm as per Indian standard specifications BIS: 516-1959. The test consists of applying compressive line loads along the opposite generators of a concrete cylinder placed with its axis horizontal between the plates. Due to the applied line loading a fairly uniform tensile stress is introduced over nearly two third of the loaded diameter as obtained from an elastic analysis.

***FLEXURAL STRENGTH TEST**

The tests on beams were carried out on Flexural testing machine of 100kN capacity under two point loading system. Flexural strength measures a paver's ability to resist breaking when pressure is applied. The result helps to ascertain the products application suitability and longevity as well as the end user's safety. Flexural testing is used to determine the flex or bending properties of a material. Sometimes referred to as a transverse beam test, it involves placing a sample between two points or supports and initiating a load using a third point or with two points which are respectively call 3-Point Bend and 4-Point Bend testing. High flexural strength is essential for stress-bearing restorations, when high pressure/stress is exerted on the material or restoration. As a result, flexural strength also determines the indications for which a material can be used: The more strength a material offers, the more units a restoration can include.

CHAPTER-2
REVIEW OF RELEATED LITERATURE

Guney et al. (2010) studied the effect of waste foundry sand (WFS) on the slump of concrete. Fine aggregates were partially replaced with 0, 10, 20, 30 and 40% WFS. It was observed that waste foundry sand decreased the fluidity and the slump value of the fresh concrete. This may be probably due to the presence of clayey type fine materials in the waste foundry sand, which are effective in decreasing the fluidity of the fresh concrete.

Etxeberria et al. (2010) determined the slump of concrete containing chemical foundry sand and green foundry sand. The mixture proportion on concrete made with chemical foundry sand was 300 kg cement, 447.5 kg foundry sand, 399.6 kg natural sand and 1150 kg coarse aggregates per cubic meter of concrete, with water/cement ratio of 0.61, whereas, proportion of concrete with green foundry sand was 300 Kg cement, 326 kg foundry sand, 458 kg natural sand and 1150 kg coarse aggregates with water/cement ratio of 0.69. Values of slump were 150 mm and 75 mm for concrete made with chemical foundry sand and green foundry sand respectively.

Bakis et al. (2006) explored the possible use of waste foundry sand (WFS) in asphalt concrete. Indirect tensile strength tests were conducted as per AASTHO (1989). As the percentage of WFS was increased, the strength of the asphalt concrete mixtures linearly decreased, yielding values from 1.39 MPa with 0% WFS to 0.94 MPa with 20% WFS.

Siddique et al. (2009) determined the effect of waste foundry sand (WFS) as partial replacement of fine aggregate on the splitting tensile strength of concrete. The splitting tensile strength of concrete mixtures made with and without foundry sand was measured at the ages of 7, 28 days. The variation in the splitting-tensile strength with foundry sand content was similar to that observed in case of the compressive strength. Splitting-tensile strength of concrete mixtures increased with the increase in foundry sand content. At 28-day, splitting tensile strength of control mixture M-1 (0% WFS) was 2.75 MPa, whereas mixtures M-2 (10% WFS), M-3 (20% WFS) and M-4 (30% WFS) achieved strength of 2.85, 2.9 and 3.0 MPa respectively; a marginal

Increase of 3.6, 5.4 and 9% in comparison with the strength of the control mixture M-1 (0% WFS).

Rafat Siddique, Geert de Schutter and Albert Noumowe, (2008): This paper shows the after effects of a complete test to find the concrete properties with FA s in part supplanted with 10%, 20%, 30% ,40% WFS. Compressive quality, parting rigidity, flexural quality, and modulus of versatility were resolved at 28days. Test outcomes showed minimal increment in the quality of ordinary concrete by consideration of UFS as fractional substitution of natural sand.

Gurpreet Singh (2011): This experiment was performed to evaluate the strength and durability of concrete where normal sand was supplanted with WFS taking 0%, 10%, 20%, 30%, and 40% by weight of it. Pressure test and parting rigidity test, Modulus of flexibility and ultrasonic test were completed to assess the quality properties of cement at the age of 7, 28 days.

Dr. Bhimani, Jayesh Kumar Pitroda, Jayabev bhai (2013): In this research work, strength, behavior of concrete by partial replacement of FA with 0%,10%,20% ,30% ,40% WFS by weight for M25 grade concrete.

Bavita Bhardwaj et.al According to her, several studies have been conducted to investigate the effect of addition of waste foundry sand as partial and complete replacement of regular sand in concrete. It has been found suitable to be used as partial replacement of sand in structural grade concrete. A number of properties have been reviewed in the current paper, the results observed from the various studies depict that replacement of foundry sand to a certain extent enhance the durability as well as strength properties of the concrete but simultaneously decreases the slump value with the increase of replacement level of waste foundry sand.

Maria Auxiliadora et.al Aimed to characterize and analyse the use of a very fine sand, referred here as waste foundry exhaust sand, WFS, from Waste Foundry Sand from the foundry of pieces in the automotive industry in conventional concrete production partially replacing the fine aggregate. The test on the physical properties such as size classification, specific gravity and density were carried out according to the Brazilian standards to obtain the mixture. The chemical characterization of the leachate solution of the waste was assessed to identify the presence of

Heavy metals. The waste was classified as non-inert and non-hazardous and physically adequate for use in conventional concrete.

Thiruvenkitam Manoharan et.al His investigations were carried out to evaluate the mechanical, durability and micro structural properties of M25 concrete at the age of 7, 28 day. XRD (X-ray Diffraction), EDX (Energy Dispersive X-ray) and Optical microscopic imaging analysis were performed to identify the presence of various compounds and micro cracks in the concrete with WFS. The study shows that, WFS is compatible for the replacement of fine aggregate in concrete. He also stated that,

Mechanical and durability properties for different grade of concrete can be the future concern.

Francesca Tittarelli1 et.al Waste foundry sand (WFS) is a discarded material coming from ferrous (iron and steel) and nonferrous (copper, aluminium, and brass) metalcasting industry to create moulds and cores. About 1 ton of foundry sand for each ton of iron or steel casting produced is used. Typically, suppliers of the automotive industry and its parts are the major generators of foundry sand (about 95% of the estimated WFS). Moulding sands are manufactured using virgin silica sands with the addition

of binding agents . Silica sand is mainly used because of its thermal conductivity. It can absorb and transmit heat.

N.Gurumoorthy et.al this paper presents the results of an experimental investigation carried out to evaluate the micro structural and mechanical properties of concrete mixtures in which fine aggregate (river sand) was partially replaced with WFS. Test results indicated a marginal increase in the strength properties and good micro structural properties of plain concrete by the inclusion of WFS as partial replacement of fine aggregate (sand). This will pave the way for making good quality concrete and

Disposing of the Used Foundry Sand safely without disturbing the environment. Used Foundry Sand (WFS) is the high-quality silica sand by-product from the production of both ferrous and nonferrous metal casting industry. The WFS from ferrous metal casting industry contains more iron content. Inclusion of WFS without proper treatment in concrete will reduce the binding and strength properties. In order to minimize the iron content, the WFS was treated with acid. While treating with acid, the silica in foundry sand has been enriched. This is called as Treated Used Foundry Sand (TWFS). In Treated Used Foundry Sand, silica content is about 80% when treated

With 5% HCl. Mechanical properties of concrete mixtures increase with the increase in the percentage of TWFS content. TWFS concrete mixtures show enhanced mechanical properties (compressive strength, splitting tensile strength and
Flexural strength) with respect to age for all the percentage of replacement.

M Nithya et.al Properties of concrete containing waste foundry sand for partial replacement of fine aggregate in concrete. Her study demonstrated that the feasibility of waste foundry sand in concrete as a substitute for fine aggregate by evaluating the durability properties of concrete. The durability evaluation in terms of acid resistance and alkalinity has shown relative supremacy over conventional concrete mix. Concrete produce with WFS suffered similar losses in weight and compressive strength as
Compared to ordinary concrete when subjected to sulphuric acid attack.

B. J. Lee et al. investigated the physical and chemical properties of concrete containing waste foundry sand as a partial replacement to natural sand. Strength and durability properties were evaluated in order to determine the influence of waste foundry sand on the behavior of concrete. From their study it was concluded that, control mix shows almost equal strength as that of the concrete mix with 30% of WFS. The durability properties of concrete mixtures containing waste foundry sand also showed a similar trend in their results as that of mechanical properties. From the entire test results it was concluded that, the concrete mixture containing 30% replacement of WFS can be effectively used in the construction industry without affecting the strength and durability properties of the concrete.

J. M. Khatib et al. investigated the properties of concrete incorporated with waste foundry sand. In
Their research fine aggregates were replaced with 0%, 30%, 60% and 100% WFS. Water content, water to cement ratio, cement content and coarse aggregate content were kept constant throughout the research. The properties like compressive strength, water absorption, ultra-sonic pulse velocity were studied at different curing periods (7, 28 days). The results showed that due to capillary action there was a systematic increase in water absorption. Compressive strength and ultrasonic pulse velocity indicated a
Decreasing trend in their values with the increase in waste foundry sand (WFS) content. They also

Concluded that sufficient strength can be attained by suitable replacement of WFS.

S. Monosi et al. investigated the fresh and hardened properties of mortars and concretes containing different dosages of waste foundry sand (WFS) as partial replacement of natural river sand.

Mortars and concretes were evaluated with respect to the uniformity of fresh mix and compressive strength of the hardened concrete material. Dynamic elastic modulus was determined for different concrete mixtures at 28 days curing.

2.1 CONCLUSIONS ON REVIEWS

Published literature has shown that WFS could be used in manufacturing Controlled Low-Strength Materials and concrete. The paper presents an overview of some of the research published on the use of WFS in concrete. Effect of WFS on concrete properties such as compressive strength, splitting tensile strength, freezing-thawing resistance, and shrinkage are presented. The use of waste foundry sand in concrete presents properties of waste foundry sand including applications of waste foundry sand. Effect of waste foundry sand on the fresh, strength and durability properties of concrete. At the end, result for 20% alternative of waste foundry sand suggest that the concrete produced is an economical sustainable and high strength concrete. Using the waste foundry sand in the large proportion by replacing the fine aggregates may result in the loss of strength and durability in the concrete.

CHAPTER 3

EXPERIMENTAL PROGRAM

GENERAL

The chapter describes the details of experimental programs for the measurements of fresh properties, strength properties (compressive strength, splitting tensile strength and flexural strength) and durability properties such as abrasion resistance, deicing salt surface scaling and rapid chloride permeability of concrete mixes made with varying percentages of waste foundry sand as partial replacement of fine aggregates.

3.1 MATERIALS USED

3.1.1 Cement

Portland pozzolana (fly ash based) cement was used. It was tested as per Indian standard specification (BIS-1489 part 1:1991). Test results are given in Table 3.1.

Table 3.1: Physical Properties of Portland Pozzolana Cement

Physical Properties	**BIS-1489:1991**	**Test Result**
Soundness Le-chat expansion	10.0 Max	1.6
Setting time (mm)		
Initial	30 Min.	92
Final	600 Max	248
Compressive Strength (MPa)		
3 day	16	18
7 day	22	36
28 day	33	47.8
Specific gravity	_	3.07
Standard Consistency (%)	_	35%
Drying shrinkage (%)	0.15 Max	0.024

3.1.2 Fine aggregates

Locally available natural sand with 4.75mm maximum size was used as fine aggregate. Its physical properties and sieve analysis are given in Tables 3.2 and Table 3.3 respectively.

Table 3.2: Physical Properties of Fine Aggregate

Sr.No.	***Properties***	**Observed values**
1.	Bulk Density (Loose), kg/m^3	1690
2.	Bulk Density (Compacted), kg/m^3	1890
3.	Specific Gravity	2.68
4.	Water Absorption (%)	1.2
5	Moisture content (%)	0.16
6	Material finer than 75µ (%)	0.5

Table 3.3: Sieve Analysis of Fine Aggregates

Weight of the sample taken = 1.0 kg

I.S. Sieve Size	**Weight retained in grams**	**Percentage weight retained in grams**	**Cumulative percentage of weight retained**	**Percentage passing**	**IS: 383-1970 Requirement for Zone II**
10.0mm	00	00	00	100	100
4.75mm	10	1.0	1.0	99	90-100
2.36mm	62	6.2	7.2	92.8	75-100
1.18mm	235	23.5	30.7	69.3	55-90
600µm	170	17	47.7	52.3	35-59
300µm	338	33.8	81.5	18.8	8-30
150µm	145	14.5	96.0	4.0	0-10
Pan	40	4	100	0	--

Fineness modulus of fine aggregate = 2.64

The sand conforms to grading zone II as per BIS: 383-19

3.1.3 Coarse aggregates

Crushed stone with maximum 12.5mm graded aggregates (nominal size) were used. Physical properties and sieve analysis results are given in Tables 3.4.

Table 3.4: Physical Properties of Coarse Aggregates

Properties	Observed values
Maximum size (mm)	12.5
Bulk Density (kg/m^3)	1650
Specific Gravity	2.7
Total Water Absorption (%)	1.14
Moisture content (%)	Nil

Table 3.5: Sieve Analysis of Coarse Aggregates

Weight of the sample taken = 2.0 kg.

I.S. Sieve Size	Weight retained in grams	Percentage weight retained in grams	Cumulative percentage of weight retained	Percentage passing	BIS: 383-1970 Requirement
80mm	00	00	00	100	----
40mm	00	00	00	100	----
20mm	00	00	00	100	----
12.5mm	0.97	4.8	4.8	95.2	90-100
10mm	642	32.1	36.9	63.1	40-85
4.75mm	1184	59.2	96.1	3.9	0-10
pan	77	3.85	100	00	----

Fineness modulus of coarse aggregate = 6.35Coarse aggregates conformed to BIS: 383- 1970.

3.1.4 Foundry Sand

Foundry sand obtained from samarth foundry services pvt. Ltdwas used. The physical, chemical properties and sieve analysis of foundry sand are given in the Tables 3.6,3.7 and 3.8 respectively.

Table.3.6: Physical Properties of Foundry Sand

Sr. No.	Properties	Observed Values
1.	Color	Grey (Blackish)
2.	Bulk Density (Loose), kg/m^3	1336
3.	Bulk Density (Compacted),	1638
4.	Specific Gravity	2.18
5	Fineness Modulus	1.89
6	Water absorption (%)	0.42
7	Moisture Content (%)	0.11
8	Material Finer than 75μ (%)	8

Table.3.7: Chemical Properties of Foundry Sand

Constituents	% by Weight (Used in present study)
Silica (SiO_2)	83.8
Iron Oxide (Fe_2O_3)	5.39
Alumina (Al_2O_3)	0.81
Calcium Oxide (CaO)	1.42
Magnesium oxide (MgO)	0.86
Titanium Dioxide (TiO_2)	0.22
Sodium Oxide (Na_2O)	0.87
Potassium Oxide (K_2O)	1.14
Sulphur Trioxide (SO_3)	0.21
Manganese Oxide (Mn_3O_4)	0.047
Strontium Oxide (SrO)	Nil

Table.3.8: Sieve Analysis of Waste Foundry Sand

Weight of the sample taken = 1.0 kg

I.S. Sieve Size	Weight retained in grams	Percentage weight retained in grams	Cumulative percentage of weight retained	Percentage passing
4.75mm	00	00	00	100
2.36mm	11	1.1	1.1	98.9
1.18mm	15	1.5	2.6	97.4
600µm	25	2.5	5.1	94.9
300µm	791	79.1	84.2	15.8
150µm	122	12.2	96.4	3.6
Pan	36	3.6	100	00

Fineness modulus of waste foundry sand = 1.89

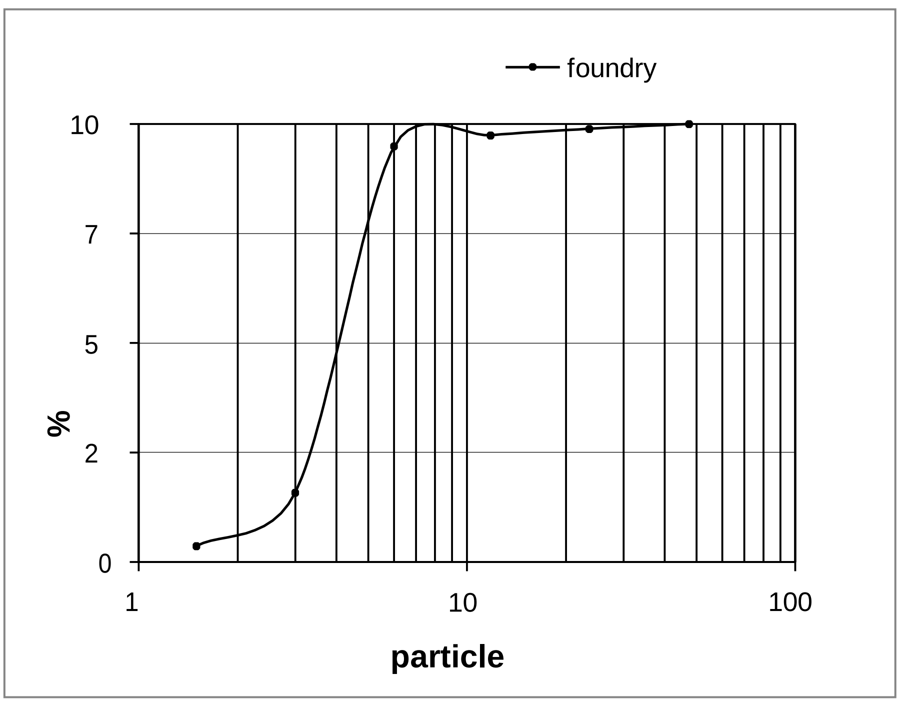

Fig. 3.1 Particle Size Analysis of Waste Foundry Sand

3.1.5 SUPER PLASTICIZER

It was observed that increase in waste foundry sand content in concrete mixes lead to decrease the slump value of concrete. It could be due to the increase in fine particle of WFS in concrete mixes lead to increase the surface area of the fine aggregate with constant water cement ratio. To maintain the slump value, a polycarboxylic ether based super plasticizer (Sika viscocrete-10R) of SIKA brand complying with BIS: 9103-1999 was used. Specifications of super plasticizer are given in Table 3.9

Table 3.9: Specifications of Superplasticizer

Basis	**Aqueous solution of modified polycarboxylate**
Appearance	Brown liquid
Density	1080g/l at 30°C
pH	Approx. 5.0

3.1.6 Water

Water used for casting specimens conformed to the requirements of BIS: 456-2000. Test results are given in Table 3.10

Table 3.10: Properties of Water

Properties	**Observed value**
pH	8.0
Dissolved Solids (mg/l)	290
Suspended Solids	Nil
Chlorides (mg/l)	20
Sulphates (mg/l)	74
MPN Value/100 ml.	Nil

3.2 METHODOLOGY ADOPTED FOR MIX DESIGN

Mix design is a process of selecting suitable ingredients for concrete and determining their proportions which would produce, as economically as possible, a concrete that satisfies the job requirements. The proportioning of the ingredients of concrete is an important phase of concrete technology as it ensures quality and economy. In pursuit of the goal of obtaining concrete with desired performance characteristics, the selection of component materials is the first step, the next step is a process called mix design by which one arrives at the right combination of the ingredients. There are many methods of designing concrete mixes.

3.2.1 Design of Concrete Mix

The compressive strength of concrete is considered as the index of its quality. Therefore the mix design is generally carried out for a particular compressive strength of concrete with adequate workability so that the fresh concrete can be properly mixed, placed and compacted. The proportions for the mix were calculated adopting the requirements of water as specified in BIS: 10262-1982.

The proportioning of concrete mixes consists of three interrelated steps.

i. Selection of suitable ingredients-cement, supplementary cementing materials, aggregates water and chemical admixtures.
ii. Determination of the relative quantities of these materials in order to produce as economically as possible a concrete, that has desired rheological properties i.e. strength and durability.
iii. Careful quality control of every phase of the concrete making process.

In the present study Mix Design for M25 (Design value at the age of 28 day) grade concrete is done according to BIS: 10262-1982.

M25 design mix

Data:

Characteristic strength at 28 days	=	25 N/mm^2
Degree of quality control expected at site	=	Good
Maximum size of aggregate	=	12.5mm
Degree of workability desired (C.F.)	=	0.9 (Medium)
Type of exposure	=	Mild, no sulfate attack
Concrete use	=	Concrete structure
Target mean strength	=	30 N/mm^2

Table 3.11 Mix Proportion Ratio of M25 Grade of Concrete

		Mix proportion ratio M25 (1:1:2) IS 10262 2009				
Specimens	Cement(kg/ m^3)	Fine aggregate(kg/ m^3)	Foundry sand(kg/ m^3)	Coarse aggregate(kg /m^3)	Water content(kg/m^3)	Water cement ratio(kg /m^3)
Conventional concrete	554.4	558.25	-	1155	249.48	0.45
WFS 10% concrete	554.4	502.43	55.82	1155	249.48	0.45
WFS 20% concrete	554.4	446.6	111.65	1155	249.48	0.45
WFS 30% concrete	554.4	390.78	167.47	1155	249.48	0.45
WFS 40% concrete	554.4	334.95	223.3	1155	249.48	0.45

3.2.2 CASTING OF SPECIMENS

All the specimens were cast having mix proportions. For these mix proportions, required quantities of materials were weighed. The mixing procedure adopted was as follows:

The cement and foundry sand were dry mixed in a tray for about 5 minutes. A uniform color was obtained without any clusters of cement, foundry sand. Weighed quantities of coarse aggregates and sand were then mixed in dry state.

The mix of cement and foundry sand was added to the mix of coarse aggregates and sand these were mixed thoroughly until a homogeneous mix was obtained.

Water was then added in three stages as given below: 50% of total water to the dry mix of concrete in first stage.40% of water and superplasticizer to the wet mix. Remaining 10% of water was sprinkled on the above mix and it was thoroughlymixed in the mixer. All the moulds were properly oiled before casting the specimens. The casting immediately followed mixing, after carrying out the tests for fresh properties. The top surface of the specimens was scraped to remove excess material and achieve smooth finish. The specimens were removed from moulds after 24 hours and cured in water till testing or as per requirement of the test.

3.3 TESTING PROCEDURE

After required period of curing, the specimens were taken out of the curing tank and their surfaces were wiped off. Besides measuring the fresh properties (workability, air content and concrete temperature), following tests were performed on hardened concrete.

3.3.1 Strength Properties

- Compressive strength (BIS: 516 – 1959)
- Splitting tensile strength (BIS: 5816 – 1999)
- Modulus of elasticity (BIS: 516 – 1959)

These properties were determined at the age of 7, 28, 91, and 365 days.

3.3.2 Durability Properties

- Abrasion resistance (BIS: 1237 – 1980)
- Rapid chloride permeability test (ASTM C 1202)
- Deicing salt scaling resistance (ASTM C 672)

The specimen properties were determined at the age of 28, 91, and 365 days.

3.3.3 Non-Destructive Testing

Rebound hammer and Ultrasonic pulse velocity tests were conducted on concrete cubes of both the grades of concrete made with WFS.

3.4 FRESH PROPERTIES

The workability of fresh concrete is a composite property which includes the diverse requirements of stability, mobility, compactability, placeability and finishability. There are different methods for measuring the workability. Each of them measures only a particular aspect of it and there is really no unique test which measures workability of concrete in its totality.

The fresh properties were studied in the following tests with the order of testing as mentioned below:

i. Slump test
ii. Compaction factor

For determining the fresh properties, slump flow and Compaction factor tests were performed as envisaged by BIS: 1199-1959. All fresh test measurements were duplicated and the average of measurements was given.

For determining the fresh properties, slump flow and Compaction factor tests were performed as envisaged by BIS: 1199-1959. All fresh test measurements were duplicated and the average of measurements was given.

3.4.1 Slump Cone Test

The vertical settlement of unsupported fresh concrete, flowing to the sides and sinking in height is known as slump. Slump is a measure indicating the consistency or workability of cement concrete. It gives an idea of water content needed for concrete to be used for different works. A concrete is said to be workable if it can be easily mixed, placed, compacted and finished. A workable concrete should not show any segregation or bleeding. The setup of the slump test is shown in Fig. 3.2.

Fig. 3.2. Slump Cone Test

3.4.2 Compaction Factor Test

Compaction factor test is based on the definition, that workability is that property of the concretethat determines the amount of work required to produce full compaction. The test consists essentially of applying a standard amount of work to standard quantity of concrete and measuring the resulting compaction as shown in Fig.3.3.

Fig.3.3 COMPACTION TEST

3.5 STRENGTH PROPERTIES

Compressive strength, splitting tensile strength and flexural strength of mixes were determined at various ages as per BIS 516:1959 are given below:

i. Cube Compressive strength at the age of 7, 28 days.
ii. Split Tensile strength of cylinders at the age of 7, 28 days.
iii. Flexural Strength at the age of 7, 28 days.

3.5.1 Compressive Strength

Cube specimens of size 150mm were cast for compressive strength as per Indian standard specifications BIS: 516-1959. After casting, all tests specimens were finished with steel trowel. Immediately after finishing, the specimens were covered with sheets to minimize the moisture loss from them. Specimens were demoulded after 24-hours and then cured in water at approximately room temperature till testing. Compressive strength tests for cubes were carried out at 7, 28, 90 and 365 days. All the specimens were tested in an automated CTM shown in Fig.

The compressive strength was then calculated according to the formula:

$$\sigma = P / A$$

Where σ = Compressive Strength

(N/mm^2)P = Maximum load (N)

A = Cross section area of cube (mm^2)

Fig.3.4 Compressive Strength Test

3.5.2 Split Tensile Strength

The splitting tensile strength is well known indirect test used for determining the tensile strength of concrete. Tensile strength is one of the most important fundamental properties of concrete. An accurate prediction of tensile strength of concrete will help in mitigating cracking problems, improve shear strength prediction and minimize the failure of concrete in tension due to Inadequate methods of tensile strength prediction. The splitting tensile strength was determined at the age of 7, 28 days on cylinders 150 mm x 300 mm as per Indian standard specifications BIS: 516-1959. The test consists of applying compressive line loads along the opposite generators of a concrete cylinder placed with its axis horizontal between the plates. Due to the applied line loading a fairly uniform tensile stress is introduced over nearly two third of the loaded diameter as obtained from an elastic analysis. The magnitude of this tensile stress (acting in a direction perpendicular to the line of action of applied compression) is given by

$$\sigma = 2P/\pi dL$$

Where σ = Tensile Stress (N/mm^2)

P = Applied load at failure (N)

d=Diameter of cylinder (mm)

L = Length of cylinder (mm)

The load `P' is applied (as line load) on the cylinder specimen in compression testing machine. At failure load P the specimen fails by splitting along the loaded diameter as shown in Fig. 3.5.

Fig.3.5 Split Tensile Strength

3.5.3 FLEXURAL STRENGTH

The tests on beams were carried out on Flexural testing machine of 100kN capacity under two point loading system. Flexural strength measures a paver's ability to resist breaking when pressure is applied. The result helps to ascertain the products application suitability and longevity as well as the end user's safety. Flexural testing is used to determine the flex or bending properties of a material. Sometimes referred to as a transverse beam test, it involves placing a sample between two points or supports and initiating a load using a third point or with two points which are respectively call 3-Point Bend and 4-Point Bend testing. High flexural strength is essential for stress-bearing restorations, when high pressure/stress is exerted on the material or restoration. As a result, flexural strength also determines the indications for which a material can be used: The more strength a material offers, the more units a restoration can include.

3.6 DURABILITY PROPERTIES

For the measurement of durability resistance of mixes, following tests were performed.

i. Abrasion resistance of concrete according to BIS 1237-1980
ii. Scaling resistance of concrete surfaces exposed to deicing chemicals according to ASTM C 672.
iii. Permeability of mixes by Rapid chloride permeabilitytest (RCPT) according to ASTM C 1202.

3.6.1 Abrasion Resistance Test

For abrasion testing, specimens were weighed accurately on a digital balance. After initial drying at room temperature for about 1-2 hours and weighing, the thickness of the specimens was measured at five points (i.e. one at the center and four corners). The grinding path of the disc of the abrasion-testing machine was evenly distributed with 20-gram of abrasive (aluminum) powder. The specimens were fixed in the holding device of the abrasion machine, and a load of 300 N was applied. The grinding machine was then put in motion at a speed of 30 revolutions per minute, and the abrasive powder was continuously fed back in to the grinding path so that it remained uniformly distributed in the track corresponding to the width of the test specimen. The thickness and weight of specimens were taken every 10 minutes interval until the end of the test (60 minutes). The extent of abrasion was determined from the difference in values of thickness measured before and after the abrasion test. Loss in thickness of specimens was also confirmed by the calculation of average loss in thickness of the specimens using the following formula:

$$T = \frac{W_1 - W_2}{W_1} \times \frac{V_1}{A}$$

Where T is average loss in thickness in mm; W1 is the initial weight of the specimen in gram; W2 is the mass of the specimen after abrasion in gram; V1 is the initial volume of the specimens in mm3; A is the surface area of the specimens in mm2

3.6.2 Rapid Chloride Permeability Test

A durable concrete is the one that performs satisfactorily under anticipated exposure condition during its service life span. One of the main characteristics influencing the durability of concrete is its permeability to the ingress of chloride. The chloride ion present in the concrete can have harmful affect on concrete as well as on the reinforcement. Swelling of concrete due to chloride ion penetration is 2 to 2.5 times larger than that observed with water penetration. So this test covers the experimental evaluation of electrical conductance of concrete to provide rapid indication of concrete resistance against chloride ion penetration.

The test method (according to ASTM C 1202-97) covered the determination of the electrical conductance of concrete to provide a rapid indication of its resistance to the penetration of chloride ions. According to Table 3.17 the chloride ion penetrability was decided on the basis of charge passed. The test method consisted of monitoring the amount of electrical current passed through 2-in. (51-mm) thick slices of 4-in. (102-mm) nominal diameter cores or cylinders for a 6-h period. A potential difference of 60 V dc was maintained across the ends of the specimen, one of which was immersed in a sodium chloride solution, the other in a sodium hydroxide solution. The total charge passed, in coulombs, was related to the resistance of the specimen to chloride ion penetration.

Producing, conditioning and testing of the concrete specimen

The cylinders (100mmx200mm) were cast. Specimens were placed in the vacuum desiccator's bowl as shown in Fig 3.7 which illustrates the setup of the vacuum pump, desiccator with stopcock, vacuum gauge and valve and the deaerated water container after the water has filled the desiccators. The vacuum was maintained in the desiccators bowl for 3 hours. The de-aerated water was allowed to flow into the desiccator, so that it completely covers the specimens and no air was allowed to enter. Again the vacuum was maintained for another one hour. Then the specimens were left to soak in the container water for another 18 hours. The specimens were removed from the dessicator, dried and placed in gasket. The liquids (3.0% NaCl and 0.3 N NaOH solutions) were filled in the two cells. Power supply was set to 60V, and initial current reading was recorded. Set up of the apparatus is shown in Fig.3.8. Temperatures of the specimen, applied voltage cell and solutions were maintained at 68 to 77øF (20 to 25øC) at the time the test was initiated (when the power supply was turned on). During the test, the air temperature around the specimens was maintained in the range of 68 to 77øF (20 to 25øC). The values for the current were recorded.

Fig.3.6 Rapid Chloride Permeability Test Set Up

3.7 NON DESTRUCTIVE TEST

In the non-destructive method of testing the Specimen are not loaded to failure. Ultrasonic pulse velocity and Rebound hammer tests were conducted on 150mm concrete cubes as per BIS 13311 (Part 1) and BIS 13311 (part 2) respectively.

3.7.1 Ultra Sonic Pulse Velocity

USPV method consists of measuring the time of travel of an ultrasonic Pulse passing through the concrete to be tested. The Pulse generator Circuit consists of electronic circuit for generating pulse and a transducer for transforming these electronic pulses into mechanical energy having vibration frequency in the range of 20 to 150 KHz. The time of travel between initial on set and the reception of the pulse is measured electronically. The path length between transducer divided by the time of travel gives the average velocity of wavepropagation.

Battery operated fully portable digitized unit PUNDIT (Portable Ultrasonic Non-destructive Digital Indicating Tester) was used shown in Fig. 3.7. The Direct transmission way was used for measuring pulse velocity through concrete.

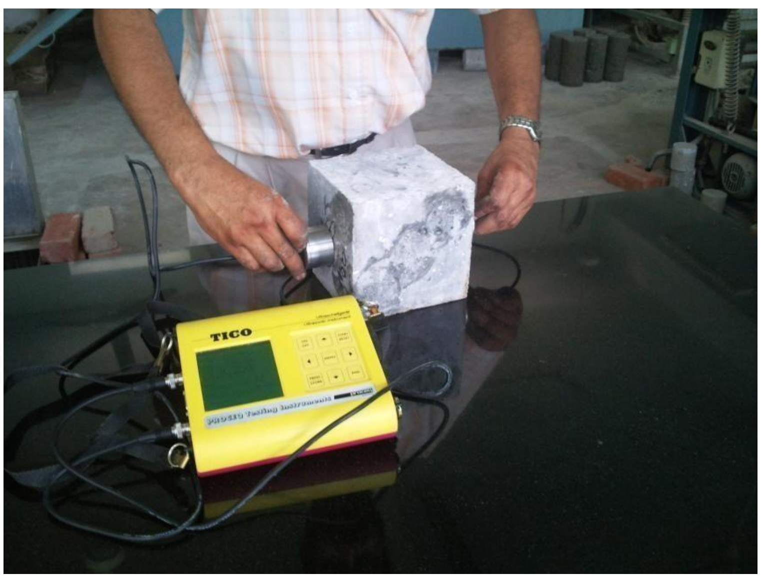

Fig. 3.7 Ultrasonic Pulse Velocity Test

This method was used to check the quality of concrete in terms of density homogeneity and uniformity of concrete. The quality grades of concrete are given in

Table 3.12 Velocity Criterion for Concrete Quality Grading

Pulse velocity m/sec	Concrete Quality Grading
Above 4500	Excellent
3500 – 4500	Good
3000 – 3500	Medium
Less than 3000	Doubtful

3.7.2 Rebound Hammer

Rebound hammer test is also called surface hardness method. The rebound hammer test measure the elastic rebound of concrete and primarily for compressive integration. The test was conducted on 150mm cube at the age of 28 days. SCHMIDT rebound hammer (digital) was used for testing as shown in Fig. 3.8. In this method a test hammer hits the concrete at a definite energy 2.2Nm and compressive strength is directly obtained from rebound hammer. The equipment was operated vertically downward. The plunger was pressed strongly and steadily against the concrete surface to be tested at right angle. Normally grid was used to locate impact points not less than 20mm apart from each other. BIS 13311(part 2) recommended 12 reading taken over an area mean of compressive strength values was calculated.

Fig. 3.8 Rebound Hammer Test

According to BIS 13311 (part 2), the estimation of strength of concrete by rebound hammer method cannot be held to be very accurate and probable accuracy of prediction of concrete strength in structure is ñ 25 percent.

SUMMARY

In this chapter various properties (specific gravity, fineness modulus, moisture content etc.) of the materials (cement, fine aggregate course aggregate and waste foundry sand) that are used in present work, are presented. Ingredients of M25 Grade of concrete mixes were determined in accordance with Indian standard code. After this specimens were made and tested for various strength and durability properties of both the grades of concrete mixes.

CHAPTER 4

RESULT AND DISCUSSION

GENERAL

The findings of experimental investigations are presented. In which, various tests were conducted to evaluate the effect of waste foundry sand on compressive strength, splitting tensile strength, Flexural strength, rapid chloride penetration. In non-destructive testing, rebound hammer was used to determine the compressive strength and to check the quality of concrete, ultrasonic pulse velocity test was conducted. Waste foundry sand was used as a partial replacement of fine aggregate at the percentage of 0, 10, 20, 30 and 40%. Design of different concrete mix and procedure of various tests are described in chapter 3.

4.1 COMPRESSIVE STRENGTH

Table 4.1 Compressive Strength of M25 Grade Concrete

Mix Proportion	Mix Designation	Average Compressive Strength (N/mm^2)	
		7 Days	28 Days
Concrete mix with100% CA+100% cement+0 % WFS+100 %FA	FS-0%	23.5	31.4
Concrete mix with 100% CA+100% cement+10 %WFS+90%FA	FS-10%	22.08	29.45
Concrete mix with 100%CA+100% cement+20 % WFS+80 %FA	FS-20%	24.22	32.12
Concrete mix with 100% CA+100% cement+30% WFS+70 %FA	FS-30%	21.57	29.19
Concrete mix with 100 CA+100% cement+40 % WFS+60%FA	FS-40%	19.32	28.43

Comparative study of compressive strength between all ages indicated that % increase in compressive strength decreased with the increase in WFS content for all mixes.

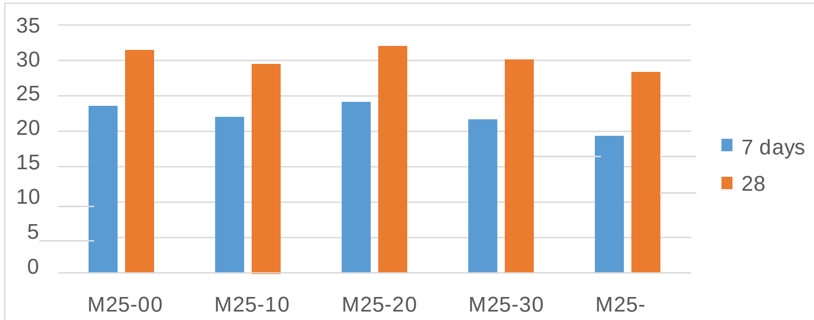

Fig.4.1 Compressive strength of M25 grade concrete

4.2 SPLIT TENSILE STRENGTH

Table 4.2 Splitting Tensile Strength for M25 Grade

Mix Type F.S	Spilt tensile Strength (N/mm²)	
	7 days	28 days
M-1(0% F.S)	2.98	4.23
M-2(10% F.S)	2.52	4.57
M-3(20% F.S)	2.45	4.76
M-4(30% F.S)	2.39	4.69
M-5(40% F.S)	2.28	4.56

The variations in splitting tensile strength with waste foundry sand content were similar to that observed in case of compressive strength. Splitting tensile strength of concrete mixes increased with the increase in WFS content and then decreased. Splitting tensile strength of control mix M-1(0% WFS) was 2.98 MPa at 7 days and it increased by 4.23MPa at 28 days. M-2(10% WFS) was 2.52 MPa at 7 days and it increased by 4.57MPa at 28 days.M-3(20% WFS) was 2.45 MPa at 7 days and it increased by 4.76MPa at 28 days.M-4(30% WFS) was 2.39 MPa at 7 days and it increased by 4.69MPa at 28 days.M-5(40% WFS) was 2.28 MPa at 7 days and it increased by 4.56MPa at 28 days.

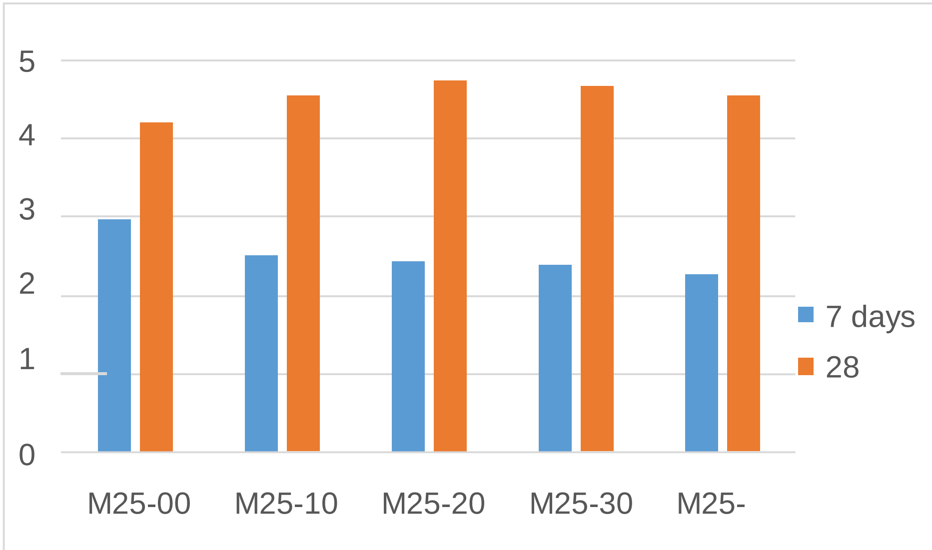

Fig. 4.2 Split tensile strength of M25 grade concrete

4.3 FLEXURAL STRENGTH TEST

Table 4.3 Flexural Strength Test for M25 Grade concrete

Mix Type F.S	Flexural strength (N/mm²)	
	7days	28days
M-1(0%F.S)	2.95	3.15
M-2(10%F.S)	3.04	3.25
M-3(20%F.S)	3.15	3.45
M-4(30% F.S)	3.05	3.17
M-5(40% F.S)	3.28	3.54

The variations in flexural strength test with waste foundry sand content at different moulds are M-1(0% WFS) was 2.95 MPa at 7 days and it increased by 3.15MPa at 28 days. M-2(10% WFS) was 3.04 MPa at 7 days and it increased by 3.25MPa at 28 days.M-3(20% WFS) was 3.15 MPa at 7 days and it increased by 3.45 MPa at 28 days.M-4(30% WFS) was 3.05 MPa at 7 days and it increased by 3.17 MPa at 28 days.M-5(40% WFS) was 3.28 MPa at 7 days and it increased by 3.54 MPa at 28 days and the values are plotted on the graph as shown in the below figure.

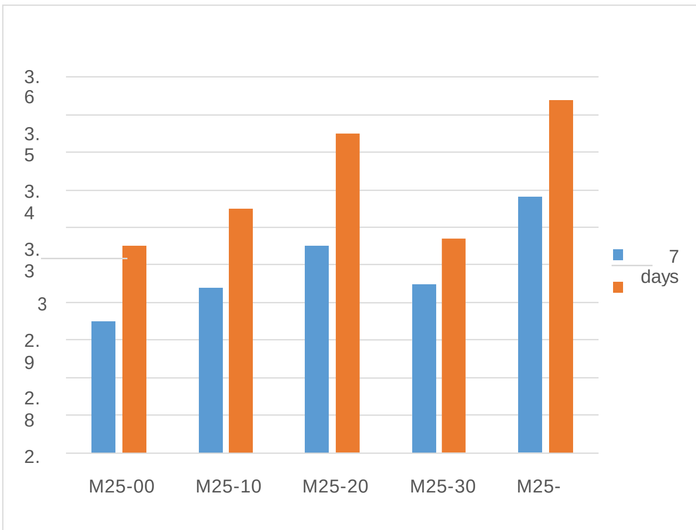

Fig.4.3 Flexural strength of M25 grade concrete

SUMMARY

In this chapter, the findings of experimental investigations were discussed. Various tests were conducted to determine the effect of waste foundry sand on strength and durability properties of M25 Grade of concrete. In non-destructive testing, rebound hammer and ultrasonic pulse velocity test was performed. Natural sand was replaced with waste foundry sand by 0 to 40% at an interval of 10%. In this investigation it was found that at 20% replacement, WFS showed considerable improvement on strength properties (compressive strength, splitting tensile strength and modulus of elasticity) and durability properties for M25 grade of concrete.

CHAPTER-5

CONCLUSION AND FUTURE ENHANCEMENT

GENERAL

The present work investigated the influence of waste foundry sand as partial replacement of fine aggregate (sand) on the properties of M25 Grade of concrete. On the basis of the results from the present study, following conclusions are drawn.

1. So it is concluded that, the foundry waste sand can be used as a construction material as a partial replacement of the fine aggregate.
2. That will help making Eco-friendly concrete from recycled materials saves energy and conserves resources which lead to a safe sustainable and economic environment.
3. Plit tensile strength increases with increase in some proportion of waste foundry sand and there after it decreases.
4. Use of waste foundry sand in concrete reduces the production of waste via metallic industries i.e. it's an eco-friendly building material.
5. The end result for 20% alternative of waste foundry sand suggest that the concrete produced is an economical sustainable and high strength concrete for the following tests conducted.

5.1 DURABILITY PROPERTIES

5.1.1 Abrasion Resistance Test

Waste foundry sand concrete mixes showed higher abrasion resistance (less depth of wear) than that of concrete mixes which contain no waste foundry sand. Abrasion loss of waste foundry sand concrete mixes decreased as the replacement of waste foundry sand increased. Maximum abrasion resistance was observed at 20% replacement of fine aggregate with waste foundry sand. Results have indicated that concrete made with (up to 20%) WFS could suitable be used for making structural concretes, as well as for applications where abrasion is also important parameter.

5.1.2 Rapid Chloride Permeability Resistance

Chloride permeability resistance of concrete mixes increased with the increase in waste foundry sand content. All concrete mixes (with and without waste foundry sand) for M25 grade of concrete come under "low" permeability against chloride at all age as per ASTM standards. Only concrete mix M-2(20% WFS) comes under very low permeability at 28 days of curing.

5.2 NON DESTRUCTIVE TEST

5.2.1 ULTRASONIC PULSE VELOCITY

In this investigation, ultrasonic pulse velocity method was used to predict the quality of concrete and to know the effect of waste foundry sand on quality of concrete in term of homogeneity and uniformity of concrete.

Result showed that ultrasonic pulse velocity increased with the inclusion of waste foundry sand in M25. All concrete mixes of M25 concrete satisfied the criteria of BIS 13311 (part-1) 1992 Ultrasonic pulse velocity of all concrete mixes lies between 3500m/s to 4500m/s. it means that with addition of WFS in concrete, quality of concrete mixes improved. Maximum velocity was observed at 20% replacement of fine aggregate with WFS for both grades of concrete. It also increased with age.

5.2.2 REBOUND HAMMER

Rebound hammer is used to predict the compressive strength of the concrete. It is not an accurate method. According to BIS: 13311 (part 2)-1992, accuracy of prediction of concrete strength in structure is 20 percent. Due to inclusion of waste foundry sand content in concrete, the compressive strength was observed higher than that of control one. It was also found that compressive strength was increased with age of 28 days of M25 Grade of concrete.

STATISTICAL ANALYSIS

In this analysis, correlation between the strength and durability properties was investigated. It was observed that there is good correlation between strength and durability properties for M25.

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A Major Project Report

On

EXPERIMENTAL STUDY ON STRENGTHENING OF CONCRETE BY REPLACING TURRITELLA AND BENTONITE

SUBMITTED TO

Jawaharlal Nehru Technical University, Hyderabad

In Partial Fulfillment of the requirement for the award of Degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Submitted

by

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JUNE 2021

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BONAFIDE CERTIFICATE

This is to certify that the major project report entitled with "**EXPERIMENTAL STUDY ON STRENGTHENING OF CONCRETE BY REPLACING TURRITELLA AND BENTONITE**" that is being submitted by **Ms. G.Nithisha (17K81A0182)** , **Mr. S.Ganesh (17K81A010), Ms. Y.Divya (17K81A01A8), Mr. M.Praneeth kumar (17K81A0190),** in partial fulfillment for the award of degree of **BACHELOR OF TECHNOLOGY IN** Civil Engineering is recorded of bonafide work carried out by them.The results embodied in this report have been verified and found satisfactory.

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DECLARATION

We hereby **G.NITHISHA, S.GANESH, Y.DIVYA, M.PRANEETH KUMAR,** declare that the report of the major work entitled **"EXPERIMENTAL STUDY ON STRENGTHENING OF CONCRETE BY REPLACING TURRITELLA AND BENTONITE"** which is being submitted to the **St.Martin's Engineering College**, Hyderabad, in partial fulfilment of the requirements for the award of the Degree of **BACHELOR OF TECHNOLOGY,** is a bonafide report of the work carried out by us. The material contained in this report has not been submitted to any University or Institution for the award of any degree.

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ABSTRACT

Self-compacting concrete, also referred to as self-consolidating concrete, is in a position to go with the flow and consolidate under its personal weight and is de-aerated almost definitely whilst flowing in the formwork. It is cohesive enough to fill the spaces of almost any size and structure barring segregation or bleeding. This makes SCC in particular really helpful at any place putting is difficult, such as in heavily-reinforced concrete contributors or in complex work forms. The goals of this lookup is blended effects of turritella and bentonite included in self-compaction concrete in order to make bigger in strength and a higher bonding between combination and cement paste. SCC has an advantage over conventional concrete in that it can be easily placed without vibration or mechanical consolidation. The properties of SCC have been studied in many researches due to its importance and ability to solve the problems of concrete mix.

Turritella and bentonite is used to replace cement in stepped concentration of 0 %, 5%, 10%, 15%, and used to gain characteristic compressive strength of M_{30} grade concrete mix and cured normal water and nitric acid solution (HNO_3) in for different ages (7 days and 28 days) were determined. Nitric acid used for the curing of normal water in the concentration of 1% and 5%.This lookup is aimed to look at the degradation of self-compacting concrete (SCC) due to nitric acid assault particularly based totally on measurement of compressive energy loss. The outcomes of excessive extent turritella and bentonite at 0% to 15% cement substitute degrees on the extent of degradation to nitric acid will be assessed in this study. Trial mixes with the various water cement ratio, substitute percentage, extent of notable plasticizer and viscosity bettering agent, have been equipped and tested. The test results for acceptance characteristics of self-compacting concrete such as slump flow and T_{50}cm, V-funnel, T_5 minutes and L-Box are presented.

Keywords: Bentonite, Compressive strength, Nitric acid, Super plasticizer, Self-compactingconcrete,turritella.

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Nomenclature

SCC	**Self compacting concrete**
RHA	**Rice husk ash**
HPC	**High performance concrete**
OPC	**Ordinary Portland cement**
CA	**Coarse aggregate**
FA	**Fine aggregate**

CHAPTER 1

INTRODUCTION

1.1 General

Self-compacting concrete (SCC) is a new kind of high performance concrete (HPC) developed in Japan in 1986. The development of SCC has made casting of dense reinforcement and mass concrete convenient. Fresh self-compacting concrete SCC flows into formwork and around obstructions under its own weight to fill it completely and self-compact (without any need for vibration), without any segregation and blocking. SCC mixes generally have a much higher content of fine fillers, including cement, and produce excessively high compressive strength concrete, which restricts its field of application to special concrete only.

Self-compacting concrete has been successfully used in Japan, Denmark, France, U.K., etc. It is widely been accepted because of its enhanced properties also it reduces noise pollution, saves time, labour and energy.

Cement used in concrete is a mixture of complex compounds. Cement is a major industrial commodity that is manufactured commercially in over 120 countries. Mixed with aggregates and water, cement forms the ubiquitous concrete which is used in the construction of buildings, roads, bridges and other structures. In countries, even where wood is in good supply, concrete also features heavily in the construction of residential buildings. Production of concrete using Portland cement is popular all over the world. This is due to mainly low cost of materials and construction for concrete structures as well as low cost of maintenance. But high amount of energy is required for manufacturing of cement which emits carbon dioxide (CO_2) which is very harmful for the environment. In order to minimize this problem we use the concept of supplementary cementitious material. Some of agricultural and industrial waste ash which was fulfilled the criteria as supplementary cementitious materials.

With the addition of turritella and bentonite weight density of concrete reduces by 72-75%. Thus, the use of turritella and bentonite in concrete leads to around 8-12% saving in material cost. So, the addition of turritella and bentonite in concrete helps in making an economical concrete. Under the acid attack also turritella and bentonite concrete shows better compressive than the normal concrete.

An experimental study on mechanical properties, such as compressive strength, flexural strength of self-compacting concrete (SCC) and the corresponding properties of self-compacting concrete were studied. The age at loading of the concretes for 7 and 28 days curing.

Making concrete structure without compaction has been done in the past. Like placement of concrete underwater by the use of term i.e., without compaction. Inaccessible areas were concreted using such techniques. The production of such mixes often used expensive admixtures and very large quantity of cement. But such concrete was generally of lower strength and difficult to obtain. SCC is a high performance concrete that consolidates under its self-weight, and adequately fills all the voids without segregation, excessive bleeding or any other separation of materials, without the need of mechanical consolidation.

Concrete is the most basic element for any kind of construction work. No matter what type of building structure it is, the concrete used should be study and well compacted. The main reasons for compacting any type of concrete are:

- To ensure maximum density by removal of any entrapped air.
- To ensure that the concrete used is in full contact with both the steel reinforcement and the form work.

Ensuring the above points not only provide additional strength to the structure but also good finish and appearance to the final product. The compacting of any conventional concrete is done through external force using mechanical device.

For SCC, it is generally necessary to use super plasticizers in order to obtain high mobility. Adding a large volume of powdered material or viscosity modifying admixture can eliminate segregation. The powdered materials that can be added are turritella and bentonite.

Self compacting concrete (SCC) is a fluid mixture, which is suitable for placing in difficult conditions and also in congested reinforcement, without vibration. Development of self-compacting concrete (SCC) is a desirable achievement in the construction industry in order to overcome problems associated with cast-in-place concrete.

1.2 Acid attack on concrete

- Concretes made of Portland (OPC) are highly alkaline with pH values normally above 12.5 and are not easily attacked by acidic solutions.

- As the pH of the solution decreases the equilibrium in the cement matrix is being distributed, and the hydrated cement compounds are specially altered by hydrolytic decomposition which leads to the severe degradation of the technical properties of the material

Figure 1.1 Acid attack on concrete

- At pH values lower than 12.5 portlandite is the first constituent starting dissolution.

- The final reaction products of the acid attack are the corresponding calcium salts of the acid as well as hydrogels pf the silicium, aluminium, and ferric oxides.

- The solubility of Al_2O_3 .aq, and Fe_2O_3 depends on the pH value of the acting solution, while SiO_2 is insoluble in acidic solutions except in HF.

Types of acids which attack on concrete

ACID ATTACK

WEAK ACIDS

- Acetic acid
- Carbolic acid
- Carbonic acid
- Lactic acid
- Phosphoric acid
- Tannic acid

STRONG ACIDS

- Hydrochloric acid
- Sulphuric acid
- Sulphurous acid
- Nitric acid
- Hydroflouric acid
- Hydrobromic acid

Figure 1.2 Decomposition of concrete

SULPHURIC ACID ATTACK:

- Sulphuric acid attack causes extensive formation of gypsum in the regions close to the surfaces, and tends to cause disintegrating mechanical stresses which ultimately lead to spalling and exposure of the fresh surface.

- Owing to the poor penetration of sulphuric acid, the chemical changes of the cement matrix are restricted to the regions close to the surfaces.

- However, in some cases it is observed that deterioration process occurs accompanied by the scaling and softening of the matrix due to the early decomposition of calcium hydroxide and the subsequent formation of large amount of gypsum.

- The chemical reactions involved in sulphuric acid attack on cement based materials.

NITRIC ACID ATTACK:

- Nitric acid usually occurs in chemical plants producing explosives, artificial manure and similar products.

- Nitric acid can be formed from the compounds and radicals of nitrates in the presence of water.

- Though $HN0_3$ is not as strong as H_2S0_4, its effect on concrete at brief exposure is more destructive since it transforms CH into highly soluble calcium nitrate salt and low soluble calcium nitro-aluminate hydrate.

- Pavlik reported that the corroded layer developed by the action of nitric acid solution with concentrations ranging between 0.025 to 0.5 mol 1-1 is soft, and porous with visible cracks.

- Nitric acid attack is a typical acidic corrosion for shrinkage of the corroded layer due to leaching of highly soluble calcium nitrate.

- Such volume contractions of the corroded layer, especially for the case of nitric acid, can result in the formation of visually observable cracks across the corroded layer.

- In the presence of these cracks the transport rate of acid and corrosion products to and from the corrosion front increases and this accelerates the process of deterioration

ACETIC ACID ATTACK:

- Concrete in use in agricultural applications may be attacked by the silage effluents containing mainly acetic and lactic acid.

- Acetic acid reacts with cement hydration products to form calcium acetate.

- Attack by Acetic acid resembles the process of corrosion in nitric acid. However the growth of the corroded layer in solutions of acetic acid is relatively slower than that in the same concentrations of nitric acid solution.

- The chemical composition of the corroded layer is different from that in nitric acid solution of the same concentration due to higher pH values of the acetic acid solution, and due to its buffering effect in corroded layer.

- In lower concentrations of both acetic and nitric acid solutions, e.g. 0.025 mol 1-1, results in the formation of an additional zone, called as core-layer, which is relatively hard and located behind the corroded layer.

- Chemical compositions of the core layers in both acetic and nitric acid attacks are similar.

- Core-layer originates due to portlandite dissolution in unaffected part of the cement paste and diffusion of Ca_2+ and OH- ions towards corrosion zone where they meet the acid diffusing from the opposite direction.

- Formation of the core layer is noticeable only when the concentration of acid is low because in such a case the rate of diffusion of ions from the acidic solution is high enough to dissolve portlandite, but not sufficiently high to decalcify the other hydrates.

HYDROCHLORIC ACID ATTACK:

- The chemicals formed as the products of reaction between hydrochloric acid and hydrated cement phases are some soluble salts and some insoluble salts.

- Soluble salts, mostly with calcium, are subsequently leached out, whereas insoluble salts along with amorphous hydro gels, remain in the corroded layer.

- Besides dissolution, the interaction between hydrogels may also result in the formation of some Fe-Si, A1-Si, Ca-Al-Si complexes which appear to be stable in pH range above 3.5.

- The reaction essentially causes leaching of from the set cement.

- After leaching out of C-S-H and ettringite start to decompose, with release of Ca_2+ to counteract the loss in and the set cement starts to disintegrate accelerating the dissolution.

- There are few indications through experiments about the formation of Friedel's salt, $C_3A.CaC1_2.10H_20$, by the action of $CaC1_2$, formed due to reaction of HCL with CH and C_3A.
- Hydrochloric acid attack is a typical acidic corrosion which can be characterized by the formation of layer structure.
- Chandra divided the cross section of damaged prisms into three main zones; undamaged zone, hydroxide mixture zone or brown ring, and attacked zone.
- By hydroxide mixture zone, he referred to a layer formed by undissolved salts seen as a dark brown ring

CHAPTER II

LITERATURE REVIEW

R.Venu , B.suraj ,G.VenkataRamana (2018): The characteristics of SCC have been studied in many researches due to its importance and ability to solve the problems of concrete mix. Turritella and bentonite and sugarcane bagase ash (SCBA) is used to substitute cement in s percentages of 0 %, 5%, 10%, 15%, 20% and used to obtain characteristic compressive strength and cured ordinary water and nitric acid solution (HNO_3) in for exclusive a long time (7days, 28days) is to be determined. Nitric acid used for the curing in the attention of 1%, 3%, 5%. This research is to look into the degradation of self compacting concrete due to assault of nitric acid based totally on measurement of compressive strength loss. The take a look at consequences want to be should acceptance the characteristics of self-compacting concrete such as slump flow, V-funnel, U-box and LBox are presented and cured in 1% of acid solution.

B.Ranganath, G.Sailaja Kumari (2018): In this study the past decades covered the Sulphate attacks from different aspects to improve the resistance of concrete to acid attacks, used mineral additives such as Fly ash and Silica fume. In this study, the different admixtures were used to study their sole and combined effects on the resistance of concrete in addition to their effects on mechanical and durability properties by the replacement of admixtures by 10%, 20% & 30% by the weight of cement. Here 5% of HNO_3 used.

Sagar W. Dhengare, Dr.S.P.Raut, N.V.Bandwal, Anand Khangan(2015): The utilization of industrial and agricultural waste produced by industrial processes has been the focus on waste reduction. Ordinary Portland cement (OPC) is partially replaced with finely sugarcane bagasse ash. The concrete mixtures, in part, are replaced with 0%, 10%, 15%, 20%, of SCBA respectively. In addition, the compressive strength, the flexural strength, the split tensile tests were determined. The mix design used for making the concrete specimens was based on previous research work from literature. The water –cement ratios varied from 0.44 to 0.63. The tests were performed at 7, 28, 56 and 90 days of age in order to evaluate the effects of the addition SCBA on the concrete. The test result indicate that the strength of concrete increase up to 15% SCBA replacement with cement.

K Meeravali, K V G D Balaji, T. Santhosh Kumar (2014): They studied on, "Partial replacement of Cement in Concrete with bentonite behaviour in HNO_3 Solution". In this paper concrete cubes are casted with different percentages of Sugarcane Bagasse ash replaced with cement by weight (i.e. 0%, 5%, 10%, 15%, 20%,and 25%), and this cubes are exposed to 5% HNO_3 environment. Compressive strength of cubes for 7days, 28 days and 60days are observed.

Divyachopra et al (2015): Carried out a study on strength, permeability and micro structure of self compacting concrete containing Turritella and bentonite. The cement is replaced by Turritella and bentonite as supplementary cementations material. SCC was tested for fresh and hardened state for four different mixes. The Turritella and bentonite is replaced by cement by varying percentages from 0, 10, 15 and 20. To improve the workability high range water reducer super plasticizer is used up to 25% without loss of workability. By the replacement of 15% Turritella and bentonite shows good workability and up to 33% of strength increased. The replacement increased to 20% the strength decreased but 20%Turritella and bentonite mix shows increase in porosity, but it is still less than the control mix. In this study porosity decreased with increases in age. This is basically due to large formation of C-S-H gel, dense structure is formed, so porosity decreased. From XRD and SEM analysis shows the formation of C-S-H gel at the replacement of 15% Turritella and bentonite concrete helps increase in compressive strength. Pores and cracking were at maximum for the control mix.

Kannan et al (2013): Carried out an experiment of chloride and chemical resistance of self compacting concrete using Turritella and bentonite and Metakaolin (MK) as filler materials and replacement of cement. Seventeen different mixes for various proportions were designed including ordinary SCC and tested for suitability. The percentage replacement of Turritella and bentonite and MK adopted in this study were 5%, 10% 15%, 20%, 25% and 30% in separate and combined percentage replacement of Turritella and bentonite and MK were 5%, 10%, 15% and 20% with the addition of super plasticizer (SP). The fresh state is tested for all mix and the flow properties are observed. From the results it was observed that compressive strength increased at a replacement of 15% (Turritella and bentonite), 20% and 30% (MK) in combination of both. The durability test to determine the acid resistance is carried out by immersing the cube in H2SO4 solution, the result shows that there is a better improvement during individual replacement of Turritella and bentonite and MK at 25% and 5% respectively and 40% of combination of turritella and bentonite and MK. The SEM analysis clearly states that there were no pores while Turritella and bentonite and MK are combined together.

Edwin Fernando et al (2014): Carried out an experimental investigation on self compacting concrete by replacing the fly ash as a filler material and copper slag as fine aggregate at a percentage of 5%, 10%, 15%, 20% and 25%. Mix design is done as per EFNARC specification by keeping water cement ratio of 0.40 all mix and super plasticizer was used to increase the flow properties. The fresh and hardened properties of concrete was tested as per the standards and compared for normal SCC and SCC with partial replacement of fly ash and copper slag. The result shows a marginal improvement in the replacement of cement by turritella up to 40%.

Nileena et al (2014): Replaced the Ground Granulated Blast Furnace Slag and Granulated Blast Furnace Slag as filler material by the water cement ratio of 0.45. Six different mix proportions were prepared with a partial replacement of cement by GGBS at 30%, 40% and 50% and GBS at 30%, 40% and 50% as partial replacement of fine aggregate. Super plasticizer is used to achieve the self compatibility. The standard tests for fresh and hardened concrete was carried out and it was observed that only a small increase in compressive strength was achieved for 20% partial replacement of GGBS and GBS. But, ultrasonic pulse velocity shows an excellent result that there is no crack or undulations inside the specimen.

Columna (1974) Had started the primary work on Turritella and bentonite at the Asian Institute of Technology. Rice husks were converted into ash at temperature less than 300˚C. Little has been reported about the characteristics of cement based on uncontrolled combustion of the husks. However, since the ash is largely crystalline, the lime-silica reaction was weak and reported that the strength of resulting cement was low.

Mehta (1975) Has reported that when the rice turritella and bentonite was burnt in the open air in conventional Turritella and bentonite mill.Turritella and bentonite hull produced crystalline silica ash. A process for developing cement from Turritella and bentonite hull has been developed and patented by Mehta at the University of California at Berkely. When burnt under proper conditions, especially in a controlled temperature furnace, the residue was a highly reactive black ash, which when mixed with lime, became turritella and bentonite black cement. Blend of turritella and bentonite hull ash with Portland cement produced a cementing material which was capable of moulding mortars and concretes with 28 day compressive strength of over 8000 psi (27 MPa). Laboratory results had shown that rice hull cement containing only from 15- 20 % lime was acid resisting. Reinforcing of rubbers with turritella was another application of turritella and bentonite ash.

Mehta (1977) Has shown that when turritella and bentonite were burnt under controlled condition, the ash was in the form of amorphous silica with a cellular microstructure, making it a super pozzolan of high reactivity. When turritella and bentonite was added to Portland cement, turritella and bentonite reacted faster than fly ash with the lime released from Portland cement during hydration and that helped to improve the early-age strength of concrete, but formed a calcium silicate hydrate (CSH gel) around the cement particles with dense and less porous. In this study properties of both lime-turritella and bentonite and OPC-turritella and bentonite cements were investigated. Due to relatively high water demand, the lime-turritella and bentonite cement developed lower compressive strength. However the strength characteristics were considered adequate for general masonry works. OPC-turritella and bentonite cement containing up to 50% ash showed compressive strengths which were considerably higher than that control portland cement even at the early age of 3 and 7 days. It is also reported that the cement containing turritella and bentonite had excellent resistance to dilute organic and mineral acids.

Mehta and Pirtz (1978) Have reported that a highly reactive silica ash produced by incineration of turritella and bentonite hulls could be successfully used in mass concrete applications requiring high strength without excessive rise in adiabatic temperature. Due to exceptionally high surface area of the ash, the concrete containing RHA showed only 13mm slump as compared to 95mm slump for control concrete. To provide the same slump as that of control concrete, additional water and corresponding cementitious material would have been needed, hence the strength. Under this condition the difference in heat evaluation could have been substantially reduced. In a concrete mixture when 30% turritella and bentonite by weight of total cementing material was present, the 7 and 28 days compressive strength were higher and the adiabatic temperature rise was 18° F (10°C) lower than that of control concrete. It was also shown that mortars made with turritella and bentonite ash cement had superior resistance to acidic environments compared even to OPC and other pozzolans. When the lime turritella and bentonite mixes were stored in 1% acetic acid solution, it remained in excellent condition for more than five years, whereas Portland cement showed surface softening and substantial weight loss within one year.

Vyavhare et al. Optimized the workability and flow ability. Bagasse ash was partially replaced in the ratio of 0%, 10%, 20%, 30% and 40% by volume of fine aggregate in concrete. Fresh concrete tests like the compaction factor test and the slump cone test were undertaken along with hardened concrete tests like compressive strength, split tensile strength and sorptivity in accordance with Indian Standards. The result shows that bagasse ash can be a suitable replacement to fine aggregate.

Srinivasan et al. Studied chemical and physical characterization of SCBA, and partially replaced in the ratio of 0%, 5%, 15% and 25% by weight of cement in concrete. Compressive strength, split tensile strength, flexural strength and modulus of elasticity at the age of 7 and 28 days was obtained as per Indian Standards. It was found that the cement could be advantageously replaced with SCBA up to a maximum limit of 10%. Therefore it is possible to use sugarcane bagasse ash (SCBA) as cement replacement material to improve quality and reduce the cost of construction materials such as concrete

Kawade et al. Studied the effect of use of SCBA on strength of concrete by partial replacement of cement at the ratio of 0%, 10%, 15%, 20%, 25% and 30% by weight for compressive strength. If some of raw material having similar composition can be replaced by weight of cement in concrete then cost could be reduced without affecting its quality. It was found that the cement could be advantageously replaced with SCBA up to maximum limit of 15%. Partial replacement of cement by SCBA increases workability of fresh concrete; therefore use of super plasticizer is not essential. All tests were done in accordance with American Standards.

Singh et al (2000) Evaluated the hydration of the bagasse ash blended Portland cement by employing a number of experimental techniques. It was found that in the presence of bagasse ash, setting times were increased and free lime content was decreased. The overall results indicated that BA act as a pozzolanic material, and in its presence the extent of hydration was lower as compared to that of control. However, in the presence of 10 % BA the compressive strength values were found to be higher than that of control at all ages of hydration. The chemical deterioration of blended cement mould in the presence of N/60 H_2SO_4 was lower compared to that of control. It was due to the pozzolanic reaction of BA and the reduction in permeability in its presence.

Praveen Kumar Gupta, Rakesh Kumar, Y.K. Gupta and P.K. Mehta (2017): The SCC samples were prepared by replacing of 10, 15 and 20 % Ordinary Portland Cement (OPC) by fly ash. The NVC was prepared with OPC only. The parameters investigated include visual inspection, percentage loss of compressive strength and mass loss in 2% sulfuric acid and 2% hydrochloric acid solution.

J. Guru Jawahar, A. Bhavana.(2015): The compressive strength, weight and ultrasonic pulse velocity (UPV) values of GPC mixes were determined after 28 days of immersion in 3% sulphuric acid (H_2SO_4) after 28 days of ambient room temperature curing. The slag and quarry dust replaced GPC mixes performed better than bottom ash replaced mixes at ambient room temperature curing at all ages.

S.A.Kristiawan (2016): The effect of high volume fly ash at 50-70% cement replacement levels on the extent of degradation owing to sulfuric acid will be assessed in this study. It can be shown that an increase in the utilization of fly ash to partially replace cement tends to reduce the degradation as confirmed by less compressive strength loss and diameter change. The effect of fly ash to reduce the degradation of SCC is more pronounced at a later age with 2% acid solution.

CHAPTER III

OBJECTIVES OF THE PROJECT

3.1 Objectives

The main objective is to obtain specific experimental data, to understand fresh and hardened properties of the self compacting concrete and design M_{30} grade self compacting concrete. The following are the important objectives of the self compacting concrete. They are

- To design and produce mix proportions for self compacting concrete (SCC).
- To obtain and compare the physical and chemical properties of self compacting concrete.
- To evaluate the physical properties and chemical properties of turritella and bentonite .
- To observe the literature review of self compacting concrete using turritella and bentonite .
- To determine the various tests such as slump flow and T_{50cm}, L-box, U- box, T_5 minutes and V-funnel etc.
- In this project, admixtures such as turritella and bentonite ash is used the replacement of cement because of gain the strength of concrete.
- The turritella and bentonite used to replacement of cement in stepped concentration of 0%, 5%, 10%, 15 to gain characteristic compressive strength of M_{30} grade concrete mix and cured normal water in Nitric acid solution (HNO3).
- Nitric acid used for curing of normal water in the percentage of 1% and 5%.

CHAPTER IV

DATA COLLECTION

4.1 Materials used in the present work

Self compacting concrete has material requirements same as standard concrete, but it requires admixtures like turritella and bentonite to enhance the workability. Type of materials required and their applications and properties for self compacting concrete are discussed. The super plasticizer and nutric acid also discussed in the present project. The materials used in the present work are cement, fine aggregate, coarse aggregate, turritella and bentonite nitric acid, super plasticizer.

Following are the materials used for the self compacting concrete. They are

4.1.1 Cement

Turritella and bentonite admixture used in the replacement of cement in the percentages of 0%, 5%, 10%, 15%, and 20%.The cement used was ordinary Portland cement (OPC) of 53 grades. It is made from a mixture of lime stone ($CaCO_3$) and clay, shale, other alumina silicate. The initial setting time OPC is 30 minutes (minimum) and final setting time is 600 minutes (maximum). The chemical compositions of OPC are

CaO	60-67%
SiO_2	17-25%
Al_2O_3	3.0-8.0%
Fe_2O_3	0.5-6.0%
MgO and SO3	0.1-4.0% and 1.3- 3.0%
Alkalies (K_2O, Na_2O)	0.4-1.3%

4.1.2 Fine Aggregate

The river sand, passing through 4.75mm sieve and retained on 600μm sieve, conforming to Zone II was used as fine aggregate in the present study. The sand is free from clay, silt and organic impurities. The aggregate was tested for its physical requirements such as gradation, fineness modulus, and specific gravity and bulk modulus.

Fine mixture normally consists of natural, crushed, or manufactured sand. Natural sand is the traditional issue for everyday weight concrete. In some cases, manufactures light weight particles are used for mild weight concrete and mortar. Heavy weight particles made of metallic elements are now and again used to produce heavy weight concrete for nuclear protective purposes.

4.1.3 Coarse Aggregate

A Machine crushed angular granite metal of 12mm nominal size from the local source is used as coarse aggregate. It is free from impurities such as dust, clay particles and organic matter etc. It is an important compound of concrete. It decreases the shrinkage and economical of the structures.

Coarse aggregates can be normal weight, light weight or heavy weight in nature. Normal weight coarse aggregates can be made of herbal gravel or beaten stone. Light weight coarse aggregate are generally made of increased clay such as shale, pumice or blast furnace slag.

4.1.4 Water

The water used for the study was obtained from a free flowing stream. The water was clean and free from any visible impurities. The pH value should not be less than 6.

Water used in this work is found to be free from oils, acids, alkali, salts, sugar and organic matter. Portable water is used to combine more than a few mortars and concretes. The equal water is also used for curing.

Importance of water

Water that can be used in the concrete work has to have the following properties:

- It should be free from injurious quantity of acids and alkalis or other such natural and inorganic impurities.
- It ought to be free from injurious quantity of oils.
- It have to be free from iron, vegetable count number or any different substance that can have an unfavorable impact on the concrete and reinforcement.
- It should be in shape for ingesting purpose.

4.1.5 turritella and Bentonite

Turritella and Bentonite is obtained by burning turritella and bentonite in a controlled manner without causing environmental pollution. When properly burnt, it has high SiO_2 content and can be used as a concrete admixture.Turritella and Bentonite exhibits high pozzolanic characteristics and contributes to high strength and high impermeability of concrete. The chemical composition of turritella and bentonite is found to vary from one sample to another due to the differences in the type of paddy, crop year, climate and geographical conditions..

Sl. No	Parameters	Values
1	Fineness passing 45 micron	96%
2	Specific gravity	2.06
3	Specific surface (nitrogen absorption) m^2/kg	27400
4	Silicon dioxide (SiO_2)	87.20%
5	Aluminium oxide (Al_2O_3)	0.15%
6	Ferric oxide (Fe_2O_3)	0.16%
7	Calcium oxide (CaO)	0.55%
8	Magnesium oxide (MgO)	0.35%
9	Sulphur trioxide (SO_3)	0.24%
10	Carbon (C)	5.91%
11	Loss on ignition	5.44%
12	Pozzolanic activity	84%
13	Particle size (μm)	7

Figure 4.1 properties of turitella and bentonite

4.1.6 Nitric acid (HNO3)

Nitric acid or muriatic acid is a colorless inorganic chemical system with the formula H_2O:HNO3. Nitric acid has a distinctive pungent smell. It is classified as strongly acidic and can attack the skin over a wide composition range, since the hydrogen chloride completely dissociates in an aqueous solution. Nitric acid is the simplest chlorine-based acid system containing water. It is a solution of hydrogen chloride and water, and a variety of other chemical species, including hydronium and chloride ions. It is a naturally-occurring component of the gastric acid produced in the digestive systems of most animal species, including humans. It is an important chemical reagent and industrial chemical, used in the production of polyvinyl chloride for plastic. In households, diluted Nitric acid is often used as a decaling agent. In the food industry, nitric acid is used as a food additive and in the production of gelatin. Nitric acid is also used in leather processing.The HNO3 adding water in the curing tank in the percentages of 1% as shown figure 4.2

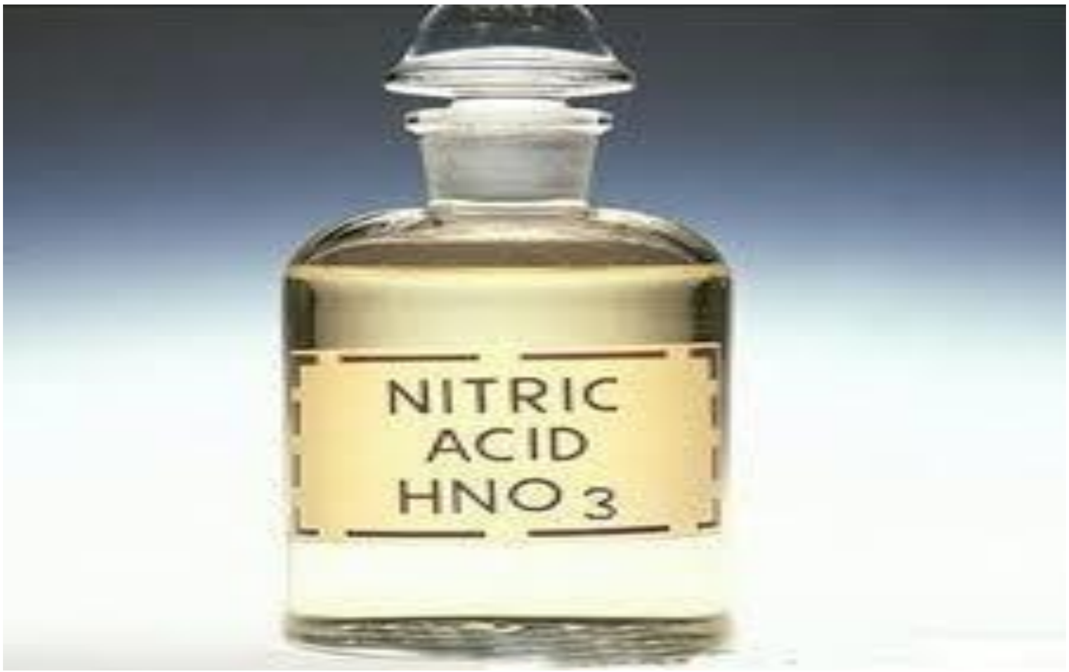


Figure 4.2 Nitric acid

Figure 4.3 Curing Tank

4.1.7 Super Plasticizer

Conplast sp 430 in liquid structure with 65% free water is used. High range water reducing admixture called as super plasticizers are used for improving the flow or workability for decreased water-cement ratio without sacrifice for compressive strength. These admixtures when they disperse in cement agglomerates significantly decrease a viscosity of the paste by forming a thin film around the cement particles.

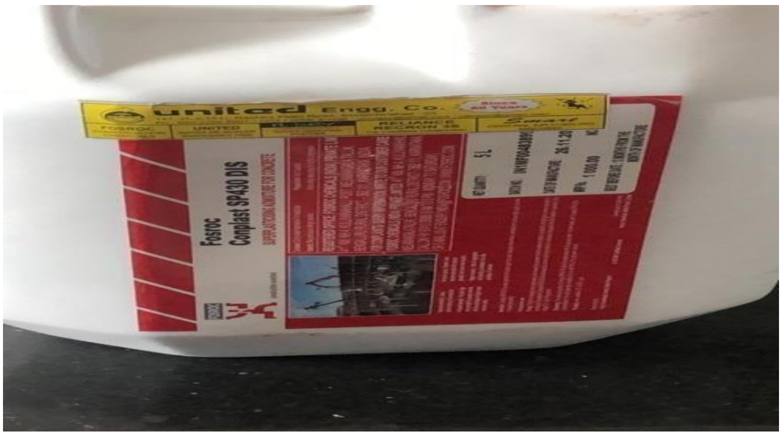


Figure 4.4 Super plasticizer

4.2 Uses of Turritella and Bentonite

Turitella and Bentonite is used in concrete improvement as an choice of cement in concrete.

- Due to the increasing charge of environmental air pollution and the consideration of sustainability issue have made the thought of utilizing turritella and bentonite.
- They have a very low bulk density of ninety to 150kg/m3. These penalties in a extended price of dry volume.
- The turritella and bentonite itself has a very rough surface which is abrasive in nature. These are for this cause resistant to herbal degradation.

4.3 Properties of Concrete with Turritella and Bentonite

The turritella and bentonite itself has a very hard surface which is abrasive in nature. These are consequently resistant to natural degradation. This would end result in improper disposal problems. So, a way to use these by-products to make a new product is the first-rate sustainable idea. Among all industries to reuse this product, cement, and concrete manufacturing industries are the ones who can use turritella and bentonite in a better way. The turritella and bentonite has true reactivity when used as a partial substitute for cement. These are distinguished in nations the place the rice production is abundant. The properly turritella and bentonite are located to be active inside the cement paste. So, the use and sensible utility of turritella and bentonite for concrete manufacturing are important.

The following homes of the concrete are altered with the addition of turritella and bentonite :

- The warmth of hydration is reduced. This itself help in drying shrinkage and facilitate durability of the concrete mix.
- The discount in the permeability of concrete structure. This will assist in penetration of chloride ions, hence warding off the disintegration of the concrete structure.
- There is a higher make bigger in the chloride and sulphate assault resistance.
- The turritella and bentonite in the concrete react with the calcium hydroxide to deliver greater hydration products.

4.4 Applications of Turritella and Bentonite

The turritella and bentonite is a green supplementary fabric that has applications in small to massive scale. It can be used for waterproofing. It is also used as the admixture to make the concrete resistant towards chemical penetration.

The main purposes of turritella and bentonite in the construction are:

- High-performance concrete
- Insulator
- Green concrete
- Bathroom floors
- Industrial factory floorings
- Concreting the foundation
- Swimming pools
- Waterproofing and rehabilitation

4.5 Chemical composition of Turritella and Bentonite

The paper deals with the bodily homes and chemical composition of turritella

and bentonite and dust. turritella and bentonite dust is formed as a end result of the discharge upon the receipt of turritella and bentonite from vehicles, elimination of impurities, sorting with the resource of size, in the direction of separation of membranes, crushing, grinding, polishing, shifting grain alongside the elevators and conveyors, i.e. at some point of all technological operations manufacturing of rice grouts. In order to dispose of dust, the group cyclone and the bag filter-cyclone are hooked up in the pneumatic conveying structures and suction plants. The paper shows the chemical composition of samples of turritella and bentonite, retained by using the use of the crew cyclone, and dust retained by using way of the bag filter-cyclone. Removing of impurities, sorting by means of size, at some stage in separation of membranes, crushing, grinding, polishing, moving grain along the elevators and conveyors, etc., i.e. all through all technological operations of the rice groats production. High filth recognition in the air is one of the most vital unfavorable factors, ensuing in environmental air pollution and occupational diseases. Prolonged respiration in the dusty air motives heavy damage to human health. Dust with a diameter larger than 10 microns motives irritation of the top respiratory tract.

The following are chemical composition of turritella and bentonite . They are

Particulars	**Proportion**
Silicon dioxide	86.94%
Aluminium dioxide	0.2%
Iron oxide	0.1%
Calcium oxide	0.3 – 2.25%
Magnesium oxide	0.2 - 0.6%
Sodium oxide	0.1 - 0.8%
Potassium oxide	2.15 - 2.30%

4.6 Burning Process of turritella and Bentonite

a) Open – Field Burning: This method of open burning of turritella and bentonite produces horrible first-rate turritella and bentonite. These produces specifically crystalline structure form which is of restrict reactivity.

b) Fluidized -Bed Furnace Burning: This is a managed approach of burning the turritella and bentonite. The combustion warmness of turritella,bentonite is used for the science of electricity. This is carried out for a longer time so that total getting rid of of the carbon is taken and the temperature is accelerated from seven hundred to 800 Celsius for a time of 1 minute.

c) Industrial Furnace: This approach is put in elevate to facilitate environmental and monetary reasons. This approach helps in producing the turritella and bentonite ashes with amorphous silica and mobile cell phone shape products. The turritella and bentonite ash produced with the aid of this strategy is in particular pozzolanic.

4.7 Principle of self compacting concrete

- Fluidity that allows self – compaction without external energy
- Remain homogeneous in a form during and after the placing process and
- Flow easily through reinforcement.

4.8 Properties of SCC

The key properties of SCC are filling ability, passing ability and resistance to segregation. Filling ability helps SCC to flow through the formwork and completely fill all the spaces within it. Passing ability is the property by which it flows without any blocking. The benefit of resistance to segregation imparts the advantage to the concrete in maintaining a uniform composition hence the paste and the aggregate bind together.

4.9 Application of SCC

The application of SCC aims at obtaining a concrete of high performance, better and more reliable, improved durability, high strength and faster construction. For SCC it is generally important to use super plasticizers in order to obtain high mobility. Some volume of powdered materials such asturitella and bentonite is also involved.

4.10 Advantages of SCC

At present self compacting concrete (SCC) can be classified as an advanced construction material. The SCC as the name suggests, does not require to be vibrated to achieve full compaction. This offers benefits and advantages over conventional concrete.

- Improved quality of concrete and reduction of onsite repairs.
- Faster construction times.
- Lower overall costs.
- Facilitation of introduction of automation into concrete construction. Improvement of health and safety is also achieved through elimination of handling of vibrators.
- Possibilities for utilization of dusts which are currently waste products and which are costly to dispose of.
- Better surface finishes.
- Easier placing.
- Thinner concrete sections.
- Greater freedom in design.
- Improved durability, and reliability of concrete structures.
- Ease of placement results in cost savings through reduced equipment and labour requirement

CHAPTER V

METHODOLOGY

5.1 Experimental Investigation

- In this project, for developing rich concrete mix, it is important to select proper ingredients, evaluate their properties and understand the interaction among different materials for optimum usage.
- The materials used for this investigation is the same as that used for the normal concrete mix such as cement, fine aggregate (FA), coarse aggregate (CA) and water. Along with these materials turritella and bentonite are used as a cement replacement material and super plasticizer as a chemical admixture.
- In this experimental work, the typical size of cube150mm×150mm×150mm is used. The mix design (procedure) of concrete is done according to Indian Standard guidelines for M_{30} grade. Based upon the quantities of component of the mixes, the numbers of SCBA and turritella and bentonite for 0%, 5%, 10%, 15%, replacement by weight of sand and weight of cement is estimated.
- The ingredients of concrete are thoroughly mixed in mixer machine till uniform consistency is achieved. Before casting, machine oil is smeared on the inner surfaces of the cast iron mould.
- Concrete is poured into the mould and compacted carefully using table vibrator. The top surface was over by means of a trowel. The specimens are removed from the mould after 24hours and then cured under water for a period of 7, 28 days.
- The samples are taken out from the curing tank just prior to the test. The compressive test conducted using the capacity above testing machine. These test are lead as per the relevant Indian Standard specifications.

5.2 Mix Proportion of Self Compacting Concrete (SCC)

The detailed steps for calculation of mix proportions of SCC are presented below.

Standard data of materials:

Dry rodded unit weight = 1608kg/m^3

% of coarse aggregate in DRUW = 46

% of sand in mortar = 45.3

% of air = 2

Specific gravity of CA = 2.66

Specific gravity of FA = 2.6

% absorption of CA = 0.3

% absorption of FA = 1.06

Specific gravity of cement = 3.15

Water cement ratio = 0.45

Step1: Standard Deviation (SD)

For M_{30} grade of concrete,

Standard deviation = 5 N/mm^2

Step2: Target Mean Strength

Target mean strength = f_{ck} + (1.65* SD)

= 30 + (1.65 * 5)

= 38.25N/mm^2

Step3: Select Water Cement ratio

Water cement ratio = 0.50

Step4: Calculation of Water Content

For 12mm and 10mm nominal maximum size of aggregate,

By interpolation,

10 ------ 200

20 -------180

10 ------ 20

6.........x

x = 6 * 20/10

x = 12

X = 208 + 12 = 220kg/m^3

Water content = 220kg/m^3

Step5: Calculation of Cement Content

Take W/C ratio = 0.50

Cement content = Water content/ w/c ratio

= 202/0.50

Cement content = 440 kg/m^3

Step6: Calculation of CA Content In concrete Volume

Coarse aggregate weight = 1608 * 46/100

= 739.68kg/m^3

CA = 739.68kg/m^3

Coarse aggregate volume = [771.84 * 60/100/2.66] + [771.84 * 40/100/2.66]

= 305.870Litre/m^3

= 30.5%

Step7: Calculation of Mortar Volume

Mortar volume = concrete volume – CA volume

= 1000 – 305.87

= 694.13Litre/m^3

Step8: Calculation of Sand Volume

% of sand in mortar volume = 45.30

Sand volume = 694.13 * 45.30/100

=314.4 Litre/m^3

Sand volume =314.4 *2.6

=817.44kg/m^3

Step9: Calculation of Paste Volume

Paste volume = Motar volume - Sand volume

= 694.13- 314.4

= 388.28Litre/m^3

Step10: Calculation of Constituent Materials for Concrete

Specific gravity of sand = 2.6

% of absorption of CA = 0.3

% of absorption of FA = 1.06

% of moisture in CA = 0

% of moisture in FA = 0

Water content = 220kg/m^3

Cement = 440kg/m^3

CA = 739.68kg /m^3

For 12mm CA1 = 739.68 * 35/100

= 258.88 kg/m^3

For 10mm CA2 = 739.68 * 75/100

= 308.736kg/m^3

Adjusted water content:

Initial water – [CA1 *(% of moisture - % of absorption/100)] – [CA2 *(% of moisture - % of absorption/100)] – [Sand *(% of moisture - % of absorption/100)]

= 192- [463.104 *(0 - 0.3/100)] - [308.736 *(0 - 0.3/100)] - [836.043 *(0 – 1/100)]

= 192 + 1.39 + 0.92 + 8.36

= 220.2Litre/m^3

Adjusted 12mm CA:

= CA1 * [1+ % of moisture/100]

= 463.104[1+0/100]

= 463.104kg/m^3

Adjusted 10mm FA:

= CA2 * [1+ % of moisture/100]

= 258.88 [1+0/100]

= 258.88 kg/m^3

Adjusted FA or Sand: = FA * [1+ % of moisture/100]

= 503.04[1+0/100]

= 503.04kg/m^3

Step11: Mix Proportion of Constituent Materials

Cement = 440kg/m^3 or 1.00

Fine aggregate or sand = 503.04kg/m^3 or 1.14

Coarse aggregate = 739.68 kg/m^3 or 1.68

Water = 220kg/m^3 or 0.50

Mix Proportion by mass = 1.00:1.14:1.68:0.50

5.3 Casting of Specimens

Concrete specimens of 150 X 150 X 150mm cubes were casting. After 24 hours the specimens were demoulded and subjected to curing for 7days, 28days in clean fresh water. The total cubes are casted in the characteristic compressive strength of M_{30} grade concrete. The total 30 concrete cubes were casted in the percentages of 0%, 5%, 10%, 15%as shown in figure 5.1 and 5.2.

Figure 5.1 Casting of Specimens

Figure 5.2 Casting of Specimens

5.4 Workability Test Methods

The Self compacting concrete has the residences such as filling ability, passing ability and segregation resistance. Various workability assessments techniques are available for self compacting concrete such as slump go with the flow tests, V-funnel test, L-box test, T5 minutes and U-Box test as shown below table.

The tests strategies here are devised in particular for self compacting concrete. Existing rheological take a look at procedure have no longer regarded here, though the relationship between the effects of these exams and the rheological characteristics of the concrete is probable to discern especially in future work, which include standardization work. Test methods to determine workability of Self Compacting Concrete are:

List of test methods for workability properties of SCC

1. Slump flow Test	Filling Ability
2. T50cm Slump Flow	Filling Ability
3. V- Funnel Test	Filling Ability
4. V – Funnel at T5 minutes	Segregation and Resistance
5. L- Box Test	Passing Ability
6. U- Box Test	Filling Ability

5.4.1 Slump Flow & T50 test

Slump Flow is definitely one of the most commonly used SCC tests at the current time. This test involves the use of the slump cone used with self compacting concrete. the Slump Flow test measures the “spread” or “flow” of the concrete sample once the cone is lifted rather than the traditional “slump” (drop in height) of the concrete sample. The T_{50} test is determined during the Slump Flow Test, it is simply the amount of time that the concrete takes to flow to a diameter of 50 centimeters. Typically, Slump Flow values of approximately 24 to 30 inches are within the acceptable range; acceptable T50 times range from 2 to 5 sec.

Apparatus

- Mould in the shape of a truncated cone with the internal dimensions 200 mm diameter at the base, 100 mm diameter at the top and a height of 300 mm
- Base plate of a stiff non-absorbing material, at least 700mm square, marked with a circle marking the central location for the slump cone, and a further concentric circle of 500mm diameter.
- Trowel
- Scoop
- Ruler
- Stopwatch

Procedure for slump flow and T50

- Dampen slump flow table and slump cone as shown figure 5.3.
- Level the slump flow table.
- Place cone on the centre of the table that has a circle having a diameter of 50 centimetres drawn concentrically to the location for the slump cone.
- Using funnel and with one person holding cone down (as to avoid concrete pushing itself underneath the cone), continuously fill the cone with a representative sample concrete from bucket.
- Screed and level the concrete from the top of the cone as to ensure the proper amount of concrete is within the cone.
- Immediately remove funnel as shown figure 5.3.
- Immediately lift cone in an upward direction and begin to time the concrete (from the instant the lift started) for the T_{50} time (the cone should be raised at a rate of approximately one foot in two seconds). 8. Stop the timing device when the concrete reaches the T50 line and record this time to the nearest ½ second as the T50 value.
- Once the concrete has ceased to flow (no more than one minute from the lifting of the cone) measure the width of the spread of concrete across the widest dimension through the center of the spread to the nearest ½"; measure again at a 90 degree angle.
- Record the Slump Flow as the average of the two measurements.

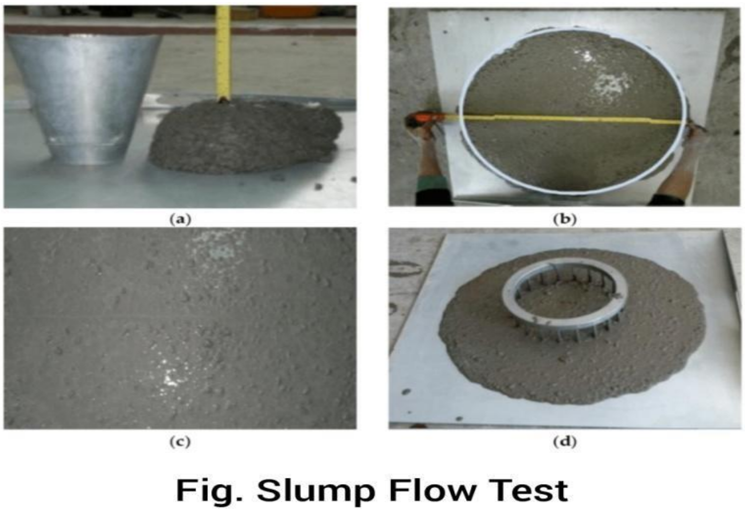


Figure 5.3 Slump Flow Test

5.4.2 Slump Cone Test

The droop waft test is used check the horizontal free float of self compacting concrete in the absence of obstructions. It was first developed in Japan for use in assessment of underwater concrete. The check method is primarily based on the take a look at approach for finding out the slump. T is the diameter of the concrete circle is a measure for the filling capacity of the concrete.This is a simple, speedy check procedure, though two human beings are wished if the T_{50} time is to be measured. It can be used on site, though the size of the base plate is truly unwieldy and degree ground is essential. It is the most often used test, and gives a true evaluation of filling ability. It offers no indication of the capacity of the concrete to pass between reinforcement except booking, but may supply some indication of resistance to segregation. It can be argued that the definitely free flow, unrestrained by way of any foundries, is now not representative of what occurs in concrete construction, but the check can be profitably be used to verify the consistency of grant of furnish of ready-mixed concrete to a web site from load to load.

Apparatus:

• Slump cone,

• Scale for measurement,

• Temping rod (steel)

Procedure:

- The mold for the droop testis a frustum of a cone, 300 mm (12 in) of height. The base is 200 mm (8in) in diameter and it has a smaller opening at the pinnacle of one hundred mm (4 in).
- The base is positioned on a easy flooring and the container is stuffed with concrete in three layers, whose workability is to be tested.
- Each layer is temped 25 times with a popular 16 mm (5/8 in) diameter metal rod, rounded at the end.
- When the mould is totally stuffed with concrete, the pinnacle floor is struck off (leveled with mould pinnacle opening) by skill of screening and rolling movement of the temping rod.
- The mildew ought to be firmly held against its base in the path of the entire operation so that it may additionally desire to now no longer pass due to the pouring of concrete and this can be accomplished through means of handles or foot - rests brazed to the mold.
- Immediately after filling is completed and the concrete is leveled, the cone is slowly and cautiously lifted vertically, an unsupported concrete will now slump.
- The limit in the height of the middle of the slumped concrete is known as slump.
- The hunch is measured thru placing the cone simply barring the hunch concrete and the temping rod is positioned over the cone so that it have to also come over the place of slumped concrete.
- The decrease in pinnacle of concrete to that of mould is noted with scale(usually measured to the nearest 5 mm (1/4 in) as shown in figure 5.4.

Figure 5.4 Slump Cone Test

5.4.3 L-box test

The L-box value is a ratio of the levels of concrete at each end of the box after the test is complete. The L-box consists of a “chimney” section and a “trough” section after the test is complete, the level of concrete in the chimney is recorded as H1. The level of concrete in the trough is recorded as H2. The L-box value (also referred to as the “L-box ratio”, “blocking value”, or “blocking ratio”) is simply H2/H1. Typical acceptable values for the L-box value are in the range of 0.8 to 1.0. If the concrete was perfectly level after the test is complete, the L-box value would be equal to 1.0, if the concrete was too stiff to flow to the end of the trough the L-box value would be equal to zero.

Apparatus

1. L-Box of a stiff non-absorbing material

2. Trowel

3. Scoop

4. Stopwatch

Procedure

- Dampen all surfaces of the L-box that will be in contact with concrete.

- ➢ Make sure that the gate is restrained as to avoid premature flow of concrete through the L-box.
- ➢ Continuously fill the upper portion of the L-box with a representative sample concrete from a bucket.
- ➢ Screed the concrete from the top of the box as to ensure the proper amount of concrete is within the apparatus.
- ➢ Promptly open/lift the gate to allow flow of concrete through the L-box.
- ➢ Once the concrete has ceased to flow (no more than one minute from the opening/lifting of the gate) measure the height of concrete at the "trough end" (record this as H2) and at the "chimney end" (record this as H1) of the L-box to the nearest ½ inch as shown in figure 5.5.
- ➢ The L-box ratio is calculated as H2/ H1.

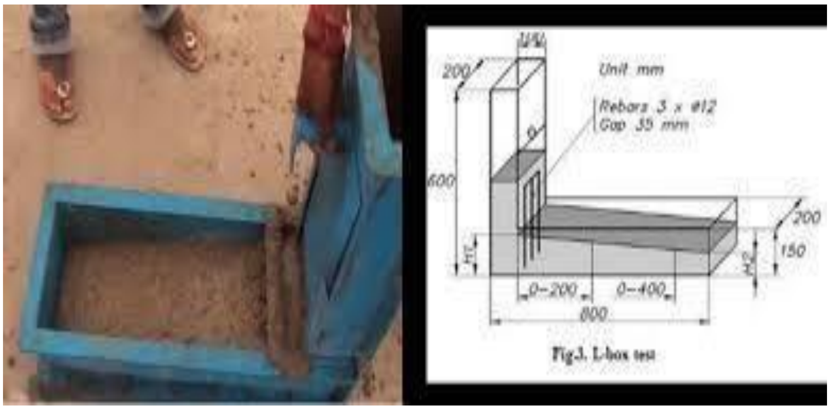


Figure 5.5 L- Box Test

5.4.4 V-funnel test and V-funnel test at T5minutes

V-funnel test is used to determine the filling ability (flow ability) of the concrete with a maximum aggregate size of 12mm. The funnel is filled with about 12 liters of concrete and the time taken for it to flow through the apparatus measured. After this the funnel can be refilled concrete and left for 5 minutes to settle. If the concrete shows segregation then the flow time will increase significantly.

Apparatus

1. V-funnel

2. Bucket (±12 litres)

3. Trowel

4. Scoop

5. Stopwatch

The Procedure for the flow time

- About 12 litres of concrete is needed to perform the test, sampled normally.
- Set the V-funnel on firm ground. Moisten the inside surfaces of the funnel.
- Keep the trap door open to allow any surplus water to drain.
- Close the trap door and place a bucket underneath.
- Fill the apparatus completely with concrete without compacting or tamping; simply strike off the concrete level with the top with the trowel.
- Open within 10 sec after filling the trap door and allow the concrete to flow out under gravity.
- Start the stopwatch when the trap door is opened, and record the time for the discharge to complete (the flow time).
- This is taken to be when light is seen from above through the funnel. The whole test has to be performed within 5 minutes.

The Procedure for the flow time at T5minutes

- Do not clean or moisten the inside surfaces of the funnel again.
- Close the trap door and refill the V-funnel immediately after measuring the flow time.
- Place a bucket underneath.
- Fill the apparatus completely with concrete without compacting or tapping, simply strike off the concrete
- Level with the top with the trowel.
- Open the trap door 5 minutes after the second fill of the funnel and allow the concrete to flow out under gravity.

- ➢ Simultaneously start the stopwatch when the trap door is opened, and record the time for the discharge to complete (the flow time at T 5 minutes). This is taken to be when light is seen from above through the funnel as shown in figure 5.6.

Figure 5.6 V- Funnel Test

5.4.5 U- Box test

This is a effortless check to conduct, on the other hand the equipment may moreover additionally be hard to construct. It affords a right direct evaluation of filling ability. U-container take a seem at is used to parent out the filling functionality (flow ability) of the concrete with a most mixture dimension of 12mm.

Apparatus

1. U- problem of a stiff non absorbing material

2. Scoop

3. Trowel

4. Stopwatch

Procedure

- ➢ About 20 litres of concrete is wished to operate the test, sampled normally. Set the tools stage on organization ground, make sure that the sliding gate can open freely and then shut it.
- ➢ Moisten the interior floor of the apparatus, get rid of any surplus water, fill the vertical vicinity of the apparatus with the concrete sample.

- Leave it stand for 1 minute. Lift the sliding gate and allow the concrete to go with the float out into the different compartment.
- After the concrete has come to rest, measure the pinnacle of the concrete in the compartment that has been filled, in two places and calculate the advocate (H1).
- Measure also the pinnacle in the different equipment (H2). Calculate H1-H2, the filling height. The total take a seem at has to be performed internal 5 minutes.

5.5 Compressive Strength Test

- Compression test is the most common test conducted on hardened concrete, partly because it is an easy test to perform and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.
- Compressive strength is done for the cube samples of size 150 mm x 150 mm x 150 mm. concrete cubes are casted with partial replacement of cement with rice husk ash as 0%, 5%, 10%, 15%, .The test is conducted after 7 days and 28 days of curing period.
- Compressive strength constantly increases as the curing period goes on increasing. Adding of increasing quantities of turritella and bentonite generally decreased the strength at a given age due to the greater porosity of the material as specified by higher water necessity.
- The highest compressive strength is achieved when the mixture contained turritella and bentonite of 20% of cement replacement w/c ratio of 0.50.

5.5.1 Testing of Specimens for 7days and 28 days

Test for compressive strength is carried out both on cube or cylinder. Various widespread codes recommends concrete cylinder or concrete cubes as the fashionable specimen for the test. American society for testing materials ASTM C39/C39M offers standard test method for compressive electricity of cubical concrete specimens.

These specimens are tested via compression checking out desktop after 7 days curing as shown in figure 5.7 to 5.10 and 28 days curing as shown in figure 5.11 to 5.13. Load should be utilized gradually at the 140kg/cm2 per minute till the Specimens fails. Load at the failure divided via location of specimen offers the compressive strength of concrete. Minimum three specimens ought to be tested at each chosen age.

Compressive strength of concrete cubes test present thinking about all the characteristics of concrete. By this single test one choose that whether concreting has been accomplished exact or not. Concrete compressive strength for general construction building varies from 15 MPa to 30 MPa and greater in business and industrial structures.

Compressive strength of concrete depends on many elements such as water-cement ratio, cement strength, nice of concrete material, best control in the course of manufacturing of concrete etc.

5.7 Normal Curing of specimens

Figure 5.8 Compressive Strength Test after 7days

Figure 5.9 Compressive Strength Test after 7days

Figure 5.10 Compressive Strength Test after 28days

Figure 5.11 Compressive Strength Test after 7days

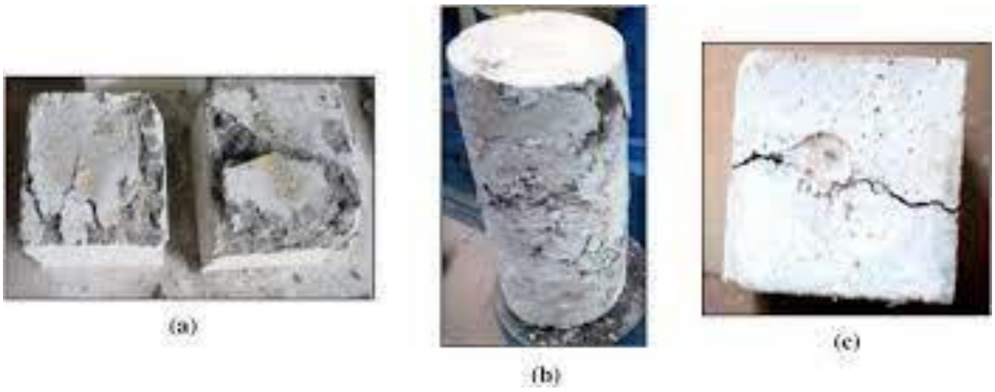


Figure 5.12 Compressive Strength Test after 28days

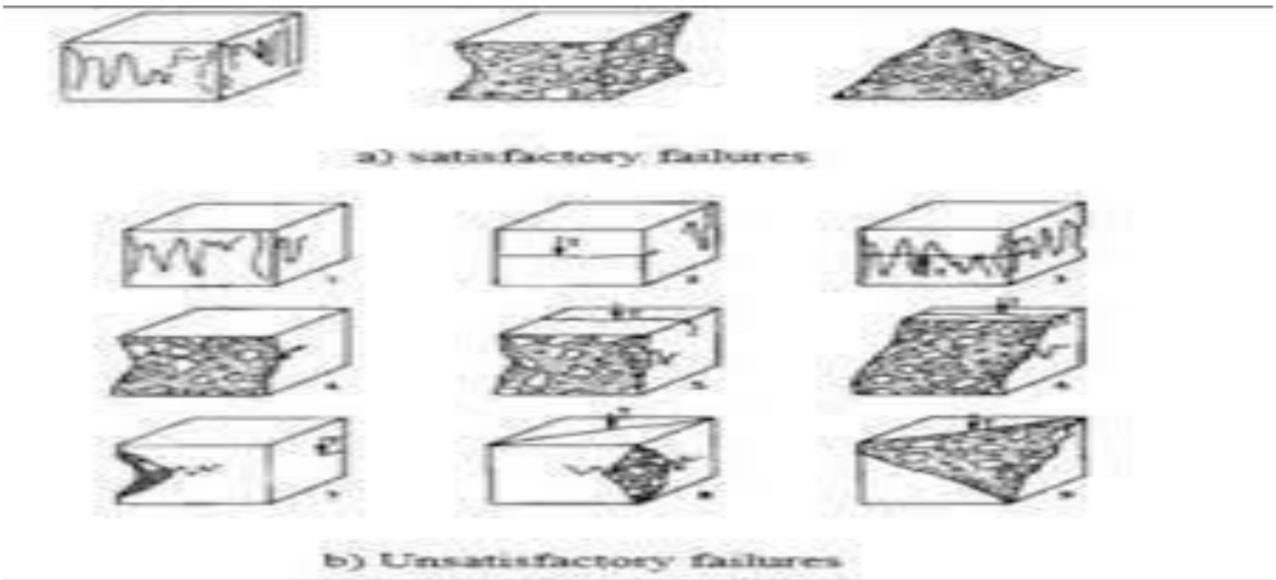


Figure 5.13 Compressive Strength Test after 28 days

5.5.2 Curing of specimens in 1% HNO_3 solution in curing tank

After curing of specimens in normal curing water for 28days, four specimens are for testing of 28days and remaining two specimens are cured in HNO_3 solution for other

28days in curing tank which have acid solution .Again after 28days the specimens are tested and note down the decreased in strength of the specimens.

Figure 5.14 HNO_3 solution curing tank.

CHAPTER VI

ANALYSIS AND RESULTS

Design mix concrete is the type of concrete used in the construction to produce the grade of concrete having the required workability and characteristic strength nominal mix will reduce the cement content which is used in the concrete reduce the water cement ratio also will increase the strength. The test results of M_{30} grade self compacting concrete cubes were tested in the different percentages like 0%, 5%, 10%, 15%, exposed to nitric acid solution in the concentration of 1% and 5%.The admixtures such as turritella and bentonite is combined used in the various percentages of 0%, 5%, 10%, 15% and super plasticizer added in the concrete because of reduce the water content will increase strength. The graphical representation of compressive strength for 7 days and 28 days is discussed. The different tables show the compressive strength percentage of admixtures such as turritella and bentonite will produced compressive strength N/mm^2.

Table 6.1 Mix proportions of M_{30} grade SCC

Type of concrete	cement (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	Water (kg/m^3)	Superplasticizer
	440	503.04	739.68	220	0.2%
	1.00	1.14	1.68	0.50	0.2%

To design and produce mix proportions for self compacting concrete (SCC). The characteristic compressive strength of M_{30} grade design mix concrete was used. The mix proportions of self compacting concrete was 0.5:1.00:1.14:1.68 (cement:FA:CA:water) by weight. The super plasticizer was 0.2% used in this mix proportions as shown in table 6.1.

Table 6.2 Fresh concrete properties of M_{30} grade SCC

	Slump flow (mm)	T50 (sec)	V-funnel (sec)	T5 minutes (sec)	L-Box
Test results	705	3.8	9	11	0.95

The self compacting concrete has the properties such filling ability, passing ability and resistance segregation. Various workability test methods are available for self compacting concrete such as slump flow, T50cm, V- Funnel, and L- Box as shown in Table 6.2. The workability test results of slump flow = 705mm, T50cm = 3.8sec, V-Funnel = 9sec, T5 minutes = 11sec, and L-Box = 0.95 as shown in Table 6.2

Table 6.3 Compressive strength results for cubes cured in water after 7 days

% of Turritella and Bentonite	Load (KN)		Area (mm^2)	Average load (KN)	Compressive Strength (N/mm^2)
	T_1	T_2			
0%	400	380	22500	390	16.81
5%	320	360	22500	340	15.1
10%	320	280	22500	300	13.3
15%	318	279	22500	297	13.2

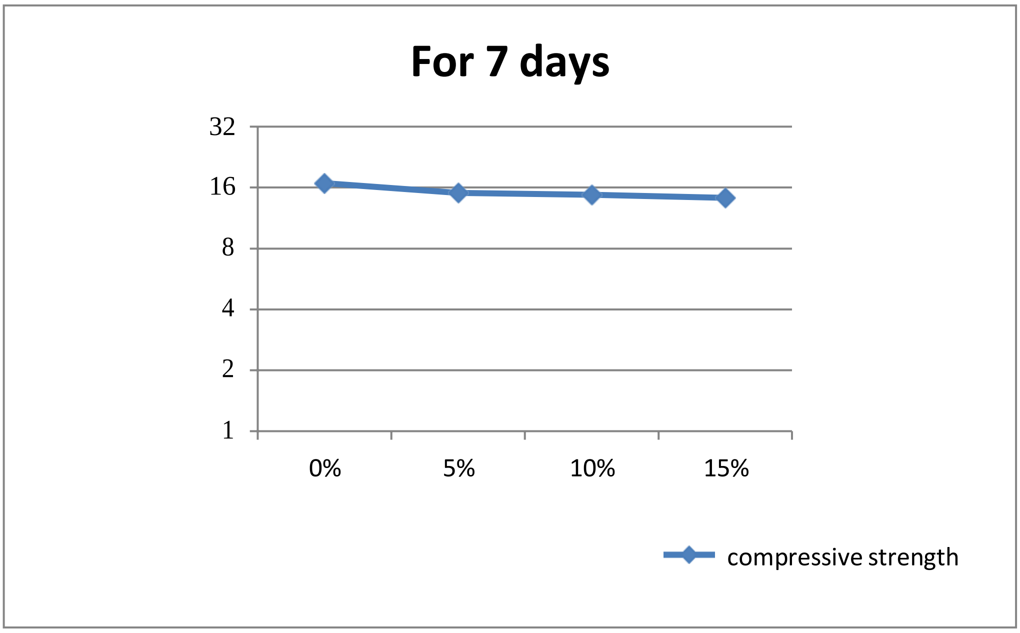


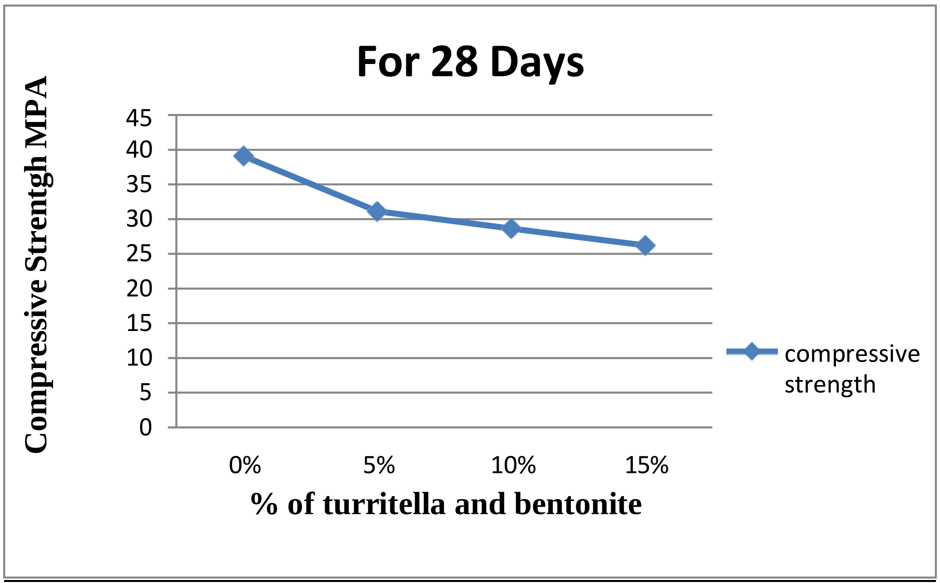
Figure 6.1: Graphical Representation of Compressive Strength after 7days

The test results of compressive strength after cured in water for 7 days with various combined percentages of rice husk ash such as 0%, 5%, 10%, 15% and produced target mean of the compressive strength for 7 days at 0% is 26.81N/mm^2 and 20% is 23.25N/mm^2. The loads of cubes were tested in different trials such T1, T2 calculated average load find out average compressive strength (N/mm^2). The graphical representation of compressive strength for 7 days plotted between horizontal axis taken combined percentage of rice husk ash and vertical axis taken as target mean compressive strength (N/mm^2). The graph represented by the line with various combined percentages of RHA such as 0%, 5%, 10%, 15% and compressive strength (N/mm^2) as shown in figure 6.1.

Table 6.4 Compressive strength results for cubes cured in water after 28 days

% of Turritella and Bentonite	Load (KN)		Area (mm^2)	Average load (KN)	Compressive Strength (N/mm^2)
	T_1	T_2			
0%	880	900	22500	890	39.10
5%	680	720	22500	700	31.12
10%	610	650	22500	650	28.65
15%	580	620	22500	600	26.22

Figure 6.2: Graphical Representation of Compressive Strength after 28 days



The test results of compressive strength after cured in water for 28 days with various combined percentages of rice husk ash such as 0%, 5%, 10%, 15% produced target mean of the compressive strength for 28 days at 0% is 39.10N/mm^2 and 15% is 26.22N/mm^2. The loads of cubes were tested in different trials such T1, T2 calculated average load find out average compressive strength (N/mm^2).

The graphical representation of compressive strength for 28 days plottedbetween horizontal axis taken cd percentage of rice husk ash and vertical axis taken as target mean compressive strength (N/mm^2). The graph represented by the line with various percentages of RHA such as 0%, 5%, 10%, 15% and compressive strength (N/mm^2) as shown in figure 6.2.

Table 6.5 Compressive strength results for cubes exposed to 1% by volume of HNO3 solution after 28 days

% of Turitella and Bentonite	Load (KN)		Area (mm^2)	Average load (KN)	Compressive Strength (N/mm^2)
	T_1	T_2			
0%	700	740	22500	720	32.15
5%	630	670	22500	650	28.15
10%	580	620	22500	600	26.66
15%	520	580	22500	550	24.66

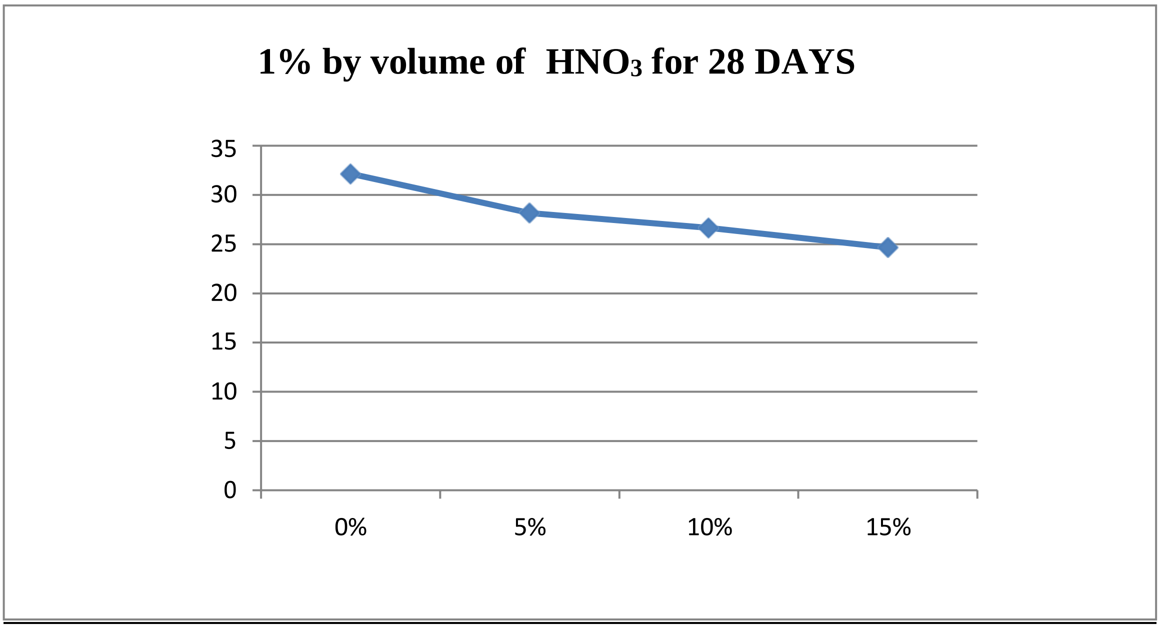


Figure 6.3: Graphical Representation of Compressive Strength exposed 1% by volume HNO3 solution

The test results of compressive strength for cubes exposed to 1% by volume nitric acid solution after cured in water for 28 days with various percentage of Turitella and Bentonite such as 0%, 5%, 10%, 15% and produced target mean of the compressive strength for 28 days at 0% is 32.15N/mm^2 and 15% is 24.66N/mm^2. The loads of cubes were tested in different trials such T1, T2 calculated average load find out average compressive strength (N/mm^2).

The graphical representation of compressive strength for 28 days plotted between horizontal axis taken percentage of rice husk ash and vertical axis taken as target mean compressive strength (N/mm^2). The graph represented by the line with various percentages of Turitella and Bentonite uch as 0%, 5%, 10%, 15% and compressive strength (N/mm^2) as shown in figure 6.3.

Table 6.6 Compressive strength results for cubes exposed to 5% by volume of nitric acid solution after 28 days

% of Turitella and Bentonite	Load (KN)		Area (mm^2)	Average load (KN)	Compressive Strength (N/mm^2)
	T_1	T_2			
0%	500	600	22500	550	24.4
5%	400	500	22500	450	20.67
10%	380	420	22500	400	18.20
15%	340	420	22500	380	16.11

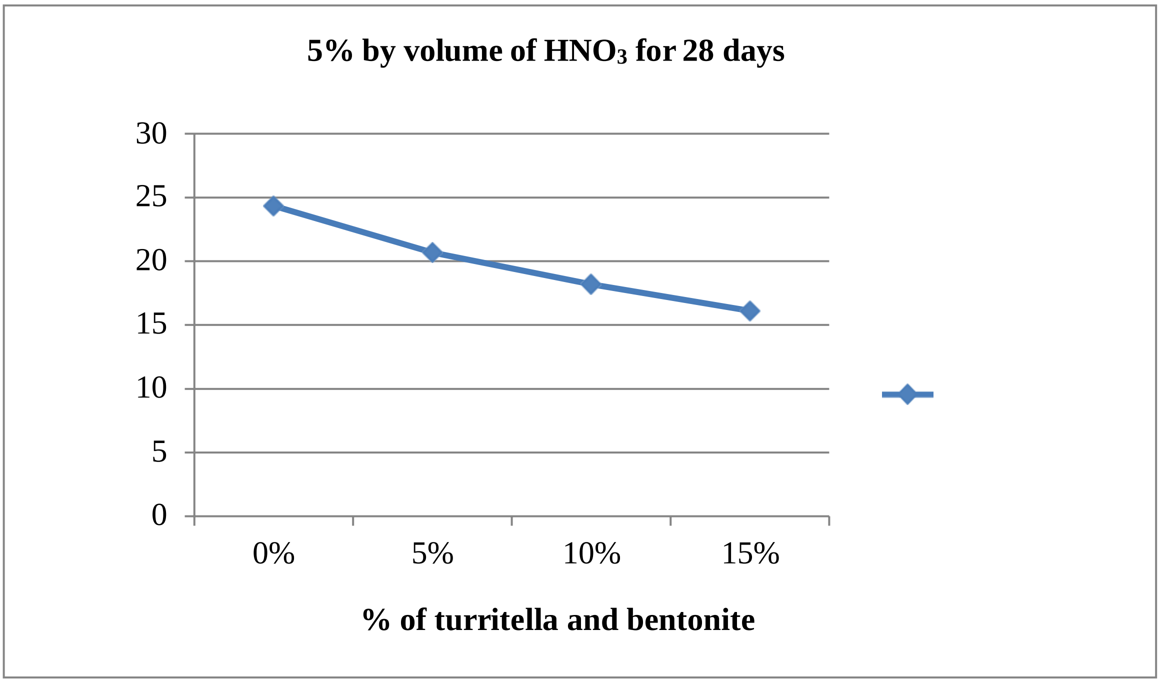


Figure 6.4: Graphical Representation of Compressive Strength exposed 5% by volume nitric acid solution

The test results of compressive strength for cubes exposed to 5% by volume nitric acid solution after cured in water for 28 days with various combined percentages of rice husk ash such as 0%, 5%, 10%, 15% produced target mean of the compressive strength for 28 days at 0% is 23.34N/mm^2 and 15% is 16.11N/mm^2. The loads of cubes were tested in different trials such T1, T2 calculated average load find out average compressive strength (N/mm^2).

The graphical representation of compressive strength for 28 days plotted between horizontal axis taken combined percentage of turitella and bentonite vertical axis taken as target mean compressive strength (N/mm^2). The graph represented by the line with various percentage of turitella and bentonite such as 0%, 5%, 10%, 15% and compressive strength (N/mm^2) as shown in figure 6.4.

CHAPTER VII

DISCUSSIONS OF RESULTS

- Total 30 cubes were cast of which one fourth were placed in normal water, another one fourth were placed in 1% and 2% nitric acid solution.
- Four samples from each environment were tested at the age of 7, 28 days respectively. The results are presented graphically below. Graph 1 to 4 represent the compressive strength of concrete specimens with cement replacement level by 0%, 5%, 10%, 15% by Turitella and Bentonite respectively cured in normal water and indifferent percentages of nitric acid solution. From all graphs it is seen that the compressive strength increases with the age of days.
- The test results of compressive strength after cured in water for 7 days and28 days with various percentage of Turitella and Bentonite such as 0%, 5%, 10%, 15% and produced target mean of the compressive strength for 7 days and 28 days at 0% are16.81 mm^2, 39.10N/mm^2 and 15% are 14.22N/mm^2, 26.22N/mm^2. The loads of cubes were tested in different trials such T1, T2 calculated average load find out average compressive strength (N/mm^2).
- The graphical representation of compressive strength for 7 days and 28 days plotted between horizontal axis taken combined percentage of Turitella and Bentonite and vertical axis taken as target mean compressive strength (N/mm^2). The graph represented by the line with various percentage of RHA such as 0%, 5%, 10%, 15% and compressive strength (N/mm^2).
- The test results of compressive strength for cubes exposed to 1%, by volume nitric acid solution after cured in water for 28 days with various percentage of Turitella and Bentonite such as 0%, is 32.10N/mm^2 and 15% is 24.66% and produced target mean of the compressive strength for 7 and 28 days at at 0% are16.81N/mm^2, 39.10N/mm^2 and 15% are 14.22N/mm^2, 26.22N/mm^2. The loads of cubes were tested in different trials such T1, T2 calculated average load find out average compressive strength (N/mm^2).
- The test results of compressive strength for cubes exposed to 5%, by volume nitric acid solution after cured in water for 28 days with various percentages of rice husk ash such as 0%, is 24.34 N/mm^2 and 15% is 16.11% and produced target mean of the compressive strength for 7 and 28 days at at 0% are16.81N/mm^2, 39.10N/mm^2 and 15% are 14.22N/mm^2, 26.22N/mm^2.

CHAPTER VIII

CONCLUSIONS

- The compressive strength of concrete (with 0%, 5%, 10%, 15%) weight replacement of cement with Turitella and Bentonite cured in normal water for 7days and 28 days have reached the target mean strength.
- Comparative study on rice husk ash concrete with various replacement percentage of Turitella and Bentonite showed that, and shows better strength than other replacements due to high pozzolanic activity.
- From results M_{30} grade Turitella and Bentonite concrete for nitric acid solution exposure in 28 days, the various replacement showed better compressive strengths.
- The compressive strength decreased with the increase in concentrations of ntric acid in curing water.
- At various replacements of Turitella and Bentonite gives maximum strengths and shows good resistance to nitric attack.
- Utilization of Turitella and Bentonite its application are used for the development of the construction industry, material science.
- It is the possible alternative solution of safe disposal of Turitella and Bentonite .
- Turitella and Bentonite becomes more economical without compromising concrete strength than the standard concrete. It becomes technically and economically feasible and viable.
- To compare graphs and tables values of normal water curing and nitric acid solution curing and attack the nitric acid solution then decreased the compressive strength of the self compacting concrete.
- The workability test results of slump flow and T50cm, V- funnel, L- box, T5 minutes value ranges of self compacting concrete are presented.
- To evaluate the test results of compressive strength of self compacting concrete with Turitella and Bentonite to nitric acid solution after 7 days and 28 days.

Scope of the future work

The scope of this study is focused on the properties of SCC with Turitella and Bentonite . Five volume percentages of Turitella and Bentonite is utilized to investigate the influence of volume percentage of turitella and bentonite to properties of concrete. The scope and limitations of this study are:

- The type of cement used is Ordinary Portland Cement (OPC) of 53 grade concrete mix.
- The size of crushed aggregate used is 10mm or 12mm.
- All the concrete specimens are subjected to wet curing.
- The appropriate tests and evaluations of concrete specimens are done in laboratory scaled sample.
- The testing and evaluation of concrete mainly on workability, compressive strength of concrete specimen.

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A Major Project Report

On

COMPARATIVE ANALYSIS OF RC STRUCTURE WITH AND WITHOUT OUTRIGGER USING STEEL BRACING

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

by

Mr.K BHAVINESH	**-**	**(17K81A0186)**
Mr.SHIVAM UPADHYAY	**-**	**(17K81A01A3)**
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DEPARTMENT OF CIVIL ENGINEERING

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JUNE 2021

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Dhulapally, Secunderabad, Telangana (India)-500100

BONAFIDE CERTIFICATE

This is to certify that the project entitled 'COMPARATIVE ANALYSIS OF RC STRUCTURE WITH AND WITHOUT OUTRIGGER USING STEEL BRACING', is being submitted by 1. **Mr.K BHAVINESH (17K81A0186) 2. Mr.SHIVAM UPADHYAY (17K81A01A3) 3. Ms.S HANU PRIYA (18K85A0121) 4. Mr.P PRANEETH KUMAR (18K85A0130)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN** Civil Engineering is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

Mr. Gangadhar Sajjanshetty
Assistant Professor
Department of Civil Engineering

Prof. Sandhya Kiran J K
Head of the Department
Department of Civil Engineering

Internal Examiner

External Examiner

Place:

Date:

DECLARATION

We, the student of **Bachelor of Technology** in Department of Civil Engineering', session: 2017 – 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled '*COMPARATIVE ANALYSIS OF RC STRUCTURE WITH AND WITHOUT OUTRIGGER USING STEEL BRACING*' is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

Mr.K BHAVINESH (17K81A0186)
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1. Mr.K Bhavinesh
2. Mr.Shivam Upadhyay
3. Ms.S Hanu Priya
4. Mr.P Praneeth Kumar

ABSTRACT

Tall building development has been rapidly increasing worldwide introducing new challenges that need to meet through engineering decision. As the height of the structure increases the stiffness of the structure reduces. Hence to develop the performance of the structure under seismic loading, outrigger system is proposed in the current study of work. This system is commonly used as one of the structural system to effectively control the excessive drift due to lateral load, so that during small or medium lateral load due to either wind or earthquake load, the risk of structural and non-structural damage can be minimized. In the current work, contain a comparative study on regular building with and without outrigger and irregular building with and without outrigger with centrally rigid shear wall and steel bracings as outrigger. The modeling of the structure is done using "ETABS" program. The analysis of the model is carried out by equivalent static method and response spectrum method. The stiffness and efficiency characteristics of the structure is measured in terms of lateral displacement, drift, base shear and fundamental natural period for different types of buildings to provide stiffness against static and dynamic loads. The parameters should be minimized to prevent damage to the buildings.

Key Words: Outrigger, G+30 RC Building, Truss Belt, Rectangular Building,

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CHAPTER 1
INTRODUCTION

General

Tall structure has always fascinated to vision a dreams and leading technical advancement to improve their ideas spread throughout the world. At now days the technical skills hastily growing of urbanization, tall structure has developed added suitable choice used for office and residential building. Tall buildings are commonly intended used for residential, office or commercial purpose. The response to hasty development of city populace along with the require needs by business tricks toward be there secure every extra at the same time as probable.

A huge segment of India is subjected to harmful level of seismic hazard. So that be considered the seismic load used for intend of tall rise structure. The different lateral load resisting systems are used in high-rise building as the lateral loads due to earthquake are a matter of concern. These lateral forces can produce critical stresses in the structure, inducing undesirable stresses and vibrations which causes excessive lateral sway of the structure.

Structural System

In ancient time year, structural member be unsaid to take mainly the gravity loads. Now, by the advance in structural intend or system and with high strength material, structure weight has reduced, into revolve increase slenderness, which necessitates taking into relation majorly the lateral loads such as wind and seismic. Hence, it becomes more necessary to identify the proper structural system for resisting the lateral loads depending upon the height of the building.

Structural system some of like for buildings are: -

a) Rigid frame system
b) Braced frame and shear walled frame system
c) Braced frame system
d) Outrigger system

e) Shear walled frame system

f) Frame tube system

g) Braced frame system

h) Bundled tube system

Introduction of outrigger: -

The outrigger and belt truss system is one of the lateral loads resisting system in which the external columns are tied to the central core wall with very stiff outriggers and belt truss at one or more levels. The belt truss tied the peripheral column of building while the outriggers engage them with main or central shear wall. The outrigger and belt truss system is commonly used as one of the structural system to effectively control the excessive drift due to lateral load, so that, during small or medium lateral load due to either wind or earthquake load, the risk of structural and non-structural damage can be minimized. For high-rise buildings, particularly in seismic active zone or wind load dominant, this system can be chosen as an appropriate structure.

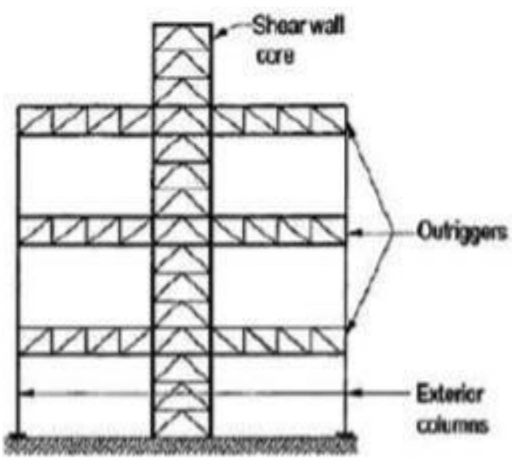

Fig 1(a) Outrigger with central core

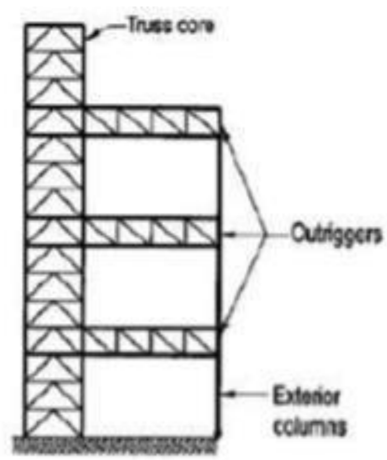

Fig 1(b) Outrigger system with offset core

Different types of outrigger system: -

a) Conventional outrigger concept

b) Virtual outrigger concept

Conventional outrigger system: -

In conventional outrigger, the outrigger truss or girder that are directly coupled to center of core of shear walls or at center core of braced frames and columns are located outboard of core. The columns are an outer edge of the structure. The amount of outrigger that above a stature of the structure that be able to varied since one to four or extra. The outrigger trusses, which are connected to the core and to columns outboard of the core, restrain rotation of the core and convert part of the moment in the core into a vertical couple at the columns. Reduction and elongations of the columns and deformation of the truss will may allow some initial rotation of center core at the outrigger.

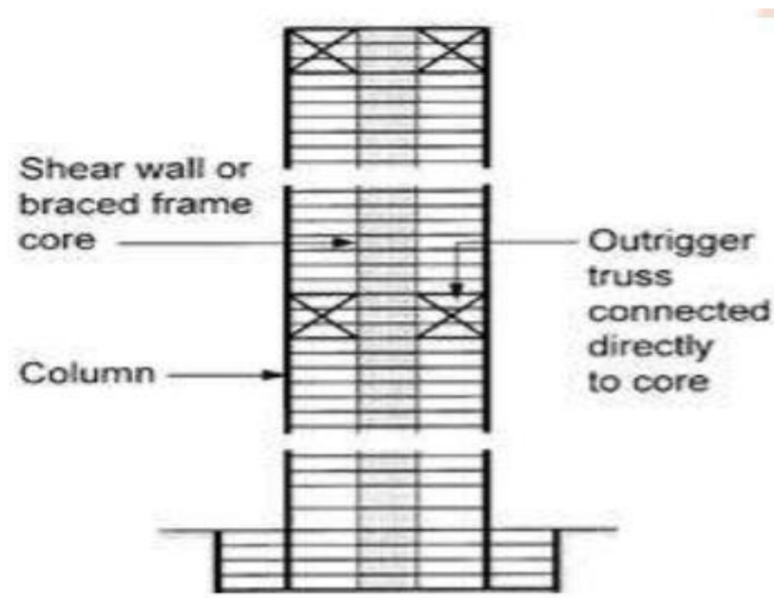

Fig 2 Conventional outrigger system

Virtual outrigger system: -

In the system the outrigger truss or girder are equally transfer they are connected to core of shear wall or braced frame and the columns at located at side of structure. But without any direct link between the truss and shear wall core, it may avoid the problems linked with the outrigger. The main plan of "Virtual Outrigger Concept" that to be utilize floor diaphragms, which they may be typical they are extremely firm and strong through their at individual plane, while convey movement in type of a parallel connect from the shear wall middle to truss but they are not linked directly to core.

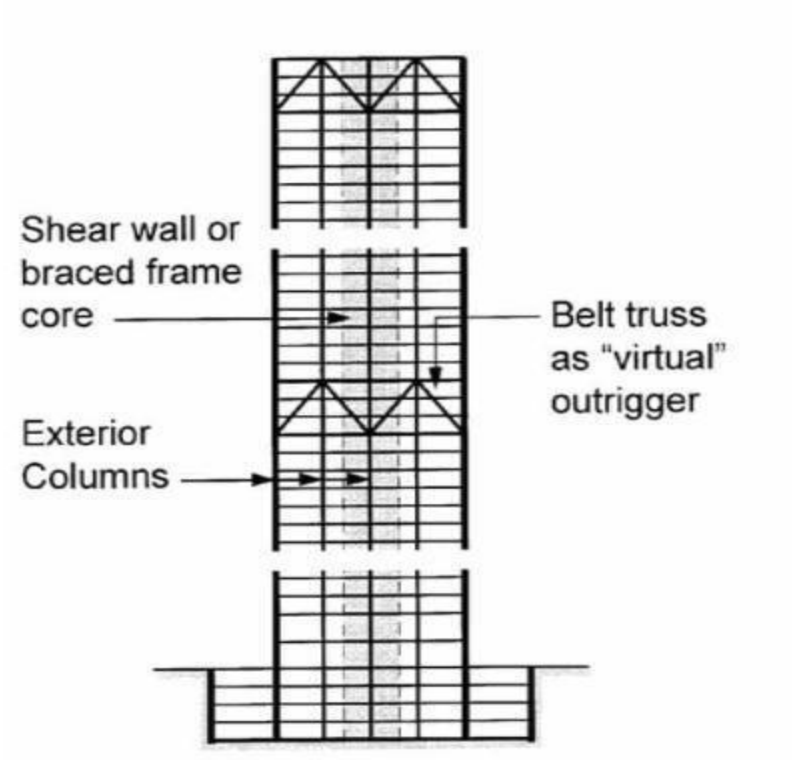

Fig 3 Virtual outrigger system

About project introduction: -

The horizontal deformations suitable to this load must be avoided structural with unstructured damage in arrange toward find the strength and rigidity of the structure alongside the lateral loads in the analyze along with intend of tall buildings. To raise rigidity, the cut core ensures operation against wind and seismic loads with external frame within large buildings. The actual strength of the structure increases while outrigger is added. The work to be done by carrying outrigger in large building. The structure be analyze for a 30 storey structure, there are four types of building they areuse of symmetrical buildings with and without outrigger and an irregular symmetric building withand without outrigger.

The proposed building, instead of the original wall, provides a cut wall through columns insert inside it. The outriggers are made of steel bracings. The analysis is made by E-tabs software along with result to be generated by different parameter. The equivalent static method with dynamic method to be adopted for analysis. The results are generated, tabulated and graphed. The values are compared with different building used for lateral stiffness in the seismic force.

The performance of various type of structure is identified through different zone with it of lateral load on top of the structure while outrigger is provided. The main use of structural system is to transfer the gravity loads without causing any damage into buildings. The main effective loads of buildings are

- Dead load
- Live load
- Wind load
- Seismic load

The structure is subjected toward parallel lateral building cause due to the act of wind and earthquake forces. The lateral load lead can break to high buildings through produce huge stress through causing vibration. So that it becomes important for building supposed to be provide by essential strong point with install of structural system.

The tall structure is provided with shear walls which have columns, these columns are installed in the shear wall primarily to carry the gravity loads. The shear wall in the building will provide strength and lateral stiffness to the building in the direction of building orientation by reducing the lateral sway and damage to the structure. The outriggers with steel bracings are provided which increase the axial stiffness with the peripheral columns to resist the overturning moments.

The theory of outriggers and bracings are combined it decreases the bending moments in beams and shear force in column through increasing the column axial compression. The building consists of inner core comprises shear wall by horizontal girder or cantilever sort of truss called outriggers made of by steel bracing connecting to the outer columns of building. The shear wall is mainly located at centre by extend of outriggers on equally on the side of column. While parallel load act resting on the structure then outriggers resist the rotation of the inner center wall or shear wall by causing the lateral deflection and minimizing the effect of the loads on the building.

Organization of thesis: -

The project contains six chapters. The chapters are overview briefly and given it below: -

Chapter 1 - Contains introduction, different types of outrigger, about project overview.

Chapter 2 - Deals with literature review of previews of research on comparative analysis of structure with outrigger without outrigger with steel bracing and brief literature review.

Chapter 3 - Involves problems and definition and objective of present study.

Chapter 4 - Involves methodology, types of analysis and summary of the present study, modeling details and procedure, definition of terms considered of analysis.

Chapter 5 - Contains obtained results and discussions of the work done, where the results of models are extracted and the graphs are plotted for the same and the results obtained are compared.

Chapter 6 - Contains of drawn from present work and scope for the future work.

Chapter 7 – Lists out the References and Codes/ Standards.

CHAPTER 2
LITERATURE REVIEW

INTRODUCTION

Outrigger is nowadays used in construction projects and tall building structures. Outrigger is advanced structural system that can be used for the lateral load resistance of tall buildings and provide significant drift control for tall structure and thus to improve performance of building under seismic loading and can prove to be very effective. So many case studies and projects have been done. An outrigger is a deep stiff beam and rigid horizontal structure designed to improve building overturning stiffness and strength by connecting building core or shear wall to exterior columns when compared to the system with freely standing core without outriggers. When the structure is subjected to lateral forces, the outrigger and the columns resist the rotation of the core and thus significantly reduce the lateral deflection and base moment, which would have arisen in a free core and differential column shortening is reduced by these horizontal trusses.

Po Seng Kiran and Frits Torang Siahaan (2001)

Researchers have worked on the idea to increase the stiffness and make the structure proficient under wind as well as seismic load by introducing outrigger and belt truss system connecting core to exterior column. In this research work authors have studied the application of diagonal outrigger and belt truss with different configurations. They have carried out the analysis on a 40 storied 2-dimensional models and 60 storied 3D models subjected to wind load by introducing outrigger and belt truss systems with eight different configurations by varying the locations of outrigger as per the British standard. Similarly, 60 storied 3- dimensional models subjected to earthquake load by incorporating outrigger and belt truss system with 5 different configurations by varying Locations, numbers and height of diagonal outrigger beam and belt truss.

A comparative study has been carried out to examine the reduction in lateral displacement. Researchers have also focused on to determine the optimum location of outrigger. Investigation of this research paper have found that 65% and 18% maximum reduction in displacement is attained in the 40 storied 2D and 60 storied 3D models subjected to wind load by providing two outriggers. The first outrigger is assigned at the top and second at the mid height of the structure.

Herath N et al., (2009)

In this paper they have said a special attention should be given for high rise RC buildings, since tall buildings often accommodate thousands of occupants. When the height of building increases, the consideration of stiffness is very important in tall building. In such case outrigger beam is proposed to be provided in between the shear wall and external columns to improve satisfactory lateral stiffness to the structure. The main intention of this research was to optimize the location of Outrigger for safety against Earthquakes and Economy in design. For this purpose, researchers have considerd 9 previous earthquake records and based on acceleration to velocity ratios (A/V Ratio) namely, Park field (28 June 1966), Friuli (6 may 1976), Patras (29 Jan 1974), Gazli (17 may 1976), El Centro (18 May 1940), Spitak (7 Dec 1988), Mexico City (19 Sep 1985), Tabas (13 Sep 1978), San Fernando (9 Feb 1971).

The performance of high rise building has been examined by studying different configurations of outrigger structural system. A model of 50 stories was analyzed for three different ratios of peak ground acceleration to peak ground velocity. Response spectrum analysis was conducted to determine behavior of the building considering parameters such as lateral displacement and inter storey drift. It was proved from this study that the structure is optimized when the outrigger is placed between 22-24 levels. Therefore, it can be concluded that the optimum location of the structure is between 0.44-0.48 times its height (taken from the bottom of the building).

Abbas Hangollahi et al., (2012)

In this research paper they worked for high rise steel frame building structure, subjected to seismic load for optimize location of outrigger. In this work basic concept to take out study of results obtain from lateral displacement and storey drift by non-linear time historey and response spectrum method. By taking 20 and 25 storey model has been analyzed by considering ground accelerations of several actual earthquakes in earlier period study about drift and displacement. They have taken 0.44 times and 0.5 times of stature of building as from top. By employing non-linear time historey analysis, the optimum location of outriggers and belt trusses were on high storey14 and 16. So accordingly the researcher it may be secure that outriggers optimum location must be placed at high level.

Kiran Kamath et al., (2012)

In this paper researchers have worked on the differential column shortening due to long term effect in tall building by using outrigger structural system. The basic idea for this research is that the cumulative differential shortening of columns causes the slabs to tilt with resulting rotation of partitions. It is very important to study the effect of column shortening and need special consideration in design. The primary objective of this research was to find out the optimum location of outrigger in high-rise RC building to reduce differential column shortening.

In this research work researchers have analyzed a 60 storied 3-dimensional model with various configurations of outriggers with different H/h1 ratios. From the analytical investigation it is observed that the differential shortening was decreased by 34% when one outrigger system was introduced at H/h1 = 1.715 as well as the same model was analyzed by keeping one outrigger fixed at its optimum position with H/h1=1.715 and second outrigger optimum position is found to be at H/h2=1.33 which will further reduce the differential shortening by a total of 58% so this study conclude that differential shortening of columns was reduced to a great extent by introduction of outriggers.

Halkure S.A. et al., (2014)

In this paper they investigated on irregular shape structure on effect of seismicity in tall rise buildings reinforced concrete building. They researched to study on response of irregular shape structure which will reduce displacement through shear wall to increase the stiffness of building. In tall building it is very important to identify the effective, efficient and ideal location as well as orientation of shear wall.

The researcher took 11 storey structure of irregular with unsymentry structure while comparative analyzed by equivalent force method as per I.S codes, by introducing shear wall with 14 different configurations by changing their percentages of length of shear wall with their possible combination of location of shear wall. Accordingly, the model which gives good seismic response when subjected to earthquake load by considering parameters, such as top displacement, base shear, beam moment and column moment, storey drift and torsion is figured out.

From the whole investigation study, researchers have found that application of shear wall about 23-31% of perimeter structure was found very much effective in controlling displacement.

Gururaj et al., (2014)

In this paper they have focused on the effect of floor which has different loads i.e. mass irregularity in multi-storeyed reinforced concrete building. The main objective of this research work was to examine the seismic response of high-rise building by performing various seismic analysis methods, such as Equivalent static analysis, Response Spectrum analysis and Time Historey Analysis by considering Earthquake data of BHUJ Earthquake (Jan 26, 2001) and KOYNA Earthquake (Dec 11, 1964) to know the realistic behavior during earthquake. So in this research work researchers have modelled 10 storied RCC Building and performed seismic analysis as per Indian Standard Code by different methods as mentioned above to examine the performance of multi-storey building by considering parameters of base shear and storey displacement.

The complete comparative analysis reveals that, to know the non-linear behavior of the irregular structure, the time historey analysis must be performed.

Vijaya kumara gowda M.R et al., (2015)

The researcher has worked on lateral load resisting system by adopting belt trusses at top and mid height of building. This proves to more rate to get better their recital of structure subjected to seismic load. Mainly belt trusses which provide all along their tangential column of building at minimum height of structure to develop the firmness with stiffness next to lateral loads. The researcher has carried out by study of using several of belt trusses which include likely X, V, inverted V diagonal, etc. for different earthquake zones criteria to know the importance of belt trusses.

To study, researcher had modeled 30 storied 3D models by implement various type of belt trusses and model analyzed for equivalent static method and response spectrum method as per IS code. Each type of trusses gives different results for different seismic zones, therefore based on economic conditions researchers have concluded that inverted V-type of belt truss is one of the best type of belt truss in all seismic zones to increase the efficiency of the building.

Alpana L. Gawate and J. P. Bhusari (2015)

In this paper they investigated on irregular shape structure on effect of seismicity in tall rise reinforced concrete buildings. They researched, to study on reaction of irregular twisted building that has to reduce displacement through shear walls to increase the stiffness of building. In tall buildings to recognize the efficient of ideal place as known their location of orientation of shear wall.

The researcher took 12 storey structure of irregular with unsymmetry structure while comparative analyze by equivalent forces process as per I.S codes, through introducing shear wall with various configuration via changing their percentages through length of shear wall with their possible combination of shear wall and their location. Such parameters like displacement, beam moment, column moment, base shear and storey drift is figured out.

Shivshankar K et al., (2015)

In this paper, they have involved outrigger structural system, in tall vertical regularity structure while parallel dimensions of lateral forces resist method are above more than 15% of nearby storey. In this study, for 30 storey model having vertical irregularity has taken. Here model changes at 11^{th} and 21^{th} storey. And analyzed for single bare frame and bare frame through outrigger and belt trusses by changing their position at six configurations as usually bare frame at two outrigger of belt trusses of 5 different configurations and evaluated under various parameter.

It was recognized through this research that around 28.58% and 27% lateral deflection and building drift was restrain by providing outrigger structural system in high rise vertical irregularity structure when it is provided at 0.67 times its height compares to bare frame as well as 37.7% and 36.11% of the Deflection and drift is controlled by providing outrigger with belt truss at 0.67 times its height and 0.5 times it's when compared with bare frame. To examine the behaviour of vertical irregularity of outrigger structural system, linear static analysis has been carried out as per the Indian standard.

Thejaswini R. M. et al., (2015)

In this research paper they have studied comparative study and analysis of various lateral load resting of structural system toward known the practical concert of structure while during seismic activity due to extreme wind anxiety to decide on type of structural system through high rise structure to keep in superior state by an cause of live load and lateral load, at instant and shear forces through an certain force and stiffness.

In paper they have modelled a geometrically irregular 14 storey RCC high rise building with different forms of structural system, such as Rigid frame structure, Core wall structure, and Shear wall structure with different configurations of shear wall location, Tube structure and outrigger structure. Results of the analysis reveal that the values of displacement were less in tube structure and outrigger structural system. The authors have also stated that in geometrically irregular structure; stability of structure will boost and the columns sway can be reduced by implementing L-shaped shear wall along the corners of the structure. One important conclusion that the researchers have drawn from this study is that when outrigger structural system is provided at a storey which has maximum drift, it can perform as a maximum drift controller.

Shrinivas B.N et al., (2015)

In this paper they have carried regular and vertical irregular structure to increase axial stiffness at outer column to resist at over turning moment by using steel bracing in outrigger structural system. The researcher had compared analysis for 3-dimensional regular and vertical irregular structure with symmetric plan for 20 storey structure "with and without outrigger beam" subjected to seismic loads.

By analyzing of structure, taking equivalent static methods as per Indian standard code. They have considered parameter, such as storey drift, displacement, fundamental natural time period and base shear. They had various different zones as behavior of outrigger through equivalent static method and response spectrum system by incorporate concert and steel bracing outriggers. And they focus to vary lateral displacement and natural time period. When outriggers had introduced in regular and irregular structure which has improve in stiffens in structure. Base shear will reduce and inner storey drifts too by incorporating outriggers. In vertical irregular, there was further efficient due to reduction of self-weight when compared to regular structure and as by providing X- bracing by reduction of lateral storey displacement was found.

Rahul Y. et al., (Feb 2017)

In this research work they have considered dynamic analyze of tall rise steel by shear wall. The outrigger performs to lateral stiffness that provides drift controller for tall structure. They include shear wall, rigid frame, wall frame and outrigger of structure. The main objective is to perform outrigger structural system in tall structure subjected to wind load and seismic loads as per Indian standard codes. They compared on static and dynamic analysis on the conduct of comparative structure of various cases of 50 storey structure by using finite element method. They mainly compared bare frame with steel bracing with center core of structural in efficiency by measured of lateral displacement, storey shear, base shear and time period values. The provision of outrigger along a shear wall increases

the force and stiffens of structure against seismic and wind load. And shear walls without openings and by reduction at inner storey drift can be achieved.

Summary of Literature

By studying various lateral load resisting structural system such as Rigid Frame System, Rigid Frame with Shear Wall System, Shear wall system with opening and outrigger system, it was found that outrigger structural system is not only proficient in controlling top displacement but also plays an important role in reducing inter storey drift. By incorporating outrigger beam, differential shortening of column is decreased to a great extent. When only one outrigger was incorporated, the differential shortening of column was shortened by 34% at 1.715 relative height ratio of outrigger. When two outriggers were incorporated, the differential shortening of column was shortened by total 58% at 1.715 relative height ratio of first outrigger and at 1.33 relative height ratio of second outrigger.

By providing proper symmetry in the structure tensional irregularity can be avoided and by providing outrigger structural system having maximum drift at a storey, it performs as the maximum drift controller. Outrigger performs an essential role in improving the structural flexural stiffness by reducing base shear when the structure is subjected to earthquake static and dynamic loads. There is a considerable reduction in Time period when outrigger was introduced in regular and irregular building structure which will improve the overall stiffness of the structure by reducing lateral displacement and inter storey drift.

Geometric vertical irregularity is more effective due to reduction of self-weight compared to regular building. When there is provision of only one outrigger, the system is not effective for maximum drift controller. There is a remarkable change in drift profile when two outriggers are provided. In geometrically regular and symmetrical structure with simple grid plan it is found that by considering the criteria for reduction in top displacement, optimum position of outrigger is at mid height of the building with relative flexural rigidity of 0.25. In time historey analysis in all earthquake histories of California region the top lateral displacement was least for outrigger structure with relative height of 0.5.

CHAPTER 3
PROBLEM CONTEXT AND OBJECTIVES

Problem Context: -

At present days, the people are turning into more and more falling to need of tall structure building is to plenty essential. So that tall constructing construction has been hastily increase international by introduce a latest demand situation to wants to convene during engineering judgment. As an tall of the constructing increases, the stiffness and power of the constructing decreases several structural damages suffer by using frequent modern homes at several stage in current earthquakes by illustrate the significance of avoid a rapid change in lateral stiffness. Outrigger systems are at present days very famous. They are using like sky rappers for multi storey building designing their needs and fulfilling their advantages. Outrigger system is greater effective to lateral load resting system. The main stream of outrigger which connected steel bracing in multi storey constructing, that can be owned to its advantage over the outrigger of creation.

Problem definition: -

Hence the main aim of the present work is to study on influence of outrigger with steel bracing in tall structure subjected static and dynamic loads. The four models such as taken a symmetrical and unsymmetrical building by selecting as rectangular and hexagonal comparing with outrigger and without outrigger. In outrigger with steel bracing selecting the best geometry of structure to resist loads and restrict the displacement. The G+30 storey R.C.C building frame situated in earthquake zone IV considering for analysis. The analysis is done with an static method and dynamic method by using E-TABS 2015 software.

Objectives: -

a) To model and analyze the structure and to get mainly effective structure to resist lateral loads.

b) To study the use of outriggers in an regular and vertical irregular structure under seismic force.

c) The buildings with and without outrigger are compared.

d) To acquire behavior of outrigger introduced as a steel bracing in a R.C tall structure.

e) To compare the effect of outriggers by both Equivalent static method and Dynamic Analysis method (Response spectrum method) as per IS 1893 – 2002.

f) To study parameters such as storey shear, displacement, storey drift, storey stiffness, fundamental natural time period and base shear.

CHAPTER 4

METHODOLOGY

Subsequent is to adopted for analysis of outrigger with steel bracing and without outrigger

1) R.C Structure is considered for study having 30storey of height 90m each floor is 3m height.
2) The regular R.C concrete moment resisting frame of square plan with core in center location is measured as base.
3) The floor height as kept steady for all floors to get accurate results.
4) Outrigger has adopted an steel bracing frame, comparing with geometric models.
5) To understand the behavior under lateral loads applied as per IS 1893-2002 are used respectively.
6) Based on the results and response from earthquake load applied conclusions are made.

Model Data

Structure	OMRF
No. of stories	G+30
Storey height	3.0 m
Base storey	3.0 m
Plan dimension	2704 m (for regular building)
	2421 m (for irregular building)
Grade of concrete	M30 and M25
Grade of steel	Fe500
Thickness of slab	150 mm
Beam size	550*300 mm
	450*300 mm
Column size	1000*1000 mm
	900*900 mm
Outrigger Steel Bracing	ISA 150*150*15 mm

Shear wall thickness	0.3 m
Type of soil	medium soil

Lateral Load Analysis of Tall Structure

The intend measures in favor of tall homes having a stability, serviceability, power and extravagance worked meant for human being. The components deal with a thin homes and organization of tall structure of all occurrences of human reassurance serviceability closer to parallel burdens. This artwork put forth the attempt to investigate tall structure's basic frameworks, especially Outriggers frameworks of various geometric designs. For seismic assessment same static technique and time records utilized as unique and for wind assessment. To test the variety of models for magnificent boundaries like storey removal, storey go along with the glen, and storey shear, mode shape by appreciate toward term are provided designed for load examples. The result of seismic tremor powers on building structure is to dislodge the both ground simultaneously headed for make bury storey floats. Because of hub distortions inside the shape flexural form resolve create with support before inclining bracings disfigurement shear method will exist.

Design Lateral Force due to earthquake as per IS 1893

The majority of the structural designing frameworks resolve experience extra prominent all through seismic activity than disaster because of wind force. Seismic force powers be confounded in natural world with we can't anticipate that quake should get up on numerous occasions, normally at some phase in limited ability to length of existence. During seismic, top soil layer beneath secondary structure that happen upon incredibly great kinds of vibration into 3 dimensional directions, in which miracle wave engenders be of P-waves, longitudinal waves and S-waves.

Predominantly 2 type of structure strategies,

Equivalent Static Analysis

Dynamic Response Spectrum Analysis

Equivalent Static load analysis of structure of Design Seismic Base shear

Initially discover configuration base shear, the plan base shear of every structure next to standard bearing is known

$V_b = (A_h) \times W$

where A_h= Design horizontal seismic co-efficient value.

W= weight of the seismic structure.

At parallel co-efficient of the structures it is given by

$A_h = (Z\ I/2R) *Sa/g$

In this condition,

Z =Seismic Zone factor relies upon the area wherein the structure is built.

I = Importance factor.

R = Response reduction fact

Sa/g = it is the normal reaction quickening co-effective, it is changing for various sort of soil.

T = Approximate essential normal period of vibrations.

T_a = 0.075h^0.75 for RC outline structure (for RC MRF building)

Parallel power at every floors relies upon masses of the floors.

Base shears Distribution all along tallness structure elevation is specified by

$Q_i = V_b*(W_i\, h_i^2/\sum_{j=1}^{n}(W_j*h_j^2))$

Q_i = Design lateral force at floor i,

W_i = Seismic load of floor i,

h_i= Height of floor i estimated from base, and

n = Number of storeys in the structure that is, the quantity of levels at which the majority are Located.

Response Spectrum Method:

The representation of maximum response of idealized multi degree of freedom (MDOF) system expressed in terms of superposition of modal response and each model being determined to single degree of freedom during earthquake ground motion. The undammed natural period for various damping values for maximum response is plotted which is expressed as maximum acceleration value and maximum relative velocity to maximum relative displacement. For this case response spectrum analysis has been performed according to IS 1893 (part 1):2002. The behavior of flexible structures by dynamic analysis is studied. Static analysis is carried out in which inertia forces can be neglected. But if there is any change in dynamic load, the response with the help of dynamic analysis must be determined in which the inertial force cannot be neglected and is equal to mass time of acceleration (Newton's 2nd law)

$$F = M \times a$$

Where,

F = inertial force,

M = inertial mass and

a = acceleration.

Wind Analysis

Wind is absolutely individual of nature constrain an amazing way to exist constantly and highlight an impact on especially tall or over the top upward push structures. A large portion of the enduring RCC structures are intended to withstand wind heaps of high power. Twist regularly cerates attractions or horrendous power on leeward thing and dynamite pressure along wind ward rules. Pull might be experienced even at the factor parcels or rooftop which is predicated upon at the geometric design of the structure. Weight might be consistently different all through the ground albeit not in pinnacle of the structure. Because wind heading be erratic, with might exist a heap at the structure in a few of the course, auxiliary arrangement engineer need to address those circumstances. Introduction from extents of Diaphragms are considered for the accompanying information sources.

Wind Load: IS- 875 (part 3): 1987

Wind Speed V_b = 50 m/s

Terrain Category = 4

Structure Class = B

Risk Co-efficient = 1

Topography Factor = 1

Modeling

a) Rectangular without outrigger

b) Rectangular with outrigger with steel bracing

c) Hexagonal without outrigger

d) Hexagonal with outrigger with steel bracing

Building Modeling and Loading Data's

Type of Structure – Concrete Moment Resisting Outrigger with Steel Bracing Plan Configurations - Rectangular and Hexagonal.

No of Stories - G+30 (30 Storied)

Height of each floor - 3 m

Height of building - 90 m

Building type- Commercial

Grade of concrete fck – M30

Grade of steel fy -500

Density of Concrete – 25KN/m3

Damping Ratio – 5%

4.10 Gravity and Lateral load consideration

Gravity load:

a. Live-load - 4 kN/m^2 (IS-875 (part 1) :1987)
b. Floors-finish - 1 kN/m^2 (IS-875 (part 2): 1987)
c. Seismic load - IS-1893 (part 1): 2002

Earthquake inputs as per IS 1893 (Part 1): 2002

Soil type- Type II

Importance factor- 1.0

Response reduction factor - 5.0

Seismic Zone- IV (0.24)

4.10 Load Combinations

Table 4.1 load combination

Type	Design Load Combinations
Gravity analysis	1.5 DL +1.5 LL
Equivalent Static Analysis	1.5 DL+1.5 EQX
	1.5 DL-1.5 EQX
	1.5 DL+1.5 EQY
	1.5 DL-1.5 EQY
	1.2 DL+1.2 LL+1.2 EQX
	1.2 DL+1.2 LL-1.2 EQX
	1.2 DL+1.2 LL+1.2 EQY
	1.2 DL+1.2 LL-1.2EQY
	0.9DL+1.5EQX
	0.9DL-1.5EQX
	0.9DL+1.5EQY
	0.9DL-1.5EQY
Wind load patterns	1.5(DL+WLX)
	1.5(DL-WLX)
	1.5(DL+WLY)
	1.5(DL-WLY)

	1.2(DL+LL+WLX)
	1.2(DL+LL-WLX)
	1.2(DL+LL+WLY)
	1.2(DL+LL+WLY)
	1.2(DL+LL-WLY)
	0.9DL+1.5WLX
	0.9DL-1.5WLX
	0.9DL+1.5WLY
	0.9DL-1.5WLY

4.10 Introduction to ETABS 2015

The software used on this models is ETABS 2015. ETABS software is a special laptop program evolved in particular for exclusive constructing systems. However, the need for unique applications like ETABS, has in no way been more glaring for structural engineer to locate non-linear static and dynamic analysis into exercise with to utilize the more PC control available these days to make large, greater composite systematic fashions. E-TABS, modeling with editing a model, analyses, layout with optimizing the intend these kinds of completed during a unmarried interface which is absolutely included in Microsoft home window. These ETABS produces graphical presentations of the effects extra easily.

4.10 Step by step procedure for

modelling and AnalysisStep 1:

Create new model define units.

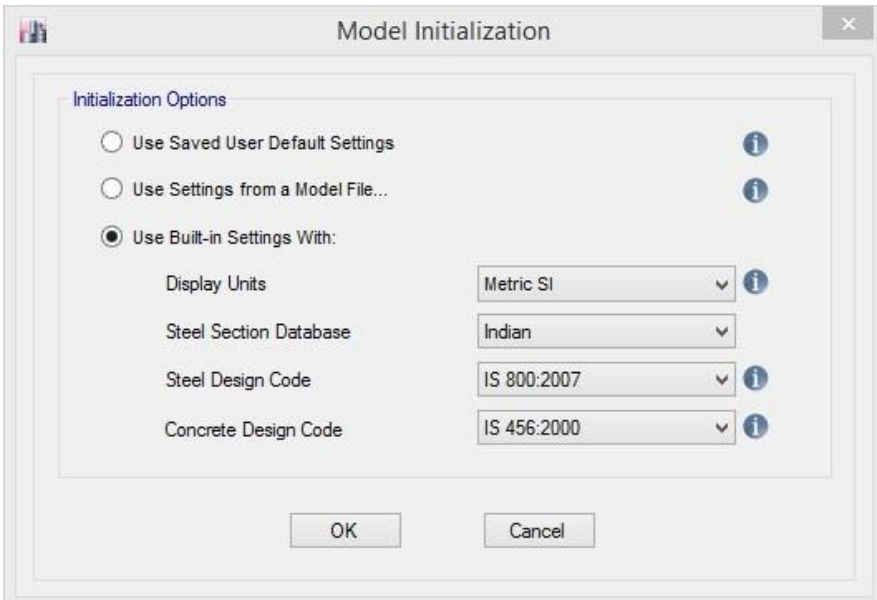

Fig 4.1 model define units

Step 2: Setting Number of grids and its spacing

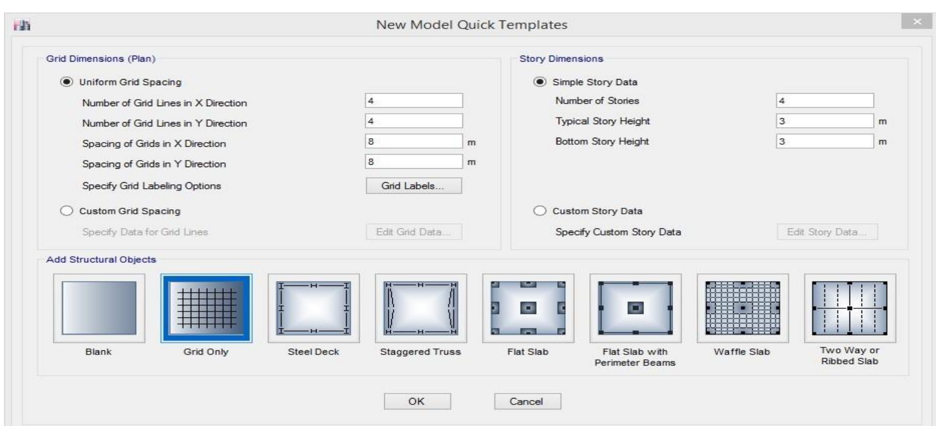

Fig 4.2 Setting Number of grids and its spacing

Step 3: Define Material Property.

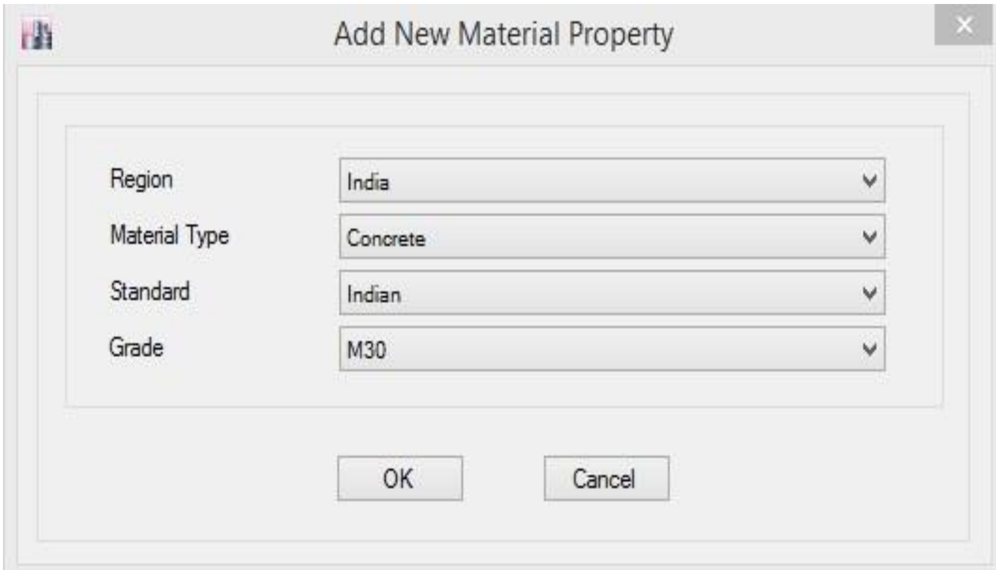

Fig. 4.3 Define material property form

Step 4: Define section property like Frames, slabs, walls etc.

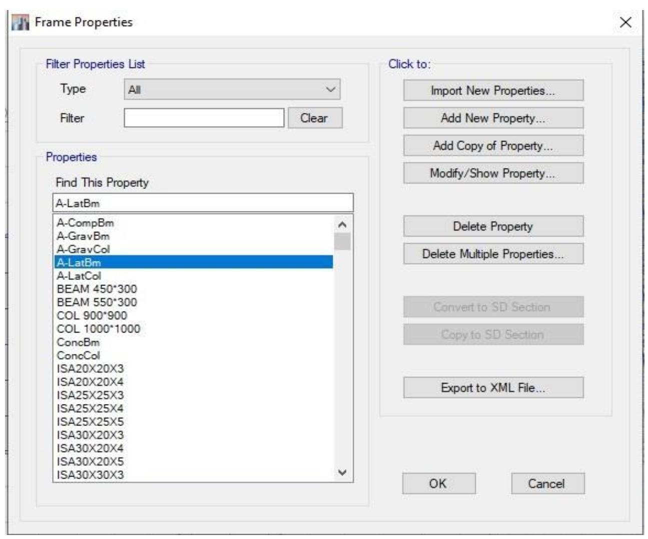

Fig 4.4 Define section property like Frames, slabs, walls etc.

Step 5: Assign properties.

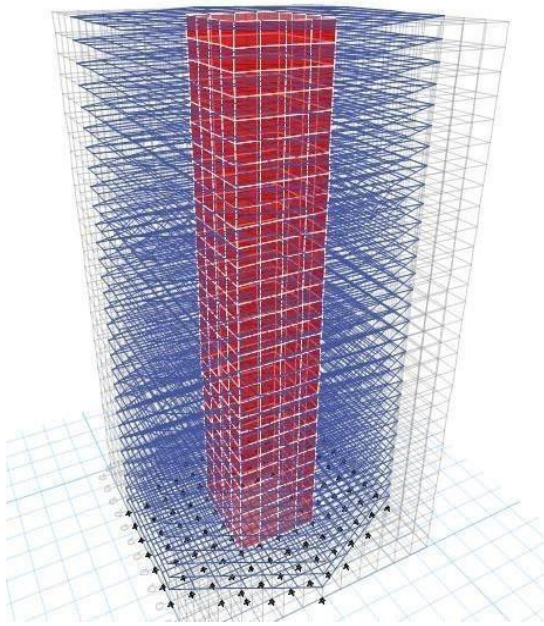

Fig. 4.5 Assign defined properties

Step 6: Define load Patterns and assign.

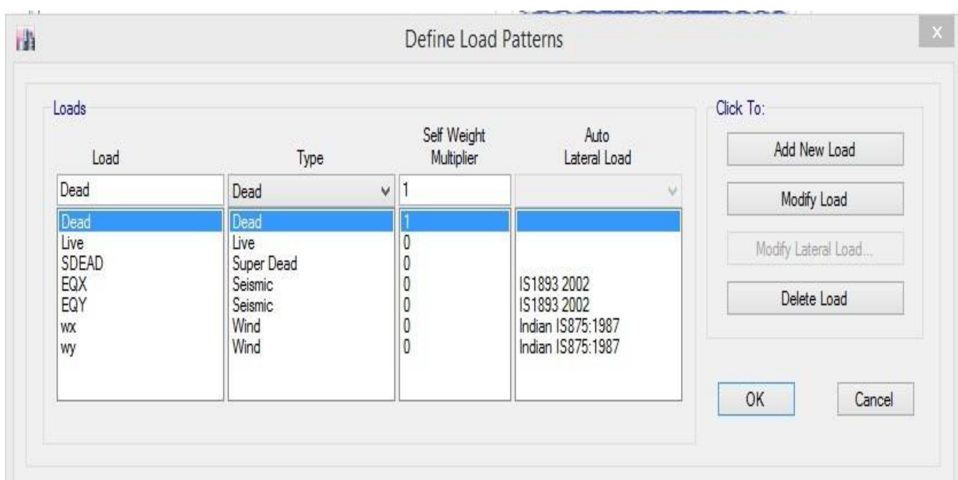

Fig. 4.6 Define load patterns form

Step 7: Load-Combination.

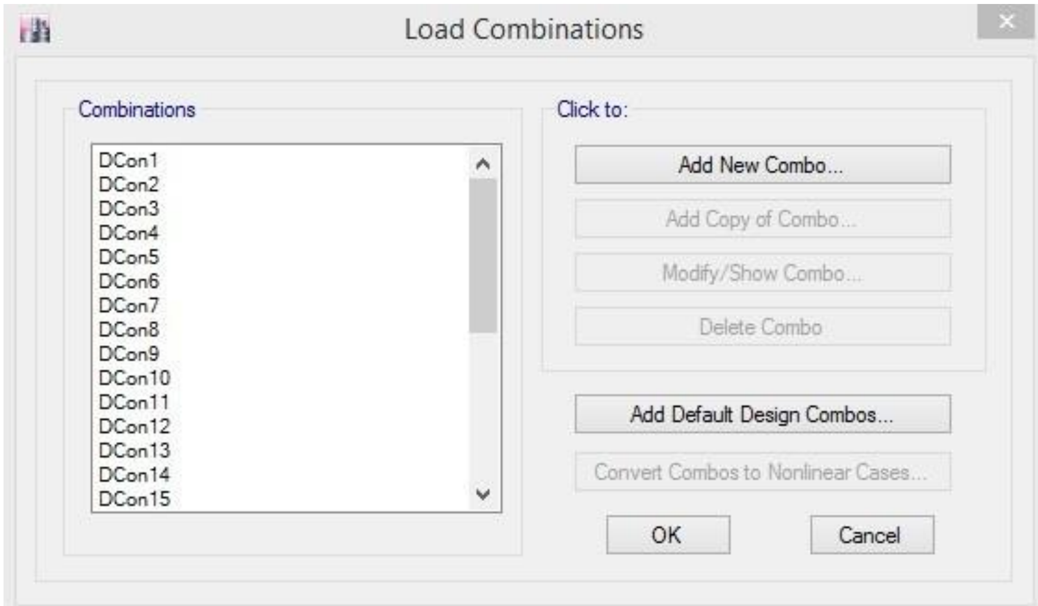

Fig. 4.7 Load Combinations Form

Step 8: Define mass sources.

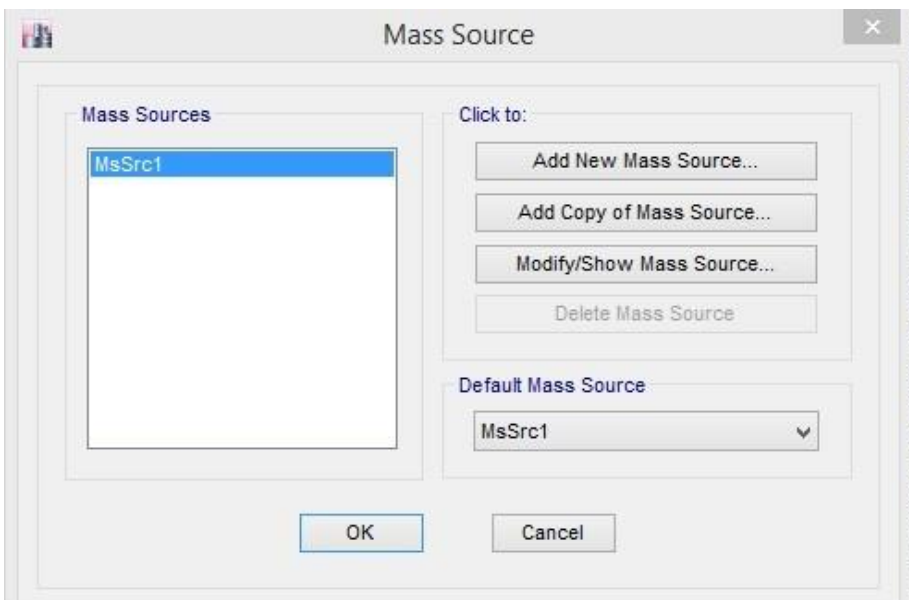

Fig. 4.8 Mass Source define form

Step 9: Check model and run analysis model, extract results

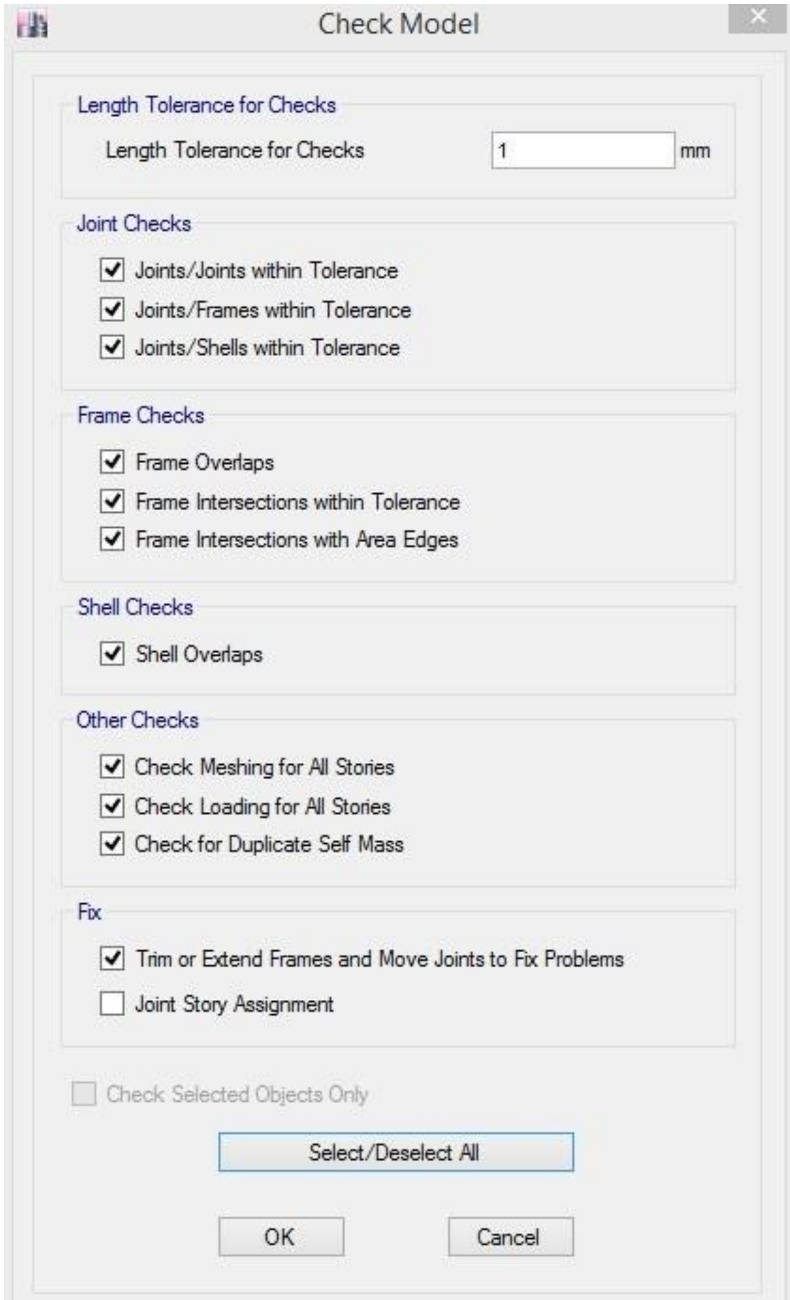

Fig. 4.9 Check model

4.10 Geometric configuration of outrigger with steel bracing

Following geometric configuration are taken used for the current study and modeled usingE-TABS 2015

a) **Model 1:** Square moment resist framed without outrigger structure.

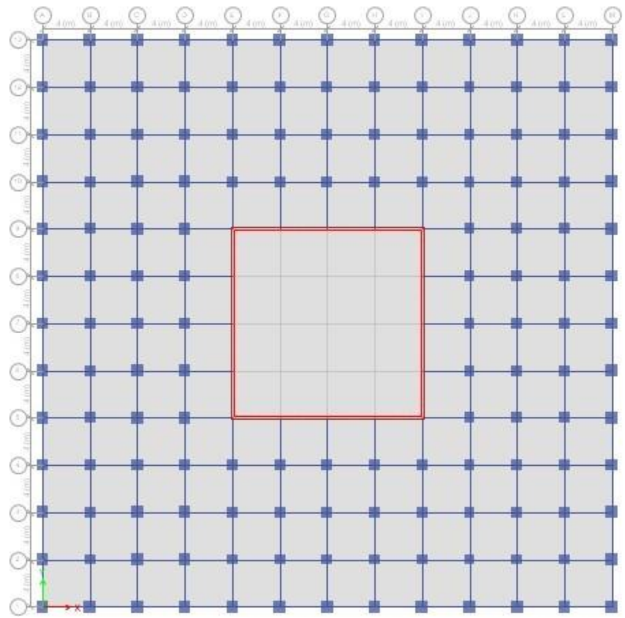

Fig. 4.10 Plan view of model

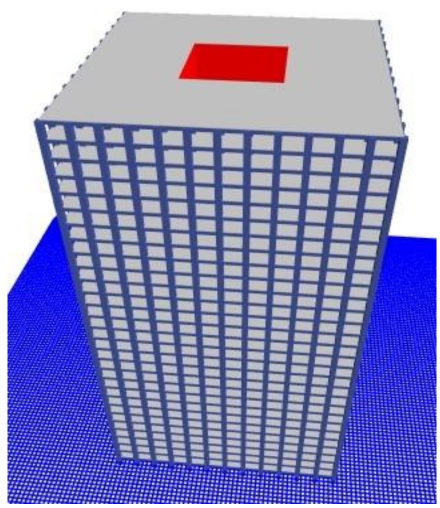

Fig. 4.11 Rectangular 3D model

Model 2: Square moment resist frame with
outrigger structure.

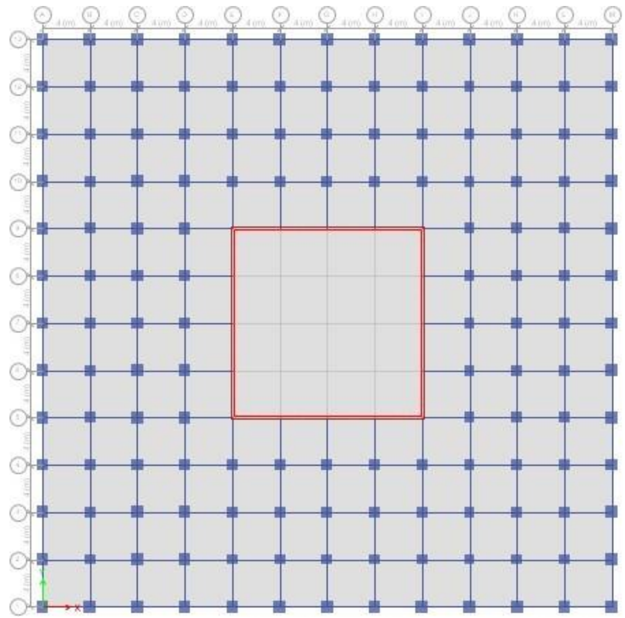

Fig. 4.12 Plan view of model

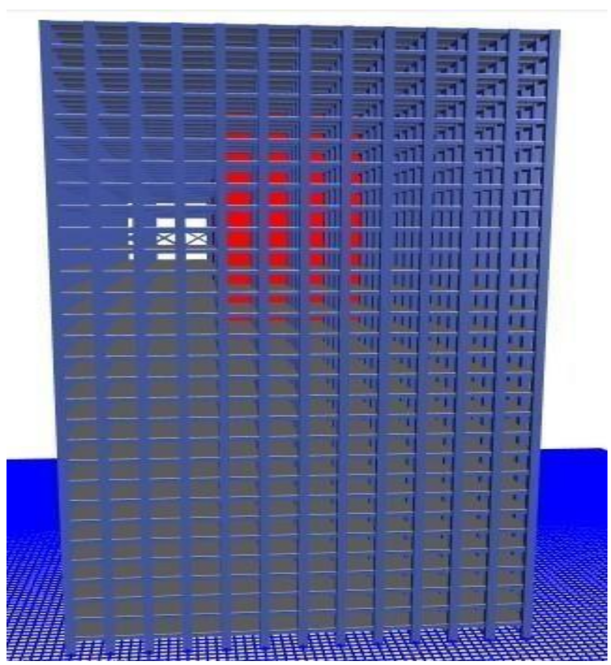

Fig. 4.13 Elevation view of model.

Model 4: Hexagonal moment resisting framed without outrigger structure.

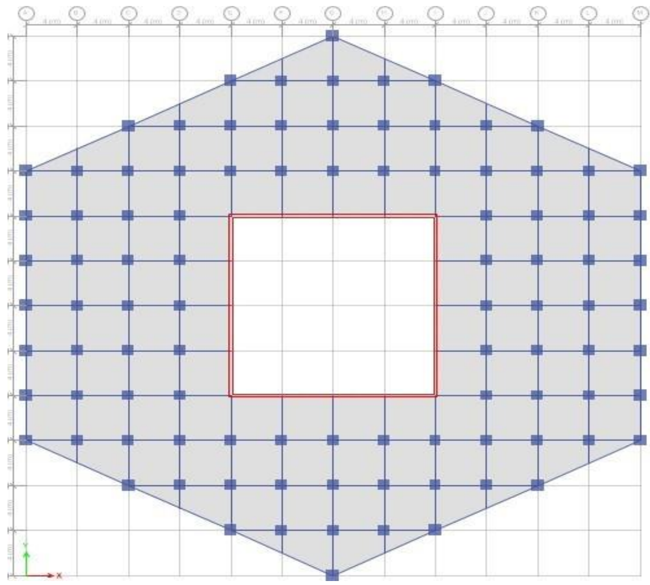

Fig. 4.14 Plan view of model

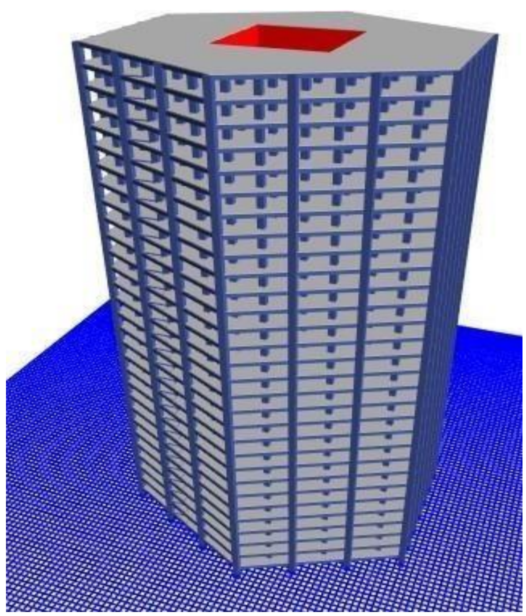

Fig. 4.15 3D-view of model

Model 5: Hexagonal moment resisting framed outrigger with steel bracing structure.

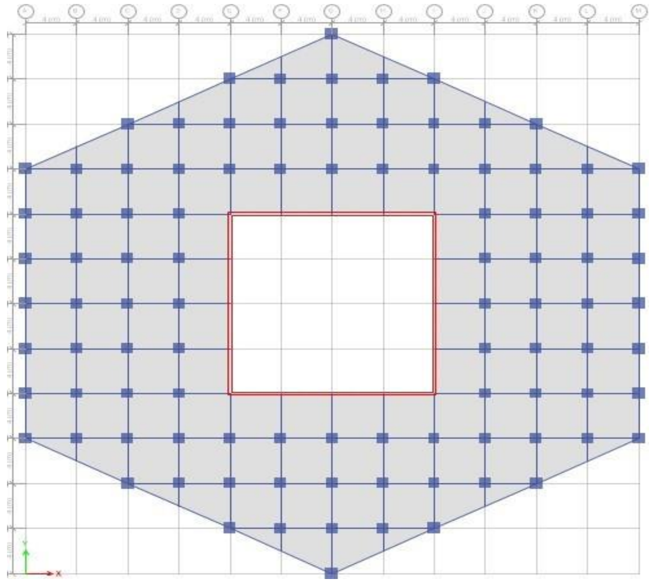

Fig. 4.16 Plan view of model

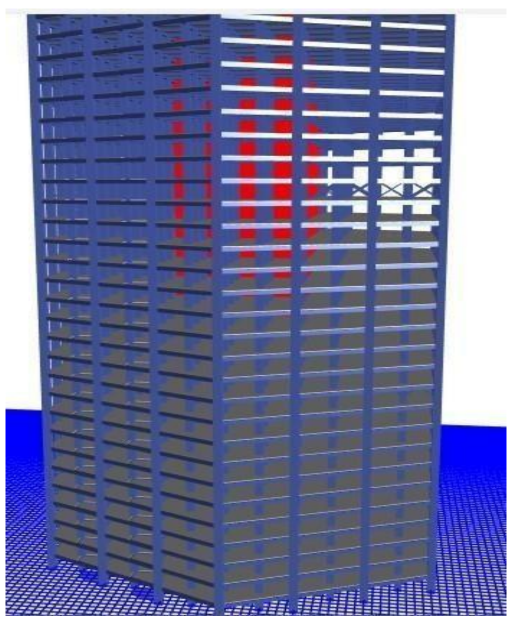

Fig. 4.17 3D model

CHAPTER 5

RESULTS AND DISCUSSIONS

General

In this chapter the behavior of each model is captured and the results are tabulated. The variation of systematic parameters like storey lateral displacement, storey drift, Storey stiffness, Storey shear and base shear has been studied for equivalent static method. The results of all the models are observed and the most suitable model is selected by comparingthe results of each model.

Storey Displacement

The lateral displacements obtained for equivalent static method (EQS) for G+30 storey building models of different geometric shapes, along both X and Y directions are listed in the tables below.

Table 5.1 Storey Displacement EQX for Z-IV in mm

Storey	X-Dir REC with outrigger	X-Dir REC without outrigger
	mm	mm
Storey30	33.3	44.7
Storey29	32.5	43.5
Storey28	31.6	42.3
Storey27	30.7	40.9
Storey26	29.7	39.5
Storey25	28.7	38.1
Storey24	27.6	36.6
Storey23	26.4	35
Storey22	25.3	33.4
Storey21	24.1	31.8
Storey20	22.8	30.4
Storey19	21.5	28.7
Storey18	20.2	27
Storey17	18.9	25.2
Storey16	17.5	23.4
Storey15	16.2	21.6
Storey14	14.8	19.7

Storey13	13.5	17.9
Storey12	12.1	16.1
Storey11	10.8	14.5
Storey10	9.5	13
Storey9	8.3	11.4
Storey8	7	9.8
Storey7	5.8	8.2
Storey6	4.7	6.7
Storey5	3.7	5.3
Storey4	2.7	4
Storey3	1.8	2.8
Storey2	1	1.7
Storey1	0.4	0.8
Base	0	0

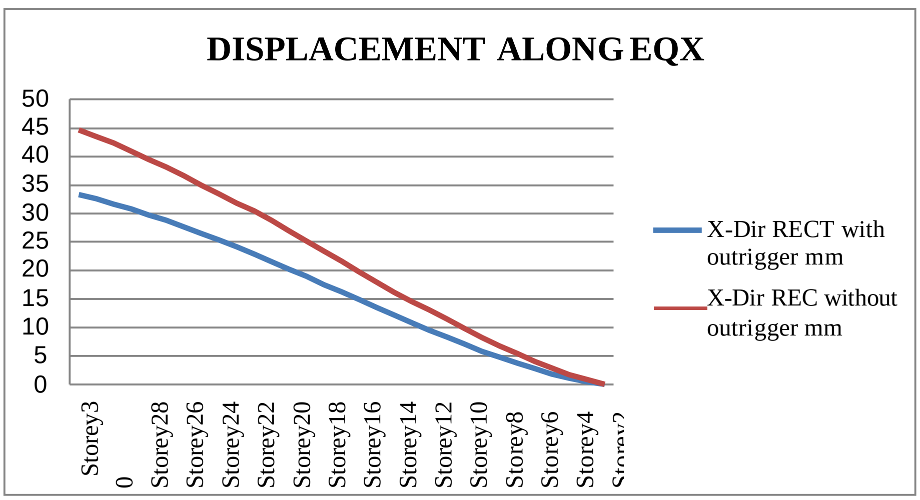

Fig. 5.1 Plot of Rectangular Storey Displacement vs. Storey Number EQX –IV

Table 5.2 Storey Displacement EQX with Hexagonal for IV in mm

Storey	**X-Dir HEXA without outrigger**	**X-Dir HEXA with outrigger**
	mm	mm
Storey30	36.3	35.2

Storey29	34.3	34.2
Storey28	33.4	33.1
Storey27	32.4	32
Storey26	31.3	30.8
Storey25	30.2	29.6
Storey24	29	28.3
Storey23	27.8	27
Storey22	26.6	25.7
Storey21	25.4	24.3
Storey20	24.3	23
Storey19	23	21.6
Storey18	21.6	20.1
Storey17	20.2	18.7
Storey16	18.8	17.3
Storey15	17.3	15.9
Storey14	15.9	14.5
Storey13	14.4	13.1
Storey12	13	11.7
Storey11	11.7	10.3
Storey10	10.5	9
Storey9	9.2	7.8
Storey8	7.9	6.6
Storey7	6.7	5.4
Storey6	5.5	4.3
Storey5	4.3	3.3
Storey4	3.3	2.4
Storey3	2.3	1.6
Storey2	1.4	0.9
Storey1	0.6	0.3

Base	0	0

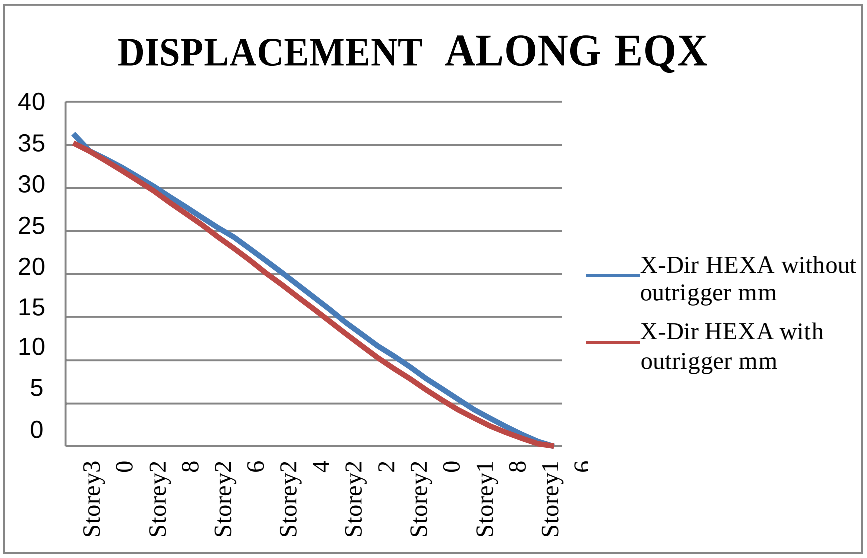

Fig. 5.2 Plot of Hexagonal Storey Displacement vs. Storey Number EQX IV

Table 5.3 Storey Rectangular Displacement EQY for Z-IV in mm

Storey	Y-Dir REC without outrigger	Y-Dir REC with outrigger
	mm	mm
Storey30	47.4	36.0
Storey29	46.1	35.0
Storey28	44.7	34.0
Storey27	43.3	32.9
Storey26	41.8	31.8
Storey25	40.3	30.6
Storey24	38.6	29.4
Storey23	37.0	28.1
Storey22	35.3	26.8
Storey21	33.5	25.4
Storey20	31.7	24.0
Storey19	29.9	22.6
Storey18	28.0	21.2
Storey17	26.1	19.7
Storey16	24.2	18.3
Storey15	22.3	16.8
Storey14	20.4	15.4
Storey13	18.5	13.9
Storey12	16.7	12.5

Storey11	14.8	11.1
Storey10	13.1	9.7
Storey9	11.3	8.4
Storey8	9.7	7.1
Storey7	8.1	5.9
Storey6	6.5	4.7
Storey5	5.1	3.6
Storey4	3.8	2.6
Storey3	2.6	1.8
Storey2	1.6	1.0
Storey1	0.7	0.3
Base	0	0

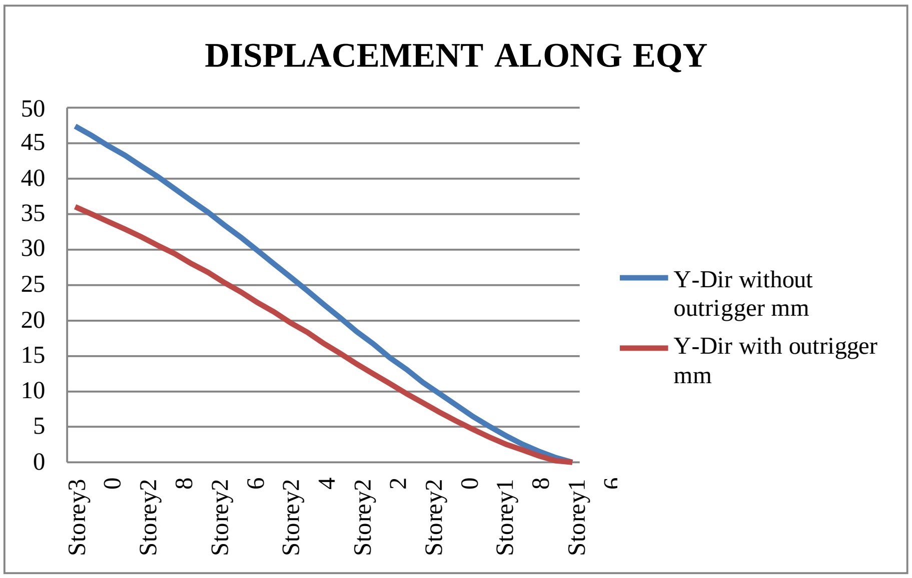

Fig. 5.3 Plot of Rectangular Storey Displacement vs. Storey Number EQY –IV

Table 5.4 Storey Displacement EQY with Hexagonal for IV in mm

Storey	Y-Dir HEXA without outrigger	Y-Dir HEXA with outrigger
	mm	mm
Storey30	37.5	35.2
Storey29	36.5	34.2
Storey28	35.5	33.1
Storey27	34.4	32
Storey26	33.3	30.8

Storey2 5	32.1	29.5
Storey2 4	30.8	28.3
Storey2 3	29.5	27
Storey2 2	28.2	25.7
Storey2 1	26.8	24.3
Storey2 0	25.4	22.9
Storey1 9	23.9	21.5
Storey1 8	22.5	20.1
Storey1 7	21	18.7
Storey1 6	19.5	17.3
Storey1 5	18	15.8
Storey1 4	16.5	14.4
Storey13	15	13
Storey12	13.5	11.7
Storey11	12	10.3
Storey10	10.6	9
Storey9	9.2	7.8
Storey8	7.9	6.5
Storey7	6.6	5.4
Storey6	5.4	4.3
Storey5	4.2	3.3
Storey4	3.2	2.4
Storey3	2.2	1.6
Storey2	1.3	0.9
Storey1	0.6	0.3
Base	0	0

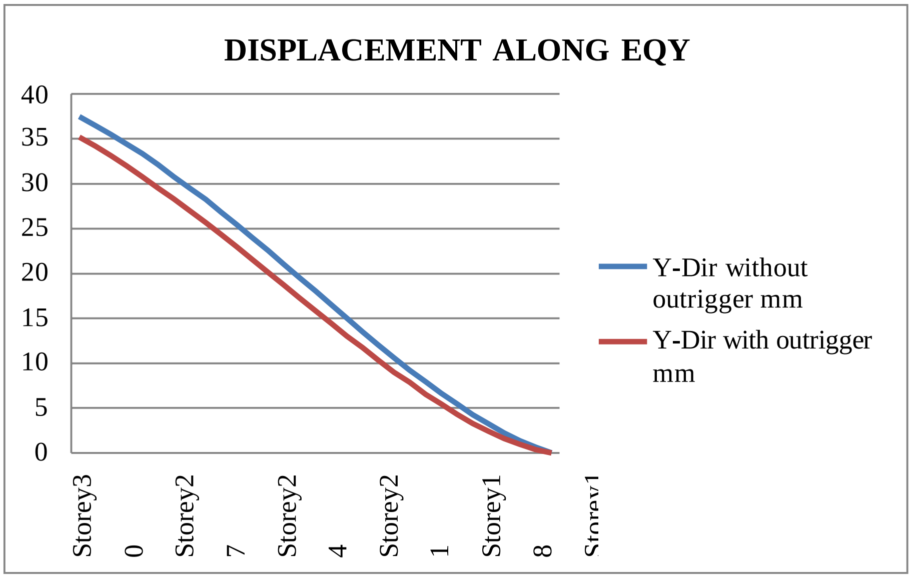

Fig. 5.4 Plot of Hexagonal Storey Displacement vs. Storey Number EQY IV

Table 5.5 Storey Displacement VS Response Spectrum for zone- IV in mm

Storey	**REC without outrigger**	**REC with outrigger**	**HEXA without outrigger**	**HEXA with outrigger**
	mm	mm	mm	mm
Storey30	27.6	23	23.4	22.4
Storey29	27	22.5	22.6	22
Storey28	26.3	21.9	21.9	21.5
Storey27	25.6	21.2	21.1	20.8
Storey26	24.7	20.5	20.3	20.2
Storey25	23.9	19.9	19.5	19.5
Storey24	23	19.1	18.7	18.8
Storey23	22.1	18.4	17.8	18.1
Storey22	21.2	17.6	17	17.3
Storey21	20.3	16.8	16.1	16.6
Storey20	19.4	16	15.2	15.9
Storey19	18.5	15.2	14.3	15.2
Storey18	17.4	14.3	13.4	14.3
Storey17	16.4	13.4	12.5	13.5
Storey16	15.3	12.6	11.6	12.6
Storey15	14.2	11.7	10.7	11.7
Storey14	13.2	10.8	9.8	10.8
Storey13	12.1	9.9	8.9	9.9

Storey12	11	9	8.1	9
Storey11	10	8.1	7.2	8.2
Storey10	9	7.2	6.3	7.4
Storey9	8	6.3	5.5	6.6
Storey8	7	5.4	4.7	5.7
Storey7	5.9	4.5	3.9	4.8
Storey6	4.9	3.7	3.1	4
Storey5	3.9	2.9	2.4	3.2
Storey4	2.9	2.1	1.8	2.4
Storey3	2.1	1.4	1.2	1.7
Storey2	1.3	0.8	0.7	1
Storey1	0.6	0.3	0.2	0.5

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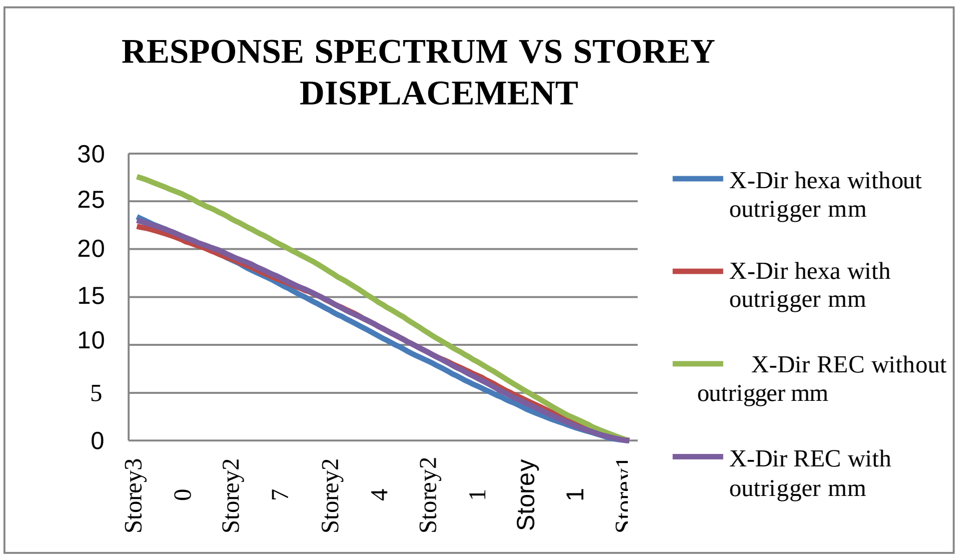


Fig. 5.5 Plot of Storey Displacement vs Response Spectrum Method for Zone-IV

Observations and Discussions on Storey Displacement

By studying from Table 5.1 to Table 5.2 and comparing their values in fig. 5.1 to 5.2. we can see that displacement increases as storey height increases. We can clearly see that there is increased of lateral displacement for with outrigger compare to without outrigger structure Increased by 3.68% along both X and Y direction. Compare to without outrigger structure rectangular frame with outrigger Rectangular structure is increased by 24%, 25% along X and Y direction and hexagonal structure increased by 10.02%, 19.48% along X and Y directions respectively for equivalent static analysis.

By studying from table 5.5 comparing values by response spectrum storey displacement increased of lateral displacement for rectangular increased 16.6% and hexagonal it increased 4% by dynamic analysis.

Storey Drift

Storey drift obtained for G+30 storey all building models along both X and Y directions are listed for Equivalent static methods in the below tables

Table 5.6 Storey Drift Rectangular EQX for Z-IV in m

Storey	X-Dir REC without outrigger	X-Dir REC with outrigger
	m	m
Storey 30	0.00039	0.00027
Storey 29	0.00042	0.00029
Storey 28	0.00044	0.00031
Storey 27	0.00047	0.00033
Storey 26	0.00049	0.00034
Storey 25	0.00050	0.00036
Storey24	0.00052	0.00038
Storey23	0.00053	0.00039
Storey 22	0.00052	0.00041
Storey 21	0.00048	0.00042
Storey 20	0.00055	0.00043
Storey 19	0.00058	0.00044
Storey 18	0.00060	0.00044
Storey 17	0.00061	0.00045
Storey 16	0.00061	0.00045
Storey 15	0.00061	0.00045
Storey 14	0.00060	0.00045
Storey 13	0.00059	0.00045

Storey 12	0.00056	0.00044
Storey 11	0.00049	0.00043
Storey 10	0.00053	0.00042
Storey 9	0.00054	0.00041
Storey 8	0.00052	0.00039
Storey 7	0.00050	0.00038
Storey 6	0.00047	0.00035
Storey 5	0.00044	0.00033
Storey 4	0.00040	0.00030
Storey 3	0.00036	0.00026
Storey 2	0.00031	0.00022
Storey1	0.00028	0.00013
Base	0	0

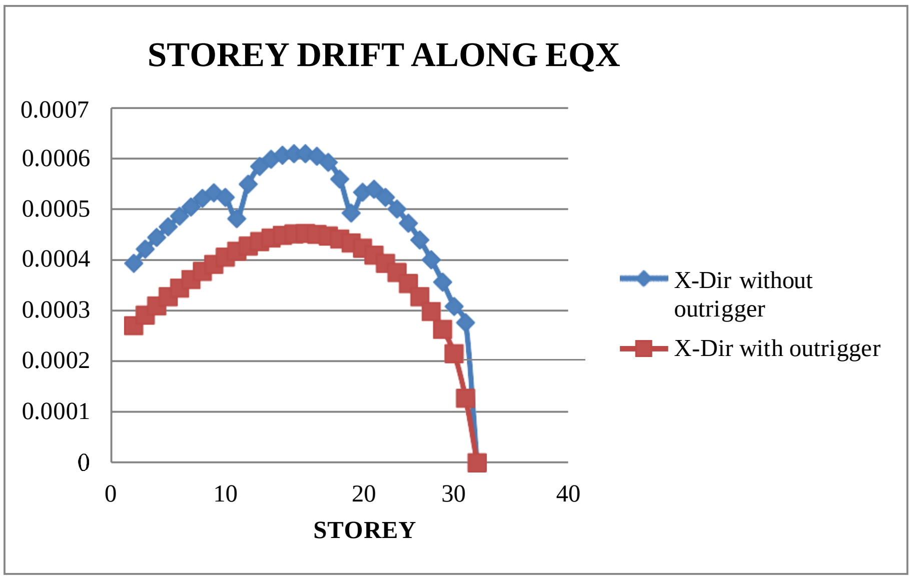


Fig. 5.6 Plot of Rectangular Storey Drift vs Storey Number EQX Z-IV

Table 5.7 Storey Drift Hexagonal EQX for Z-IV in m

Storey	X-Dir HEXA with outrigger	X-Dir HEXA without outrigger
	m	m
Storey 30	0.00029	0.00034
Storey 29	0.00032	0.00036

Storey 28	0.00034	0.00038
Storey 27	0.00035	0.00039
Storey 26	0.00037	0.00041
Storey 25	0.00039	0.00042
Storey 24	0.0004	0.00043
Storey 23	0.00041	0.00044
Storey 22	0.00041	0.00045
Storey 21	0.00037	0.00046
Storey 20	0.00043	0.00047
Storey 19	0.00046	0.00047
Storey 18	0.00047	0.00047
Storey 17	0.00048	0.00048
Storey 16	0.00048	0.00047
Storey 15	0.00048	0.00047
Storey 14	0.00048	0.00047
Storey 13	0.00047	0.00046
Storey 12	0.00045	0.00045
Storey 11	0.00039	0.00044
Storey 10	0.00043	0.00042
Storey 9	0.00043	0.0004
Storey 8	0.00042	0.00038
Storey 7	0.0004	0.00036
Storey 6	0.00038	0.00034
Storey 5	0.00036	0.00031
Storey 4	0.00033	0.00027
Storey 3	0.00029	0.00024
Storey 2	0.00025	0.00019
Storey 1	0.00023	0.0001

Base	0	0

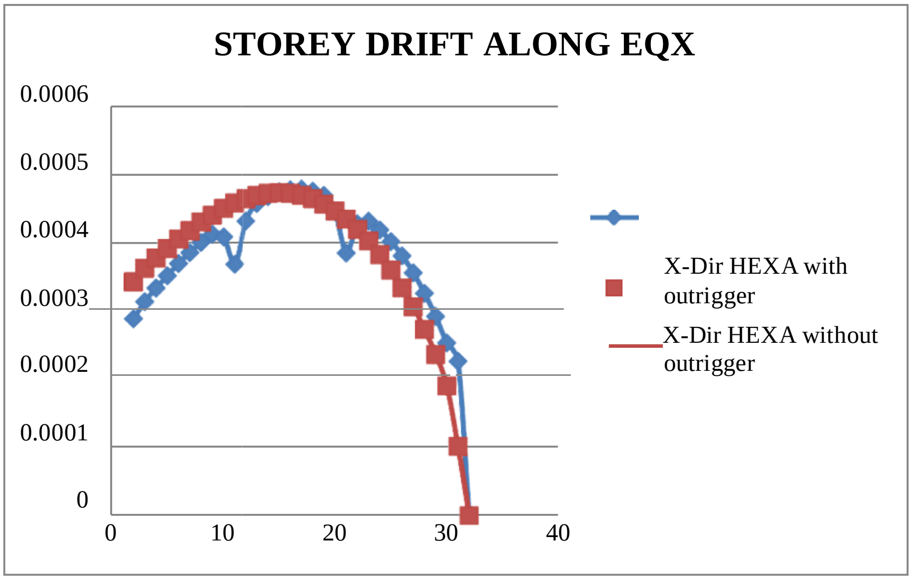


Fig. 5.7 Plot of Hexagonal Storey Drift vs Storey Number EQX Z-IV

Table 5.8 Storey Drift Rectangular EQY for Z-IV in m

Storey	Y-Dir REC without outrigger	Y-Dir REC with outrigger
	m	m
Storey 30	0.00036	0.00027
Storey 29	0.00046	0.00035
Storey 28	0.00048	0.00036
Storey 27	0.00050	0.00038
Storey 26	0.00052	0.00040
Storey 25	0.00054	0.00041
Storey 24	0.00056	0.00043
Storey 23	0.00057	0.00044
Storey 22	0.00059	0.00045
Storey 21	0.0006	0.00046
Storey 20	0.00061	0.00047

Storey 19	0.00062	0.00048
Storey 18	0.00063	0.00048
Storey 17	0.00063	0.00049
Storey 16	0.00064	0.00049
Storey 15	0.00063	0.00049
Storey 14	0.00063	0.00048
Storey 13	0.00062	0.00048
Storey 12	0.00061	0.00047
Storey 11	0.00059	0.00046
Storey 10	0.00058	0.00044
Storey 9	0.00056	0.00043
Storey 8	0.00053	0.00041
Storey 7	0.0005	0.00039
Storey 6	0.00047	0.00036
Storey 5	0.00043	0.00033
Storey 4	0.00039	0.0003
Storey 3	0.00035	0.00026
Storey 2	0.0003	0.00021
Storey 1	0.00026	0.00012
Base	0	0

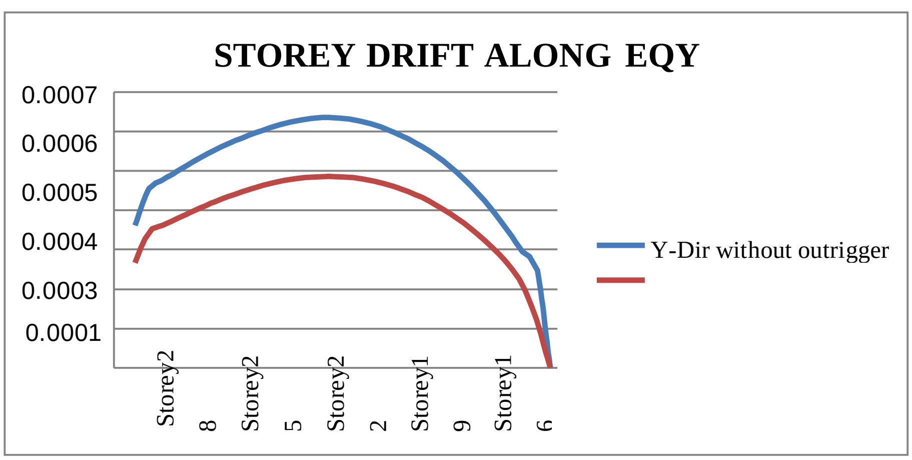


Fig. 5.8 Plot of Rectangular Storey Drift vs Storey Number EQY Z-IV

Table 5.9 Storey Drift Hexagonal EQY for Z-IV in m

Storey	Y-Dir HEXA without outrigger	Y-Dir HEXA with outrigger
	m	m
Storey 30	0.00035	0.00032
Storey 29	0.00037	0.00035
Storey 28	0.00038	0.00037
Storey 27	0.00039	0.00038
Storey 26	0.00041	0.0004
Storey 25	0.00042	0.00042
Storey 24	0.00043	0.00043
Storey 23	0.00044	0.00045
Storey 22	0.00045	0.00046
Storey 21	0.00046	0.00047
Storey 20	0.00047	0.00048
Storey 19	0.00047	0.00049
Storey 18	0.00047	0.0005
Storey 17	0.00048	0.0005
Storey 16	0.00047	0.0005
Storey 15	0.00047	0.0005
Storey 14	0.00047	0.0005
Storey 13	0.00046	0.00049
Storey 12	0.00045	0.00048
Storey 11	0.00044	0.00047
Storey 10	0.00042	0.00046
Storey 9	0.0004	0.00045
Storey 8	0.00038	0.00043

Storey 7	0.00036	0.00041
Storey 6	0.00034	0.00038
Storey 5	0.00031	0.00036
Storey 4	0.00027	0.00032
Storey 3	0.00024	0.00029
Storey 2	0.00019	0.00025
Storey 1	0.0001	0.00022
Base	0	0

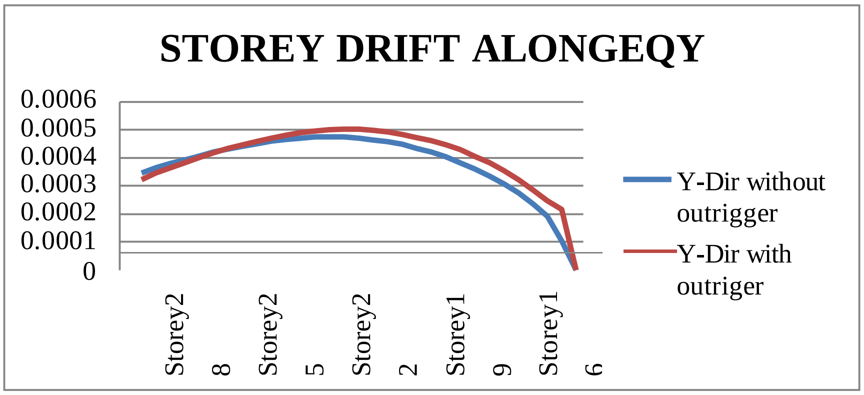
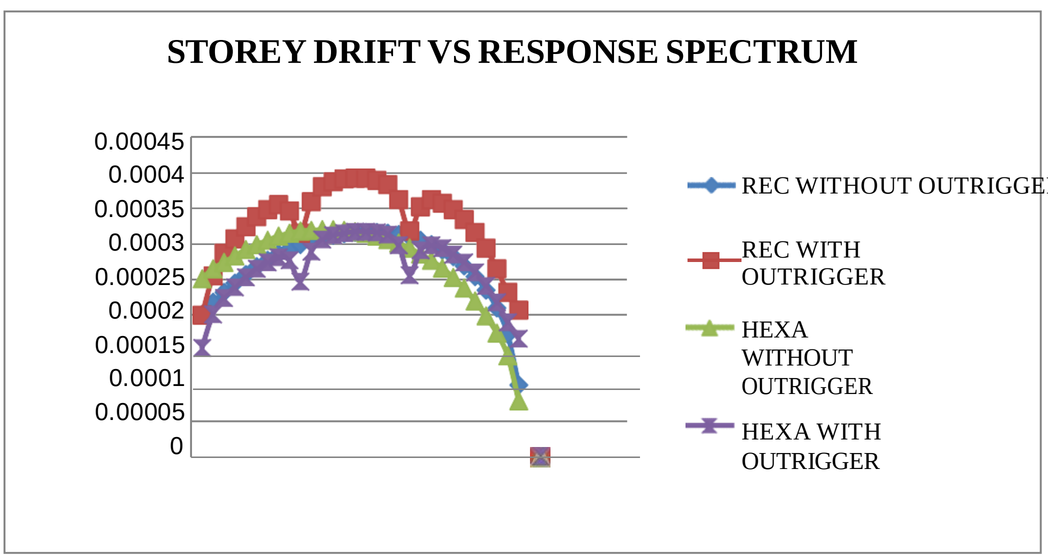


Fig. 5.9 Plot of Hexagonal Storey Drift vs Storey Number EQY Z-IV

Table 5.10 Storey Drift Vs Response Spectrum Method for Z-IV

Storey	REC-Without Outrigger	REC-With Outrigger	HEXA-Without Outrigger	HEXA-With Outrigger
Storey 30	0.000201	0.00020	0.000251	0.000154
Storey 29	0.000218	0.000255	0.000265	0.000201
Storey 28	0.000232	0.000287	0.000274	0.000224
Storey 27	0.000245	0.000307	0.000283	0.000239
Storey 26	0.000257	0.000324	0.000292	0.000253
Storey 25	0.000268	0.000338	0.000299	0.000265
Storey 24	0.000277	0.000348	0.000305	0.000274
Storey 23	0.000286	0.000355	0.000311	0.000281
Storey 22	0.000293	0.000346	0.000315	0.000277

Storey 21	0.000299	0.000315	0.000318	0.000247
Storey 20	0.000305	0.000359	0.000319	0.000289
Storey 19	0.000309	0.00038	0.00032	0.000306
Storey 18	0.000312	0.000387	0.00032	0.000312
Storey 17	0.000314	0.000391	0.000319	0.000315
Storey 16	0.000316	0.000392	0.000317	0.000317
Storey 15	0.000316	0.000392	0.000315	0.000317
Storey 14	0.000316	0.000389	0.000311	0.000316
Storey 13	0.000315	0.000383	0.000306	0.000313
Storey 12	0.000313	0.000362	0.000301	0.000298
Storey 11	0.00031	0.000318	0.000294	0.000256
Storey 10	0.000305	0.000352	0.000286	0.000291
Storey 9	0.000299	0.000362	0.000277	0.000298
Storey 8	0.000291	0.000357	0.000266	0.000294
Storey 7	0.000282	0.000348	0.000253	0.000285
Storey 6	0.000269	0.000334	0.000238	0.000274
Storey 5	0.000254	0.000316	0.00022	0.00026
Storey 4	0.000235	0.000294	0.000199	0.000241
Storey 3	0.00021	0.000265	0.000175	0.000218
Storey 2	0.000173	0.000232	0.000143	0.00019
Storey 1	0.000102	0.000207	0.00008	0.000167



0 10 20 30 40

STOREY HEIGHT

Fig. 5.10 Plot of Storey Drift vs Response Spectrum for Z-IV

5.3.1 Observations and Discussions on Storey Drift

By studying from Table 5.6 to Table 5.7 and comparing their values in fig. 5.6 to 5.7 we can see that Drift increases as storey height increases. We can clearly see that there is Increased ofStorey Drift. Compare to without outrigger structure rectangular frame outrigger Rectangular structure is increased by 7.4%, 2.8% and hexagonal structure increased by 10.02%, 19.48% alongX and Y directions respectively for equivalent static analysis.

By studying from table 5.10 comparing values by response spectrum by storey drift rectangular increased 7% and hexagonal it increased 4% by dynamic analysis.

Storey Shear

Storey shear obtained for G+30 storey all building models along both X and Y directions are listed for Equivalent static methods into the below table.

Table 5.11 Storey Shear Rectangular EQX for Z-IV in KN

Storey	X-Dir without outrigger	X-Dir with outrigger
	KN	KN
Storey30	1250.4	1004.9
Storey29	2716.2	2190.1
Storey28	4082.4	3302
Storey27	5352.6	4335.7
Storey26	6530.2	5294.1
Storey25	7618.7	6180
Storey24	8621.7	6996.3
Storey23	9542.6	7745.8
Storey22	10385	8431.3
Storey21	11153	9055.8
Storey20	11850	9622
Storey19	12478	10133
Storey18	13041	10591
Storey17	13543	11000

Storey16	13988	11362
Storey15	14378	11679
Storey14	14718	11956
Storey13	15011	12194
Storey12	15260	12397
Storey11	15470	12568
Storey10	15643	12708
Storey9	15783	12822
Storey8	15893	12912
Storey7	15977	12980
Storey6	16039	13030
Storey 5	16081	13065
Storey 4	16108	13087
Storey 3	16123	13099
Storey 2	16130	13105
Storey 1	16131	13106

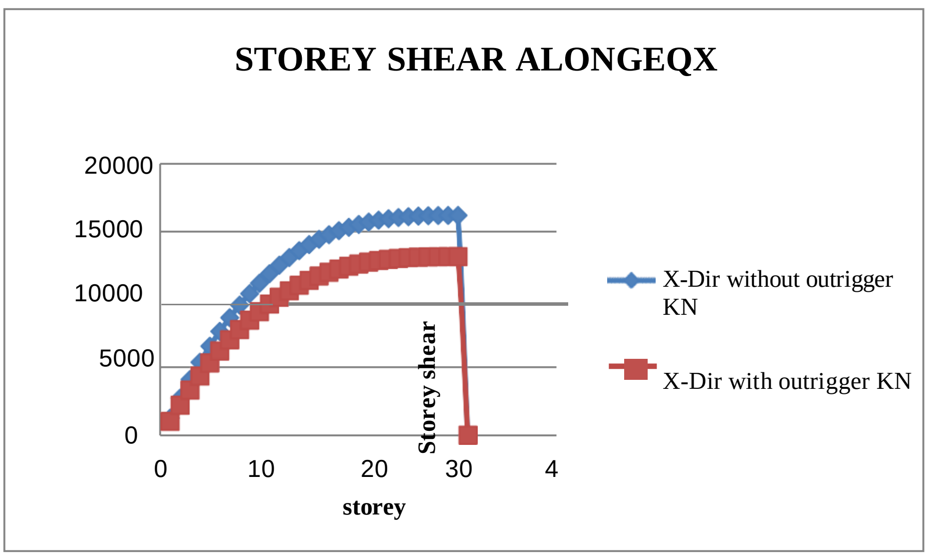


Fig. 5.11 Plot of Rectangular Storey Shear vs. Storey Number EQX Z-IV

Table 5.12 Storey Shear Hexagonal EQX for Z-IV in KN

Storey	X-Dir HEXA without outrigger	X-Dir HEXA with outrigger
	KN	KN
Storey30	1107.1	706.66
Storey29	2325.9	1553.8
Storey28	3462.7	2343.4
Storey27	4518.8	3077.5
Storey26	5498	3758
Storey25	6403.1	4387.1
Storey24	7237	4966.8
Storey23	8002.7	5499
Storey22	8703.1	5985.8
Storey21	8938	6429.2
Storey20	9922.4	6831.3
Storey19	10445	7194.1
Storey18	10913	7519.5
Storey17	11330	7809.7
Storey16	11700	8066.6
Storey15	12025	8292.2
Storey14	12307	8488.7
Storey13	12551	8658
Storey12	12758	8802.1
Storey11	12504	8923
Storey10	13077	9022.9
Storey9	13193	9103.6
Storey8	13285	9167.3

Storey7	13355	9216
Storey6	13406	9251.6
Storey5	13441	9276.2
Storey4	13464	9291.9
Storey3	13476	9300.6
Storey2	13482	9304.4
Storey1	13483	9305.2

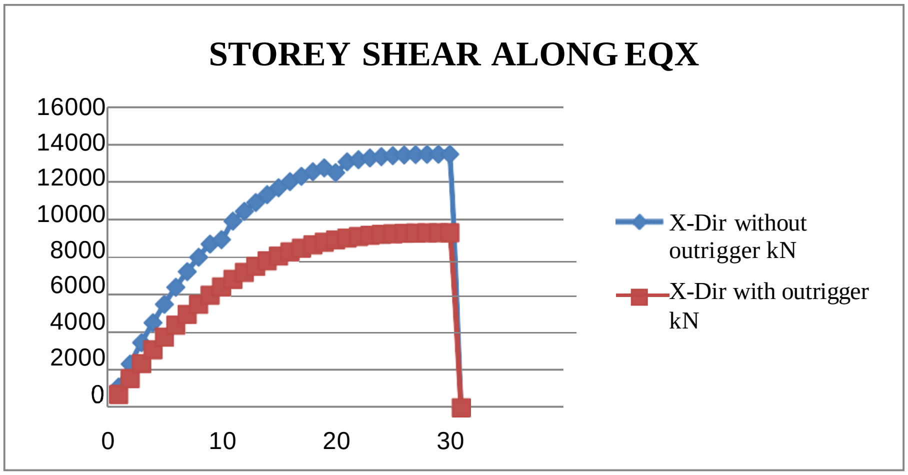


Fig. 5.12 Plot of Hexagonal Storey Shear vs. Storey Number EQX Z-IV

Table 5.13 Storey Shear Rectangular EQY for Z-IV in KN

Storey	Y-Dir REC without outrigger	Y-Dir REC with outrigger
	KN	KN
Storey3 0	1175.9	926.06
Storey2 9	2554.4	2018.3
Storey2 8	3839.3	3043.1
Storey2 7	5033.8	3995.7
Storey2 6	6141.2	4879
Storey2 5	7164.9	5695.4
Storey2 4	8108.2	6447.7
Storey2 3	8974.2	7138.4

Storey22	9766.4	7770.2
Storey21	10489	8345.7
Storey20	11144	8867.5
Storey19	11735	9338.3
Storey18	12264	9760.6
Storey17	12736	10137
Storey16	13154	10471
Storey15	13522	10763
Storey14	13841	11018
Storey13	14117	11238
Storey12	14351	11425
Storey11	14548	11582
Storey10	14711	11712
Storey9	14843	11816
Storey8	14946	11899
Storey7	15025	11962
Storey6	15083	12009
Storey5	15123	12040
Storey4	15149	12061
Storey3	15163	12072
Storey2	15169	12077
Storey1	15171	12078

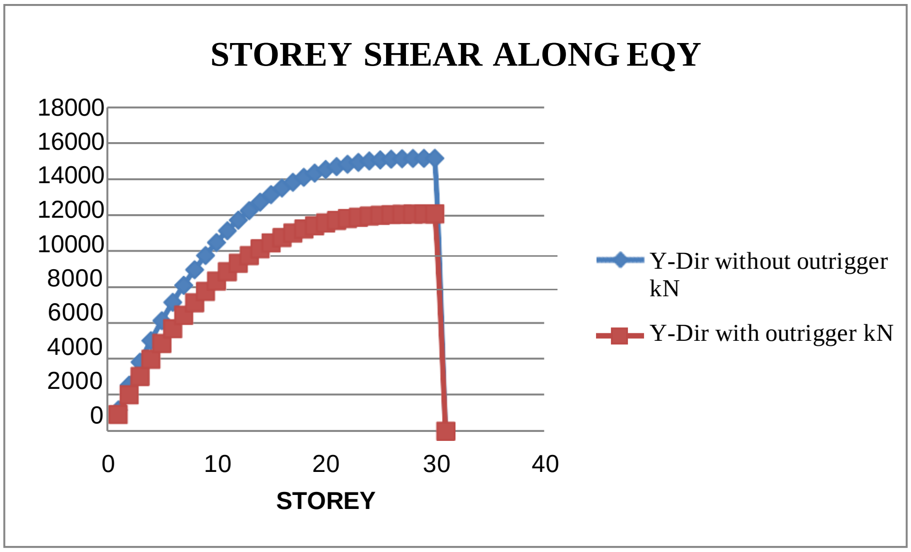


Fig. 5.13 Plot of Rectangular Storey Shear vs. Storey Number EQY Z-IV

Table 5.14 Storey Shear Hexagonal EQY for Z-IV in KN

Storey	**Y-Dir HEXA without outrigger**	**Y-Dir HEXA with outrigger**
	KN	KN
Storey30	1040.2	707.38
Storey29	2185.3	1555.4
Storey28	3253.5	2345.7
Storey27	4245.8	3080.6
Storey26	5165.7	3761.8
Storey25	6016.1	4391.5
Storey24	6799.7	4971.8
Storey23	7519.1	5504.5
Storey22	8177.2	5991.8
Storey21	8777.9	6435.7
Storey20	9322.7	6838.2
Storey19	9813.4	7201.3
Storey18	10253	7527.1
Storey17	10646	7817.5
Storey16	10993	8074.7
Storey15	11298	8300.6

Storey14	11564	8497.2
Storey13	11792	8666.7
Storey12	11987	8810.9
Storey11	12151	8932
Storey10	12286	9032
Storey9	12396	9112.8
Storey8	12482	9176.6
Storey7	12547	9225.3
Storey6	12596	9260.9
Storey 5	12629	9285.6
Storey 4	12650	9301.2
Storey 3	12662	9310
Storey 2	12667	9313.7
Storey 1	12668	9314.6

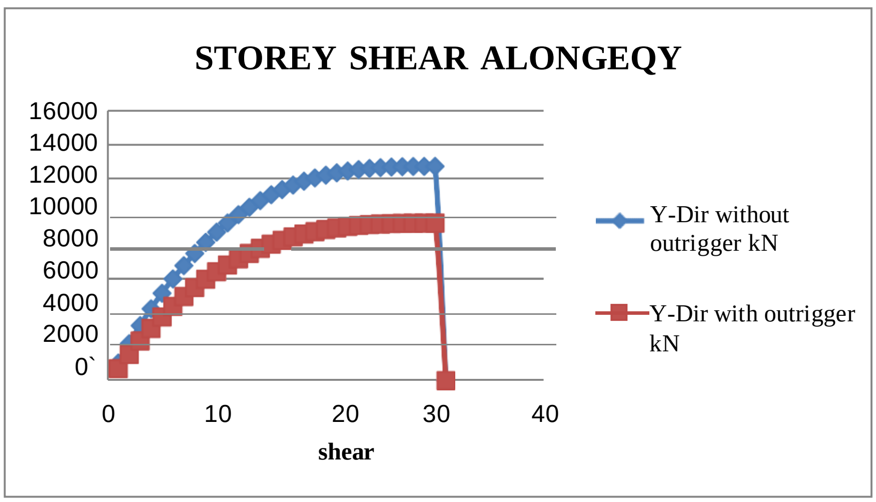


Fig. 5.14 Plot of Hexagonal Storey Shear vs. Storey Number EQY Z-IV

Table 5.15 Storey Shear vs Response Spectrum method for Z-IV

Storey	REC with outrigger	REC without outrigger	HEXA with outrigger	HEXA without outrigger
	kN	kN	kN	kN
Storey30	1125.03	1393.305	836.6441	990.7567
Storey29	2381.576	3006.031	1774.981	2501.668
Storey28	3472.57	4437.43	2574.17	3627.838

Storey27	4399.154	5666.952	3241.301	4585.964
Storey26	5178.292	6686.741	3789.861	5392.037
Storey25	5828.665	7505.067	4235.51	6064.08
Storey24	6368.054	8138.38	4593.605	6619.59
Storey23	6813.188	8614.601	4878.775	7075.316
Storey22	7180.426	8969.745	5105.026	7448.398
Storey21	7486.197	9247.914	5286.35	7470.937
Storey20	7746.872	9495.93	5436.691	8041.402
Storey19	7978.203	9725.584	5569.84	8286.8
Storey18	8194.899	9951.27	5698.69	8507.36
Storey17	8410.218	10184.1	5834.729	8717.864
Storey16	8635.666	10430.14	5987.279	8932.477
Storey15	8880.483	10693.13	6163.2	9163.517
Storey14	9151.027	10977.65	6366.535	9419.785
Storey13	9450.499	11290.94	6598.571	9706.798
Storey12	9778.937	11642.94	6857.935	10026.36
Storey11	10133.55	12046.09	7140.799	10059.04
Storey10	10509.08	12510.19	7441.298	10768.38
Storey9	10898.02	13023.62	7751.849	11173.2
Storey8	11290.77	13571.95	8063.756	11583.09
Storey7	11676.21	14134.01	8367.843	11987.58
Storey6	12042.42	14682.62	8654.855	12375.66
Storey5	12377.21	15187.77	8915.535	12734.84
Storey4	12667.88	15620.56	9140.19	13053.16
Storey3	12899.99	15957.24	9318.006	13317.34
Storey2	13056.77	16182.48	9436.97	13511.57
Storey1	13122.5	16289.8	9485.834	13615.73

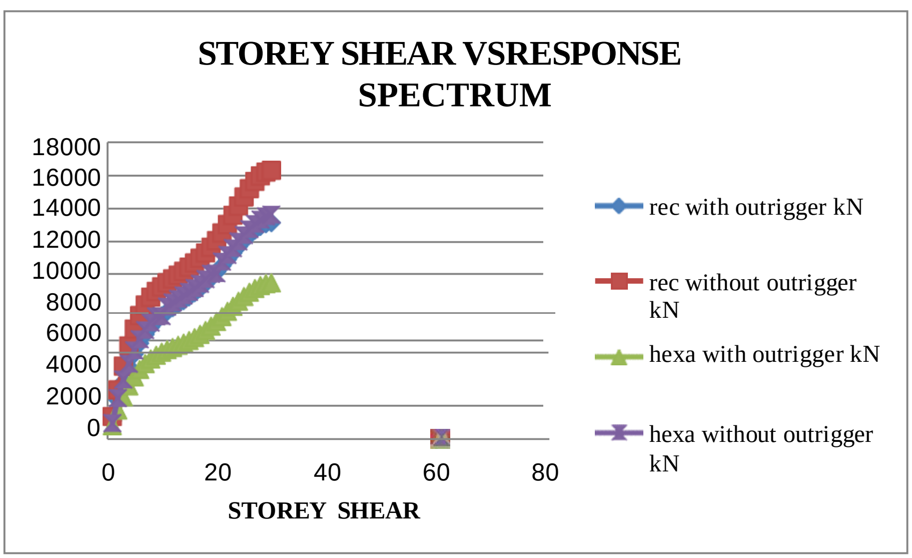


Fig. 5.15 Plot of Storey Shear vs Response Spectrum method for Z-IV

Observations and Discussions on Storey Shear

By studying from Table 5.11 to Table 5.15 and comparing their values in fig. 5.11 to 5.15 we can see that variation in Storey shear as storey height increases. we can clearly see that there isa reduction of Storey shear from bottom storey to top storey for rectangular frame compare to bare frame tube structure decreased by 2.2% along both X and Y direction. Compare to Hexagonal without outrigger frame rectangular frame is decreased by 19%, 24.5%, and hexagonal structure increased by 31%, 28% along X and Y directions respectively for equivalent static analysis.

By studying from table 5.15 comparing values by response spectrum storey shear increased for rectangular increased 19.6% and hexagonal it increased 15.5% by dynamic analysis.

Storey Stiffness

Storey stiffness obtained for G+30 storey all building models along both X and Y directions are listed for Equivalent static methods in the below tables.

Table 5.16 Storey Stiffness Rectangular EQX for Z-IV in KN/m

Storey	X-Dir REC without outrigger	X-Dir REC with outrigger
	KN/m	KN/m
Storey30	1295983	692883.1
Storey29	2528696	1448757
Storey28	3585288	2115503
Storey27	4474123	2694891
Storey26	5225891	3197925
Storey25	5868765	3635825
Storey24	6429034	4019076
Storey23	6942369	4357158
Storey22	7672100	4658565
Storey21	9244004	4930892

Storey20	8340480	5180979
Storey19	8274296	5415067
Storey18	8475062	5638975
Storey17	8698627	5858285
Storey16	8937058	6078541
Storey15	9196942	6305477
Storey14	9489734	6545298
Storey13	9846343	6805023
Storey12	10608950	7092958
Storey11	12679746	7419358
Storey10	11442430	7797415
Storey9	11428261	8244796
Storey8	11914680	8786153
Storey7	12574386	9457473
Storey6	13436835	10314114
Storey5	14583435	11447008
Storey4	16161301	13019415
Storey3	18454268	15372239
Storey2	22033932	19538365
Storey1	27885918	39403596
Base	0	0

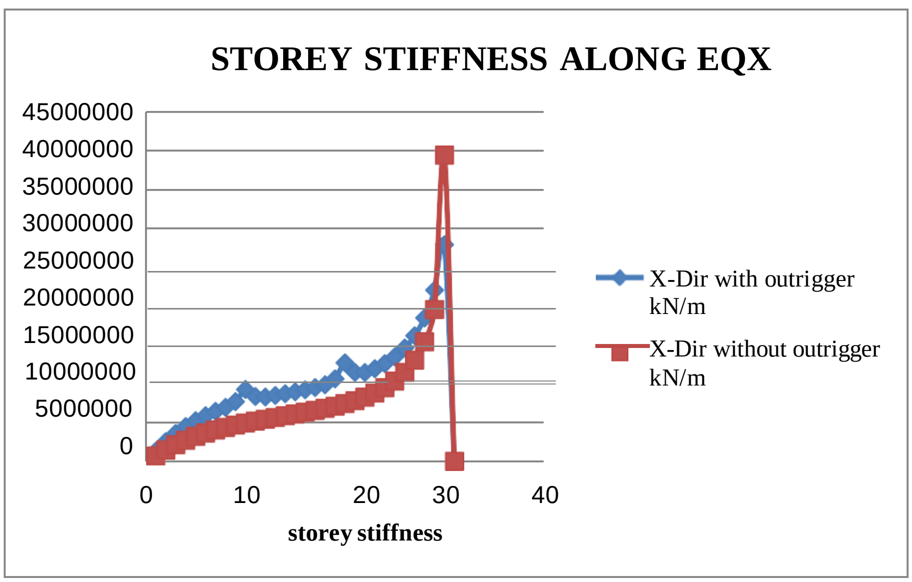


Fig. 5.16 Plot of Rectangular Storey Stiffness vs Storey Number EQX Z-IV

Table 5.17 Storey Stiffness Hexagonal EQX for Z-IV in KN/m

Storey	X-Dir HEXA with outrigger	X-Dir HEXA without outrigger
	KN/m	KN/m
Storey30	1079702	1271836
Storey29	2202138	2569678
Storey28	3164990	3673142
Storey27	3986404	4592955
Storey26	4689601	5357991
Storey25	5298240	5996425
Storey24	5837441	6532789
Storey23	6353107	6987756
Storey22	7079078	7378587
Storey21	8363867	7719720
Storey20	7738428	8023332
Storey19	7657623	8299863
Storey18	7832615	8558461
Storey17	8048445	8807396
Storey16	8283304	9054432
Storey15	8541379	9307200
Storey14	8836937	9573583
Storey13	9217716	9862162
Storey12	9991727	10182763
Storey11	11678176	10547200
Storey10	10832884	10970327
Storey9	10801730	11471639

Storey8	11250719	12077827
Storey7	11899074	12827135
Storey6	12756823	13777320
Storey5	13903150	15021748
Storey4	15487239	16727777
Storey3	17787520	19263677
Storey2	21239609	23930100
Storey1	26514612	45589454
Base	0	0

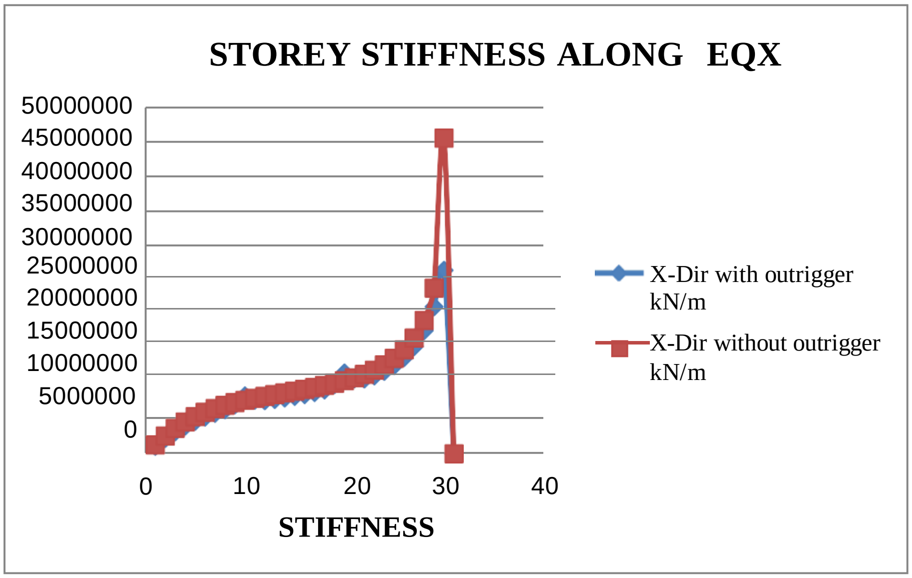


Fig. 5.17 Plot of Hexagonal Storey Stiffness vs Storey Number EQX Z-IV

Table 5.18 Storey Stiffness Rectangular EQY for Z-IV in KN/m

Storey	Y-Dir REC with outrigger	Y-Dir REC without outrigger
	KN/m	KN/m
Storey30	934164.8	958353.6
Storey29	1910762	1968238
Storey28	2755435	2843871
Storey27	3479006	3590186
Storey26	4097843	4224971
Storey25	4629069	4766265
Storey24	5088610	5230498

Storey2 3	5490882	5632063
Storey2 2	5847628	5983424
Storey2 1	6162749	6295368
Storey2 0	6437426	6577290
Storey1 9	6685339	6837498
Storey1 8	6921829	7083490
Storey1 7	7154335	7322240
Storey1 6	7389032	7560476
Storey1 5	7632597	7804968
Storey1 4	7892592	8062868
Storey1 3	8178029	8342100
Storey1 2	8498229	8651884
Storey1 1	8854913	9003441
Storey1 0	9251113	9411038
Storey9	9712550	9893579
Storey8	10274944	10477191
Storey7	10976016	11199667
Storey6	11870866	12118641
Storey5	13049183	13328258
Storey4	14667119	14998745
Storey3	17015913	17505292
Storey2	20566002	22138848
Storey1	25992122	43206029
Base	0	0

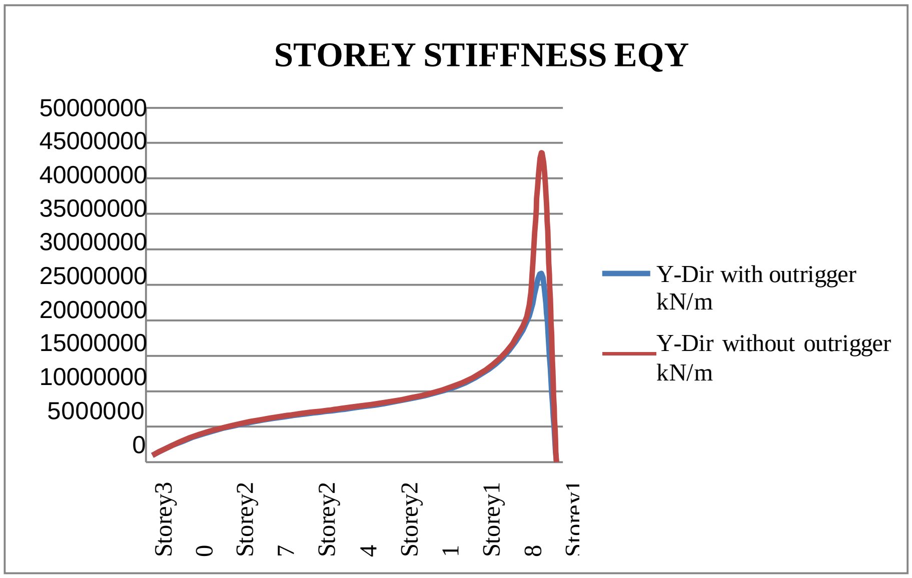


Fig. 5.18 Plot of Rectangular Storey Stiffness vs Storey Number EQY Z-IV

Table 5.19 Storey Stiffness Hexagonal EQY for Z-IV in KN/m

Storey	Y-Dir HEXA with outrigger	Y-Dir HEXA without outrigger
	KN/m	KN/m
Storey3 0	1097491	690975.6
Storey29	2156174	1445738
Storey28	3073013	2111727
Storey27	3850244	2690893
Storey26	4509658	3194161
Storey25	5071800	3632674
Storey24	5554925	4016836
Storey23	5975452	4356061
Storey22	6346969	4658787
Storey21	6674370	4932566
Storey20	6958587	5184205
Storey19	7214672	5419921
Storey18	7458649	5645517
Storey17	7697937	5866567
Storey16	7938770	6088611
Storey15	8188161	6317389
Storey14	8453571	6559115

Storey13	8744473	6820824
Storey12	9071012	7110844
Storey11	9434283	7439465
Storey10	9836356	7819924
Storey9	10304166	8269948
Storey8	10874203	8814278
Storey7	11583006	9489027
Storey6	12484636	10349740
Storey5	13666981	11487640
Storey4	15283539	13066477
Storey3	17630805	15427987
Storey2	21315416	19607803
Storey1	27376467	39542287
Base	0	0

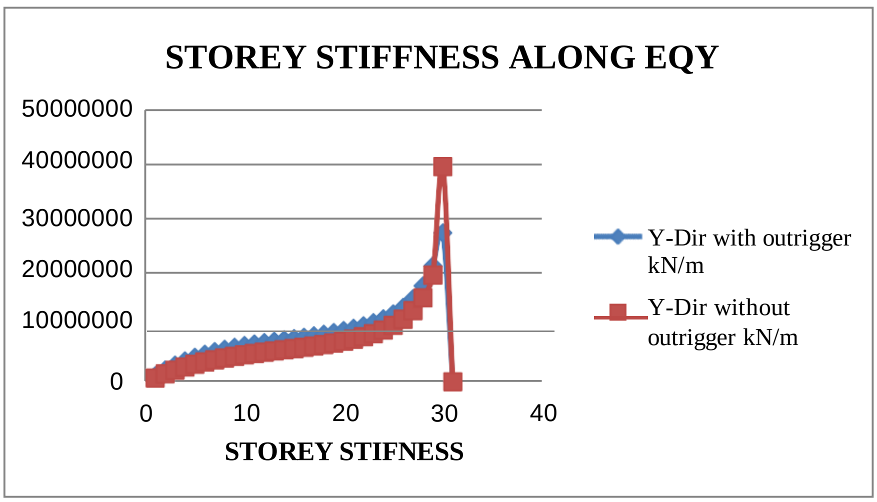


Fig. 5.19 Plot of Hexagonal Storey Stiffness vs Storey Number EQY Z-IV

Table 5.20 Storey Stiffness vs Response Spectrum Method for Z-IV in KN/m

Storey	REC without outrigger	REC with outrigger	HEXA without outrigger	HEXA with outrigger
	KN/m	KN/m	KN/m	KN/m
Storey30	2323117	1871907	2611898	1113194
Storey29	3922182	3651821	4146038	2236876
Storey28	5159838	5019361	5396469	3128913

Storey27	6152682	6034003	6384214	3813067
Storey26	6884684	6779786	7108326	4330713
Storey25	7410991	7327796	7643277	4720173
Storey24	7785875	7732108	8049667	5013157
Storey23	8093268	8033235	8387710	5235283
Storey22	8632675	8262459	8969596	5407495
Storey21	9799613	8445036	10479465	5547855
Storey20	8820013	8602075	9271817	5672466
Storey19	8525715	8751473	9030022	5796176
Storey18	8562152	8908663	9103338	5932503
Storey17	8684237	9087107	9228785	6093704
Storey16	8863835	9298707	9402841	6290478
Storey15	9101254	9553889	9636616	6532087
Storey14	9409358	9861522	9944466	6826353
Storey13	9839814	10229199	10358954	7180106
Storey12	10726997	10663843	11241988	7599758
Storey11	12629237	11172769	13548443	8092114
Storey10	11855065	11765042	12363415	8665730
Storey9	11991648	12453085	12497518	9332594
Storey8	12664001	13255038	13166270	10110996
Storey7	13554618	14198866	14012428	11030011
Storey6	14651241	15329731	15054334	12136949
Storey5	16007622	16724277	16358582	13511417
Storey4	17738982	18524770	18049663	15296249
Storey3	20068082	21062102	20366416	17789106
Storey2	23308645	25610886	23771393	21943952
Storey1	28113823	47645441	29150834	42443306

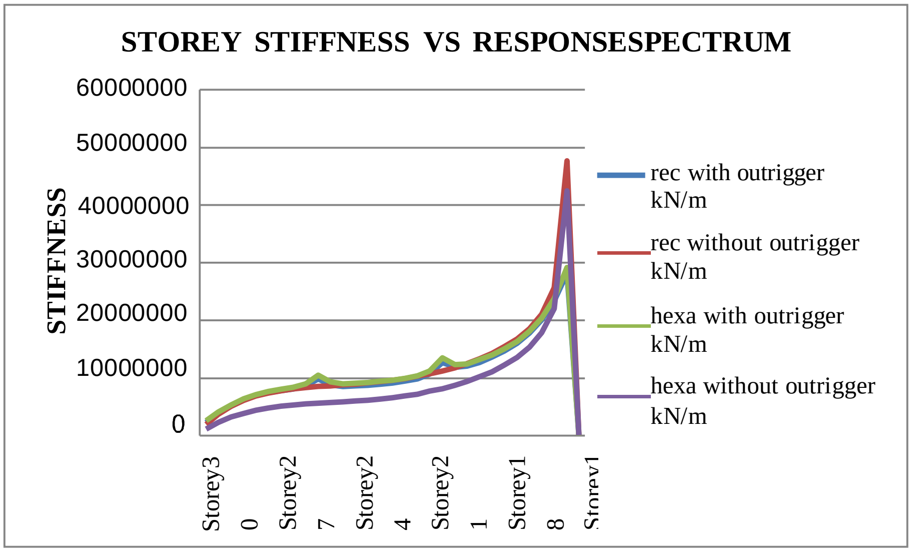


Fig. 5.20 Plot of Hexagonal Storey Stiffness vs Storey Number EQY Z-IV

Observations and Discussions on Storey Stiffness

By studying from Table 5.16 to Table 5.20 and comparing their values in fig. 5.16 to 5.19we can see that variation in stiffness as storey height increases. we can clearly see that there is areduction of storey stiffness for rectangular frame with outrigger compare to without outrigger frame structure decreased by 1.7%, 1.6 along both X and Y direction. rectangular frame with outrigger structure is increased by 7%, 17%, and hexagonal structure increased by 6.57%, 30.31% along X and Y directions respectively for equivalent static analysis. By studying from table 5.20 comparing values by response spectrum storey stiffness increased for rectangular increased 19.2% and hexagonal it increased 39.5% by dynamic analysis.

Time period

Time period obtained for different geometric models are shown below

Table 5.21 Natural Time Period for Z-IV in Sec

Mode	REC without outrigger	REC with outrigger	HEX with outrigger	HEX without outrigger
	sec	sec	sec	sec
1	2.397	1.859	1.744	1.883
2	2.23	1.713	1.743	1.755
3	2.149	1.564	1.291	1.584
4	0.71	0.522	0.469	0.536
5	0.673	0.514	0.468	0.526

6	0.644	0.493	0.429	0.514
7	0.419	0.305	0.255	0.313
8	0.335	0.258	0.229	0.27
9	0.328	0.25	0.228	0.264
10	0.292	0.213	0.18	0.221
11	0.22	0.167	0.148	0.176
12	0.217	0.163	0.147	0.173

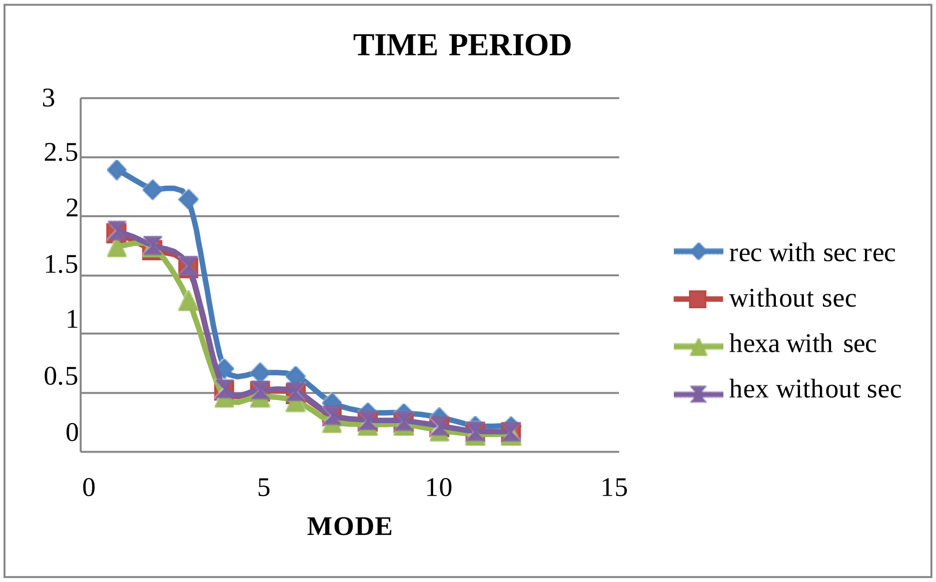


Fig. 5.21 Plot of MODE vs TIME Period in Z-IV

Observations and Discussions on modal time period

By default, software will calculate for 12 modes and we were considering only first threemodes along first mode along X-direction, second mode along Y-direction, third mode is along rotational. From the above plotted graphs we observed that Rectangular shape has maximum time period 2.397 sec due to slenderness and geometry. In hexagonal type of geometry are same but in other structures each mode has different time period due to irregularity.

Time period for rectangular outrigger structure decreases by 2.6% compared to hexagonalstructures. Compare to rectangular, the hexagonal structure is increased by 22.44%, 7.38%, respectively.

Base Shear

The shear force at base of structure for all four models in X and Y direction with responsespectrum and equivalent static method both values as get similar as per table.

Table 5.22 Base Shear in EQX for Z-IV

ZONE	REC WITH OUTRIGGER	REC WITHOUT OUTRIGGER	HEXA WITHOUT OUTRIGGER	HEXA WITH OUTRIGGER
BASE SHEAR	16352.2	13122.512	9305.25	13615.768

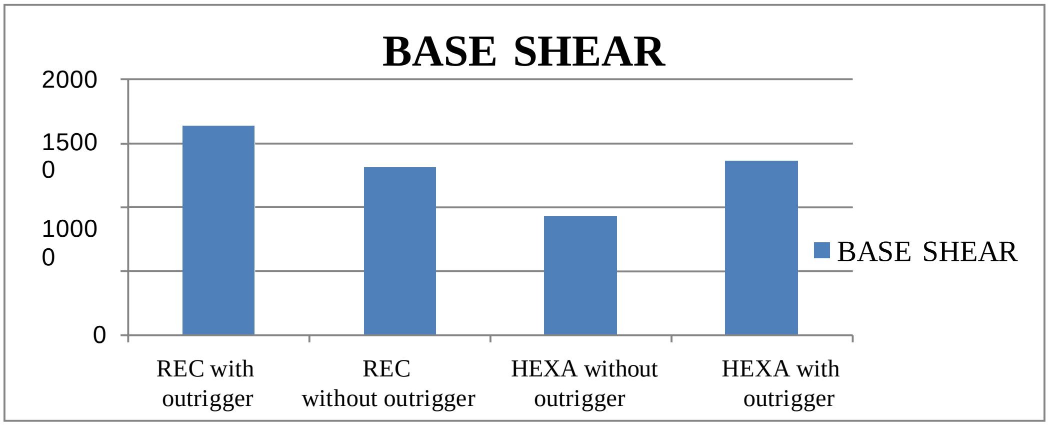


Fig. 5.22 Plot of BASE Shear in Z-IV

Table 5.23 Base Shear in EQY for Z-IV

ZONE	REC with outrigger	REC without outrigger	HEXA without outrigger	HEXA with outrigger
BASE SHEAR	15210.2	12094.977	9314.611	12689.737

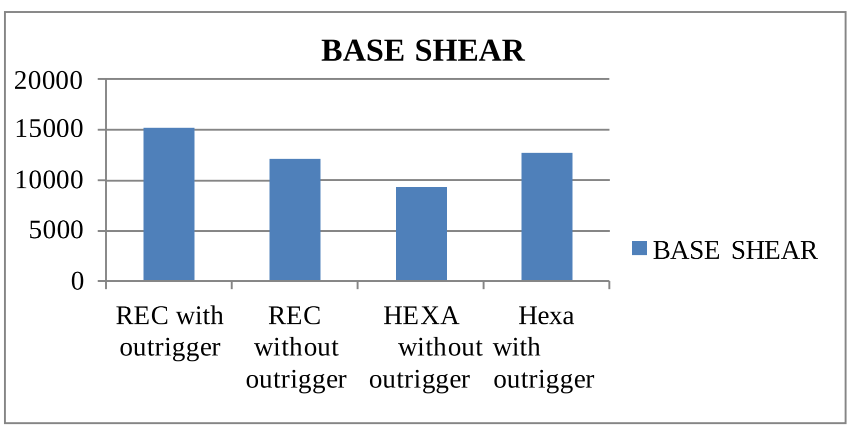


Fig. 5.23 Plot of BASE Shear along EQY in Z-IV

CHAPTER 6

Case Study

6.1 General

Table 1 : Usage of conventional outrigger concept in Ten Tallest Skyscrapers

Sl. No	Building	City	Country	Height(m)	Floors	Completed	# of outrigger levels
1	Burj Khalifa	Dubai	UAE	828	160	2010	5
2	Taipei 101	Taipei	Taiwan (ROC)	509	101	2004	11
3	Shanghai World Financial Center	Shanghai	China (PRC)	492	101	2008	8
4	International Commerce Center	Kowloon	Hongkong	483	118	2010	4
5	Petronas Tower1	Kuala Lumpur	Malaysia	452	88	1998	1
6	Petronas Tower2	Kuala Lumpur	Malaysia	452	88	1998	1
7	Nanjing Greenland Financial Center	Nanjing	China (PRC)	450	89	2010	3
8	Willis Tower (formerly Sears Tower)	Chicago	USA	442	108	1973	0
9	Guangzhou West Tower	Guangzhou	China (PRC)	440	103	2010	0
10	Trump International Hotel and Tower	Chicago	USA	423	96	2010	3

Fig1:- Petronas Tower 1&2

Fig2:- Shanghai World Financial Center

Fig3:- Trump International Hotel and Tower

Fig4:- Guangzhou West Tower

Table 2: Usage of Virtual outrigger concept in Tall Buildings

Sl. No.	Building	City	Country	Height(m)	Floors	Approved/Completed	# of outrigger levels
1	Dubai Tower Doha	Doha	Qatar	438	90	Approved/Partially completed	3
2	Plaza Rakyat office Tower	Kuala Lumpur	Malaysia	382	79	Approved/Partially completed	3
3	Aston Apartments Residential Tower	Sydney	Australia	90	30	1998	2

Fig:- Dubai Tower Doha

Fig:- Aston Apartments Residential Tower

CHAPTER 7

CONCLUSIONS

General

The present work is focused on the study of behavior of tall structure subjected to lateral loads for various geometry with varying the forms of structures like with Outrigger and without outrigger at center of wall are studied and displacement, drift, Storey stiffness are the parameters considered for all geometry of structures.

Conclusions

1. From above study we can observed that the displacement is depending on the geometry of the structures.
2. In the present study we can see that all the results obtained are within the limits as per the codal limitations.
3. The system of outriggers in the structure increase the effectiveness of the structure when compare to structure without outrigger in the action of lateral loads.
4. The structure increases flexural stiffness with providing outrigger, it plays the major role in structure while reducing base shear in static and dynamic loads.
5. The outrigger member increases their sizes, displacement in tall structure system decreases. The shear wall provided at center core with adopting outrigger in tall structure decreases forces in core.
6. The behavior of structure in the seismic loads is various for different structure.
7. The upper storey of structure get reduction in displacement is less compare at outrigger adopted at $1/3^{rd}$ of floors.
8. The outriggers are used various zones as per seismicity.
9. The outriggers are adopted as X-steel bracing as it gives better output on tall structure it minimizes lateral load.
10. The outrigger in tall structure it reduced storey drift.
11. The symmetry and asymmetry of floor its minimized its self-weight of structure.
12. The present study of work compares the differences in the behaviors of the building when outrigger is used.

13. The usage of outrigger system in the building increases the efficiency of the building when compared to building without outrigger under the action of lateral loads.
14. The outrigger plays a important role in increasing structural flexural stiffness by reducing base shear under the action of seismic static and dynamic loads.
15. The size of the outrigger member's increases, the displacement in the tall building structural system decreases provision of shear wall at central core with outrigger in the building decreases the forces in the core.
16. The displacement reduction at the top floor of the building is less compared to the outrigger provided at middle floors.
17. Provision of outriggers in the regular building and irregular building structure, there is reduction in time period, contributing to overall stiffness of the structure.
18. The load resisting capacity of the tall building structure increases by providing outriggers due its strength characteristics.
19. The irregular building with vertical floor irregularity due to the reduced self-weight is more effectual than the regular building.
20. The introduction of outrigger in the tall building will lead to minimization of inter storey drift.
21. Compared to all kinds of geometry in rectangular with outrigger of structure will carry out higher for lateral loads and hexagonal geometry is the most inclined for lateral loads.
22. For quarter-IV from results received in evaluation is more compare to all other systems so this geometry of shape isn't always advocated and we have become glad effects consistent with codal calculations of geometry of structure considered for analysis.
23. Comparing to all geometry of structures rectangular gives surest outcomes so this type of geometry is greater suitable to region-IV.

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11) Richard J, Balling S E, and Jacob S. Lee: "Simplified Model for Analysis and Optimization of Skyscrapers with outrigger and Belt Trusses" American Society of Civil Engineers 2014.

12) Preethi .M. Nagargoje and Shilpa Kewate: "Analysis of Outrigger Structural System for Tall Building Subjected to Lateral Loads" International Journal of Science Technology and Engineering 2017.

13) Pankaj Sharma and Gurpreeth Singh: "Dynamic Analysis of Outrigger Systems in High Rise Buildings against Lateral Loading" International Journal of Science Technology and Engineering 2018.

A Major Project Report
On

THE ASSESSMENT OF WATER QUALITY BY USING INTERNET OF THING(IOT)

SUBMITTED TO

JawaharlalNehruTechnologicalUniversityHyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

CIVIL ENGINEERING

by

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JUNE 2021

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BONAFIDE CERTIFICATE

This is to certify that the project entitled **The Assessment of Water Quality by using Internet of Thing(IOT)**, is being submitted by **B.RUCHITHA(17K81A0167), E.NAGACHARAN REDDY(18K85A0124), A.ROHITH(17K81A0166), J.MANIKANTA(17K81A0183)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OFTECHNOLOGY IN CIVIL ENGINEERING** is recorded of bonafide work carried out by them. The result embodied in this report has been verified and found satisfactory.

Signature of Guide

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Signature of HOD

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Professor& Head of the Department
Department of Civil Engineering

Internal Examiner

External Examiner

Place:

Date:

DECLARATION

We, the students of **Bachelor of Technology** in **Department of Civil Engineering**, of the Academic Year:2017 - 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project entitled **The Assessment Of Water Quality By Using Internet Of Thing(IOT)** is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been carried by taking care of Engineering Ethics. The result embodied in this project report has not been submitted in any university for award of any degree.

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ABSTRACT

Water pollution is one of the biggest fears for the green globalization. In order to ensure the safe supply of the drinking water the quality needs to be monitor in real time. In this paper we present a design and development of a low cost system for real time monitoring of the water quality in IOT(internet of things).The system consist of several sensors is used to measuring physical and chemical parameters of the water. The parameters such as temperature, PH, turbidity, flow sensor of the water can be measured. The measured values from the sensors can be processed by the core controller. The Arduino model can be used as a core controller. Finally, the sensor data can be viewed on internet using WI-FI system.

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CHAPTER 1

1. INTRODUCTION TO WATER QUALITY

1.1 OVER VIEW OF THE PROJECT

In the 21st century, there were lots of inventions, but at the same time were pollutions, global warming and so on are being formed, because of this there is no safe drinking water for the world's pollution. Water quality describes the condition of the water, including chemical, physical, and biological characteristics, usually with respect to its suitability for a particular purpose such as drinking or swimming.

Poor water quality can pose a health risk for people. Declining or low water quality impacts the value of lakes – both economically, ecologically, and socially. Water quality is used in determining the state of aquatic environments and is an interesting point of study in determining both human impacts and natural processes in the environment.

Water is a basic necessity either for all living organisms. Due to rapid development growth, alternative ways in obtaining water supply such as groundwater and surface water will no longer cope with high demand in water supply. This issue is expected to get worsen as many developing countries will be facing water shortage issue. Hence, to avoid water shortage issue during dry period, the current trend is to manage and monitor the accessible natural water supply.

Traditionally, detection of water quality was manually performed where water samples were obtained and sent for examination to the laboratories here transportation is also required, which is time taking process, and these tests cannot be done in all the places like dense forest. With the help of this technology we can do the tests and simple ways and can determine the quality of water in no time.

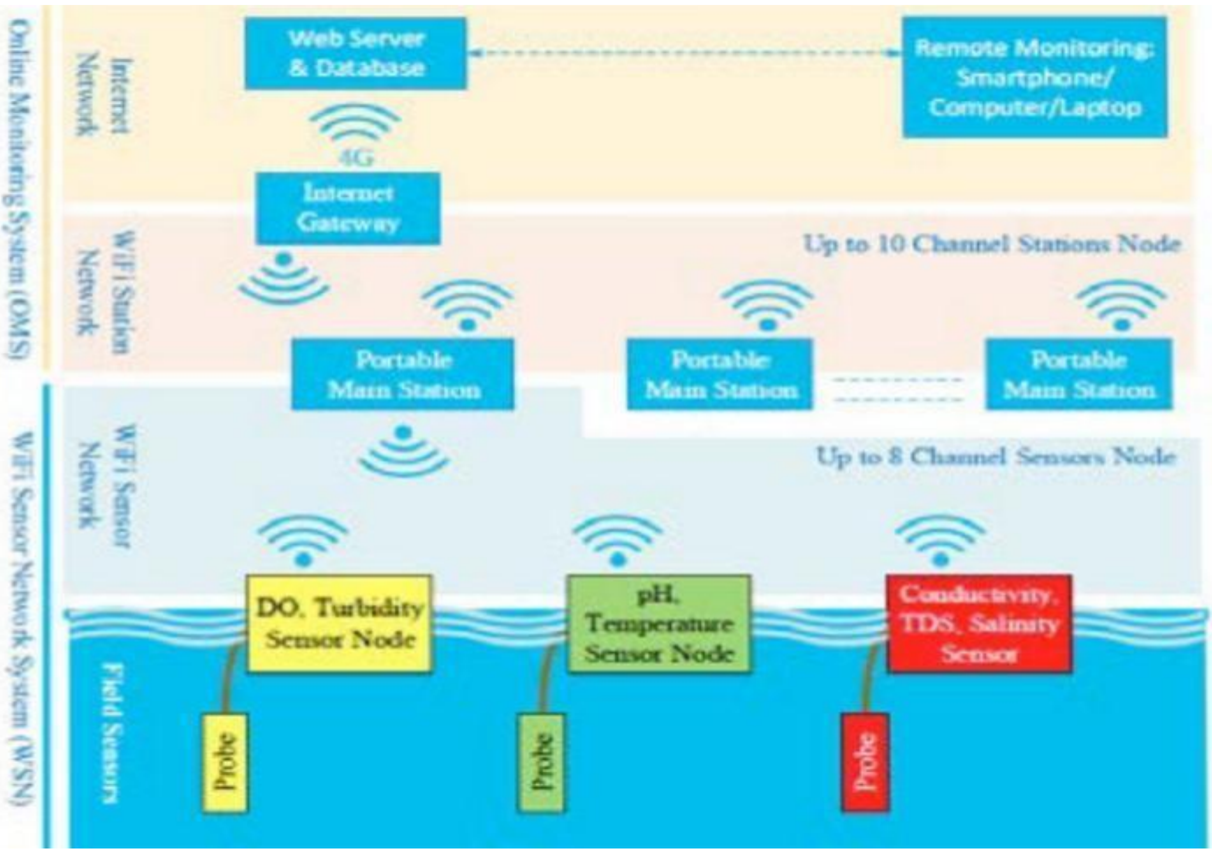
Now a day's Internet of things (IoT) is an innovative technological phenomenon. It is shaping today's world and Is used in different fields for collecting, monitoring and analysis of data from remote locations. IoT integrated Network if everywhere starting from smart cities, smart power grids, and smart supply chain to smart wearable. Though IoT is still under applied in the field of environment it has huge potential. It can be applied to detect Forest fire and early earthquake, reduce air population, monitor snow level, prevent landslide, and avalanche etc. Moreover, it can be implemented in the field of water quality monitoring and controlling system. Water quality monitoring has gained more interest among researchers in this twenty-first century. Numerous Works are either done or ongoing in this topic focusing on various aspects of it. The key theme of all the projects was To develop an efficient, cost-effective, real-time water quality monitoring system which will integrate wireless sensor Network and internet of things

1.2 STATEMENT OF THE PROBLEM

In this modern technique we will be using Advanced IOT sensors like pH, Temperature, Total dissolved solids, Dissolved oxygen and Conductivity. Here there is no need of taking water sample to the laboratories the test will be done at the site of water source and the results will be obtained in no time, with this the time can be saved and also the transportation charges. The results will also be accurate.

1.3 AIMS AND OBJECTIVES OF THE STUDY

The main aim is to identify the quality of water with the help of modern



technology by adapting to it as we know there was rapid advancement of technology. Develop a system for easy monitoring of river water quality at remote places using Wireless sensor networks with low power consumption, low-cost and high detection accuracy. pH, conductivity, Turbidity level, etc. are the limits that are analyzed to improve the water quality. Following are the aims of idea Implementation (a) To measure water parameters such as pH, dissolved oxygen, turbidity, conductivity, etc. using Available sensors at a remote place. (b) To assemble data from various sensor nodes and send it to the base station by The wireless channel. (c) To simulate and evaluate quality parameters for quality control. (d) To send SMS to an Authorized person routinely when water quality detected does not match the preset standards, so that, necessary Actions can be taken. The detailed scheme of a water quality monitoring system is shown in Figure 1.

Fig. 1. Full scheme of the system. In the proposed architecture, each water reservoir will be attached with a sensor node equipped with a set of sensor probes capable of measuring the parameters like pH, turbidity etc. According to the specifications of the sensor probes and the processor board of the sensor the signal conditioning circuit will be designed to generate the sensor output to the processor board through Analog to Digital Converter. The processor board processes the data according to the quality specifications and transmits to the central server through the transceiver. The measured data in each of the reservoir shall be sent to the central server through the respective transceivers either directly or indirectly through other sensor or repeater nodes.

Thee main objective of the proposed system is to monitor the water quality in real time. As in the proposed system, Arduino UNO is used as a core controller along with a several water quality parameter measuring sensors for measuring the parameters of water. The Arduino UNO is the main processor of the system which controls and process the data generated by the sensors. The parameter measuring sensors involves the temperature sensor, turbidity sensor, pH sensor, soil sensor, total dissolved solids. These five parameter shows the quality of water, whether it is potable water or not.

1.4 SCOPE OF THE STUDY

Now a day's water is polluted due to many reasons. In this current system, the equipment cost is high, and it takes a lot of time to process. Traditional methods have the drawbacks such as long waiting time for results high cost, low measurement precision. So with the implementation in the technology, we use different methods and techniques to check the quality of water. There is a disadvantage in the existing that the system has high complexity and low performance.

1.5. **HARDWARE REQUIREMENTS**

- Arduino UNO
- NODE MCU
- WiFi module
- PH sensors
- TDS sensor
- Turbidity sensor
- Temparechar sensor
- Conductivity sensor
- Dissolve oxygen sensor
- Power supply

1.5. SOFTWARE REQUIREMENTS:

We have to download Arduino Software for your operating system from the Arduino download page.

Download Arduino Software

The Initial Setups

The Code

Compiling the Code

Once that happens you should see the TX and RX LEDs below the LED flash. This is the communication going on between the computer and the Arduino.

2. LITERATURE REVIEW

Jayti Bhatt, Jignesh Patoliya entitled “Real Time Water Quality Monitoring System.” This paper describes to ensure the safe supply of drinking water the quality should be monitored in real time for that purpose new approach IOT (Internet of Things) based water quality monitoring has been proposed. In this paper, we present the design of IOT based water quality monitoring system that monitor the quality of water in real time. This system consists some sensors which measure the water quality parameter such as pH, turbidity, conductivity, dissolved oxygen, temperature. The measured values from the sensors are processed by microcontroller and this processed values are transmitted remotely to the core controller that is raspberry pi using Zigbee protocol. Finally, sensors data can view on internet browser application using cloud computing.

Prasad et al. (2015) the smart Water Quality Monitoring (WQM) device for Fiji using IOT and remote sensing technologies is shown in this article. The Pacific Islands of Fiji require regular collection and analysis of collected data for the water quality monitoring and uploading this data into the server. In order to monitor water quality, the authors have used IOT and remote sensing technologies. The current measurements can be enhanced by remote sensing. During the entire test period, the system has been proved worth by delivering accurate and consistent data using IOT for water monitoring in real-time. The system proposed by these authors also used a GSM module to forward the data to the mobile user via SMS.

Omar Faruq et al. (2017) A water quality monitoring system based on microcontrollers for people living in Bangladesh’s outskirts, where safe drinking water is not available, is provided in this paper. The device has been designed with a high degree of accuracy and is sensitive to several water parameters such as temperature, turbidity and hydrogen potential (pH) displayed on the LCD monitor. Finally, in this paper, each of the parameter values is compared with the predefined equipment, and sensor values and error are calculated.

Vaishnavi, V. Daigavane and Dr. M.A Gaikwad propound a design for say Water Quality Monitoring System Based on IOT. The hardware part has sensors which help to measure the real time values, another one is arduino atmega328 converts the analog values to digital one, & LCD shows these displays output from the sensors. In software they developed a program based on embedded c language. BLYNK app is installed in the android handset to see the output. When the system gets started dc current given to the kit and arduino and WIFI gets on. The parameters of water are tested and their result is given to the LCD display. The app went provided with hotspot gives the exact value as on LCD display shows on kit.

Rohit Kamble, Sagar Kakade, Abhijeet Mahajan and Akshay Bhosale propound “Automatic Water Quality Monitoring System Using Arduino” .This paper ensures the automatic water quality monitoring system which gives the data about quality of water on a webpage. By using this data we will know that how much quality have the water. When some access the webpage, data will display on it. The different water parameter sensor is connected to Arduino. The system uses GPRS module for wireless data transfer. This GPRS module is connected to Arduino and it will send data to webpage through GPRS. They create webpage and it also provides security. GPRS module sends data via internet it will upload on created Web GUI.

Dr. K.Karuppasamy M.E., Ph.D. B Abinaya, R Sudha, J P ArunPrasath entitled “Water quality monitoring and control using wireless sensor networks”. This paper ensures the lake monitoring by measure water pH, conductivity, dissolved oxygen (DO) and temperature that provides some important service such as water for drinking, domestic purpose, sites for recreational activity, and important fisheries and also agricultural purpose. In this system the WSN system gateway is one of the most essential and unique block. From multiple sensor nodes the gateway node collect all received information. The developed gateway is equipped with microcontroller unit, Global System for Mobile Communication (GSM) module, Zigbee transceiver and power supply. Through the Zigbee transceiver PIC16F877A microcontroller is used to acquire and process received sensor data from WSN sensor nodes. The GSM module residing on top of the gateway node is used to communicate with the cellular network to forward the Short Message Services (SMS) data to specified stockholders. This is quad-band low power consumption Global System for Mobile Communications (GSM)/GPRS module. In these it needs a user SIM to transmit the resulting values.

Pradeep Kumar M, Monisha J, Pravenisha R, Praiselin V, Suganya Devi K entitled “The Real Time Monitoring of Water Quality in IOT Environment”. This paper describe Routinely monitoring parameters of water quality are temperature, pH, turbidity, conductivity, dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), ammonia nitrogen, nitrate, nitrite, phosphate, various metal ions and so on. By the advantages of sensors, Monitoring of Turbidity, PH & Temperature of Water is designed and developed. The measured values from the sensors can be processed by the core controller. By the use of cloud computing we can see the sensor data on internet.

Cho Zin Myint, Lenin Gopal, and Yan Lin Aung say “WSN-based Reconfigurable Water Quality Monitoring System in IOT Environment”. The system consists of a set of water quality sensors to monitor conductivity, pH, and turbidity, a compact reconfigurable I/O (RIO) real-time embedded controller and an FPGA. In the system, the implementation of processing algorithms is difficult due to FPGA data representation format. Since the WSN platforms are used in IOT environmental monitoring applications for more cost effective and time.

Mr. Swapnil Katole, Prof. Yogesh Bhute say “The Real Time Water Quality Monitoring System based on IOT”. This system consist of several sensors (temperature, pH, turbidity, conductivity) is connected to core controller. The core controller are accessing the sensor values and processing them to transfer the data through internet. Ardunio is used as a core controller. The sensor data can be viewed on the internet using cloud computing with a separate IP address.

Jianhua Dong, Guoyin Wang, Xuerui Zhang “The smart water quality monitoring”, regarded as the future water quality monitoring technology, catalyses progress in the capabilities of data collection, communication, data analysis, and early warning. In this article, we survey the literature till 2014 on the enabling technologies for the Smart Water Quality Monitoring System. We explore three major subsystems, namely the data collection subsystem, the data transmission subsystem, and the data management subsystem from the view of data acquiring, data transmission, and data analysis. Specifically, for the data collection subsystem, we explore selection of water quality parameters, existing technology of online water quality monitoring, identification of the locations of sampling stations, and determination of the sampling frequencies. For the data transmission system, we explore data transmission network architecture and data communication management. For the data management subsystem, we explore water quality analysis and prediction, water quality evaluation, and water quality data storage. We also propose possible challenges and future directions for each subsystem.

Zin et al. utilised wireless sensor network enabled by IOT for the monitoring of water quality in real-time. The system they utilised consisted of Zigbee wireless communication, protocol, Field Programmable Gate Array (FPGA) and a personal computer. They utilised the technology to monitor the pH, turbidity, temperature, water level and carbon dioxide on the surface of the water at Curtin

Lake, northern Sarawak in the Borneo Island. The system was able to minimise cost and had lesser power requirements.

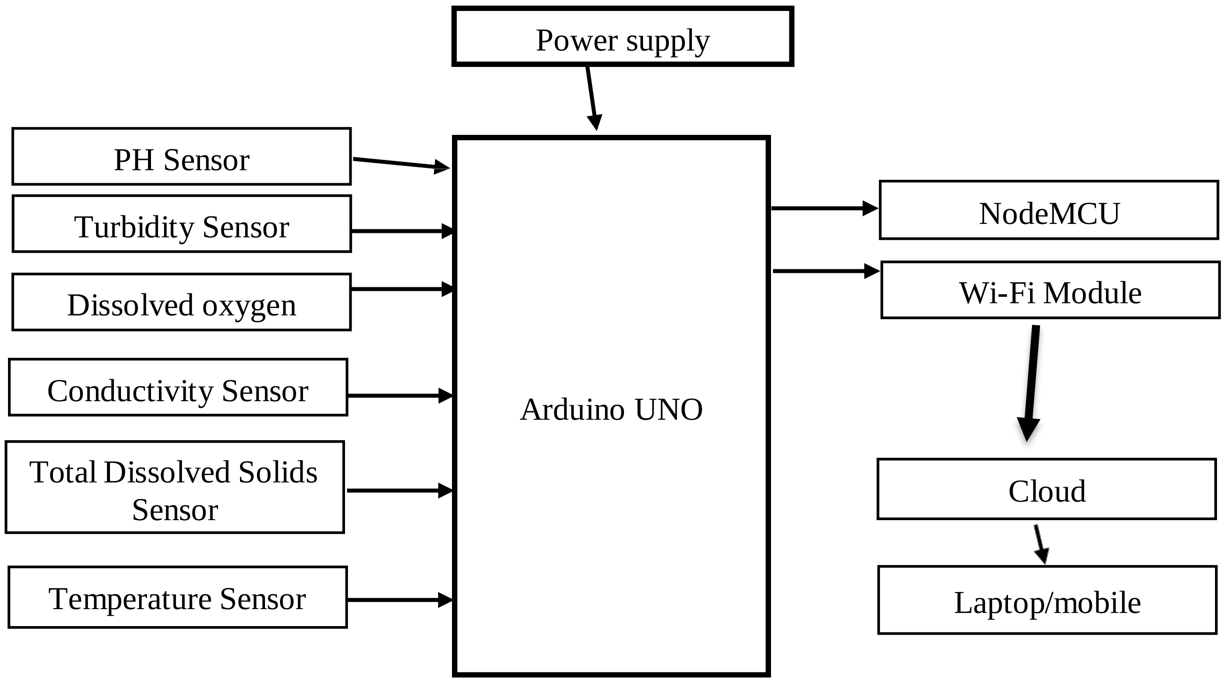
S. Geetha and S. Goutham Internet of things enabled real time water quality monitoring system Smart solutions for water quality monitoring are gaining importance with advancement in communication technology. This paper presents a detailed overview of recent works carried out in the field of smart water quality monitoring. Also, a power efficient, simpler solution for in-pipe water quality monitoring based on Internet of Things technology is presented. The model developed is used for testing water samples and the data uploaded over the Internet are analysed. The system also provides an alert to a remote user, when there is a deviation of water quality parameters from the predefined set of standard values**.**

3. METHODOLOGY

3.1 METHODOLOGY

3.1.1 HARDWARE REQUIREMENTS

3.1.2



In this, we present the theory on real time water quality monitoring system by using iot tecnology.The above block diagram is proposed system is explained.each and every block diagram of the system is explained in detail.

In this proposed block diagram consist of several sensors (PH,TDS, TURBIDITY, CONDUCTIVITY,DO, TEMPARECHAR) is connected to ARDUINO UNO. Wi-F module and NODE MCU also connected to ARDUINO UNO.The arudino uno is accessing the sensors values and processing them to transfer the data through internet.Ardunio uno is main part of this module.The sensors values can be viewed on the mobile by using internet wi-fi system.

HARDWARE REQUIREMENTS

- ARDUINO UNO
- NODE MCU
- WI-FI MODULE
- PH SENSOR
- TURBIDITY SENSOR
- TEMPARECHAR SENSOR
- TOTAL DISSOLVED SOLIDS SENSOR
- CONDUCTIVITY SENSOR
- DO SENSOR

ARDUINO UNO

The Arduino Uno is a microcontroller boards. It'salso open -source board. Arudino uno is a family of board to simplify electronic design, prototyping and experimenting for artists,hackers , hobbyist,but also many professionals. Arduinos (we use the standard Arduino Uno) are built around an ATmega microcontroller essentially a complete computer with CPU, RAM, Flash memory, and input/output pins, all on a single chip. Unlike, say, a Raspberry Pi, it's designed to attach all kinds of sensors, LEDs, small motors and speakers, servos, etc. directly to these pins, which can read in or output digital or analog voltages between 0 and 5 volts. The Arduino connects to your computer via USB, where you program it in a simple language (C/C++, similar to Java) from inside the free Arduino IDE by uploading your compiled code to the board. Once programmed, the Arduino can run with the USB link back to your computer, or stand-alone without it no keyboard or screen needed, just power.

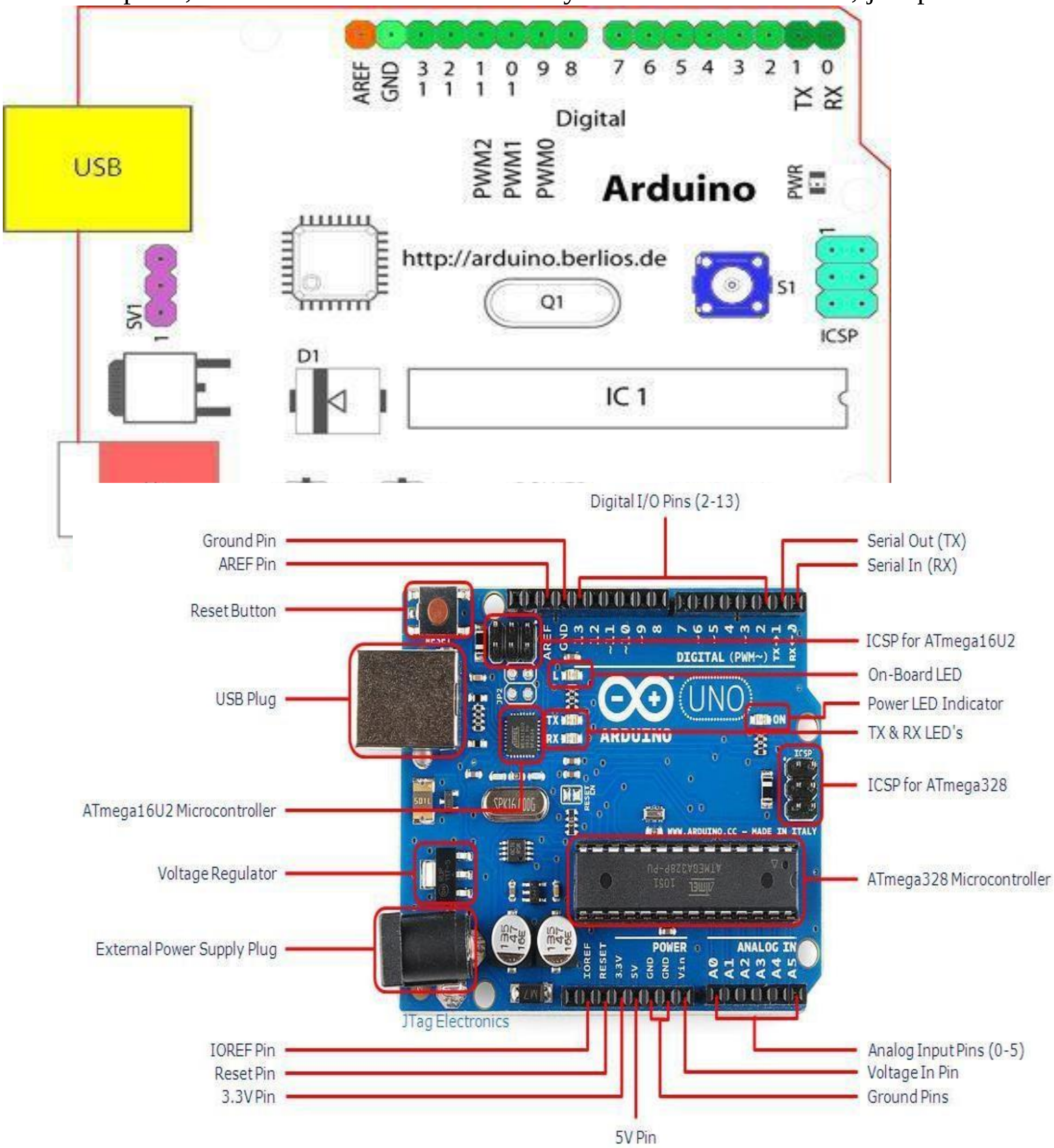


Figure: Arduino Board

Looking at the board from the top down, this is an outline of what you will see (parts of the board you might interact with in the course of normal use are highlighted).

Starting clockwise from the top center:

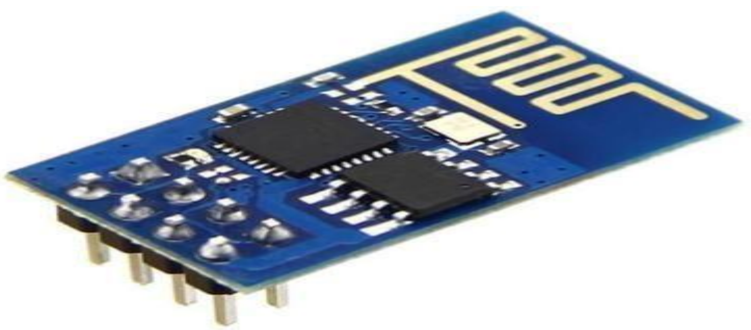
- Analog Refer
- Reset Button – S1 (dark blue)
- In-circuit Serial Programmer (blue-green)
- Analog Reference pin (orange)

- Digital Ground (light green)
- Digital Pins 2-13 (green)
- Digital Pins 0-1/Serial In/Out – TX/RX (dark green) – These pins cannot be used for digital i/o (DigitalRead and DigitalWrite) if you are also using serial communication (e.g. Serial.begin).
- Analog In Pins 0-5 (light blue)
- Power and Ground Pins (power: orange, grounds: light orange)
- External Power Supply In (9-12VDC) – X1 (pink)
- Toggles External Power and USB Power (place jumper on two pins closest to desired supply) – SV1 (purple)
- USB (used for uploading sketches to the board and for serial communication between the board and the computer; can be used to power the board) (yellow)

NODE MCU:

- NodeMCU is an open-source LUA based firmware developed for the ESP8266 wifi chip. By exploring functionality with the ESP8266 chip, NodeMCU firmware comes with the ESP8266 Development board/kit i.e. NodeMCU Development board.
- Since NodeMCU is an open-source platform, its hardware design is open for edit/modify/build.NodeMCU Dev Kit/board consist of ESP8266 wifi enabled chip. The ESP8266 is a low-cost Wi-Fi chip developed by Espressif Systems with TCP/IP protocol. For more information about ESP8266, you can refer to the ESP8266 WiFi Module.
- There is Version2 (V2) available for NodeMCU Dev Kit i.e. NodeMCU Development Board v1.0 (Version2), which usually comes in black colored PC.

WIFI MODULE:
The ESP8266 WiFi Module is a self contained SOC with integrated TCP/IP protocol Stack that can give any microcontroller access to your WiFi network. The ESP8266 is Capable of either hosting an application or offloading all Wi-Fi networking functions From another application processor. Each ESP8266 module comes pre-programmed With an AT command set firmware. The ESP8266 module is an extremely cost Effective board with a huge, and ever growing, community.



PH SENSOR:

The pH of a solution is the measure of the acidity or alkalinity of that solution.pH is measured on a scale of 0 to 14.pH sensor operates on 5V power supply and it is easy to interface with arduino.

PH value	PALATABILITY QUOTIENT
Less then 7	acidity
7	Neutral
Above 7	Base
6.5 to 8.5	Good and drinking water

TDS SENSOR

A TDS meter is a small hand held device used to indicate the total dissolved solids in a solution, usually water.

- Since dissolved ionized solids, such as salts and materials, increases the conductivity of a solution.

TDS meter measures the conductivity of the solution and estimates the TDS from the reading

TDS LEVEL IN (PPM)	PALATABILITY QUOTIENT
50 - 150	Excellent for drinking water
150 - 250	Good

250 - 300	Fair
300 - 500	Poor
Above 1200	Unacceptable

TEMPERATURE SENSOR:

Water Temperature indicates how water is hot or cold. A change in temperature can change the physical, chemicaland biological characteristics of water bodies.Certain chemical reactions, biological processes, and even electronic circuits perform best within limited temperature ranges.The range of DS18B20 temperature sensor is -55 to +125 °C.

This temperature sensor is digital type which gives accurate reading.Water temperatures in lakes during summer months is not uniform from top to bottom. Three distinct layers develop:The top layer stays warm at around 65–75 degrees F (18.8–24.5 degrees C).The middle layer drops dramatically, usually to 45–65 degrees F (7.4–18.8 degrees C).

TURBIDITY SENSOR:

Turbidity is a measure of the cloudiness of water.Turbidity has indicated the degree at which the water loses its transparency.The WTurbidityHO (World Health Organization), establishes that the turbidity of drinking water shouldn’t be more than 5 NTU, and should ideally be below 1 NTUIt refers to the clarity of water. The murkier the water, great turbidity.Turbidity increases when suspended solids are added into the water, such as

- Clay
- Silt
- Industrial waste

- Sewage waste

DISSOLVE OXYGEN SENSOR:

Dissolved oxygen sensors, both electrochemical and optical, do not measure the concentration of dissolved oxygen in mg/L or ppm (parts per million which is equivalent to mg/L). Instead, the sensors measure the pressure of oxygen that is dissolved in the sample. In an electrochemical DO sensor, dissolved oxygen diffuses from the sample across an oxygen permeable membrane and into the sensor. Once inside the sensor, the oxygen undergoes a chemical reduction reaction, which produces an electrical signal. Healthyy water should generally have dissolved oxygen concentrations above 6.5-8 mg/L and between about 80-120 %.

CONDUCTIVITY SENSOR

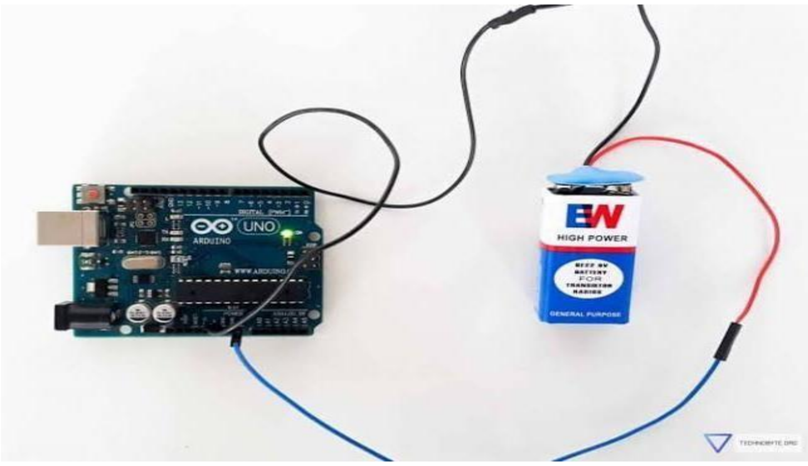
A conductivity sensor measures the ability of a solution to conduct an electrical current. It is the presence of ions in a solution that allow the solution to be conductive: the greater the concentration of ions, the greater the conductivity.

Conductivity chat (In microsiemens per centimer**)**

Pure (distilled) water	0.5 to 3µS/cm
Most fresh drinking water.	100 or less µS/cm
Range found in Lake and river water in the U.S.	50 to 1500µS/cm Lake
and stream water with healthy fish populations.	150 to 800µS/cm
Industrial waste water.	10000 or moreµS/cm
Sea water.	~50000µS/cm
Great Salt Lake in Utah.	158000µS/cm

POWER BATTERY:

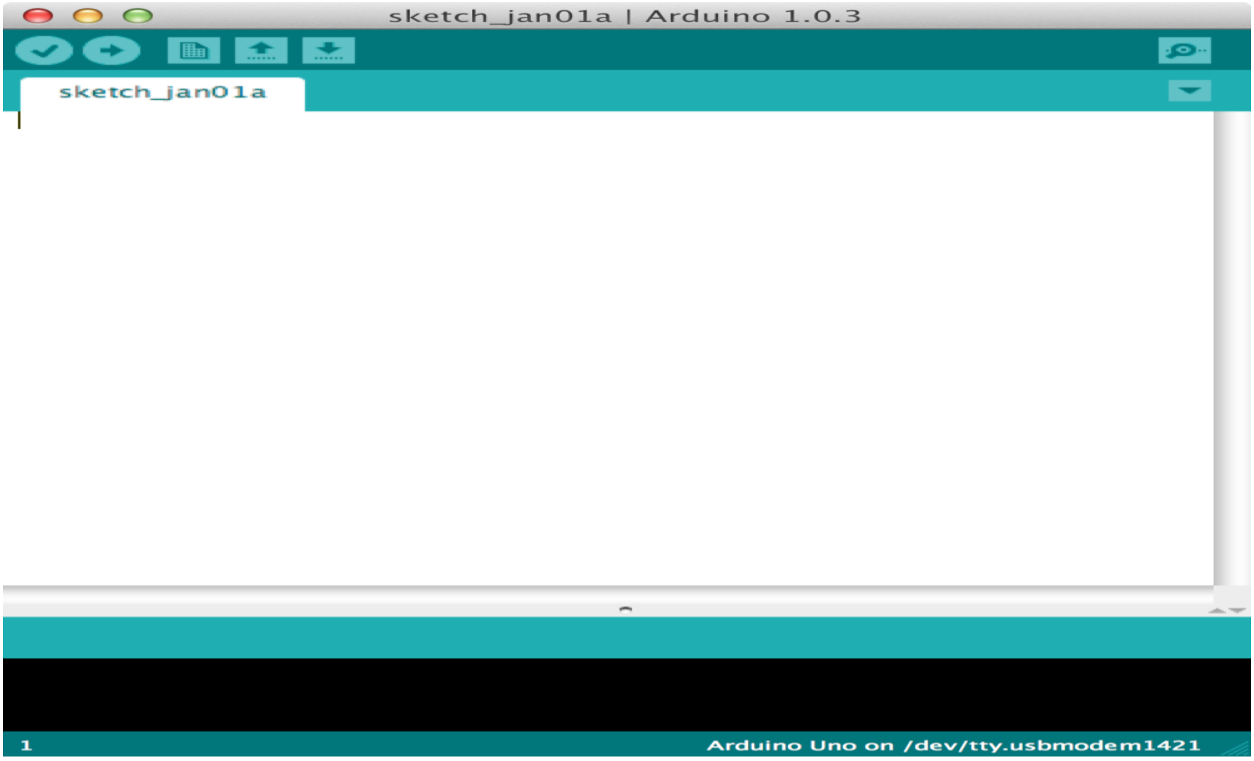
You can just plug it into the sockets of your Arduino Uno and you're set. The battery/power pack shield can be charged using a simple micro USB cable. It outputs a steady 5V that you can use to power up your Arduino. You can use either the USB B cable or a simple jumper cable to get the 5V supply. You can simply connect the + end of your battery to Arduino Vin and the – end to Arduino ground (fig 1). You should see the green light on the Arduino turn on to indicate that it is powered. It's also a good idea to attach a toggle switch in series with this battery so that you can turn your Arduino off and on.



3.1.2 SOFTWARE SYSTEMS DESIGN:

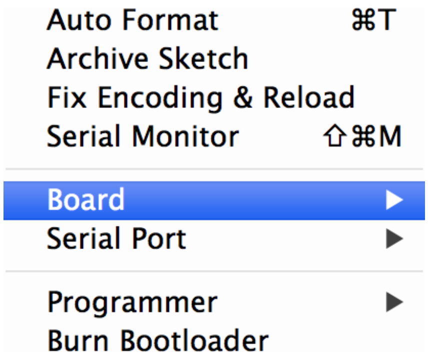
Download Arduino Software

You'll need to download the Arduino Software package for your operating system from the Arduino download page.hWhen you've downloaded and opened the application you should see something like this:



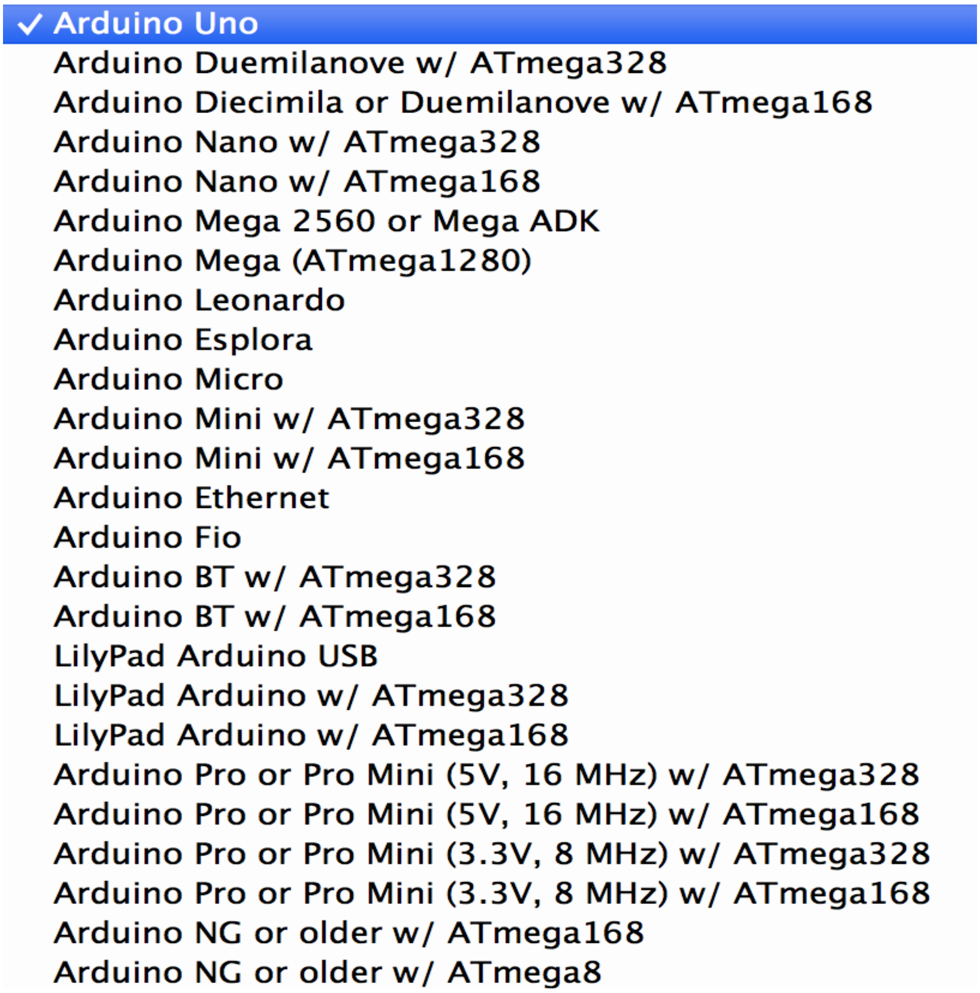
This is where you type the code you want to compile and send to the Arduino board.

The Initial Setup: We need to setup the environment to Tools menu and select Board.



Tools Menu < Board

Then select the type of Arduino you want to program, in our case it’s the Arduino Uno.



Arduino Uno

The Code

The code you write for your Arduino are known as sketches. They are written in C++.Every sketch needs two void type functions, setup() and loop(). A void type function doesn’t return any value.The setup() method is ran once at the just after the Arduino is powered up and the loop() method is ran continuously afterwards. The setup() is where you want to do any initialisation steps, and in loop() you want to run the code you want to run over and over again.So, your basic sketch or program should look like this:

```
void setup()
{
}
void loop()
{
}
```

If you notice on the top edge of the board there’s two black rectangles with several squares in. These are called headers. Headers make it easy to connect components to the the Arduino. Where they connect to the board is called pins. Knowing what pin something is connected to is essential for programming an Arduino.

The pin numbers are listed next to the headers on the board in white.

The onboard LED we want to control is on pin 13.

In our code above the setup() method let's create a variable called ledPin. In C++ we need to state why type our variable is before hand, in this case it's an integer, so it's of type int.

```
int ledPin = 13;
void setup()
{
}
void loop()
{
}
```

Each line is ended with a semicolon (;).

In the setup() method we want to set the ledPin to the output mode. We do this by calling a special function called pinMode() which takes two variables, the first the pin number, and second, whether it's an input or output pin. Since we're dealing with an output we need to set it to a constant called OUTPUT. If you were working with a sensor or input it would be INPUT.

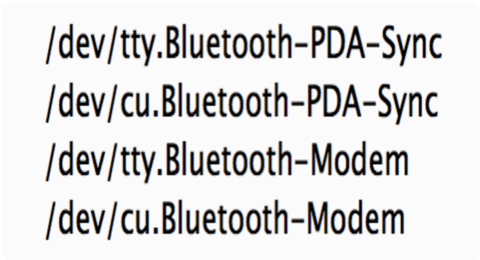
```
int ledPin = 13;
void setup()
{
    pinMode(ledPin, OUTPUT);
}
void loop()
{
}
```

Next we want to compile to machine code and deploy or upload it to the Arduino.

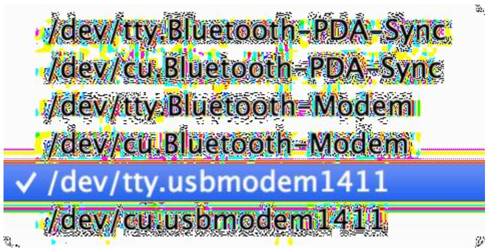
Compiling the Code

If this is your first time you've ever compiled code to your Arduino before plugging it in to the computer go to the Tools menu, then Serial Port and take note of what appears there.

Here's what mine looks like before plugging in the Arduino UNO:

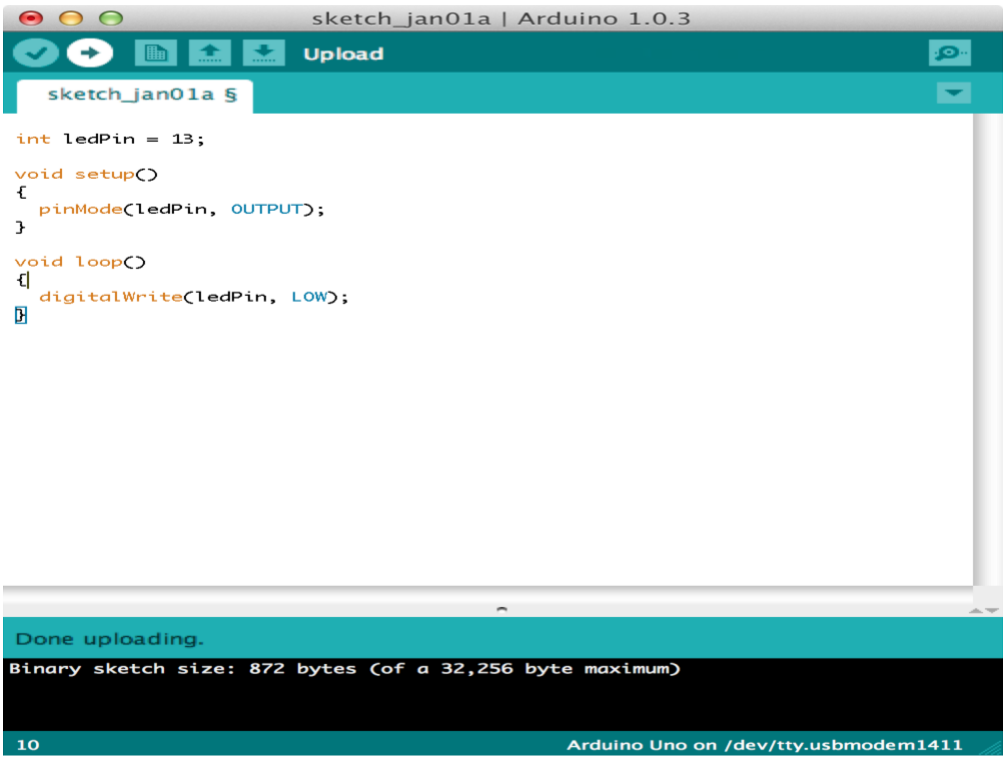


Plug your Arduino UNO board in to the USB cable and into your computer. Now go back to the Tools > Serial Portmenu and you should see at least 1 new option. On my Mac 2 new serial ports appear.



They tty and cu are two ways that computers can talk over a serial port. Both seem to work with the Arduino software so I selected the tty.* one. On Windows you should see COM followed by a number. Select the new one that appears.

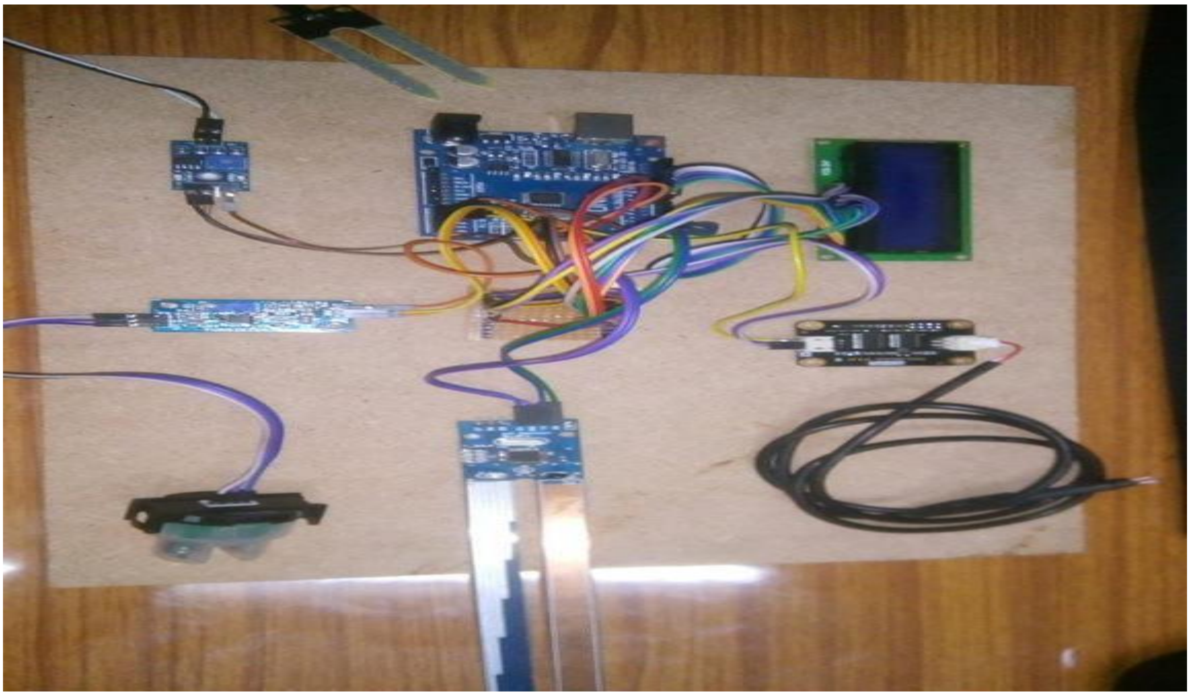
Once you have selected your serial or COM port you can then press the button with the arrow pointing to the right.



Once that happens you should see the TX and RX LEDs below the L LED flash. This is the communication going on between the computer and the Arduino. The L may flicker too. Once this dance is complete your program should be running. And your LED should be off.

Now let's try and switch it on using the HIGH constanconstant.

3.1.3 DEFINE THE MODULE



The whole system is designed to be mainly based on IOT which is newly introduced Concept in the world of development. There are two parts included, the first one is hardware & second one is software. The sensors present in the hardware will help to measure the real time values, another one is arduino uno, this converts the analog values to digital one, and LCD shows the displays output from sensors, Wi-Fi module gives the connection between hardware and software. Sensors like conductivity, pH, turbidity, temperature were connected to Arduino and Arduino is connected to Wi-Fi module. In software we developed a program based on embedded c language. The PCB is design at first level of construction and component and sensors are done after that. Arduino Software is installed in the android version to see the output. When the system get started dc current given to the kit and arduino and WIFI gets on. The parameters of water is tested but one and their result is given to the LCD display. The app that provided with hotspot gives the exact value as on LCD display shows on kit. Here at last we can observe the real time value on our Android phone at anywhere anytime when the kit is located on any specific water body and WiFi is provided. whole design of the system is based mainly on IOT which is newly introduced Concept in the world of development.

4. PROJECT IMPLEMENTATION

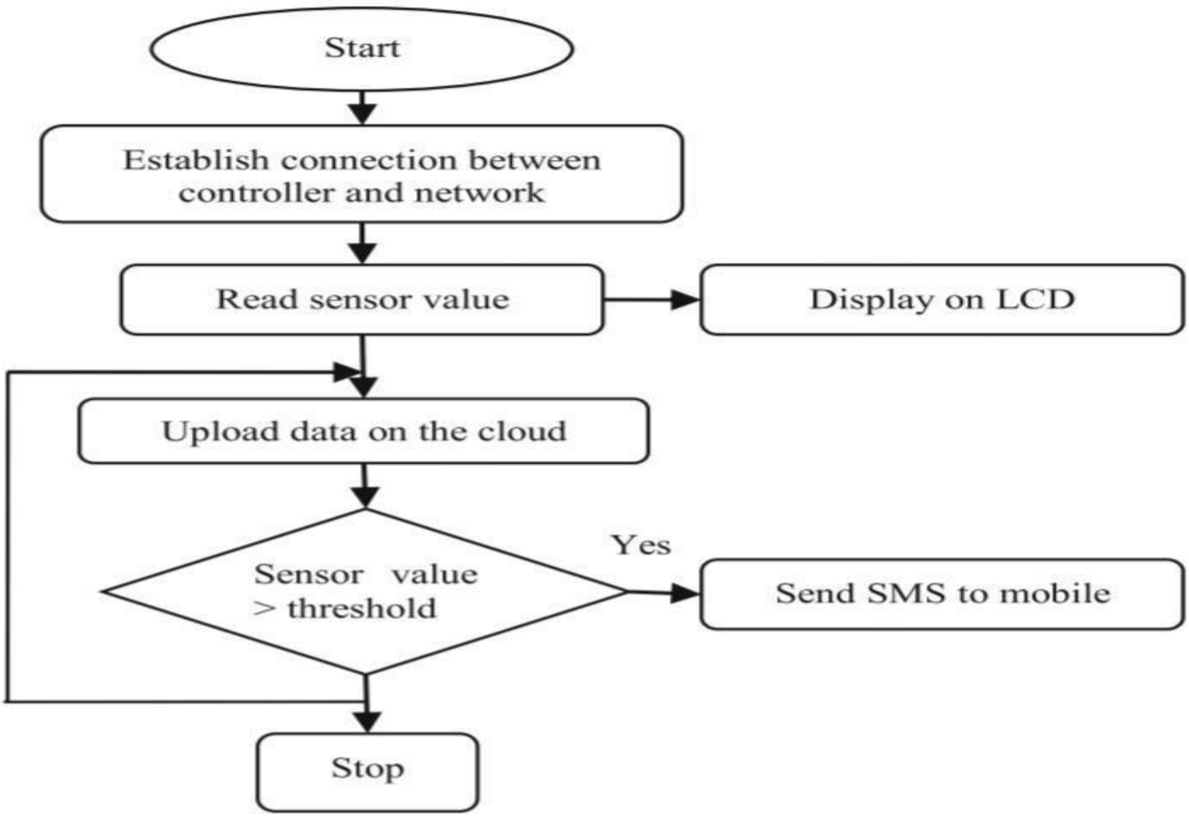
4.1 IMPLEMENTATION OF CODE

```
#include <SoftwareSerial.h>
#include<LiquidCrystal.h>
LiquidCrystal lcd(8,9,10,11,12,13);

int sensor1 = A0;
int sensor2 = A1;
int sensor3 = A2;
int sensor4 = A3;
int value1 = 0;
int value2 = 0;
int value3 = 0;
int value4 = 0;

//int fan = 7;
int motor = 6;
int buz = 7;
void setup()
{
   lcd.begin(16,2);
   Serial.begin(9600);
   pinMode(sensor1,INPUT);
   pinMode(sensor2,INPUT);
   pinMode(sensor3,INPUT);
   pinMode(sensor4,INPUT);
   pinMode(buz,OUTPUT);
   pinMode(motor,OUTPUT);
   lcd.print("water contamination");
   lcd.setCursor(0,1);
   lcd.print(" System ");
   delay(2000);
   lcd.clear();
   delay(2000);

   }

void loop()
{
 value1 = analogRead(A3);
 value1=(value1/3);
 delay(1000);
 Serial.println(value1);
 Serial.println(",");
 value2 = analogRead(A1);
 //value2=(value2/100);
 delay(1000);
 Serial.println(value2);
 Serial.println(",");
 value3 = analogRead(A0);
 //value3=(value3/100);
 delay(1000);
 Serial.println(value3);
 Serial.println(",");
 value4 = analogRead(A2);
 value4=(value4/3);
 delay(1000);
 Serial.println(value4);
 delay(2000);
 lcd.print("ph value=");
 lcd.setCursor(0,1);
```

```
    lcd.print(value4);
    delay(2000);
    lcd.clear();

  lcd.print("turbidity=");
  lcd.setCursor(0,1);
    lcd.print(value3);
    delay(2000);
    lcd.clear();

  lcd.print("condutivity=");
  lcd.setCursor(0,1);
    lcd.print(value2);
    delay(2000);
    lcd.clear();

  lcd.print("temperature=");
  lcd.setCursor(0,1);
    lcd.print(value1);
    delay(2000);
    lcd.clear();

 if(value1 > 30)
 {
   lcd.clear();
   lcd.print("temperature");
   lcd.setCursor(0,1);
   lcd.print("Abnormal");
   digitalWrite(buz,HIGH);
   digitalWrite(fan,HIGH);
   delay(2000);
   lcd.clear();
   lcd.print("Cool the water");
   lcd.setCursor(0,1);
   lcd.print("Fan on");
   delay(1000);
   digitalWrite(buz,HIGH);
   digitalWrite(fan,HIGH);
   lcd.clear();
   lcd.print("Fan Off");
  }

 if(value2 < 300)
 {
   lcd.clear();
   lcd.print("Conductivity");
   lcd.setCursor(0,1);
   lcd.print("Abnormal");
   digitalWrite(buz,HIGH);
   //digitalWrite(fan,HIGH);
   delay(2000);
   digitalWrite(buz,LOW);

  }
 if(value3 > 300)
 {
   lcd.clear();
   lcd.print("Turbudity");
   lcd.setCursor(0,1);
   lcd.print("Abnormal");
   digitalWrite(buz,HIGH);
   //digitalWrite(fan,HIGH);
   delay(2000);
   digitalWrite(buz,LOW);
```

```
 }
if((value4 < 5)&& (value4 > 8 ))
{
  lcd.clear();
  lcd.print("PH");
  lcd.setCursor(0,1);
  lcd.print("Abnormal");
  digitalWrite(buz,HIGH);
  digitalWrite(motor,HIGH);
  delay(2000);
  digitalWrite(buz,LOW);
  digitalWrite(motor,LOW);
  lcd.clear();
  lcd.print("Drain water");
  lcd.setCursor(0,1);
  lcd.print("Abnormal");
  delay(1500);

 }

}
```

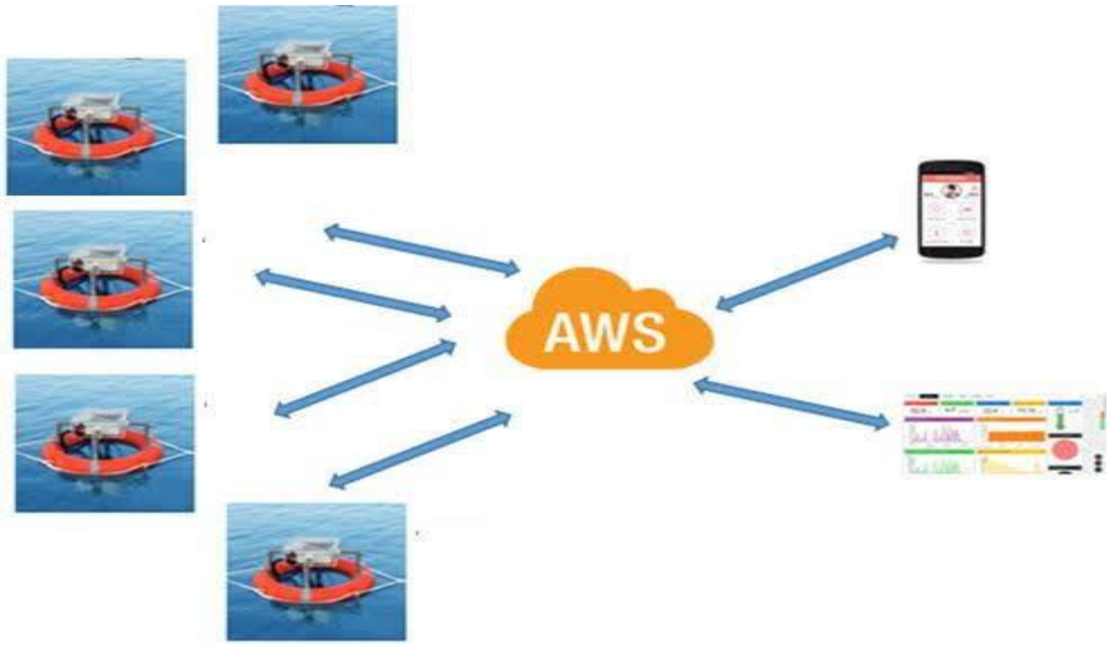
4.2. ALGORITHMS FOR RESEARCH ACTIVITY



The proposed system's entire algorithm is shown in Figure 2. Initially,The serial monitor of Arduino is initialized with 115200 baud rate. Later The ESP Wi-Fi module and the Thing Speak Server is also initialized. TheFour sensors are being connected and the values are read into the sensors.The algorithm flow of the ultrasonic and DHT 11 sensor flow is explained.The Ultrasonic sensor reads the digital value directly so it is considered asThe duration of time in seconds.

5. WORKING PROCESS

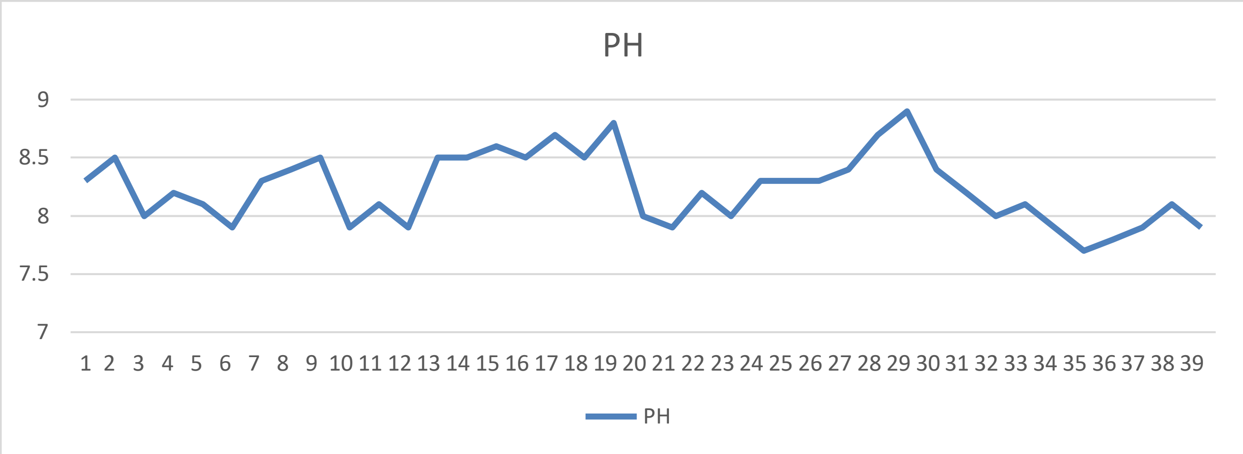
Firstly we have to select the of water like river, lake etc, thenwe have to place the machine in the water such that is should’t sink but the nodes should touch the water. The software assesses the quality of water and the sensors present in the machine takes the reading and these readings were transferred to the computer or the mobile. Qualities such as pH, Turbidity, Temperature, Conductivity, Total dissolved solids and Dissolved oxygen values can be known within no time. These values can be known to us through the wifi transmitter and received to the receiver.

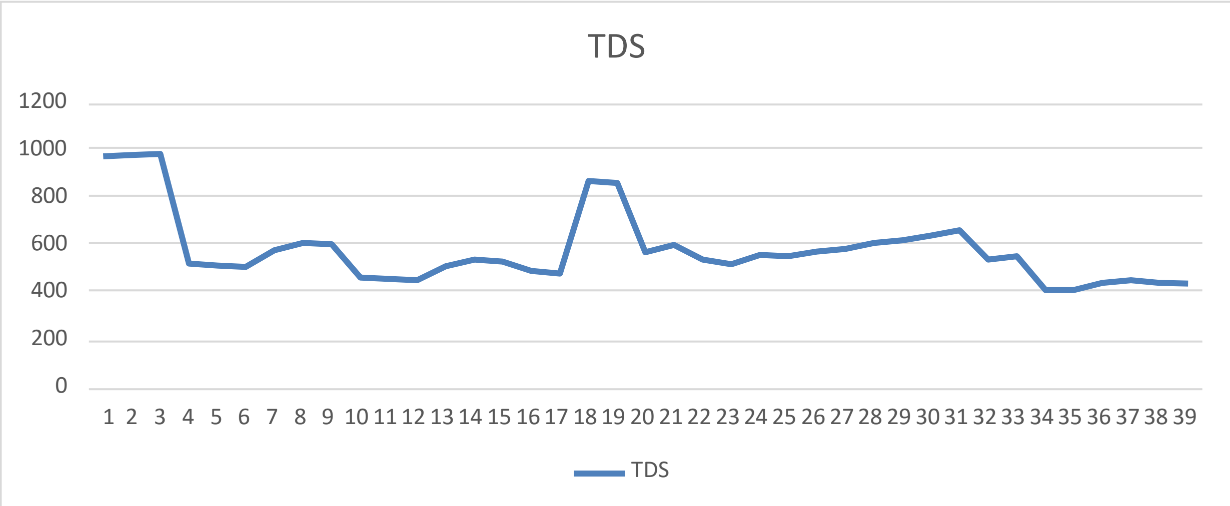


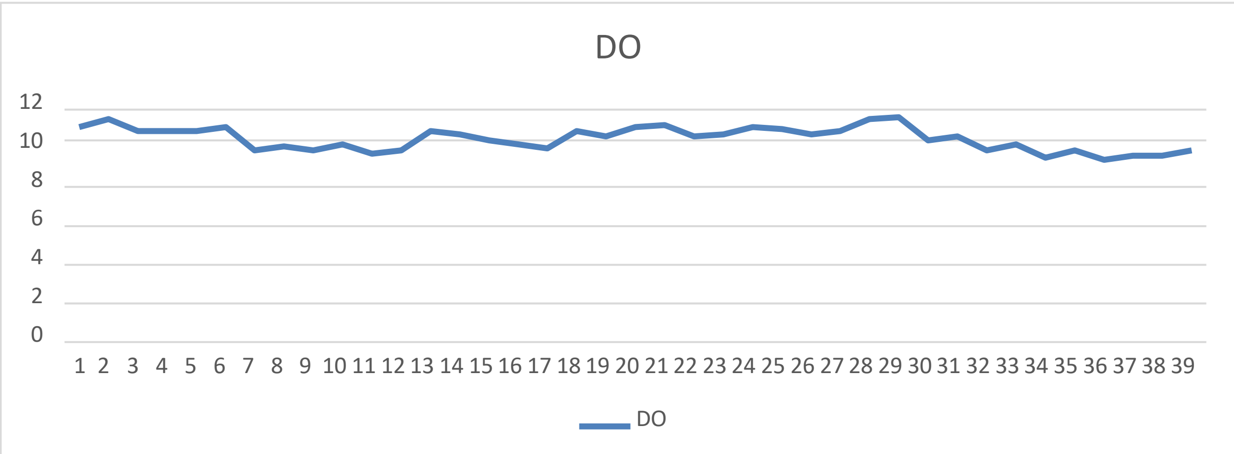
We can take the water samples in the lakes like
Hussain Sagar Lake, Osman Sagar Lake, Durgam Cheruvu Lake, Safilguda Lake, Himayat Sagar Lake, Dammaiguda Lake, Ameenpur Lake, Saroornagar Lake, Nagole Lake, Shamirpet Lake, Alwal Lake, Sikindlapur village Bangarma lake, Gomaram village Gudem lake, Navabet village Masaimma lake , Langer houes lake, Jeedimetla lake, Patancheru lake.

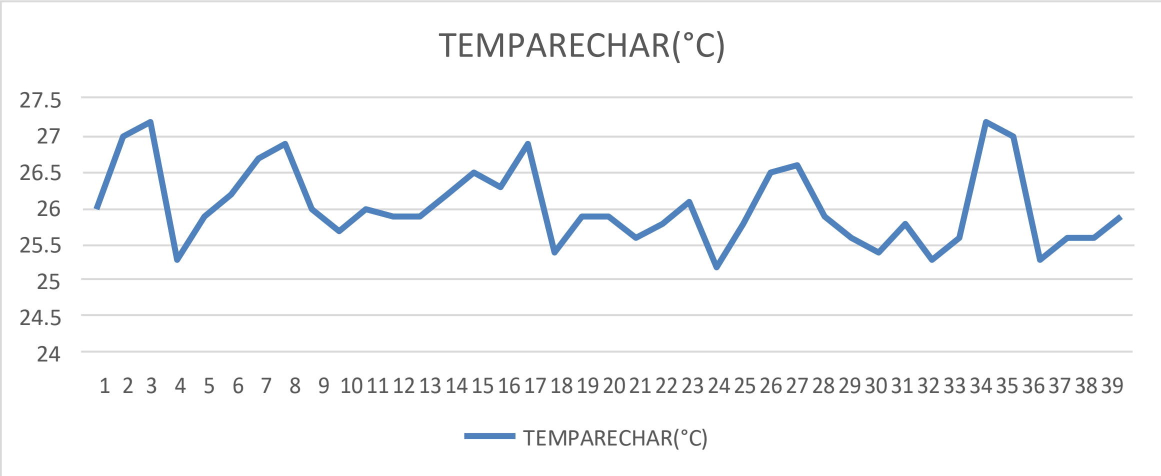
This saves the time and transportation charges.

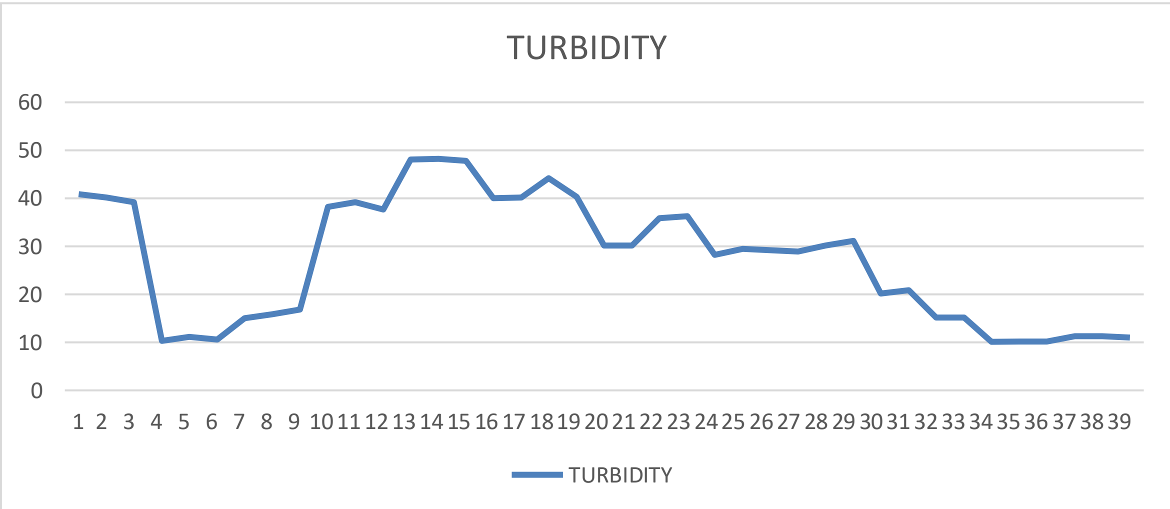
5. **RESULTS**

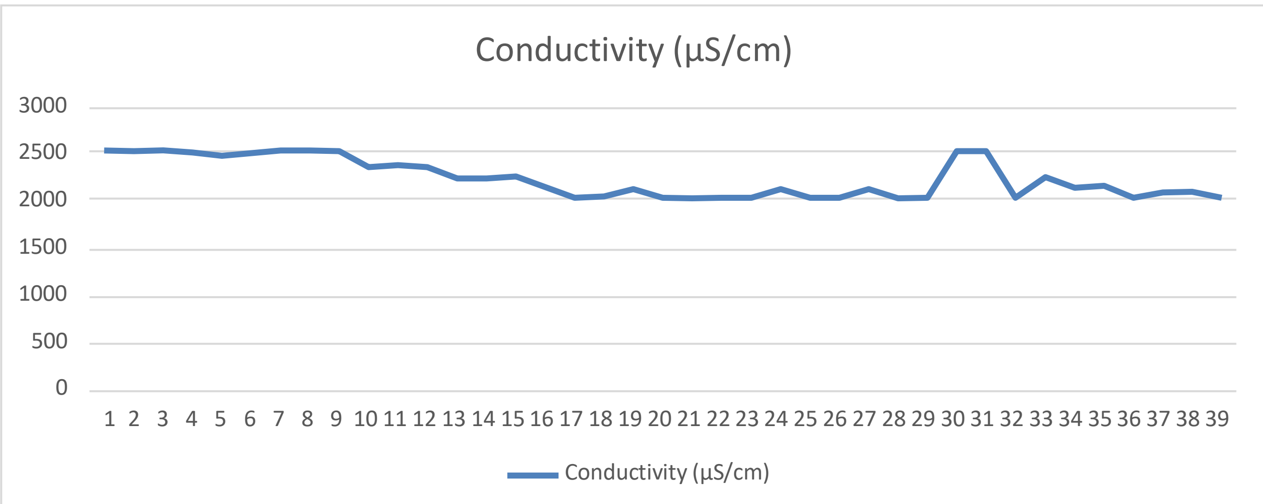

PH
9
8.5
8
7.5
7
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
PH


TDS
1200
1000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
TDS


DO
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
DO


TEMPARECHAR(°C)
27.5
27
26.5
26
25.5
25
24.5
24
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
TEMPARECHAR(°C)


TURBIDITY
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
TURBIDITY


Conductivity (µS/cm)
3000
2500
2000
1500
1000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Conductivity (µS/cm)

S.NO	LAKE NAME	PH	TDS (Mg/l)	TURBIDITY (NTU)	TEMPATURE (°C)	DISSOLVED OXYGEN (mg/l)	CONDUCTIVITY (µS/cm)
1	Hussain sagar lake	8.3	964	40.9	26	10.7	2505
		8.5	970	40.2	27	11.1	2502
		8.0	975	39.1	27.2	10.5	2510
2	Osman sagar lake	8.2	512	10.3	25.3	10.5	2489
		8.1	503	11.1	25.9	10.5	2455
		7.9	499	10.6	26.2	10.1	2478
3	Hiamarat sagar lake	8.3	570	15	26.9	9.5	2505
		8.4	600	15.9	26	9.7	2505
		8.5	595	16.8	27	9.5	2499
4	Langer harse lake	7.9	453	38.2	25.7	9.8	2331
		8.1	449	39.1	26	9.3	2356
		7.9	442	37.6	25.9	9.9	2333
5	Jedimetla lake	8.5	501	48.1	25.9	10.5	2211
		8.5	530	48.2	26.2	10.3	2210
		8.6	521	47.8	26.5	10	2232
6	Patancheru lake	8.5	481	40.0	26.3	9.8	2121
		8.7	472	40.1	26.9	9.6	2010
7	Durgam cheruv	8.5	861	44.2	25.4	10.5	2023
		8.8	852	44.3	25.9	10.2	2098
8	Safilguda lake	8.0	561	30.2	25.9	10.7	2010
		7.9	590	30.2	25.6	10.8	2001
9	Dammaiguda lake	8.2	530	35.9	25.8	10.2	2005
		8.0	511	36.2	26.1	10.3	2006
10		8.3	550	28.2	25.2	10.7	2101
		8.3	543	29.5	25.8	10.6	2005
11	Saroornagar lake	8.3	562	29.1	26.5	10.3	2007
		8.4	575	28.9	26.6	10.5	2100
12	Nagole lake	8.7	601	30.2	25.9	11.1	2001
		8.9	610	31.1	25.6	11.2	2004
13	Shamirpet	8.4	630	20.1	25.4	10.0	2504

	lake						
		8.2	655	20.9	25.8	10.2	2500
14	Alwal lake	8.0	530	15.2	25.3	9.5	2010
		8.1	545	15.2	25.6	9.8	2050
15	Gonaram village Gudem lake	7.9	401	10.1	27.2	9.1	2113
		7.7	401	10.2	27	9.5	2132
16	Sikindalpur village Bangaroma lake	7.8	430	10.2	25.3	9.0	2009
		7.9	443	11.2	25.6	9.2	2065
17	Navabet village Masaimma lake	8.1	430	11.2	25.6	9.2	2073
		7.9	429	11	25.9	9.5	2006

6. CONCLUSION AND FUTURE ENHANCEMENT

- The system can monitor water quality automatically, and it is low in cost and does not require people on duty.
- So the water quality testing is likely to be more economical, convenient and fast.
- The system has good flexibility.
- Only by replacing the corresponding sensors and changing the relevant software programs, this system can be used to monitor other water quality parameters.
- The operation is simple.
- The system can be expanded to monitor hydrologic, air pollution, industrial and agricultural production and so on.
- It has widespread application and extension value.
- By keeping the embedded devices in the environment for monitoring enables self protection (i.e., smart environment) to the environment.
- To implement this need to deploy the sensor devices in the environment for collecting the data and analysis.
- By deploying sensor devices in the environment, we can bring the environment into real life i.e. it can interact with other objects through the network.
- Then the collected data and analysis results will be available to the end user through the Wi-Fi.
- Real-time monitoring of water quality by using IoT integrated Big Data Analytics will immensely help people to Become conscious against using contaminated water as well as to stop polluting the water.
- The research is conducted Focusing on monitoring river water quality in real-time. Therefore, IoT integrated big data analytics is appeared to Be a better solution as reliability, scalability, speed, and persistence can be provided.
- Due to the limitation of the budget, we only focus on measuring the quality of river water parameters.
- Project can be extended into an efficient water management system of a local area. Moreover, other parameters Which wasn't the scope of this project such as total dissolved solid, chemical oxygen demand and dissolved oxygen Can also be quantified. So the additional budget is required for further improvement of the overall system.

PUBLICATION

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TITLE: ASSESSMENT OF THE WATER QUALITY BY USING INTERNET OF THINGS (IOT)

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A Major Project Report
On

ASSESSMENT OF DEVASTING FLOODS OF 2020 OCCURED IN INDIA AND ANALYSING THEIR CHARACTERISTICS USING PYTHON PANDA'S

SUBMITTED TO

JawaharlalNehruTechnologicalUniversityHyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

by

CH SAI PRASAD REDDY	**-**	**(17K81A0171)**
K.NIHARIKA	**-**	**(17K81A0185)**
K.SHARATH KUMAR	**-**	**(17K81A0188)**
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Under the Guidance of

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DEPARTMENT OF CIVIL ENGINEERING

ST. MARTIN'S ENGINEERING COLLEGE
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Dhulapally, Secunderabad – 500 100

JUNE 2021

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BONAFIDE CERTIFICATE

This is to certify that the project entitled **"ASSESSMENT OF DEVASTING FLOODS OF 2020 OCCURED IN INDIA AND ANALYSING THEIR CHARACTERISTICS USING PYTHON PANDA'S"**, is being submitted by CH.SAI PRASAD REDDY, K.NIHARIKA, K.SHARATH KUMAR, D.HARSHA VARDHAN,in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN CIVIL ENGINEERING DEPARTMENT** is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

Signature of guide

Ms Sandhya Kiran .J.K
(Assistant professor)
Department of civil engineering

Signature of head of the department

Ms Sandhya Kiran .J.K
(Head of the department)
Department of civil engineering

Internal Examiner

External Examiner

Place :

Date :

DECLARATION

We, the student of Bachelor of Technology in Department of CIVIL ENGINEERING DEPARTMENT', session: 2017 – 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled **"ASSESSMENT OF DEVASTING FLOODS OF 2020 OCCURRED IN INDIA AND ANALYSING THEIR CHARACTERISTICS USING PYTHON PANDA'S"**is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

CH SAI PRASAD REDDY 17K81A0171
K NIHARIKA 17K81A0185
K SHARATH KUMAR 17K81A0188
D HARSHA VARDHAN 17K81A0175

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ABSTRACT

Flood has been considered as one of the most frequent disaster in the world. India has continuously suffered by many flood in the year of 2020 which claimed huge loss of life and economy. This project is dealing with the 4 states Assam, Bihar, Kerala and Uttar Pradesh which has claimed huge loss of life and economy due to floods in the year of 2020.

On August 24, 2020, 5.69 million people in Assam were affected during the 2020 monsoon. From July 13, 2020, floods affected people in Bihar. By the third week of August, the flood affected 8.36 million people in 16 regions of Bihar . The recent heavy rain triggered the second stage of flooding in Uttar Pradesh (UP), affecting 1,090 villages in 16 districts .On 6 August, a landslide occurred in the Pettimudi settlement in Rajamala, near Munnar, in the Idukki district of Kerala, killing 52 people and 19 others missing.

In this project we enhance data of different floods that has occurred in the year of 2020 and present their common characters and damages that has occurred during floods and also calculating the return period and probability by using python .

KEY WORDS : Floods , Python

CHAPTER:1
INTRODUCTION

1.1 GENERAL:

Flood is most prevalent and natural disaster in the world which destroy both life and economy at a large extent. It can be defined as high water stadiums where water flows over its natural or artificial shores to dry land, for example a river that floods its landscape. Causes of flood can be occurred natural like heavy rains, melting of ice during volcano eruption undersea earthquake, marine landslide and also there is man made floods like bank erosion , breach of dam /barrage/embankments.

There are 5 different types of floods , and the damage each can do to your home can be quite different as well.

1. Flash floods
2. Coastal floods
3. Urban floods
4. River or fluvial floods
5. Ponding or pluvial floods.

1.Flash floods :

Flash floods are fast-moving waters that sweep away everything in their path. They are caused by heavy rain or rapid melting of snow. Floods generally cover a relatively small area and cause little attention, usually less than 6 hours. The rapid flow of water can move large objects like cars, rocks, and trees.

2.Coastal floods :

Coastal flooding is caused by strong winds or storms that move towards the coast at high tide. When powerful waves break sand dunes or dams along the shoreline, the area is often submerged. Coastal areas with less earthworks and lower elevations are the most affected. The best time to repair the gap is when the tide is out.

3. Urban floods :

Urban floods occur when the drainage system of a city or town cannot absorb water from heavy rains. The lack of natural drainage in urban areas can also lead to flooding.

The water flows into the street, which makes driving very dangerous. Although the water level may be only a few inches deep, urban flooding can cause significant structural damage.

4. River floods:

The characteristic of river floods is the gradual overflow of the river banks caused by heavy rains for a long time. The area covered by river floods depends on the size of the river and the amount of rainfall. River floods rarely cause loss of life, but can cause huge economic losses.

5. Pluvial floods :

Rainwater forms on flat areas where the ground cannot absorb rainwater, causing puddles and ponds to appear. Storm floods are similar to urban floods, but mainly occur in rural areas. Agricultural activities and property in areas where storms and floods occur may be severely affected.

1.1.1 CAUSES OF FLOODS:

Floods are usually the result of natural causes. It may also be caused by human factors. Cause great harm to life and property. There are many reasons for the flood. Some of the highlights include:

Heavy rain

Effective assistance for infrastructure and drainage system design during heavy rains. They help to discharge excess water in the tank easily. But in the case of heavy rain, the system stops working. This caused flooding.

River flood

People living along the river are always in danger of death due to river flooding. To avoid this, a series of dams were built. However, if these dams are not properly managed, they can cause large-scale flooding and destruction.

Dam collapsed

In case of heavy rain, the built dam began to collapse. Therefore, the flood situation is even critical for the people around.

Snowmelt

At a time of heavy snowmelt due to heavy rainfall and other factors, flooding occurs. Adopting sustainable measures for heavy rainfall can help cope with the flooding situation.

Deforestation

Reckless logging, i.e. deforestation, is also a major cause of man-made flooding. Trees prevent soil erosion and crop failure. Vegetation is also increasingly rich thanks to more and more trees. It also prevents large flows of rain, thus preventing flooding.

Climate change

Climate change due to human activities also increases the risk of flooding. Humans cut down trees in large quantities, which affects photosynthesis. Therefore, the increase in the level of carbon dioxide in the atmosphere causes climate changes, causing threats of natural disasters like floods, etc.

GHG Emissions

Fossil fuel burning, industrial effects, pollution deplete the levels of the ozone layer and increase the levels of greenhouse gases, becoming the main cause of anthropogenic floods .

Other factors

Damaged feed lines cause water to flow but cause less damage. In addition, there is a flow of water from the washing machine. In addition, the fact that the dishwasher is overflowing with water aggravates the situation. In addition, the lack of proper sewage drainage further compounded the devastation of this natural disaster. So floods can be caused by both natural and man-made causes.

Floods cause great loss of life and property. Waterborne diseases have been spread by floods causing health problems. In addition, destruction of roads and infrastructure, disruption of ecosystems, inadequate sewage systems all require serious efforts to adopt sustainable practices.

Taking measures, such as afforestation, to reduce emissions of harmful gases into the atmosphere can be helpful. In addition, the enrichment of vegetation, the reduction of polluting practices, and the treatment of wastewater can be useful measures to combat this situation.

1.1.2 EFFECTS OF FLOODS:

Floods, that suggest a huge quantity of water growing after which spreading throughout a region, are one of the maximum not unusualplace reasons of herbal disasters. Heavy rains, landslides, overflowing rivers, cyclones and tsunamis reason floods in India. Agricultural lands are destroyed because of plants being submerged in water. This reasons quite a few financial loss to farmers.

Floods effect on each people and communities, and feature social, economic, and environmental outcomes. The outcomes of floods, each bad and positive, range substantially relying at the vicinity and quantity of flooding, and the vulnerability and fee of the herbal and built environments they affect.

The outcomes of floods, each terrible and positive, range substantially relying on their location, duration, intensity and speed, in addition to the vulnerability and cost of the affected herbal and built environments. Floods effect each people and communities, and feature social, economic, and environmental outcomes

As maximum humans are properly aware, the instant influences of flooding consist of lack of human lifestyles, harm to property, destruction of crops, lack of livestock, and deterioration of fitness situations as a result of waterborne diseases. As conversation hyperlinks and infrastructure inclusive of energy plants, roads and bridges are broken and disrupted, a few financial sports might also additionally come to a standstill, humans are compelled to depart their houses and ordinary lifestyles is disrupted.

Similarly, disruption to enterprise can cause lack of livelihoods. Damage to infrastructure additionally reasons long-time period impacts, which include disruptions to materials of smooth water, wastewater treatment, electricity, transport, communication, schooling and fitness care. Loss of livelihoods, discount in shopping strength and lack of land cost withinside the floodplains can depart groups economically vulnerable.

Floods also can traumatise sufferers and their households for lengthy durations of time. The lack of cherished ones has deep influences, specifically on children. Displacement from one's home, lack of belongings and disruption to enterprise and social affairs can purpose persevering with stress. For a few humans the mental influences may be lengthy lasting.

There are two types losses from Floods Modified from Disaster Loss Assessment Guidelines. There are Direct loss and Indirect loss.

Flooding in key agricultural manufacturing regions can cause full-size harm to plants and fencing and lack of livestock. Crop losses via rain harm, waterlogged soils, and delays in harvesting are similarly intensified via way of means of shipping issues because of flooded roads and broken infrastructure. The flow-on results of decreased agricultural manufacturing can regularly effect nicely outdoor the manufacturing location as meals fees boom because of shortages in supply. On the opposite hand, flood occasions can bring about long-time period advantages to agricultural manufacturing via way of means of recharging water aid storages, mainly in drier, inland regions, and via way of means of rejuvenating soil fertility via way of means of silt deposition.

Damage to public infrastructure influences a much extra percentage of the populace than the ones whose houses or corporations are without delay inundated with the aid of using the flood. In particular, flood harm to roads, rail networks and key shipping hubs, inclusive of transport ports, could have vast influences on nearby and country wide economies.

Primary effects :

The number one consequences of flooding encompass lack of lifestyles and harm to homes and different structures, along with bridges, sewerage systems, roadways, and canals. Floods additionally often harm energy transmission and on occasion energy generation, which then has knock-on consequences because of the lack of energy. This consists of lack of consuming water remedy and water supply, which may also bring about lack of consuming water or extreme water contamination. It might also purpose the lack of sewage disposal facilities. Lack of smooth water mixed with human sewage withinside the flood waters increases the danger of waterborne illnesses, that can encompass typhoid, giardia, cryptosporidium, cholera and lots of different illnesses relying upon the area of the flood.

FIG 1.1: Flooded area

Secondary and long-term effects :

Economic difficulty because of a transient decline in tourism, rebuilding costs, or meals shortages main to charge will increase is a not unusualplace after-impact of excessive flooding. The effect on the ones affected might also additionally purpose mental harm to the ones affected, specially wherein deaths, critical accidents and lack of assets occur.

FIG 1.2: Disaster due to flood

1.2 PROBLEM STATEMENT:

Many states in India are experiencing heavy rains, river flooding, typhoons, and tsunamis, causing unexpected floods leading to full or partial deaths in some parts of the world. Floods are one of the most frequent and destructive natural disasters, affecting human life and causing serious economic losses. Flooding can be defined as a hydrological event characterized by a rapid increase in the flow of water in a river.

Planning for flood safety involves many aspects of analysis and engineering, including:

- Observation of previous and present flood heights and inundated areas,
- Statistical, hydrologic, and hydraulic model analyses,
- Mapping inundated areas and flood heights for future flood scenarios.
- Engineering design and construction of structures to control or withstand flooding,
- Intermediate-term monitoring, forecasting, and emergency-response planning, and
- Short-term monitoring, warning, and response operations.

1.3 OBJECTIVES :

- To analysis the characteristics of floods of the states Assam , Bihar , Kerala and Uttar Pradesh.
- To understand the causes and effects caused by the floods in the states Assam , Bihar , Kerala and Uttar Pradesh.
- To calculate the return period and probability of the rain fall using python.
- To suggest the precaution measures to reduce the effects caused due to floods.

1.4 History of floods:

From 1950 to 2004, the total number of severe floods worldwide reached 2,606, involving 172 countries and regions, with a total affected population of 2.75 billion and an economic loss of US$347.235 billion. From 1.46 million hectares in 1965 to 17.5 million hectares in 1978. Approximately 30 million people in the country are affected by floods, and more than 1,500 people die every year, accounting for about one-fifth of the global deaths caused by floods.

In the 20th century, India has effected with floods in some regions which claimed huge loss of life and economy. The following are the some areas which has undergone through floods in the 20th century.

- In October 1943, Madras (now Chennai) was hit by the worst flood in history. The flooding occurred due to heavy rain that lasted for 6 days, which caused the Coovum and Adyar rivers to overflow. The loss of life and property is huge, but the estimated figure is unknown. The flood made thousands of people homeless.

- On August 11, 1979, the Machchu-2 dam on the Machchhu River burst and flooded the town of Morbi in the Rajkot region of Gujarat. The exact number of deaths is not yet known, but it is estimated that between 1,800 and 2,500 people have been killed.

- In 1987, the Indian state of Bihar (Bihar) witnessed one of the worst flood. Due to the flooding of the Yuezhi River, 1,399 people, 302 animals and public property worth 68 billion Indian rupees have been killed.
- In 1988, all the rivers in Punjab were flooded and Punjab experienced its first flood.

- In July 1993, a flash flood killed 530 people in seven to eight states of India.

In the 21st century, floods occurred in parts of India, causing great loss of life and the economy. The following are some of the areas affected by floods in the 21st century.

- The heavy rain in Maharashtra, including large areas of the metropolis of Mumbai, rained 567 (inches) on July 26, 2005 alone, killing at least 1,094 people. This day is still remembered as the day when Mumbai came to a standstill, when the city suffered the heaviest rainfall in history. The Mumbai International Airport was closed for 30 hours, and the Mumbai-Pune highway was closed for 24 hours. The loss of public property was estimated at 5.5 billion rupees.

- North India Flood June 2013: Heavy rains caused by erupting clouds led to severe flooding and landslides in northern Indian states (mainly Uttarakhand and nearby states). More than 5,700 people are presumed to have died.

- Gujarat floods in June 2015: Heavy rains in June 2015 caused major flooding in the Solashtra area of Gujarat, killing more than 70 people. Wildlife in Gil Forest National Park and adjacent areas is also affected.

- Gujarat July 2015 Flood: Heavy rains in July 2015 caused widespread flooding in northern Gujarat, killing more than 70 people.

- floods occurred in southern India in 2015: Heavy rains from November to December 2015 caused flooding of the Adyar and Cooum rivers in Chennai, Tamil Nadu, causing economic losses and casualties.

- Assam floods in 2016: Heavy rains between July and August caused floods, affecting 1.8 million people, submerging the Kaziranga National Park, and killing about 200 wild animals.

- Gujarat floods in 2017: After heavy rains in July 2017, the Indian state of Gujarat suffered severe floods, killing more than 200 people.

- Kerala flood in August 2018: Following heavy rains in late August 2018 and monsoon rains on August 8, 2018, severe flooding affected Kerala, India, causing more than 445 deaths.

- India's August 2019 floods, including the 2019 Kerala floods: After heavy rains in late July and early August 2019, a series of floods affected more than 9 states in India. Kerala, Madhya Pradesh, Karnataka, Maharashtra and Gujarat were the hardest hit.

1.4.1 ICONIC FLOODS IN INDIA

Flooding is a common feature of the country and occurs in many parts of India every year. During the summer monsoon season from June to November every year, India loses many lives and property due to flooding. The following are the worst floods in India in the 21st century, killing more than thousands of people.

1.Kerala , August 2018 :

On August 16, 2018, Kerala in southern India suffered severe floods due to unusually heavy rainfall during the monsoon season. This is the worst flood in Kerala in nearly a century. More than 483 people have died and 140 people are missing. Approximately one million people were evacuated, mainly from Chengannur, Pandanad, Edanad, Aranmula, Kozhencherry, Ayiroor, Ranni, Pandalam, Kuttanad, Malappuram, Aluva, Chalakudy, Thrissur, Thiruvalla, Eraviperoor, Vallamkulam, Chen Palanam, North Island . All 14 areas of the state are on red alert status. According to the Kerala government, one-sixth of Kerala’s total population is directly affected by floods and related events. The Indian government has declared it a level 3 disaster or a "serious disaster". This is the worst flood in Kerala after the 99 floods in 1924.

According to IMD data, precipitation in the state from June 1, 2018 to August 19, 2018 was 2,346.6 mm, compared to an expected 1,649.5 mm. These heavy rains, coupled with the alleged delay in the opening of the dam gates by the authorities, flooded several areas of Kerala and led to landslides in Wayanad and Iduki. Later, experts called it an avoidable man-made disaster caused by deforestation, quarrying and sand mining.

The Central Water Commission stated in its report on the Kerala flood in 2018, “It can be seen that the rainfall depths of 2 days and 3 days in the Pamba, Periyar and Bharathapuzha sub-basins from August 15 to 17, 2018 are different from the Devikulam storm on July 16-18, 1924. For the entire state of Kerala, the depth of rainfall on August 15-17, 2018 was 414 mm, while the rainfall depth on July 16-18, 2018 was the same. 1924 The rainfall depth is 443 mm

FIG 1.3: Aerial view of Kerala on 16 august 2018.

2. Chennai , November 2015 :

The 2015 floods in Chennai eventually became one of the worst natural disasters in the world that year, causing India to lose more than 50 billion rupees. On November 29, the low pressure area intensified into a low pressure, causing a lot of rainfall in the coastal areas of Tamil Nadu and Andhra Pradesh. Chennai recorded 266 mm in the first 24 hours and 490 mm the next day, which eventually led to large-scale flooding. On the afternoon of December 1, 60% of the city’s power supply was interrupted, many hospitals were unable to operate, and 40% of the city’s communities were flooded. Although rescue and disaster relief began a day after the flood, many local people took the initiative to help others, but losses have already been caused. More than 500 people died, more than 50,000 houses suffered structural damage, and more than 1.8 million people were displaced.

The precipitation in Chennai in November was 1,049 mm (41.3 inches), which was the highest record since the precipitation of 1,088 mm (42.8 inches) in November 1918. The Kancheepuram district received the highest precipitation: 181.5 cm, which is 183% higher than the mean rainfall of 64 cm from October to December, while the Tiruvallur district recorded 146 cm, while the mean rainfall was 59 cm. The flooding in the city of Chennai has been described as the worst flood in a century. After the Chennai district, the Kudalor district is one of the areas most affected by the floods. Six of the 13 neighbourhoods in the area were badly damaged by the November floods. The heavy rains that resumed on December 1 again flooded the city of Cuddalore and the area, and tens of thousands of people were displaced. The rain continued until December 9. While the state government and individuals sent rescue teams and several tons of relief supplies to the area, thousands of affected people still lacked basic supplies due to insufficient distribution, leading to several rescue trucks being detained and looted. for the survivors. As of December 10, the city of Kudalor and large areas of the area remained submerged. Thousands of residents were submerged by the flood and more than 60,000 hectares of farmland were submerged; more than 30,000 people were evacuated to relief camps.

FIG 1.4: Aerial view of flood hit areas in Chennai.

3. Jammu and Kashmir, September 2014:

In 2014, major floods hit Jammu and Kashmir and parts of Pakistan. The situation in 2014 was so bad that there were reports of dead bodies floating in the streets of Srinagar. As of September 24, 2014, nearly 277 people in India and 280 people in Pakistan had died due to the floods. According to the Indian Ministry of the Interior, thousands of villages in the state were attacked and 390 villages were completely submerged. According to reports, the actual number of villages in Jammu and Kashmir was 2,600 affected, of which 390 villages in Kashmir were completely submerged. 1,225 villages in Jammu district were partially affected. 1,000 villages were affected. Many parts of Srinagar, including the headquarters of the Border Security Force (BSF) in Sanant Nagar and the army camp in Badam Bagh, were flooded. The road was flooded.

The disaster caused by heavy rains lasted eight days. Jammu and Kashmir typically receives about 100mm of rain in September, but in the first four days of 2014, the state has received 400mm of rain, leading to flooding. On September 5, it was reported that the Jhelum River in Srinagar flowed 22.40 feet (6.83 m) at 4.40 feet (1.34 m) above the hazard mark and 33 feet (10 m) at Sangam in the Anantnag district above the hazard mark. . The flow rate into the river is recorded at 70,000 cusec, while the normal flow rate is 25,000 cusec. From farms and roads to communications infrastructure, from houses to hospitals, the floods were almost undamaged. The economic value of the loss is estimated to be between Rs 50 billion and Rs 60 billion.

FIG 1.5: Aerial view of Jammu and Kashmir floods

4. Uttarakhand , June 2013 :

One of the worst floods in recent Indian history occurred in Uttarakhand in June 2013. Heavy rains caused by the storm led to flash floods and landslides in northern Uttarakhand. The debris blocked the river and caused a lot of overflowing. The main day of the flood is June 16, 2013.

Although parts of Himachal Pradesh, Haryana, Delhi and Uttar Pradesh of India suffered heavy rains, parts of western Nepal and parts of western Tibet also experienced heavy rains, which caused the drainage to flood Uttarakhand through the river system; as a result, more than 89% of casualties occurred in the state. As of July 16, 2013, according to figures provided by the Uttarakhand government, more than 5,700 people have been “presumed dead”. This total includes 934 local residents. The destruction of bridges and roads left approximately 300,000 pilgrims and tourists trapped in the valley leading to three of the four Chota Char Dham Hindu pilgrimage sites. While the military was able to evacuate more than 100,000 people trapped in landslides, an estimated 4,094 were killed . The Uttarakhand floods are considered one of the worst natural calamities in India since the 2004 Indian Ocean tsunami.

FIG 1.6: Uttarakhand flood in 2013

6.Mumbai , July 2005 :

The 2005 floods in Maharashtra affected many areas in the Indian state of Maharashtra, including large areas of the metropolis Mumbai, which is located on the Arabian Sea on the west coast of India and killed approximately 1,094 people. The flooding was caused by the eighth strong storm on record of 944 mm (37.17 inches) that hit the metropolis on July 26, 2005 and continued intermittently the following day. 644 mm (25.35 inches) were received in 12 hours between 8 a.m. and 8 p.m. During the following week, heavy rains continued. More than 1,000 people were killed in the flood, and approximately 14,000 houses were destroyed. The "Sleepless City" was actually paralyzed.

The local train stopped running overnight and the road turned into a river. The city had to bear a direct loss of 4.5 billion rupees. The city's proximity to the sea and the mismanagement of water resources by the authorities have reportedly exacerbated the situation, as roads with stagnant water have turned into rivers and electricity supply has been severely affected.

FIG 1.7: Mumbai floods in 2005.

1.4.2 Floods occurred in the year of 2020 :

This year's monsoon caused flooding in several states across the country. Each region has different types of floods. As of August 24, the states of Assam, Bihar, Uttar Pradesh and Kerala are experiencing or have suffered damage caused by floods.

1 ASSAM :

The flood is a natural disaster and it is due to heavy rain and geo-climatic conditions during monsoon season in assam . On the Brahmaputra River, floods occur every year in Assam. The worst flood of occurred in the Brahmaputra River Valley in August 2000. Soil erosion, human activities, roads and railway interruption, and landform changes and affect cultivated land because of floods. After 1998, the largest recorded flood occurred in 2012, and 21 of the

27 districts were affected. Flooding in Assam due to heavy rains in 2013 affected 396 villages in 12 districts and destroyed nearly 7,000 ha of agricultural land. During the Assam floods in 2014, the people of Assam were nearly affected by 420,000 people and 85 people died in the floods in Assam. After independence, Assam faced major floods in 1954, 1962, 1972, 1977, 1984, 1998,1993, 2002, 2004 and 2012. Another major cause of flooding in Assam is that the eroded banks of the Brahmaputra and Bar valley are covered by its tributaries. The Brahmaputra and Barak rivers in Assam are the primary sources of agricultural and water transportation in these areas. However, during the monsoon season, these two rivers caused a natural disaster of flooding due to severe rainfall. There is a Brahmaputra river in the state of Assam, and the river is enormous and transports a considerable amount of water during severe rainfall and floods.

Recently, in 2020, a flood occurred in Assam during the COVID-19 pandemic. In Assam, the first floods started in May 2020 due to heavy rains until July, and they affected between 2 and 3 million people in 27 districts. According to the Assam State Disaster Management Authority, over 3000 villages were impacted, 44 thousand people were relocated to relief shelters, and agricultural land was also devastated. Because more than half of the area in Kaziranga National Park and Pobitora Wildlife Sanctuary was devastated by the floods, the animals were relocated. The flood in 2020 was caused by an excessive summer season and impacted the state of Assam. According to the meteorological department of Assam, they received nearly 1,164 mm of rainfall until July, compared to the typical rainfall of 894mm during the period.

Floods in Assam are caused by severe rainfall during the monsoon season, with annual rainfall reaching 2480 mm in the Brahmaputra and 6350 mm in the north eastern hills, and the state of Assam is heavily affected by floods every year. Floods occur in Assam as a result of seismicity and landslides; the Brahmaputra valleys are classified as Zone V, indicating a high risk of flooding; and the Brahmaputra valleys are prone to frequent tectonic activity. Floods in Assam are caused by bank erosion, earthquake activity, and rapid population increase, particularly in flood-prone areas. Floods also occur as a result of a lack of a good drainage system, as well as the railway, buildings, roads, and bridges, which have restricted natural water flows; in vulnerable regions, embankments are collapsing as a result of the power of the water. However, another major source of floods in Assam is encroachment on forest areas and water bodies. Another factor that contributed to the flood in Assam was the release of water from dams. The uncontrolled discharge of water floods the Assam plains every year, leaving thousands of people homeless as a result of the Assam flood tragedy. The uncontrolled discharge of water floods the Assam plains every year, leaving thousands of people homeless as a result of the Assam flood tragedy.

According to the ASDMA flood report on Wednesday, Bapeta, Dibrugar, Koklajar, Bongegan, Tinsukiya and other areas were severely affected by floods in the state, which affected 343 people. A total of 2,525 villages were affected. The rising of the Yarlung Zangbo River and other tributaries have affected 515.25 hectares of crops. Up to 120 animals died due to flooding in Kaziranga National Park and, according to the national park report, 147 animals were rescued by forestry officials from the East Assam Wildlife Department. After the water entered Kaziranga, people saw many animals from the national park migrate to higher places when crossing the streets. So far, the National Disaster Response Fund (SDRF), the National Disaster Response Fund (NDRF), the Circle Offices and the locals have rescued 452 people. Rising water levels have damaged the state's levees, roads, bridges, and sewers, as well as other buildings such as houses.

The socioeconomic effects of transportation and communication Most highway routes in Assam are damaged by flooding, including metaled and non-metaled roads and bridges, as a result of water logging and flooding, which is causing communication problems. Because of the flood disaster, the impact of employment and labour in Assam has resulted in poverty. The agriculture industry is the main source of employment in rural areas; however, due to the flood, they are unable to work in agriculture for several months, resulting in unemployment. However, because of the farmer's indebtedness, capital information is not generated, resulting in a shortage of cash as well as a lack of income. Assam is the world's richest biodiversity zone, with numerous forests and wildlife sanctuaries. Every year, most animals in Assam are affected and killed by the flood disaster. Due to the worst-case scenario, certain animals, such as deer, are carried away by flood in flowing river Brahmaputra, and forest resources are also destructive.

However, the government and private parties were opposing long-term investment in the zone prone to flooding. Every year, resources are lost as a result of flooding, resulting in substantial government costs to support development plans and services.

FIG 1.8: Aerial view of assam flood in 2020.

2. BIHAR :

Bihar is one of the states in the country most severely affected by floods, accounting for approximately 17.2% of the country's flood-prone areas. The Kosi, Gandak, Burhi Gandak, Bagmati, Kamla Balan, Mahananda and Adhwara rivers originated in Nepal and flowed through high flow and very high sediment load and descended to the plains of Bihar. Approximately 65% of the catchment areas of these rivers are in Nepal / Tibet, and only 35% of the catchment areas are in Bihar. As a result, the remedial measures for the flood problems in Bihar gained an international scale. The northern plains of Bihar have reportedly seen the highest number of floods in the last 30 years. Major floods occurred in Bihar in 1998, 2004, 2007, 2008, 2012, 2013, 2016, 2017, 2018 and 2019. The total area affected by the floods, has also increased in recent years.

The floods affected Bihar from July 13, 2020. According to data from the Department of Disaster Management (DMD) of the Government of Bihar, by the third week of August, floods affected more than 8.36 million people in 16 districts. The DMD reports that the flood caused 27 deaths. According to data from the National Disaster Management Agency, Darbhanga reported the highest number of flood-related deaths with 10 people, followed by Muzaffarpur with 6 people, West Champaran with 4 people and Saran and Siwan with 2 people each. In addition, 550,792 people have been evacuated, of which nearly 5,186 are now in six rescue camps.

There are approximately 21 known rivers that have flooded northern Bihar, such as Adhwara Samuh, Lakhandehi, Rato, Marha, Manusmara, Bagmati, Kosi, Mahananda, Kankai, Kamla Balan, Gandak, Sikrana (Bhudi Gandak), Kadane, Noon, Berry, Tilawe, Dhanauti, Masan, Kareh, Ganga and Dhonas. In addition, countless small and unknown seasonal rivers that cross the border between Nepal and India drain the monsoon over the Churay Mountains in Nepal (Bihar), India. The water levels of Bagmati and Adhwara in the districts of Sitamarhi, Madhubani, Darbhanga, Muzafarpur and Samastipur the 10 flood meters exceeded the dangerous level of the water. On Thursday, Kosi water levels in the four areas of Supual, Khagaria, Bhagalpur and Saharsa also exceeded dangerous water levels. On Thursday, Kamla Balan surpassed dangerous water levels by two flood gauges for the fourth day in a row. The Burhi Gandak, Lalbakeya and Khiroi rivers also exceeded dangerous water levels in several places in northern Bihar. However, the water level of most rivers in northern Bihar has shown a downward trend, with the exception of Burhi Gandak in Samastipur district and Gagra in Sivan. The water level of the Kamla River also shows a downward trend in catchment areas in Nepal.

The impact of flooding can be roughly divided into the main impacts caused by exposure to water, such as loss of life, livestock and property, damage to infrastructure such as roads, bridges, and railways, interruption of services such as electricity, lines and telephones, pipelines, water supply lines, etc. . . And secondary impacts due to flooding, such as service interruption, health impact, and malnutrition. Secondary effects can cause indirect losses, and their harmful effects will last for a long time, so opportunities may be more important. These include long-term health effects caused by failures in water and sewage systems, and shortages of food and other necessities caused by failures in transportation networks. The infrastructure network supports various activities and services in communities and industries. The economic activity in the region has also been severely affected due to the disruption of services due to damage to the infrastructure. It may result in the partial or complete closure of industrial and commercial establishments, resulting in reduced production, and consequently adversely affecting economic growth. The impact of the flood depends on the maximum depth and duration of the flood, the extent of the flood in the floodplain, the flow rate and the rate of increase of the flood level. Flash floods have a huge and direct impact, and the gradual floods leave a lot of time for evacuation and property protection.

FIG 1.9: Flood in Bihar 2020

3. KERALA:

The wrath of the flood water level of most rivers in 1924 is still fresh in the memory of people in Kerala. In 1961 there was also a severe flood and a rise in reservoir water levels. Generally speaking, in the state, heavy rains are concentrated in the 7 to 10 days of the monsoon period, when the river will exceed the established bank and flood the low-lying areas. Kerala experienced unusually high rainfall from June 1, 2018 to August 19, 2018. This resulted in severe flooding in 13 of the state's 14 districts. According to the IMD data, the precipitation in Kerala from June 1, 2018 to August 19, 2018 was 2346.6 mm, while the expected precipitation was 1649.5 mm. The rain this time was about 42 degrees higher than normal. Furthermore, the rainfall in Kerala in June, July and from August 1 to 19 were higher than normal by 15%, 18% and 164%, respectively.

Floods, landslides and landslides after heavy rains hit Kerala for the third consecutive year. Compared with 2018 and 2019, the number of people affected by floods in 2020 has decreased. In 2018 and 2019, landslides and landslides in high areas of the state were rampant. On August 6, a landslide occurred in the Pettimudi settlement of Rajamala near Munnar in the Idukki district, killing 52 people. A search was also carried out to find another 19 people who were missing after the devastating landslide. In order to take safety measures in the event of heavy rain, the Indian Meteorological Department issued red warnings to the three areas of Wayanad, Kozhikode and Iduki. Orange alerts were also issued in five regions. On the same day, Air India Express Flight 1344 carrying 191 people crashed in Kerala, killing 18 people and injuring many others. This is because the Calicut Airport runway was flooded by heavy rain and visibility was reduced. On August 9, 2020, a landslide occurred in a tea plantation in Rajamala, killing 49 people. The state is suffering from property damage worth 190 billion rupees, deaths of personnel, livestock and major agricultural losses, especially in Kutanad in Alappuzha, also known as the "Kerala rice bowl". The state has reported to the central government. The government submitted a comprehensive plan to improve the country's disaster management capabilities.

According to reports, Munnar recorded 229 mm of rain in 24 hours on August 6. Other parts of the state experienced heavy rain during the same period. Peermade and Padinjarathara recorded 297mm and 276mm of rain on August 6 and the following day, respectively, while Kakayama recorded 261mm of rain the next day, followed by Vadakara's precipitation of 327mm. From August 1 to 10, the state's average precipitation was 476 mm, and the normal precipitation was 164.2 mm.

The unnatural increase in rainfall is caused by the monsoon surge, which is due to the strong Somali ocean current or the Somali jet stream and the low pressure in the Bay of Bengal, which carries the heavy monsoon to the west coast of the India. The west wind at 850 hPa is exceptionally strong, helping the monsoon current to penetrate the Ghats. Although Kerala received only 427mm of normal rain for the whole of August, the state received 476mm in the first ten days of August.

For centuries, agriculture in South Asia has depended on the monsoon from June to September each year. But heavy rains and floods also cause damage and billions of dollars in damage and economic losses in most parts of the region every year. The Kerala National Disaster Management Agency, Kerala Police, Indian Air Force, civilians, volunteers and fishermen from Kerala's coastal areas are actively involved in rescue operations in flood-affected areas. The Kerala government opened 545 aid camps and 12,121 prisoners were admitted to these aid camps. As part of the humanitarian response of non-governmental organizations, IAG Kerala, RedR India and Sphere India held a meeting in Palakkad to develop a preparedness and response plan for continued heavy rains, all Interagency Regional Groups (IAGs) State on 8 of August .

FIG 1.10: Flood in Kerala 2020

4. UTTAR PRADESH:

Due to the environmental imbalance in the mountains (the birthplace of all major river systems), all major river systems in the Indo-Ganga Plain region are transporting large amounts of sediment. Therefore, the sediment load in the Indo-Ganga plain area of the river system is gradually increasing, which hinders the normal flow of surface water in the river. This leads to frequent flooding of rivers. The records of the Central Water Commission stated that the Ghaghara and Rapti river basins experienced major floods in 1965, 1969, 1973 and 1998. Two floods occurred in the Balrampur area. From 1987 to 1996, it was 9 times in Basti district and 21 times in Birdghat (Gorakhpur). (S. Nandargi and Dhar D.N., 1998). The 1998 flood and its losses required a detailed study of the area, the development of flood risk mapping methods, the assessment of sediment load, and the creation of a flood management information system (RSAC) database. , 1998 and 2008) for long-term flood prone areas. planning. More than 40 million hectares (12% of the land) are prone to flooding and river erosion, and due to the flooding in Uttar Pradesh, approximately 7,336 million hectares of land are considered vulnerable to flooding.

The recent heavy rain triggered the second stage of flooding in Uttar Pradesh (UP), affecting 1,090 villages in 16 districts. According to reports, the Sharda in Palia Kalan (in Lakhimpur Kheri), the Rapti River in Shravasti, the Saryu River in Elginbridge (in Barabanki), Ayodhya and Turtipar (in Ballia) have all exceeded the danger mark. Expect other details related to the flood. Earlier this month, 19 areas in UP were affected by flooding. A total of 582 villages in these areas were affected, of which 303 villages have been abandoned. According to reports, rainfall in Uttar Pradesh decreased by 10.4% between June 1 and August 8. However, due to excessive rainfall of 20% in 15 regions of the state, four rivers-Ghaghra, Rapti, Sharda and Gandak-exceeded Marked in red. In the eastern region, parts of Uttarakhand and neighbouring Nepal. In 19 areas affected by the floods, as many as 562 households and 38,248 hectares of agricultural land were affected. According to reports, three dams in Azamgarh were damaged. Mao and Gongda areas.

The climate of Uttar Pradesh is subtropical, and meteorological conditions differ with location and season. Rainfall on the plains is highest in the east and gradually lessens as one moves north. The main reasons of the flood include heavy rainfall, low flat country, high subsurface water level, bed silting, and poor drainage .Important rivers which create floods in the state , are the ganga , the Yamuna , the Ramganga , the Gomit , the Sharda , the Ghaghra , the rapti and the gandhak.the ganga river basin of Uttar Pradesh experience normal rainfall in the region from 60cm to 190cm of which more than 80% occur during the southwest mansoon.

In Gonda and Balrampur, there have been reports of damage to the Sakraur-Bhikharipur and Balrampur-Bhadariya dikes, respectively. Measures are being taken to repair the damage. The statement said that all other dikes are safe. 22 teams from NDRF, SDRF and Uttar Pradesh Armed Police (PAC) have been deployed for search and rescue operations. This is very common in flood-affected areas and ensures that no flood shelters are established where flooded rivers cause soil erosion.

FIG 1.11: Flood in Uttar Pradesh 2020

1.5 FREQUENCY ANALYSIS OF RAINFALL/FLOOD DATA:

Frequency analysis is to estimate the probability of occurrence of future events based on the analysis of historical rainfall records. This can be done by calculating the return period and probability.

Weather forecasting represents a service in which probability forecasts are sometimes published for public consumption, although it may also be used by weather forecasters as the basis of a simpler type of forecast. For example, forecasters may combine their own experience together with computer-generated probability forecasts to construct a forecast of the type "we expect heavy rainfall"

1.5.1 RETURN PERIOD :

A return period, also known as a recurrence interval or repeat interval, is an average time or an estimated average time between events such as earthquakes, floods, landslides or a river discharge flows to occur and it is denoted by "T"

It is a statistical measurement typically based on historic data over an extended period, and is used usually for risk analysis. Examples include deciding whether a project should be allowed to go forward in a zone of a certain risk or designing structures to withstand events with a certain return period. The following analysis assumes that the probability of the event occurring does not vary over time and is independent of past events.

METHODS TO CALCULATE RETURN PERIOD:

1) By California formula : $T = N/M$

N=Total number of data

M=Rank assigned

2) Weibull's formula : $T = (N+1)/M$

N=Total number of data

M=Rank assigned

3) Hazens formula : $T = N/(M-0.5)$

N=Total number of data

M=Rank assigned

1.5.2 PROBABILITY :

A probability of precipitation (POP), also referred to as chance of precipitation or chance of rain, is a measure of the probability that at least some minimum quantity of precipitation will occur within a specified forecast period. The probability of the rainfall whose return period is T is calculated by the formula

Probability (P) = 1/T

The probability of rainfall occurring at least once in “n” successive years is calculated by

$P_1 = 1\text{-}q^n$

q=probability of the rainfall not occurring in a given year=1-P

1.6 SOFTWARES USED:

1.6.1 PYTHON:

Python is an interpreted high-degree general-reason programming language. Python's layout philosophy emphasizes code clarity with its brilliant use of tremendous indentation. Its language constructs in addition to its object-orientated method intention to assist programmers write clear, logical code for small and large-scale projects.

Python is dynamically-typed and garbage-collected. It helps a couple of programming paradigms, along with structured ,object-orientated and practical programming. Python is regularly defined as a batteries included language because of its complete general library.

Guido van Rossum began working on Python in the late 1980s, as a successor to the ABC programming language, and primary launched it in 1991 as Python 0.9.0. Python 2.0 turned into launched in 2000 and delivered new features, together with listing comprehensions and a rubbish series device the use of reference counting. Python 3.0 turned into launched in 2008 and turned into a prime revision of the language that isn't always absolutely backward-compatible.

This project uses Python software as a major factor and a Pillar. As stated in the objectives, this project takes the help of Python software for the analysing the common characteristics of floods occurred in Assam , Bihar , Uttar Pradesh and Kerala . In this Python language is executed in Jupyter notebook in Anaconda software.

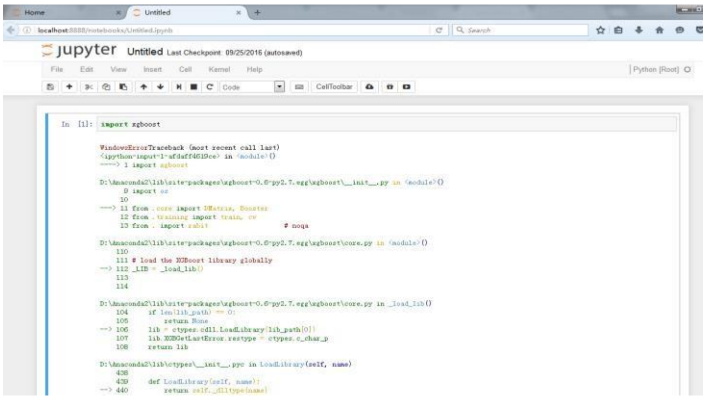


FIG 1.12: Home page of jupyter notebook

1.6.2 GOOGLE EARTH:

Google Earth is a Computer software, previously called Keyhole EarthViewer, that renders a 3D illustration of Earth based primarily on satellite imagery. The program maps the Earth by superimposing satellite images, aerial photography, and GIS data onto a 3D globe permitting customers to peer towns and landscapes from diverse angles. Users can discover the globe by entering addresses and coordinates, or by using a keyboard or mouse. Google Earth Pro version is used for this project.

Google Earth Pro was originally the business-oriented upgrade to Google Earth, with features such as a movie maker and data importer. Google Earth Pro is currently the standard version of the Google Earth desktop application as of version 7.3. The software hosts an array of features that allow users to navigate virtually to any corner of the globe, analyze global changes, get directions, add annotations, and save favourite locations.

For this project, Google Earth is used for extracting real time satellite images of the states. Google Earth found to be more appropriate than other satellite imagery softwares.

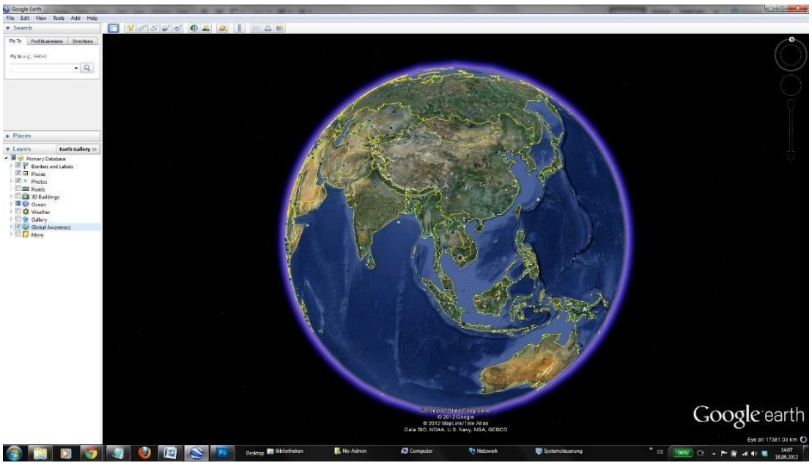


FIG 1.13: Google earth

Therefore, taking all these above Softwares, this project is aiming to analyse the common characteristics of floods occurred in Assam, Bihar, Uttar Pradesh and Kerala in year 2020.

CHAPTER: 2

LITERATURE REVIEW

Introduction to literature : In recent years there has been increasing demand from the engineering organisation in india for detailed information of rainfall to design the local drainage works and large scale structures on streams for the design of these structures it require the study on the future analysis of the rainfall or floods.In the intensive research on the future analysis of the the rainfall and falls is rquired of the stuctures to build .Following litreture reviews focus and help on future analysis of rainfall and floods

[1].Vishwas S. Kale (1997) , have worked and explained on “Flood Hydrology and Geomorphology of Monsoon-dominated Rivers: The Indian Peninsula”and summarized their conclusion as, The rivers of the Indian Peninsula's southern region are monsoonal in nature, and their hydrological characteristics differ significantly from those of Himalayan rivers. During the monsoon season, the rivers are subjected to extreme flooding. Several large-magnitude floods have occurred in recent decades.There have been reports of peak floods ranging from 10,000 to 80,000 m3/s.

Following the launch of the National Flood Control Programme in 1954 and the formation of the National Flood Commission in 1976, several flood-control programs were launched. The program calls for the construction of embankments, drainage channels, town protection works , and the raising or relocation of villages above high flood levels. In the deltaic area, especially in the Mahanadi delta and Andhra Pradesh, building embankments or "bunds" has become commonplace.to limit flood discharges from rivers, reservoirs, and other bodies of water Small ponds have been used to create detention basins.Major dams, such as the Hirakud Dam, are either check dams or major dams.The Ukai Dam, which spans the Mahanadi and the Tapi , the Tawa Dam, which spans the Tawa River in Australia.

[2]. O.N. DHAR and SHOBHA NANDARGI (2000) , have worked and demonstrated on “A study of floods in the brahmaputra basin in india” and came to the following conclusion:

During the summer monsoon months June–September, the Brahmaputra River experiences severe floods that occur year after year causing death and destruction in the Assam Valley and neighbouring Bangladesh. During the period 1987–1998, the highest flood deviations from DL at G:D sites along the main Brahmaputra River ranged from 1 to 2.28 m. During the 12-year cycle, the two G:D sites in upper Assam, Dibrugarh and Nematighat, have experienced high flood levels year after year, as well as a high frequency of floods on the order of 112–136.

The Brahmaputra River's vast water supplies are currently underutilized, and nearly all of its flood water is lost to the Bay of Bengal via Bangladesh after wreaking havoc in Assam and Bangladesh. Although there is limited scope for expanding irrigation facilities in the Assam valley beyond a certain point due to a lack of suitable storage sites (especially in the main river and some of its tributaries), there is enormous potential for expanding irrigation facilities elsewhere.hydroelectric power generation in this area, particularly at the Dihang River's 'Great Bend,' when it comes into India through Tibet and some of its tributaries.

[3] ROLANDO.P.ORENSE (2006) , have elucidated on "The 2004 sediment disaster in quezon province Philippines triggered by heavy rainfall" and gave the results as , Numerous sediment disasters and flash floods erupted on the eastern coast of Luzon Island in the Philippines from mid-november to early-december 2004, causing significant damage to life and property. The results of the saturated/unsaturated seepage analysis revealed that when the slope fails in real life, the entire slope is completely saturated and hence unstable. The strength parameters of the surface soil were back-calculated using the slip circle method based on these results. The back-calculated strength parameters can be used to assess the stability of other slopes in the area with similar soil types, as well as to create a regional landslide risk chart.

[4] Xin Huang (2008) , have described on "Flood hazard in Hunan province of China: an economic loss analysis" and generated the following outcomes, The intensity and extent of the flood, as well as the economic status of the affected people, all play a role in flood-related economic loss. The gross economic loss calculated for the 10,722 families under investigation was $8.925 million. This amounted to a loss of US$ 832.45 per family and US$ 216.75 per person on average. Not only in the nonparametric test, but also in the multivariate study, the relationship between economic loss and flood form was important. River floods caused the most economic damage. The multivariate study revealed that families who experienced flash floods suffered greater economic losses than those who experienced drainage issue floods.

[5] Petra Tschakert (2009) , have explained on “Floods in the Sahel: an analysis of anomalies, memory, and anticipatory learning” and summed up as , The consequences of recent catastrophic rainfall and flood events in the Sahel and larger West African region for climate change adaptation are examined in this paper. Floods in West Africa are a recurring event, according to this study, and are far from being a minor concern that should be ignored any more. It has been demonstrated that local stakeholders are highly aware of heavy rainfall occurrences, have a recollection of past events that closely matches climate records, and do their best to cope with flooding and the resulting losses and health implications.

While the September 2007 rains were unusually heavy, they were compounded by widespread dry periods in the preceding months of May and July, further stressing household coping strategies. In West Africa, the number of extremely wet seasons is expected to increase by 20% over the next 80 years, implying that one out of every five seasons will be extremely wet, compared to one out of every 20 in the control period in the late twentieth century, regardless of the long-term trend.

[6] Pashupati Nath (2012) , have worked and explained on “Study On Impact Of Natural Disasters And Its Relationship With Rainfall Distribution In The State Of Uttar Pradesh During 2006-2010” and summarized the conclusion as , Uttar Pradesh is already vulnerable to natural disasters such as floods and drought. The distribution of all rainfall determined floods and droughts. During the period 2006-10, the Central area was severely affected by rainfall, with maximum average rainfall of 336.020 mm and droughty conditions in Bundelkhand with low average rainfall of 194.370 mm.

one can conclude that average rainfall of the year 2008 is maximum and minimum in case of 2006. In 2008, 32 districts with a population of 41.75 lakhs were affected, with an area of 4.98 lakh hectares, agriculture land of 3.53 lakh hectares, and households totaling 41.75 lakhs. Aside from that, there were 889 human deaths and 1898 animal deaths reported. The susceptibility of 17 divisions in Uttar Pradesh, India, in terms of the effects of rainfall distribution is calculated using the results of extensive rainfall study, such as for different years using this technique.

[7] Yunzhen Chen, James P. M. Syvitski (2012) , have elucidated on "Socio-economic Impacts on Flooding: A 4000-Year History of the Yellow River, China" and summed up as triggers or pressures, technological and organisational breakthroughs encouraged the Chinese to cross certain thresholds, resulting in the commencement and amplification of a series of positive feedback loops that harmed the environment and destabilised the Yellow River's channel. These vicious rings woven a strong causal net out of different natural and human elements, resulting in a human-induced flood history.The Yellow River's and Chinese society's personalities are unmistakably different in many aspects. Its high sediment load, a river system with significant interconnectedness, overcrowding, an exclusive farming society, powerful central government, and had been the world's largest economy in most historical times before the nineteenth century, and had committed innumerable resources to remaking the river in the past millennia are among the distinctions.

[8] Omvir Singh , Manish Kumar (2013) , have described on "Flood events, fatalities and damages in India from 1978 to 2006" and generated the outcomes as, High temporal and spatial variability of rainfall qualifies India to be highly vulnerable to floods. According to records from 1978 to 2006, at least 44,991 people died in India as a result of 2,443 flood occurrences. Every month of the year has seen fatal floods in India, with July and August being the worst. However, there is a significant difference in the number of fatalities per occurrence between July and August. Furthermore, these findings suggest that flood management plans in both structural (embankments, flood walls, channel improvement, floodwater diversion) and nonstructural (flood proofing, forecasting, warning systems, rescue services) measures have not been implemented efficiently in the country . The study concludes that a detailed assessment of historical flooding occurrences and the resulting human mortality using a credible data collection such as the IMD publication on Disastrous Weather Events could be a useful tool in determining the seasonality, temporal trends, and spatial distribution of floods in India.

[9] Zameer Ahmed (2013) , have demonstrated on “Urban flooding – case study of hyderabad” and came to the conclusion as, Urban flooding differs from rural flooding in that developed catchments cause flood peaks to increase by 1.8 to 8 times and flood volumes to increase by up to 6 times. Groundwater recharge zones should be conserved and protected. Use conjunctive management to improve groundwater storage: in some cases, diverting surface water for groundwater infiltration can help with flood management by lowering peak flows. In Hyderabad, urbanisation has resulted in an increase in impervious areas, which has resulted in a considerable increase in runoff rates, resulting in the stormwater drainage system's planned capacity being exceeded. As a result of all of this, even minor amounts of rainfall can cause urban flooding. Human activities, rather than meteorological or hydrological causes, are mostly to blame for recurrent flooding in Hyderabad.

[10] C.M. BHATT and G.S. RAO (2014) , have elaborated on “Ganga floods of 2010 in Uttar Pradesh, north India: a perspective analysis using satellite remote sensing data” and gave the results as, The importance of space technology to capturing the geographic extent of water spread under extraordinary flood conditions, such as those observed along the Ganga River in September 2010, is highlighted in this research. The hydrological, meteorological, and satellite-based observations made during the extraordinary flood event can help researchers study the changes in climate regime that caused river water levels to exceed after a decade. The seven-day cumulative rainfall analysis shows that two continuous spells of more than 100 mm of rainfall with a week pause resulted in the crossing of DL by river, and if followed by a third spell, could result in an unprecedented flood situation. This observed association between rainfall and river water level can be utilised as a proxy indication for flood alarm during the monsoon season. This method can be useful in anticipating the areas that will be affected when satellite photos cannot be used efficiently owing to cloud cover, as well as in providing information about the areas that are only partially covered in satellite data.

[11] Zhenhua Liu (2014) , have worked and explained on “Analysis of flood disasters from 206 BC to 1949 in China” and presented the results as , Flood disasters cause not only immediate economic losses but also major environmental concerns, so the government has placed a high priority on flood catastrophe prevention since ancient times. Flood disasters in China have several features, including a wide spectrum of floods, frequent occurrence, extreme suddenness, and significant losses. First, there are relatively few historical records of floods before to 206 BC; nevertheless, there are more precise historical accounts of floods during the Qin and Han dynasties.

As a result, the floods from 206 BC to 1840 are mostly studied. From 206 BC until 1936, China saw 1037 flood catastrophes. Except for the Five Dynasties, the flood cycle is the falling concave curve from 206 BC to 1936. Flood disasters in the Yellow River valley were particularly severe from the 16th to 19th centuries, especially in the 19th century. Finally, we must consider flood-related water pollution and integrate organic flood control with water environment protection.

[12] Mohammad Usama (2015) , have discussed on "Management of Floods in Flood Prone Regions of Eastern Uttar Pradesh" and reported the findings as, In comparison to the western and central regions of Uttar Pradesh, the eastern districts are the most prone to flooding. The recurrence duration of very deficient rainfall in Eastern Uttar Pradesh has been calculated to be 6 to 8 years, but it is 10 years in Western Uttar Pradesh. Ballia district is a persistently flood-prone area, as the last ten-year record from 1998 to 2007 shows that the river Ghaghra passed the danger level of 64.01 ten times, causing widespread devastation in the Ballia region.

Uttar Pradesh contains 294.36 million hectares of land, of which 73.36 million hectares are flood-prone. The main flood management programmes now being implemented in the state include drainage improvement, afforestation, embankment construction, reservoir construction, and detention basin construction, among other things. As a result, frequently flood-prone areas should be classified as backward areas, and special status and measures to promote economic growth in those areas should be implemented.

[13] Pingping Luo (2015) , have talked about "Historical assessment of Chinese and Japanese flood management policies and implications for managing future floods" and summed up as , Flood prevention is greatly aided by effective flood control policies. In order to properly handle increasingly frequent catastrophic events and climate change, it is necessary to consider the history of Japanese and Chinese flood control. The creation of a multi-purpose non-dam intake structure in China was prompted by the complex needs of the area surrounding the Dujiangyan Irrigation System. Green dams have lately been demonstrated to be a useful flood management tool in Japan, where the forest covers around 80% of the entire surface area. In order to develop effective flood control policies in the future, historical flood control strategies must be considered as well as future climate circumstances. Both China and Japan must work with traditional flood management methods (building taller and stronger levees and multi-purpose flood management structures) in the short term and non-structural measures (e.g. modifying land use policies and flood plain restoration) in the long run, while boosting federal-local collaboration.

[14] Prakash Tripathi (2015) , have worked and explained on "Flood Disaster in India: An Analysis of trend and Preparedness" and summarised their conclusions as , From 1915 to 2015, India has seen 649 natural disasters. Floods were responsible for 302 of the 649 disasters, with an average of three floods every year. This accounted for almost 47% of all disasters that occurred in India in the last 100 years. Riverine floods, flash floods, coastal floods, and other types of floods are all types of floods. The lives claimed by these floods have gone from an average of 1000 per year in the 1965-75 decade to 1700 per year in 2005-15 decade.

To decrease flood losses and protect flood damage, the Indian government has implemented both structural and non-structural solutions. Artificial reservoirs and dams, natural depression (diversion of a portion of the river to a region where water stagnation and logging are not a concern), and river embankment (to prevent the river from overflowing the banks) are examples of structural measurements. Flood plain zoning and construction restrictions in flood-prone areas to lessen the impact, flood forecasting and warning systems, flood proofing, and other non-structural measures are examples.

[15] Pratisha Padmasri Deka (2015) , have worked and demonstrated on "A Study on Flood Disaster in Assam: Threats and Measures" and gave the results as , Heavy monsoon rains across the Himalayan and Patkai ranges of hills, posing hazards to gently sloping narrow river valleys, along with significant seismic activity in easily erodible hill slopes, as well as some anthropogenic sources, result in heavy flooding in Assam. Due to repeated river course shifts and river bank erosion, thousands of hectares of agricultural land in hundreds of communities with crops, towns, and infrastructure have been lost to the river. Water-related disasters have a significant impact on societal social, economic, cultural, and political changes. It is critical to resolve concerns linked to proper natural resource management and limiting infrastructure and property loss due to periodic natural disasters in order to develop flood-affected areas.

[16] Rehan Dastagir (2015) , have elucidated on “Modeling recent climate change induced extreme events in Bangladesh” and reported the finding as , Bangladesh is a resourceful and densely populated country that has been plagued by natural calamities such as cyclones, tidal surges, floods, salt incursions, and droughts, all of which inflict significant loss of life and property each year. Due to climate change and global warming, the frequency and intensity of extreme occurrences have increased dramatically in recent decades. Bangladesh is the world's sixth most flood-prone country (UNDP,2004). The most recent extraordinary flood, which occurred in 2007, inundated 62,300km2 (42 percent of total area), resulting in 1110 deaths and affecting 14 million people; 2.1 million hectares of standing farmland were submerged, 85,000 dwellings were completely destroyed, and 31,533 kilometres of roads were damaged. The estimated financial damage from this one occurrence totaled $1.1 billion.

[17] Saravanan J, Naveen Chander K (2015) , have elaborated on “Chennai Floods (2015) and Possible Solutions from Developed Countries” and generated the outcomes as , Due to uncontrolled constructions of concrete areas, encroachment of key drainage channels, shrinking of marshlands, and other factors, Chennai, one of the fastest developing metros, is likely to be harmed by a lack of drainage. The Thames Barrier (London), the Retarding Basin (Melbourne), the SMART Tunnel (Kuala Lumpur), and the MAOUDC (Tokyo) are examples of urban flood management strategies that have been installed in a number of developed countries. With the massive instances from around the world, it can be inferred that natural disasters may be smoothly handled with rising civil engineering technologies. If a metropolis like Chennai is to recover from the devastation caused by major floods, it must move quickly toward sustainable urban development using the most up-to-date recommendations available from developed countries.

[18] Zainudini MZ and Sardarzaei A (2015) , have described on “Flood Control and Flood Management of Sarbaz and Kajo Rivers in Makoran” and generated outcomes as , Since their origin, the Sarbaz and Kajo rivers have served as vital transit and trade routes. These two rivers must be re-evaluated, particularly in light of the huge increase in rainfall and water in the rivers expected by global climate change models over the next 25 years or more. Iran has large rivers, and flood planning and management are mostly focused on riverine floods that occur during the monsoon season. Flash floods, on the other hand, are widespread in hilly and mountainous places and have been shown to cause significant damage. As a result, it is frequently useful to operational authorities and related interest groups to conduct a voluntary, environmental evaluation. In this study, the corresponding area demonstrates that climate change or global warming may be affecting flooding and that flood frequency may alter.

[19] P. T. Kadave (2016) , have worked and explained on “Mumbai Floods, Reasons and Solutions” and presented the results as , Mumbai is India's financial capital, and the floods have caused significant economic devastation as well as a large loss of life, property, and livestock, as well as diseases and emotional distress among those who have survived. For the recovery of the devastation caused by the floods, a large sum of money will be invested. Heavy Rains and Rising Sea Levels, Extensive Reclamation and Faulty Zoning Regulations, Faltering Drainage Systems, Mumbai's Natural Drain: Mithi River, and Incapable Storm Water Drains are only a few of the causes of Mumbai floods. Increasing the capacity of the 'Storm Water Drains',Setting up of Storm Water Pumping Stations at the SWD outfalls, are the methods implemented by the MCGM.

[20] Omvir Singh (2017) , have elucidated on “Flood occurrences, damages, and management challenges in India: a geographical perspective” and summed up as , In India, floods are the most common and destructive weather hazard. Several devastating floods affected India in 1971, 1973, 1976, 1977, 1978, 1980, 1984, 1988, 1993, 1995, 2006, and 2010 according to existing literature. Despite this, statistics show no significant reduction in flood damage. To achieve long-term flood management, however, river-friendly and less interventionist alternatives have been proposed. The creation of appropriate flood storage in reservoirs is widely recognised as a long-term solution to flood problems. As a result, new dams and reservoirs will be required in the future to improve water management in general, as well as to create flood space for effective and successful flood control in particular. The upkeep of embankments, drainage channels, and other infrastructure should be the responsibility of the beneficiaries, and resources should be used efficiently.

[21] Kamaljit Ray (2019) , have worked on "On the recent floods in India" and generated the following outcomes , The current study aims to provide an integrated explanation for meteorological and geomorphological aspects related to four recent extreme floods in Uttarakhand (2013), Srinagar (2014), Chennai (2015), and Gujarat (2017). Rainfall increased surface run-off in the hilly area of Garhwal, affecting only the lower level terraces along the higher gradient-confined meanders; the region is more vulnerable to slope-related problems. It's worth noting that these floods occurred under various atmospheric circulations and geomorphological conditions, resulting in a very different policy planning and governance scenario. If an advance warning system based on these findings can be established, the consolidation of these issues would aid policymakers and technologists.

[22] Michaela Rättich (2020) , have been defined on "Automatic Flood Duration Estimation Based on Multi-Sensor Satellite Data" and results obtained as , The aim of this project is to create an automated procedure for estimating flood period and the uncertainty associated with the procedure's use of multi-temporal flood extent masks. Data from several satellites, including Sentinel-1, Sentinel-2, Landsat-8, and TerraSAR-X, was analysed to ensure consistently high observation frequencies. For the delineation of flood extents from the range of aforementioned sensors, satellite image processing and analysis is carried out in near real-time with an automated system of dedicated processing chains. The proposed method's ability to support satellite-based emergency mapping operations is illustrated using two examples: the 2019 flood in Sofala, Mozambique, and the 2017 flood in Bihar, India. The study's findings demonstrate the products' potential for supporting satellite-based emergency mapping efforts.

[23] Kieran M. R. Hunt (2020) , have demonstrated on "The 2018 Kerala floods: a climate change perspective" and reported the finding as , In August 2018, a low-pressure system near the beginning of the month was followed several days later by a monsoon depression, resulting in a prolonged period of very heavy rainfall in the Indian state of Kerala. About 400 people were killed and a million people were displaced as a result of the floods. To investigate the circumstances that caused the floods, a high resolution setup (4 km) of the Weather Research and Forecasting (WRF) model is used in conjunction with a hydrological model (WRF-Hydro, run at 125 m resolution) from the Weather Research and Forecasting (WRF) model.

Kerala is bordered on the west by the Arabian Sea and on the east by the Western Ghat mountain range. Around 44 rivers flow through Kerala, and there are about 50 major dams, mostly in the Western Ghats, that provide water for agriculture and hydroelectric power generation (Ramasamy et al.2019). Kerala receives the most monsoon rainfall in India, second only to the northeastern states: the total annual rainfall is about 300 cm spread over six months, with the highest amounts falling in June and July. Climate change will have the greatest effect in the state's south, according to an analysis of river streamflow at all 62 dams.

[24] S. O. Ansah (2020) , have elucidated on “Meteorological Analysis of Floods in Ghana” and generated outcomes as , On the 18th and 28th of June, respectively, the first episodes of floods triggered by heavy rainfall during the main rainy season in 2018 occurred in Accra (5.6°N and 0.17°W), a coastal area, and Kumasi (6.72°N and 1.6°W), a forest city. It conducted trend analysis to quantify the frequency of anomalous rainfall events and determine the intensity of the thunderstorm, which revealed an increasing trend for Accra with a slope of 0.045 and a decreasing trend for Kumasi with a slope of –0.07. This also coincides with less days with heavy rainfall for Accra using the 95th percentile threshold of 45.10mm and more days with less heavy rain for Kumasi. According to the National Disaster Management Organization, heavy rainfall and flooding resulted in 14 deaths, 34076 people being homeless, damaged buildings, and a total economic loss of $168,289 for the two cities (NADMO).

[25] C. M. Bhatt (2020) , have discussed on “Geospatial analysis of September, 2019 floods in the lower gangetic plains of Bihar using multitemporal satellites and river gauge data” and presented the results as , Bihar experienced significant flooding in late September 2019, which is usually associated with a time of flood recession due to the withdrawal of the south-east monsoons. Long-term data analysis of precipitation, soil moisture, vegetation, and river gauge data clearly demonstrates the flood anomaly that has been caused by the monsoon season's extension in 2019. Due to the 2019 delayed monsoon withdrawal and excessive late September rains that caused floods in most of North India, new withdrawal dates for monsoon operational services have been calculated using climatological data from 1961 to 2019 rather than the old data used from 1901 to 1940. (Pai et al. 2020). Due to the prolonged submersion by floodwaters, the NDVI and EVI values dropped by around 13.7 and 11.1 percent, respectively, from their usual values. A total of 8.36 lakh hectares of land have been flooded, affecting a population of 9.26 million people. Patna and Bhagalpur were the two worst-affected districts, with nearly 30% and 36% of the districts' geographical area flooded, respectively.

SUMMARY :

Consequently, numerous flood-prone regions were studied from the above-mentioned collections of newspapers and the causes and impacts of flooded areas were identified. The reasons why the devastating flooding in India, urban water management techniques, urban flood variations and rural floods have been explained etcetera. Intensive literature study helped to understand the causes of the floods and to take preventative measures before the flood and during the flood.

Chapter :3
STUDY AREA

The study area of the project is about the states Assam,Bihar,Uttar Pradesh and Kerala. The population of the states is (3,60,24,656) , (12,84,58,570) , (23,15,21,022) , (3,46,78,294) citizens respectively according to 2020 .These states are flooded in the year 2020 and caused different problems in the sates

The features of the states are given below.

3.1 ASSAM:

3.1.1 GEOGRAPHICAL FEATURES:

A significant geographical aspect of Assam is that it contains three of six physiographic divisions of India – The Northern Himalayas (Eastern Hills), The Northern Plains (Brahmaputra plain) and Deccan Plateau (Karbi Anglong). As the Brahmaputra flows in Assam the climate here is cold and there is rainfall most of the month. Geomorphic studies conclude that the Brahmaputra, the lifeline of Assam, is an antecedent river older than the Himalayas. The river with steep gorges and rapids in Arunachal Pradesh entering Assam, becomes a braided river (at times 10 mi/16 km wide) and with tributaries, creates a flood plain (Brahmaputra Valley: 50–60 mi/80–100 km wide, 600 mi/1000 km long). The hills of Karbi Anglong, North Cachar and those in and close to Guwahati (also Khasi-Garo Hills) now eroded and dissected are originally parts of the South Indian Plateau system. In the south, the Barak originating in the Barail Range (Assam-Nagaland border) flows through the Cachar district with a 25–30 miles (40–50 km) wide valley and enters Bangladesh with the name Surma River.

Urban centres include Guwahati, one of the 100 fastest growing cities in the world. Guwahati is also referred to as the "Gateway to the North-East India". Silchar, (in the Barak valley) is the second most populous city in Assam and an important centre of business. Other large cities include Dibrugarh, an oil and natural gas industry centre.

3.1.2 CLIMATE FEATURES:

With the tropical monsoon climate, Assam is temperate (summer max. at 95–100 °F or 35–38 °C and winter min. at 43–46 °F or 6–8 °C) and experiences heavy rainfall and high humidity.The climate is characterised by heavy monsoon downpours reducing summer temperatures and affecting foggy nights and mornings in winters, frequent during the afternoons. Spring (March–April) and autumn (September–October) are usually pleasant with moderate rainfall and temperature. Assam's agriculture usually depends on the south-west monsoon rains.

3.1.3 FLODDING:

Every year, flooding from the Brahmaputra and other rivers such as Barak River etc. deluges places in Assam. The water levels of the rivers rise because of rainfall resulting in the rivers overflowing their banks and engulfing nearby areas. Apart from houses and livestock being washed away by flood water, bridges, railway tracks, and roads are also damaged by the calamity, which causes communication breakdown in many places. Fatalities are also caused by the natural disaster in many places of the State.

3.1.4 POPULATION:

The total population of Assam was 26.66 million with 4.91 million households in 2001. Higher population concentration was recorded in the districts of Kamrup, Nagaon, Sonitpur, Barpeta, Dhubri, Darrang, and Cachar. Assam's population was estimated at 28.67 million in 2006 and at 30.57 million in 2011 and is expected to reach 34.18 million by 2021 and 35.60 million by 2026.

As per the 2011 census, the total population of Assam was 31,169,272. The total population of the state has increased from 26,638,407 to 31,169,272 in the last ten years with a growth rate of 16.93%.

3.1.5 AGRICULTURE:

In Assam among all the productive sectors, agriculture makes the highest contribution to its domestic sectors, accounting for more than a third of Assam's income and employs 69% of workforce. Assam's biggest contribution to the world is Assam tea. It has its own variety, Camellia sinensis var. assamica. The state produces rice, rapeseed, mustard seed, jute, potato, sweet potato, banana, papaya, areca nut, sugarcane and turmeric.

3.1.6 RIVERS:

In Assam state many rivers are flowing through it. The rivers flowing through the Assam state are Brahmaputra river, Barak river, Dhansri river, Manas river, Dihing river, Lohit river, Kopili river, Karmeng river, Bhogdoi river, Surma river. The origin of Brahmaputra river is in himalyas and the length of the river is 2900 km and zangmu dam is constructed across this river and the connecting state through this river is arunachal Pradesh. The connecting cities are Guwahati, Dibrugarh, Tezpur. The origin of Barak river is in Mukru river and the length of the river is 900 km. the connecting states are Manipur and Mizoram. The connecting cities are Silchar and Lakhipur. The origin of Dhansri river is Laisang peak. The length of the river is 352km. the connecting state is Nagaland and the connecting cities are Golaghat and Dimapur. The origin of Manas river is in Himalayan range and the length of the river is 376km. The connecting city is Jogighopa. The origin of Dihing river is in patkai hills and the length of the river is 380km. the connecting state is Arunachal Pradesh and the connecting cities are Ledo, Digboi, Duliajan, Naharkatia and Tinsukia.

The origin of Lohit river is in Kangri Garpo range and the length of the river is 200 km and and the connecting state through this river is Arunachal Pradesh. The connecting city is Kibitho. The origin kopili river is in Meghalaya plateau and the length of the river is 290 km and Khandong dam and Umrongso dam are constructed across this river and the connecting state through this river is Meghalaya . The connecting cities are Kamrup, Karbi anglong, Dima Hasao, Nagaon. The origin of Kameng river is in himalyan mountains and the length of the river is 264 km and the connecting state through this river is Arunachal Pradesh. The connecting cities are Tezpur, Sontipur, West kameng. The origin of Bhogdoi river is in Naga hills. The connecting city is Jorhat. The origin of Surma river is in Manipur hills and the length of the river is 900 km.

Fig 3.1: Satellite image of Assam state from Google Earth

3.2 BIHAR:

3.2.1 GEOGRAPHICAL FEATURES:

Bihar is located in the eastern region of India between latitude 24°-20'-10" N ~ 27°-31'-15" N and longitude 83°-19'-50" E ~ 88°-17'-40" E. It is an entirely land–locked state, in a subtropical region of the temperate zone. Bihar lies between the humid West Bengal in the east and the sub humid Uttar Pradesh in the west, which provides it with a transitional position in respect of climate, economy and culture. It is bounded by Nepal in the north and by Jharkhand in the south. Bihar plain is divided into two unequal halves (North Bihar and South Bihar) by the river Ganges which flows through the middle from west to east. Bihar's land has average elevation above sea level of 173 feet.

3.2.2 CLIMATE FEATURES:

The temperature in winter all over Bihar varies from 0–10 °C. On 7 January 2013, in early morning, the mercury dipped to a record low of -2 °C in Forbesganj, 0 °C in Gopalganj, 0.2 °C in Jehanabad, 0.7 °C in Vaishali, -1 °C in Patna and Muzaffarpur, as well as other cities. December and January are the coldest months in Bihar. Bihar also experiences dust storms, thunderstorms, and dust-raising winds during the hot season. Dust storms with a velocity of 48–64 km/hour are most frequent in May, followed by April and June. The hot winds (loo) of the Bihar plains blow during April and May, with an average velocity of 8–16 km/hour. The hot wind greatly affects human comfort during this season.

3.2.3 FLOODING:

Bihar is India's most flood-prone state, with 76% of the population in northern Bihar living under the recurring threat of flood devastation. According to some historical data, 16.5% of the total flood-affected area in India is located in Bihar, while 22.1% of the flood-affected population in India lives in Bihar. About 68,800 square kilometers (26,600 sq mi) out of a total geographical area of 94,160 square kilometers (36,360 sq mi), comprising 73.06% of the state, is flood-affected. Floods in Bihar are a recurring disaster which on an annual basis destroys thousands of human lives, apart from livestock and assets worth millions.

3.2.4 POPULATION:

At the 2011 Census, Bihar was the third most populous state of India with total population of 104,099,452, nearly 89% of it rural. It was also India's most densely populated state, with 1,106 persons per square kilometer. The sex ratio was 918 females per 1000 males. Almost 58% of Bihar's population was below 25 years age, which is the highest in India. At 11.3%, Bihar has the second-lowest urbanization rate in India after Himachal Pradesh.

3.2.5 AGRICULTURE:

Among the states of India, Bihar is the fourth-largest producer of vegetables and the eighth-largest producer of fruits. About 80% of the state's population is employed in agriculture, which is above the national average. The main agricultural products are litchi, guava, mango, pineapple, brinjal, lady's finger, cauliflower, cabbage, rice, wheat, sugarcane, and sunflower. Though good soil and favourable climatic conditions favour agriculture, this can be hampered by floods and soil erosion. The southern parts of the state endure annual droughts, which affect crops such as paddy.

3.2.6 RIVERS:

In Bihar state there are eleven rivers flowing through it. The rivers flowing are Ganga, Koshi river, Gharghara, Burhi gaandak river, Kamala river, Punpun river, Karmanasa river, Phalgu, Kankai river, Mechi river, Kiul river. The origin of Ganga river is in Gangotri Glacier and the length of the river is 2525 km and Tehri dam and Bansagar dam is constructed across this river and the connecting state through this river is Uttarkhand, Uttar Pradesh, West Bengal. The connecting cities are Varanasi ,Haridwar ,Kolkata ,Allahabad ,Patna ,Kanpur ,Ghazipur. The origin of Koshi river is in Sun Kosi and the length of the river is 729km and Sapta koshi high dam is constructed across this river.The connecting cities are Supal ,Saharsa ,Kursela. . The origin of Ghaghara river is in Himalyas and the length of the river is 1080 km and Chisapani dam and West Seti dam is constructed across this river and the connecting state through this river is Uttar Pradesh. The connecting cities are Lakhimpur ,Sitapur ,Fatehpur ,Faizabad , Chhapra. . The origin of Burhi gandak river is in Chautarwa Chaur and the length of the river is 320 km and the connecting state through this river is Uttar Pradesh. The connecting cities are West Champaran ,Gopalganj ,Saran ,Vaishali, Begusarai. . The origin of Kamala river is in Sindhuliagadhi and the length of the river is 328km.The connecting cities are Madhubani, Darbhanga. The origin of Punpun river is in himalyas and the length of the river is 200 km and the connecting state through this river is Jharkhand. The connecting cities are Obra, Fatuha, Palamu, Chatra, Aurangabad, Gaya, Patna. The origin of Karmanasa river is in kaimur and the length of the river is 192 km and Naugarh dam is constructed across this river and the connecting state through this river is Uttar Pradesh. The connecting cities are Kaimur, Sonbhadra, Chandauli, Varanasi, Ghazipur, Buxar. The origin of Phalgu river is in Bodh Gaya and the connecting city is Gaya. The origin of Kankai river is in Mahabharat range and the length of the river is 34 km. The connecting city is Kishanganj. The origin of Mechi river is Mahabharat range in and the length of the river is 80 km and High dam and Kosi High dam is constructed across this river and the connecting state through this river is West Bengal. The connecting cities are Kishanganj ,Naxalbari.

Fig 3.2: Satellite image of Bihar state from Google Earth

3.3 UTTAR PRADESH:

3.3.1 GEOGRAPHICAL FEATURES:

Uttar Pradesh is India's fourth largest and most populous state of India, located in the north-central part of the country. Uttar Pradesh is bounded by Uttarakhand and Himachal Pradesh on the north-west, Haryana and Delhi on the west, Rajasthan on the south-west, Madhya Pradesh on the south, Chhattisgarh and Jharkhand on south-east and Bihar on the east. Situated between 23°52'N and 31°28'N latitudes and 77°3' and 84°39'E longitudes, this is the fourth largest state in the country in terms of area, and the first in terms of population.

3.3.2 CLIMATE FEATURES:

The climate of the state is tropical monsoon. The average temperature varies in the plains from 3 to 4 °C in January to 43 to 45 °C in May and June. There are three distinct seasons - winter from October to February, summer from March to mid-June, and the rainy season from June to September.

3.3.3 FLOODING:

The rainfall in the plains is heaviest in the east and decreases towards the north-west. Floods are a recurring problem in the state, causing damage to crops, life, and property. The worst floods were in 1971, when 51 of the 54 districts of the state were affected — an area of nearly 52,000 square kilometres. The eastern districts are the most vulnerable to floods, the western districts slightly less and the central region markedly less. The eastern districts susceptibility to floods is ascribed, among other things, to heavy rainfall, low flat country, high subsoil water level and the silting of beds which causes river levels to rise. The problem in the western districts is mainly poor drainage caused by the obstruction of roads, railways, canals, new built-up areas etc. There is water logging in large areas. The major flood-prone rivers are the Ganges, Yamuna, Gomti, Ghaghara, Rapti, Sharda and Ramganga. The inadequate drainage capacity of the smaller western Sirsa, Kali and the Aligarh drain is also a cause of floods.

3.3.4 POPULATION:

As per details from Census 2011, Uttar Pradesh has population of 19.98 Crores, an increase from figure of 16.62 Crore in 2001 census. Total population of Uttar Pradesh as per 2011 census is 199,812,341 of which male and female are 104,480,510 and 95,331,831 respectively. In 2001, total population was 166,197,921 in which males were 87,565,369 while females were 78,632,552. The total population growth in this decade was 20.23 percent while in previous decade it was 25.80 percent. The population of Uttar Pradesh forms 16.50 percent of India in 2011. In 2001, the figure was 16.16 percent. As per projection, population of Uttar Pradesh in 2021 is 23.50 Crore.

3.3.5 AGRICULTURE:

Agriculture is the leading occupation in Uttar Pradesh and play vital role in the economic development of the state. In terms of net state domestic product (NSDP), Uttar Pradesh is the second-largest economy in India after Maharashtra, with an estimated gross state domestic product of ₹14.89 lakh crore, and hence contributes 8.406% of India. According to the report generated by India Brand Equity Foundation (IBEF), in 2014–15, Uttar Pradesh has accounted for 19% share in the country's total food grain output. The state has experienced a high rate of economic growth in the past few years. Food grain production in the state in 2014–15 stood at 47,773.4 thousand tonnes. Wheat is the state's principal food crop and sugarcane is the main commercial crop particularly in Western Uttar Pradesh. About 70% of India's sugar comes from Uttar Pradesh. Sugarcane is the most important cash crop as the state is country's largest producer of sugar. As per the report generated by Indian Sugar Mills Association (ISMA), total sugarcane production in India was estimated to be 28.3 million tonnes in the fiscal ending September 2015 which includes 10.47 million tonnes from Maharashtra and 7.35 million tonnes from Uttar Pradesh State industries are localised in the Kanpur region, the fertile purvanchal lands and the Noida region.

3.3.6 RIVERS:

In Uttar Pradesh state there are fifteen rivers flowing through it. The rivers flowing are Babai river, Betwa river, Chambal river, Ganga, Gharghara, Gomti river, Hindon river, Karmanasa river, Ken river, Sharda river, Sarayu, Sindh river, Son river, Tamsa river, Yamuna. The origin of Babai river is in Dang Valley and the length of the river is 400km.The connecting city is Bahraich. The origin of Betwa river is in Vindhya Range and the connecting state through this river is Madhya Pradesh. The connecting cities are Vidisha and Hamipur. The origin of Chambal river is in Janapav Valley and Vindhyachal Ranges and the length of the river is 960km and the connecting state through this river is Madhya Pradesh and Rajasthan . The connecting cities are Kota and Sahon. The origin of Ganga river is in Gangotri Glacier and the length of the river is 2525 km and and the connecting state through this river is Uttarkhand, Uttar Pradesh, West Bengal, Jharkhnad . The connecting cities are Varanasi ,Haridwar ,Kolkata ,Allahabad ,Patna ,Kanpur ,Ghazipur, Sahebganj. The origin of Gomti river is in Gomat Taal and the length of the river is 900 km . The connecting cities Lucknow ,Jaunpur, Sultanpur. The origin of Hindon river is in Upper Shivaliks and Saharanpur and the length of the river is 400 km . The connecting cities Muzaffarnagar ,Meerut, Ghaziabad ,Nodia, Delhi.

The origin of Ghaghara river is in Himalyas and the length of the river is 1080 km. The connecting cities are Ballia , Chhapra. The origin of Karmanasa river is in kaimur and the length of the river is 192 km and Naugarh dam is constructed across this river and the connecting state through this river is Bihar. The connecting cities are Kaimur, Sonbhadra, Chandauli, Varanasi, Ghazipur, Buxar. The origin of Ken river is in Ahigawan Kaimur Range and Jabalpur the length of the river is 427 and the connecting state through this river is Madhya Pradesh. The connecting cities are Jabalpur. The origin of Sharda river is in Kalapani and Uttarkhand and the length of the river is 350 km and Pancheshwar dam is constructed across this river and the connecting state through this river is Uttarkhand. The connecting cities are Kumaon, Pithogarh ,Udham Singh Nagar, Lakhimpur Kheri. The origin of Sarayu river is in Himalayas and the length of the river is 350km and the connecting state through this river is Uttarkhand. The connecting cities are Bahraich, Ayodhya. The origin of Sindh river is in Malwa Plateau and the length of the river is 470 km and Manikheda dam is constructed across this river and the connecting state through this river is Madhya Pradesh. The connecting cities are Vidisha, Guna, Ashoknagar, Shivapuri, Datia, Gwalior, Bhind, Jalaun. The origin of Son river is in Amarkantak and the length of the river is 784 km and Bansagar dam and Indrapuri Barrage dam is constructed across this river and the connecting states through this river is Madhya Pradesh, Jharkhand, Bihar. The connecting cities are Sidhi, Dehri, Patna. The origin of Tamsa river is in Tamakund and the length of the river is 264 km and the connecting state through this river is Madhya Pradesh. The connecting cities are Maihar, Sisra. The origin of Yamuna river is in Yamunotri and the length of the river is 1376 km and Tajewala Barrage dam and Somb river dam is constructed across this river and the connecting state through this river is Uttarkhand, Himachal Pradesh, Harayana, Delhi. The connecting cities are Agra, Allahabad, Mathura, Yamunanagar, Noida, Delhi, Etawah, Kalpi, Firozabad, Baghpat, Hamirpur.

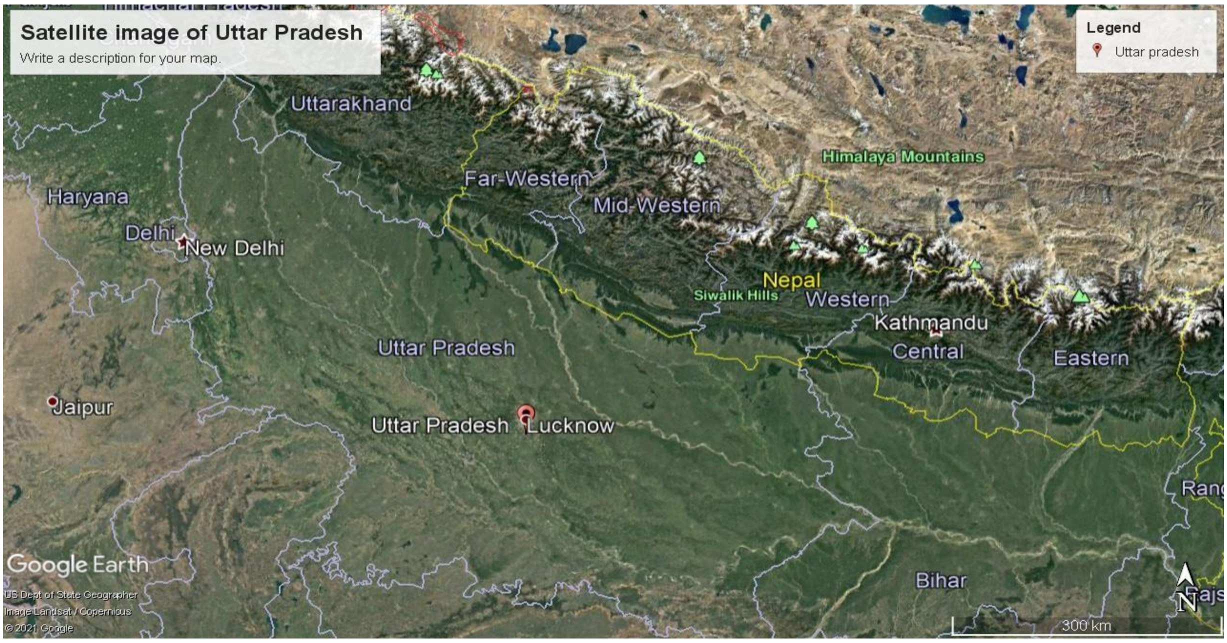


Fig 3.3: Satellite image of Uttar Pradesh state from Google Earth

3.4 KERALA

3.4.1 GEOGRAPHICAL FEATURES:

Kerala is situated between the Arabian Sea to the west and the Western Ghats to the east. Kerala's coast runs some 580 km in length, while the state itself varies between 35–120 km in width. Geographically, Kerala roughly divides into three climatically distinct regions. These include the eastern highlands, the central midlands, and the western lowlands. Located at the extreme southern tip of the Indian subcontinent, Kerala lies between northern latitude of 8°.17'.30" N and 12°. 47'.40" N and east longitudes 74°.27'.47" E and 77°.37'.12" E.

3.4.2 CLIMATE FEATURES:

Kerala's climate is mainly wet and maritime tropical, heavily influenced by the seasonal heavy rains brought up by the monsoon.Kerala, which lies in the tropic region, is mostly subject to the type of humid tropical wet climate experienced by most of Earth's rainforests. As per Köppen climate classification, it belongs to the category of Tropical monsoon climate Meanwhile, its extreme eastern fringes experience a drier tropical wet and dry climate. Kerala receives an average annual rainfall of 3107 mm – some 7,030 crore m3 of water. This compares to the all-India average is 1,197 mm. Parts of Kerala's lowlands may average only 1250 mm annually while the cool mountainous eastern highlands of Idukki district – comprising Kerala's wettest region – receive in excess of 5,000 mm of orographic precipitation annually. Kerala's rains are mostly the result of seasonal monsoons. As a result, Kerala averages some 120–140 rainy days per year. In summer, most of Kerala is prone to gale-force winds, storm surges, and torrential downpours accompanying dangerous cyclones coming in off the Indian Ocean. Kerala's average maximum daily temperature is around 37 °C; the minimum is 19.8 °C.

3.4.3 FLOODING:

Although the Kerala state does not experience floods as severe as in the Indo-Gangetic plains, incidence of floods in the State is becoming more frequent and severe. The latest among them was the 2019 Kerala floods. Continuous occurrence of high intensity rainfall for a few days is the primary factor contributing to the extreme floods in the State. Other factors include wrong landuse practices and mismanagement of the water resources and forests. The human interventions contributing to flood problems are predominantly in the form of reclamation of wetlands and water bodies, change in landuse pattern, construction of dense networks of roads, establishment of more and more settlements, deforestation in the upper catchments etc. Increasing floodplain occupancy results in increasing flood damages. A number of extreme flood events occurred during the last century causing considerable damage to life and property highlight the necessity for proper flood management measures in the State. The flood problems are likely to worsen with the continued floodplain occupancy and reclamation of water bodies and wetlands. It is estimated that about 26% of the total geographical area accommodating about 18% of the total population of the State is prone to floods.

3.4.4 POPULATION:

As per details from Census 2011, Kerala has population of 3.34 Crores, an increase from figure of 3.18 Crore in 2001 census. Total population of Kerala as per 2011 census is 33,406,061 of which male and female are 16,027,412 and 17,378,649 respectively. In 2001, total population was 31,841,374 in which males were 15,468,614 while females were 16,372,760. The total population growth in this decade was 4.91 percent while in previous decade it was 9.42 percent. The population of Kerala forms 2.76 percent of India in 2011. In 2001, the figure was 3.10 percent. As per projection, population of Kerala in 2021 is 3.48 Crore.

3.4.5 AGRICULTURE:

The most essential or the staple crop is the rice or paddy. About 600 varieties of rice are grown in the sprawling paddy fields of Kerala. In fact the Kuttinad region of the district of Kerala is known as the 'rice bowl of the state' and enjoys a significant status in the production of rice. Next to rice is another very important crop which is known as Tapioca and is cultivated mainly in the drier regions. Tapoica is a major food of the Keralites.Besides production of the main crop, Kerala is also a major producer of spices that form the cash crops of the state. Kerala's spice trade is about 3000 years old and it is well known how the fresh aroma of the superb quality Kerala spices lured foreigners into this country in the medieval ages. Kerala produces 96% of the country's national output of pepper. The important spices are cardamom, cinnamon, clove, turmeric,nutmeg and vanilla. Cardamom is exported and brings great revenues to the country.

3.4.6 RIVERS:

In Kerala state many rivers are flowing through it. The rivers flowing through the Kerala state are Periyar, Bharathappuzha, Pamba river, Chaliyar, Chalakudy river, Achankovil, Kallada river, Manimala river, Payaswini river, Kadalundi river, Kabini river, Valapattanam, Perumba river, Neyyar, Meenachil river, Vamanapuram river, Mahe river, Korapuzha river. The origin of Periyar river is in Sivagiri hills and Sundaramala the length of the river is 244 km and Mullaperiyar dam and Idukki dam is constructed across this river and the connecting state through this river is Tamil Nadu. The connecting cities are Aluva, Neriamangalam, Kalady, Malayattor. The origin of Pamba river is in Pulachimalai and the length of the river is 176 km. The connecting cities are Pathanamthitta and Alappuzha. The origin of Bharathappuzha river is Anamalai hills. The length of the river is 209km. the connecting state is Tamil Nadu .The origin of Chaliyar is in Western Ghats and the length of the river is 169km. The connecting state is Tamil Nadu and the connecting cities are Nilambur, Edavanna,Areekode, Kizhuparamba, Cheekode, Vazhakkad, Cheruvadi. The origin of Chalakudy river is in Anamalai hills and the length of the river is 145.5km. the connecting state is Tamil Nadu and the connecting city is Chalakudy. The origin of Achankovil river is in Pasukidamettu and Rishimalai the length of the river is 128 km .The connecting cities are Pathanamthitta, Chengannur, Adoor, Mavelikara, Konni. The origin of Kallada river is in Kulathupuzha hills and the length of the river is 121 km. The connecting cities are Punalur, Pathanapuram, kunnathur.The origin Manimala river is in Muthavara hills and the length of the river is 91.73 km and The connecting cities are Kottayam, Pathanamthitta, Alappuzha. The origin of Payaswini river is in Koinadu and the length of the river is 105 km and the connecting state through this river is Karnataka. The connecting cities are Kodagu, Dakshina, Kannada, Kasaragod. The origin of Kadalundi river is in Cherakomban Mala and the length of the river is 130 km. The connecting city is Malappuram. The origin of Kabini river is in Panamaram Wayanad and the length of the river is 240km. and kabini dam is constructed across the river. The connecting state is Karnataka. The origin of Perumba river is in Pinukunnu Hills and the length of the river is 51km. The origin of Meenachil river is in Western ghats and the length of the river is 78km. and Idukki dam is constructed across the river. The connecting cities are Poonjar, Teekoy, Erattupetta, Palai, Ettumanoor, Kottayam. The origin of Neyyar river is in Western ghats and the length of the river is 56km. the connecting city is Thiruvananthapuram. The origin of Vamanapuram river is in Chemunjimotta Hills and the length of the river is 88km. The connecting cities are Thiruvananthapuram and Kollam. The origin of Mahe river is in

Western Ghats and the length of the river is 54km. The length of the Korapuzha river is 40km and the connecting city is Kozhikode.

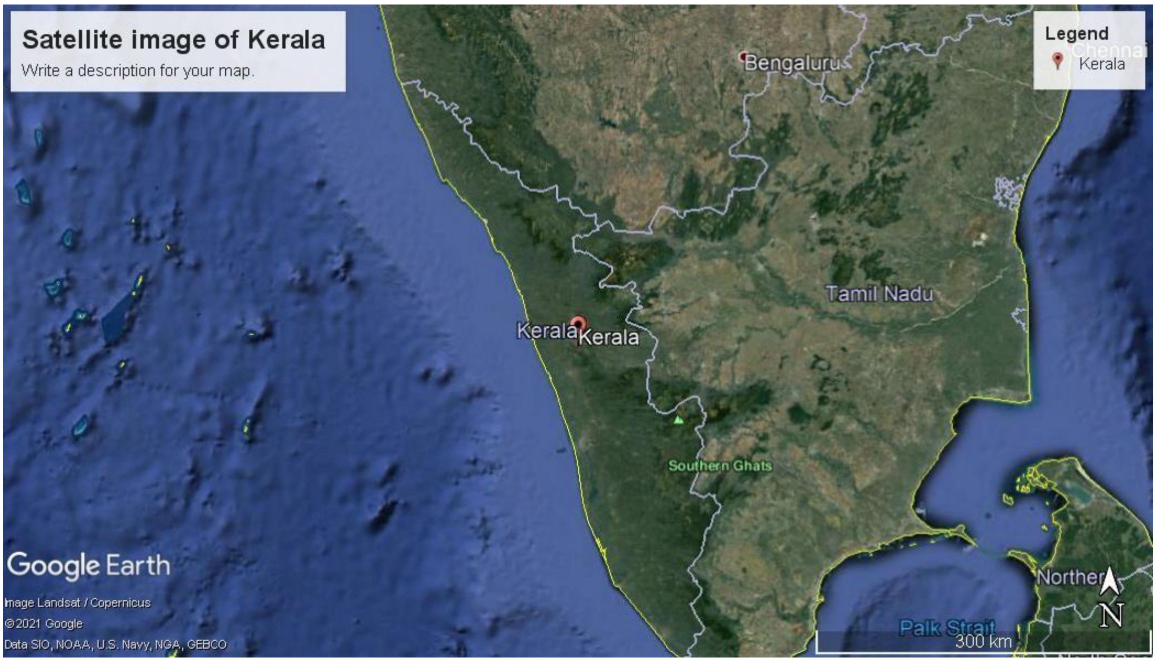
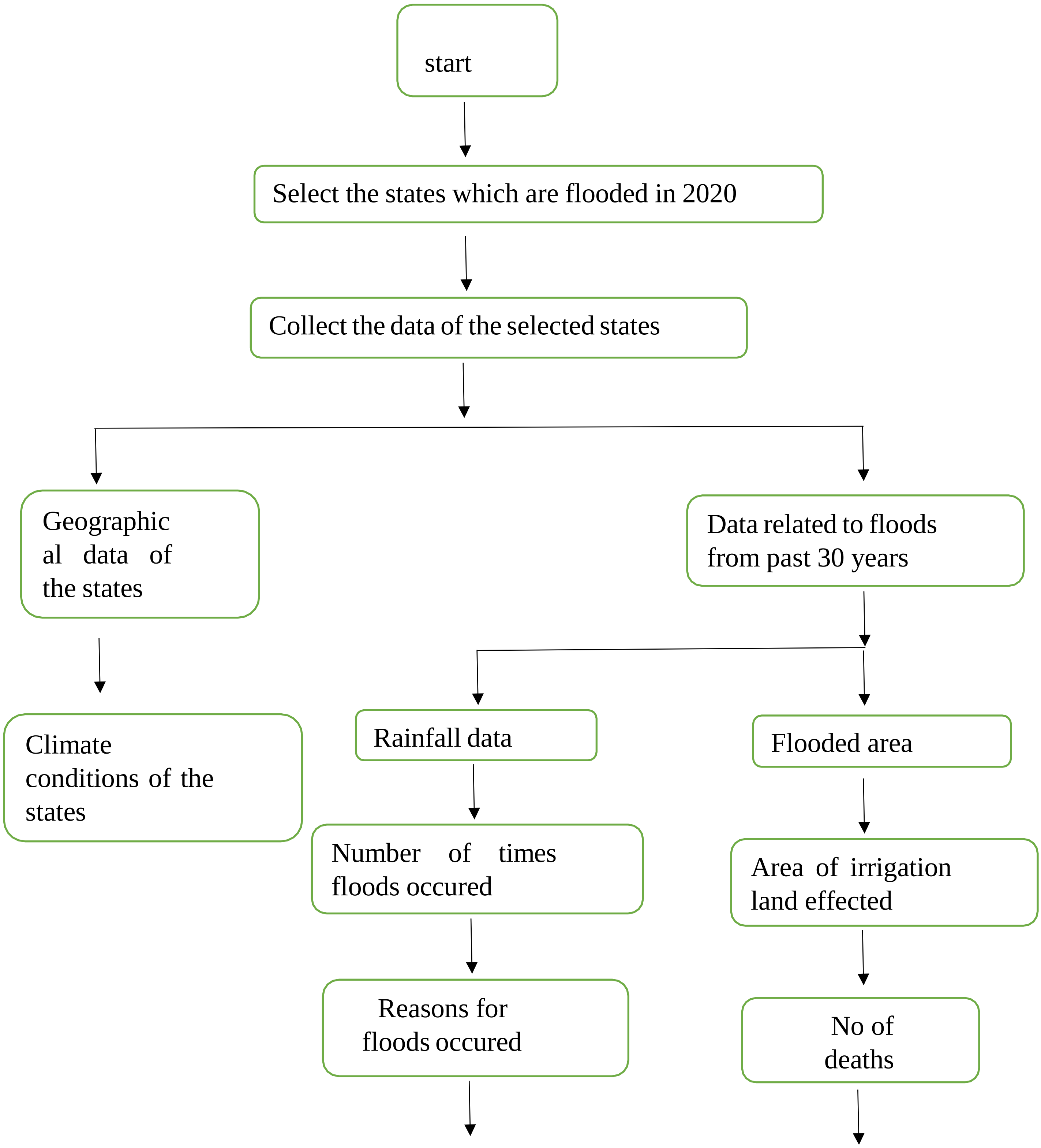


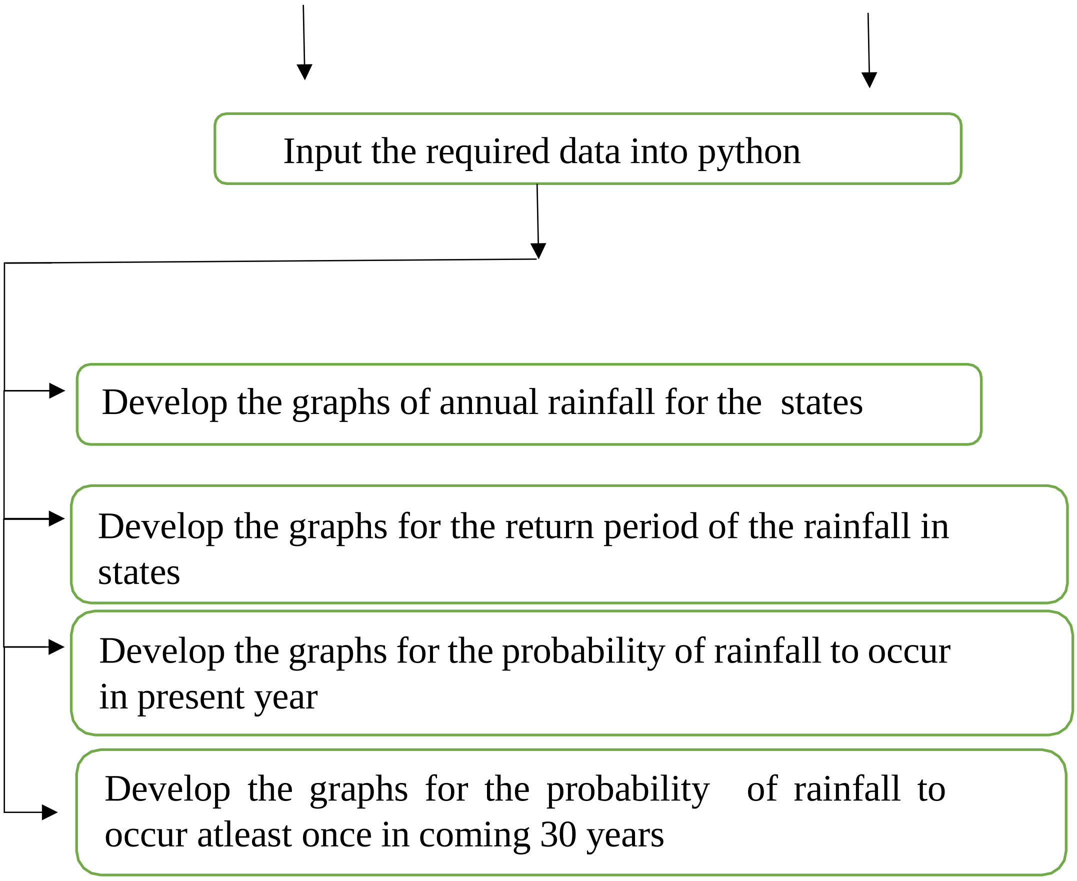
Fig 3.4: Satellite image of Kerala state from Google Earth

CHAPTER:4

METHODOLOGY

In this chapter discuss about the step by step process of our project. The Flow Chart:4.1, below represents the over view of the steps involved in the project





Flow chart 4.1: Methodology of this project

The detailed explanation of the flow chart is below

4.1. Elucidation of Methodology:

- The main objective of the project is to calculate the return period and probability of the rainfall to occour in future .
- First step is to select any 4 states which are highly flooded in the year 2020 and gone through heavy floods.
- After the selection of the states start collecting the data which includes geographical data ,rainfall data .etc
- Geographical data includes the total population of the states which are selected,total number of times floods occurred in the respective states , total iirigation land that is effected due to floods , total number of deaths caused due to these floods etc
- The rainfall data which is collected of these selected states is to be of past 30 years so that it will be used for the calculation of the return period and porabability of the each rainfall to occur
- The rainfall data is to be collected from 1990 to 2020 from any of the genuine source

- These rainfall data which is collected is to be saved in the form of (.csv) fomat so that it can be easily imported into prython softwate
- For the saving of the rainfall data in (.csv) format it can be done easily by using exel software (.csv format fie is basically a excel file but it will has extention of (.csv))
- Save an extra copy of this exel file so that 1st file is used to examine the rainfall data for the past years and 2nd file is used to edit the values according to the requirement for calculation of the return period and probability of the rainfall
- First file is imported into python and then develop the code that can extract the required values from the file uses it to plot the graph of rainfall data whith respect to years for all the four states
- Now in the 2nd file arrange the rainfall data in desending oder the arrangement can also be done in pyton but it become easy to arrange the rainfall in desending oder including the year of rainfall in excel sheet
- The rainfall data of the all the states is to be in be arranged in the same way as explained above
- After the arranging the data it become easy if the alla the states rainfall data is in the same file .now import the exel sheel into python program
- Using the certain code that is developed to calculate the return period and probability of the rainfall data and develop the graphs as required whit an another code
- Now the required graphs
    1. Years vs rainfall data
    2. Return period vs rainfall data
    3. Probability vs rainfall data
    4. Probability of rainfall to occur atleast once in coming 30 years vs rainfall data are developed and shown as the results

CHAPTER : 5

RESULTS AND DISCUSSIONS

In this chapter,the graphs of the annual rainfall analysis ,graphs of return period and the probability of the rainfall to occur in Assam, Bihar, Kerala, Uttar Pradesh states is shown clearly and explained. These graphs are drawn by using python software .

This data of the rainfall from 1990 to 2020 is collected from IMD

5.1 INUNDATION OF MAPS:

These inundation maps has been collected from bhuvan website

a) ASSAM

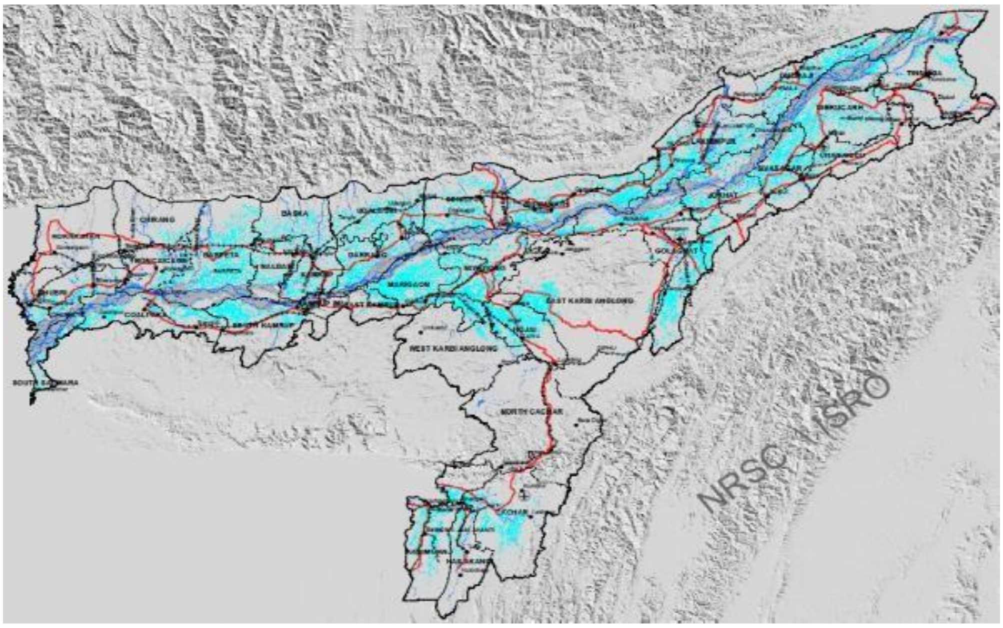


Fig 5.1 : Inundation map of Assam

Hojai .Dhemaji , Lakhimpur , Biswanthi , sanitpur and about 30 Assam districts affected by floods in 2020 . From June 1st to till august 24th , the state has received 1223.60mm of rainfall. There are 10063 houses permanently damaged and approximately 46490 have been partially damaged.

(b) BIHAR

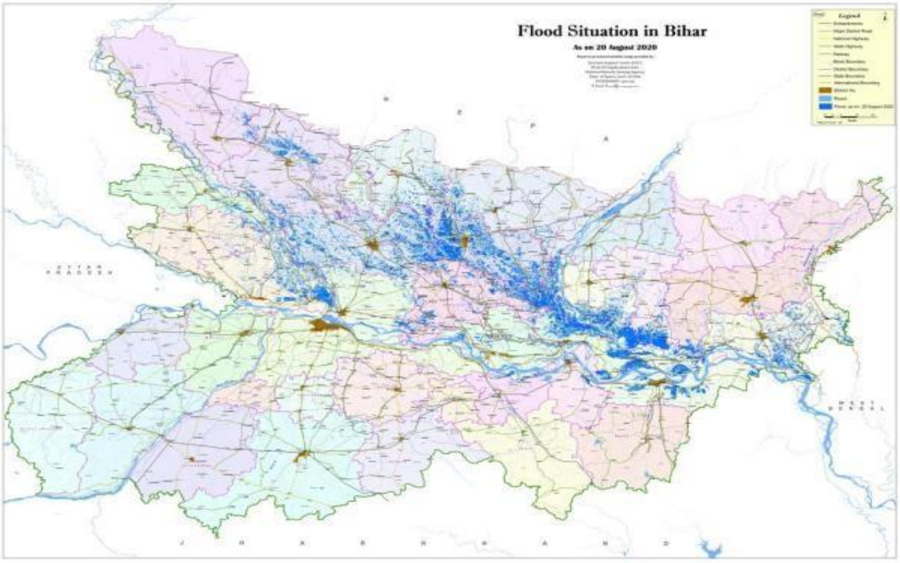


Fig 5.2 : Inundation map of Bihar.

Sitamurhi , sheohar, supaul , kushanganj , Darbhanga , siwan around 16 districts have affected by flood in 2020 . Several rivers such as the Baghmati , burhi gandak , kamlabalan and the khiroi are flowing above the danger level.

b) KERALA

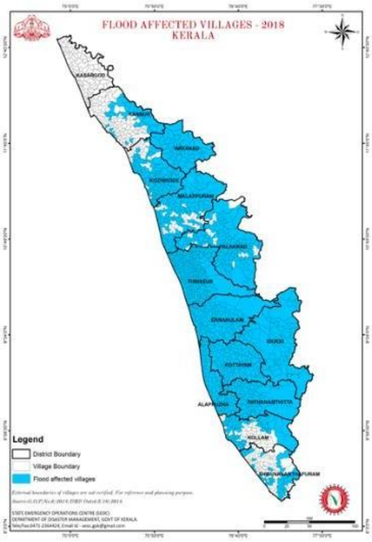


Fig 5.3 : Inundation map of Kerala.

Munnar , Peermader , padinjarathara these recorded the highest rainfall in 2020 . Kerala has recorded 132+ deaths and 19000 crores property damaged . Major rivers like periya , chalakudy , meenachil , bhavani . neyyar have breached their banks and the coastal districts are facing a food like situation as the water is not flowing into the sea due to high water triggered by strong winds.

(c) UTTAR PRADESH

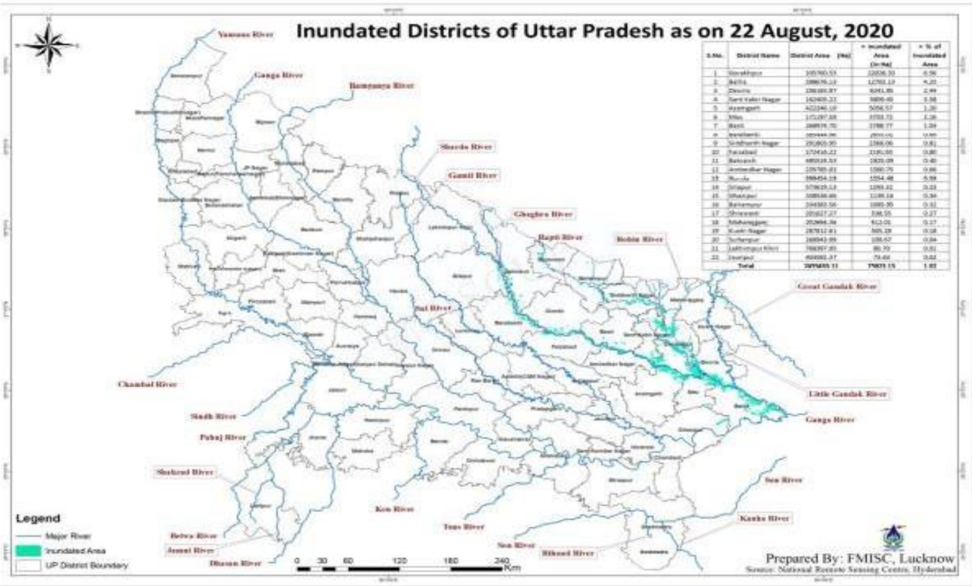


Fig 5.4 : Inundation map of Uttar Pradesh.

Over 600 villages in 16 districts of Uttar Pradesh have been affected by floods , with the sharda and the saryu rivers flowing above the danger level at some places in the state. The sharda river was flowing above the danger mark at palia kalan in Lakhimpur kheri , while the saryu river was flowing above the danger mark at ayodhya , elginbridge in barabanki and turtipar in ballia.

5.2. Analysis of future rainfall using past 30 years data :

Step:1 Collecting the rainfall data of the states

The rainfall data of the past 30 years in the Assam, Bihar, Kerala, Uttar Pradesh states are collected and shown below.

- ASSAM

years	Annual Rainfall(mm)
1990	2207
1991	2628
1992	2161
1993	2776
1994	2290
1995	2297
1996	2304
1997	2172
1998	2374
1999	2274
2000	2347
2001	1995
2002	2249
2003	2174
2004	2691
2005	2347
2006	1824
2007	2541
2008	2268
2009	1932
2010	2458
2011	1779
2012	2268
2013	1805
2014	1886
2015	2277
2016	2076
2017	2396
2018	1903
2019	2084
2020	1651

- BIHAR

years	Annual Rainfall(mm)
1990	1115
1991	1086
1992	868
1993	1320
1994	1120
1995	1229
1996	1281
1997	1522
1998	1403
1999	1447
2000	1293
2001	1066
2002	949
2003	1265
2004	1158
2005	995
2006	1203
2007	1520
2008	1311
2009	1005
2010	938
2011	1338
2012	949
2013	1148
2014	1040
2015	891
2016	1168
2017	1112
2018	860
2019	1194
2020	1275

- KERALA

years	Annual Rainfall(mm)
1990	2606
1991	3014
1992	3150.7
1993	2658.9
1994	3368.9
1995	2728.9
1996	2571
1997	3307.3
1998	3070.7
1999	2974.2
2000	2219
2001	2628.9
2002	2600
2003	2311.7
2004	2719.7
2005	2300.7
2006	3155.8
2007	3128.2
2008	2395.5
2009	2584
2010	3085
2011	2784.4
2012	2078.4
2013	3188.5
2014	2968.2
2015	2557.6
2016	1837.4
2017	2664.9
2018	3518.9

- UTTAR PRADESH

years	Annual Rainfall(mm)
1990	842.2
1991	705.5
1992	758.3
1993	743.2
1994	776.6
1995	793.5
1996	1008.4
1997	912.5
1998	1151.9
1999	858.9
2000	870.8
2001	778.8
2002	725.3
2003	1141.1
2004	724
2005	761.1
2006	690.4
2007	699.2
2008	943.7
2009	611.1
2010	1002.8
2011	874.4
2012	657.6
2013	949.8
2014	507
2015	613.6
2016	701.9
2017	652.1
2018	798

2019	3119.2
2020	2227.9

2019	814.5
2020	1200

Step:2.Importing the rainfall data into excel sheet:

The rainfall data of the past 30 years that is collected in above step is to be stored in excel format with file name Rainfall data, So that it can be easily imported into python.The conversion of the data into excel format is done by any source or it can be done manually

O18 *fx*

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Rainfall(in mm) data in past 30 years of the states Assam,Bihar,kerala,Uttar pradesh													
2														
3	Assam			Bihar			kerela			Uttar pradesh				
4	years			years	Rainfall		years	Rainfall		years	Rainfall			
5	1990	2207		1990	1115		1990	2606		1990	842.2			
6	1991	2628		1991	1086		1991	3014		1991	705.5			
7	1992	2161		1992	868		1992	3150.7		1992	758.3			
8	1993	2776		1993	1320		1993	2658.9		1993	743.2			
9	1994	2290		1994	1120		1994	3368.9		1994	776.6			
10	1995	2297		1995	1229		1995	2728.9		1995	793.5			
11	1996	2304		1996	1281		1996	2571		1996	1008.4			
12	1997	2172		1997	1522		1997	3307.3		1997	912.5			
13	1998	2374		1998	1403		1998	3070.7		1998	1151.9			
14	1999	2274		1999	1447		1999	2974.2		1999	858.9			
15	2000	2347		2000	1293		2000	2219		2000	870.8			
16	2001	1995		2001	1066		2001	2628.9		2001	778.8			
17	2002	2249		2002	949		2002	2600		2002	725.3			
18	2003	2174		2003	1265		2003	2311.7		2003	1141.1			
19	2004	2691		2004	1158		2004	2719.7		2004	724			
20	2005	2347		2005	995		2005	2300.7		2005	761.1			
21	2006	1824		2006	1203		2006	3155.8		2006	690.4			
22	2007	2541		2007	1520		2007	3128.2		2007	699.2			
23	2008	2268		2008	1311		2008	2395.5		2008	943.7			
24	2009	1932		2009	1005		2009	2584		2009	611.1			
25	2010	2458		2010	938		2010	3085		2010	1002.8			
26	2011	1779		2011	1338		2011	2784.4		2011	874.4			
27	2012	2268		2012	949		2012	2078.4		2012	657.6			
28	2013	1805		2013	1148		2013	3188.5		2013	949.8			
29	2014	1886		2014	1040		2014	2968.2		2014	507			
30	2015	2277		2015	891		2015	2557.6		2015	613.6			
31	2016	2076		2016	1168		2016	1837.4		2016	701.9			
32	2017	2396		2017	1112		2017	2664.9		2017	652.1			
33	2018	1903		2018	860		2018	3518.9		2018	798			
34	2019	2084		2019	1194		2019	3119.2		2019	814.5			
35	2020	1651		2020	1275		2020	2227.9		2020	1200			
36														
37														
38														
39														
40														
41														

Fig 5.5: Rainfall data of past 30 years

As this data in the excel format covert the file into “.csv" format so it can be easily imported into python software

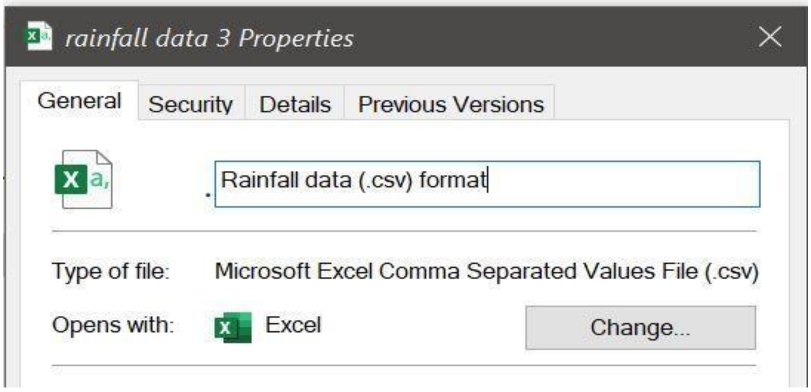


Fig 5.6: File in .csv format

The above fig shows the converted file of the rainfall data which was stored in excel format

Step:3.Arranging the rainfall data in descending order

An other copy of the above file (Rainfall data) is saved by the name “Rainfall data 2” in this file rainfall values are arranged in descending order so that it can be used for the calculation of the return period and probability

T33

	A	B	C	D	E	F	G	H	I	J	K
1	Rainfall data of the states in desnding oder										
2											
3	Assam			Bihar			Kerala			Uttar pradesh	
4	year	Rainfall		year	Rainfall		year	rainfall		yearup	rainfall
5	1993	2776		1997	1522		2018	3518.9		2020	1200
6	2004	2691		2007	1520		1994	3368.9		1998	1151.9
7	1991	2628		1999	1447		1997	3307.3		2003	1141.1
8	2007	2541		1998	1403		2013	3188.5		1996	1008.4
9	2010	2458		2011	1338		2006	3155.8		2010	1002.8
10	2017	2396		1993	1320		1992	3150.7		2013	949.8
11	1998	2374		2008	1311		2007	3128.2		2008	943.7
12	2000	2347		2000	1293		2019	3119.2		1997	912.5
13	2005	2347		1996	1281		2010	3085		2011	874.4
14	1996	2304		2020	1275		1998	3070.7		2000	870.8
15	1995	2297		2003	1265		1991	3014		1999	858.9
16	1994	2290		1995	1229		1999	2974.2		1990	842.2
17	2015	2277		2006	1203		2014	2968.2		2019	814.5
18	1999	2274		2019	1194		2011	2784.4		2018	798
19	2008	2268		2016	1168		1995	2728.9		1995	793.5
20	2012	2268		2004	1158		2004	2719.7		2001	778.8
21	2002	2249		2013	1148		2017	2664.9		1994	776.6
22	1990	2207		1994	1120		1993	2658.9		2005	761.1
23	2003	2174		1990	1115		2001	2628.9		1992	758.3
24	1997	2172		2017	1112		1990	2606		1993	743.2
25	1992	2161		1991	1086		2002	2600		2002	725.3
26	2019	2084		2001	1066		2009	2584		2004	724
27	2016	2076		2014	1040		1996	2571		1991	705.5
28	2001	1995		2009	1005		2015	2557.6		2016	701.9
29	2009	1932		2005	995		2008	2395.5		2007	699.2
30	2018	1903		2002	949		2003	2311.7		2006	690.4
31	2014	1886		2012	949		2005	2300.7		2012	657.6
32	2006	1824		2010	938		2020	2227.9		2017	652.1
33	2013	1805		2015	891		2000	2219		2015	613.6
34	2011	1779		1992	868		2012	2078.4		2009	611.1
35	2020	1651		2018	860		2016	1837.4		2014	507

Fig 5.7: Rainfall data arranged in desending oder

Step:4.Importing the files into python

Both the files which are created above are to be imported into the python software

In this study jyupter notebook is used to develop the code.importing of the files into the python is done by developing the code which inputs the data from both the files. The file named "Rainfall data" is used to develop the annual rainfall analysis of the states and the file named "Rainfall data 2" is used for the calculation of the return period, probability the same file is used for the developing the graphs of return period, probability,probability of the ranfall to occur atleast once in coming 30years

Step:5. Calculation of Return period and Probability

For the calculation return period and probability the excel file in which values are arranged in descending order is used after executing the code for the calculation of the results are shown below

- Return Period : [32,16,10.67,8, 6.4 ,5.33, 4.57, 4 ,3.56, 3.2, 2.91,2.67, 2.46, 2.29, 2.13, 2 ,1.88, 1.78, 1.68, 1.6, 1.52, 1.45, 1.39, 1.33, 1.28, 1.23, 1.19, 1.14, 1.1 , 1.07, 1.03]

- Probability : [0.03, 0.06, 0.09, 0.12, 0.16, 0.19, 0.22, 0.25, 0.28, 0.31, 0.34, 0.38, 0.4 1, 0.44, 0.47, 0.5, 0.53, 0.56 , 0.59, 0.62, 0.66, 0.6 , 0.72, 0.75, 0.78, 0.81, 0.84, 0.88, 0.91, 0.94, 0.97]
- Probability of the rainfall to occur atleast once in coming 30 year : [0.59899293, 0.8 4374439, 0.94094703, 0.97839869, 0.99464969,0.99820299, 0.99942079, 0.9998214 2, 0.99994752, 0.99998536,0.99999614, 0.99999941, 0.99999987, 0.99999997, 0.999 99999,1,1, 1, 1 , 1,1,1,1,1,1, 1, 1, 1, 1, 1, 1]

The above values of return period , probability to occur in present year, probability of the rai nfall to occur atleast once in coming 30 years represents the rainfall values of the each state s respectively

Step:6 Developing the graphs

Import the rainfall data from excel sheet and develop the annual rainfall, return period , probability graphs using python pandas.

I. UTTAR PRADESH:

The 30 years annual rainfall data (1990 to 2020) of Uttar Pradesh is acquired from the Indian meteorological department, and the frequency of rainfall over the past 30 years is displayed in the form of graphs created with Python Pandas. The return period and probability of receiving 30 years of rainfall in the year 2021, as well as the probability of receiving the greatest rainfall once per 30 years, have been calculated and graphed using Python Panda's.

(a) Annual rainfall data analysis for past 30 years using python panda's:

From 1990 to 2020, Uttar Pradesh has seen the highest rainfall of approximately 1200mm in 2020, affecting 1,090 villages in 16 districts of Uttar Pradesh, and the lowest rainfall of around 507mm in 2014.

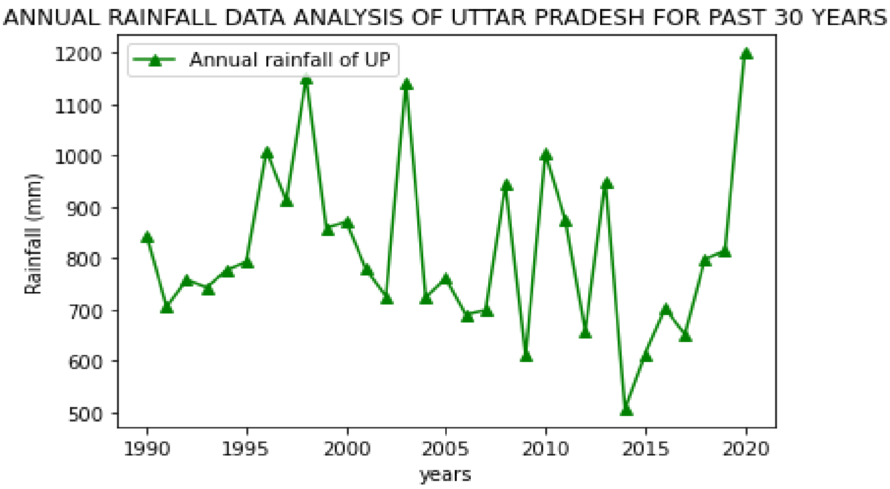


Fig 5.8: Annual rainfall of Uttar Pradesh for past 30 years

(b) return period of rainfall data :

In the year 2020, Uttar Pradesh had 1200mm of rain. According to Weibull's formula, the return period for receiving 1200mm of rainfall is 32 years, while the return period for receiving the smallest amount of rainfall, 507mm, which occurred in 2014, is 1.04 years.

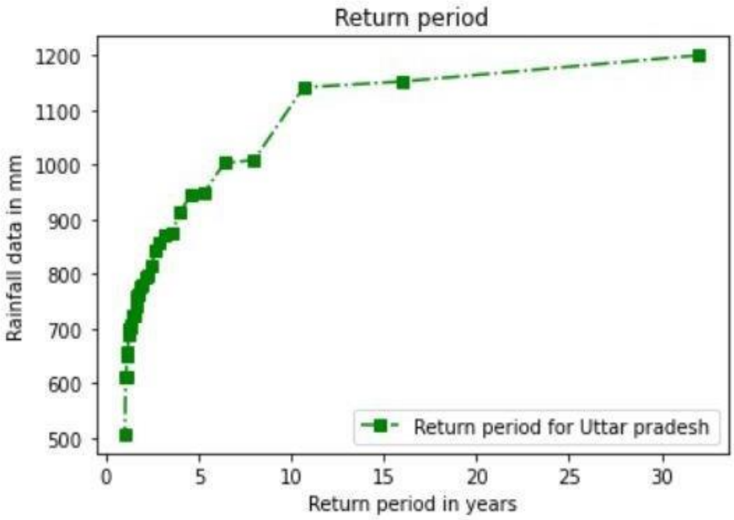


Fig 5.59: Return period for Uttar Pradesh

(c) Probability of the rainfall to occur in the present year:

In the year 2020, Uttar Pradesh had 1200mm of rain. The probability of receiving 1200mm of rainfall is 0.03 according to Weibull's formula, whereas the probability of receiving the lowest rainfall, 507mm, which occurred in 2014, is 0.97.

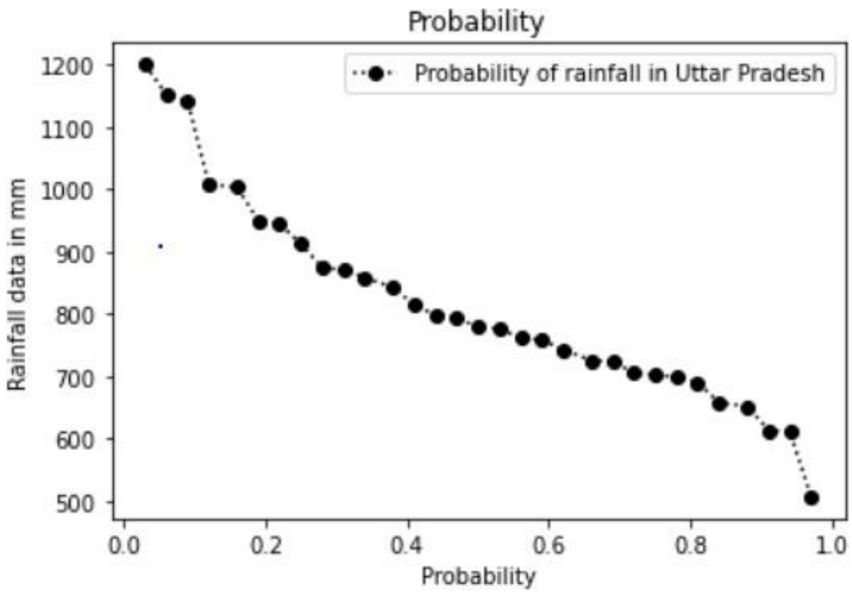


Fig 5.10: probability of rainfall in Uttar Pradesh.

(d) Probability of the rainfall to occur atleast once in coming 30 years:

The probability of receiving 1200mm of rainfall once in the next 30 years, as occurred in 2020, is 0.59, while the probability of receiving the lowest rainfall of 507mm once in the next 30 years is 1.

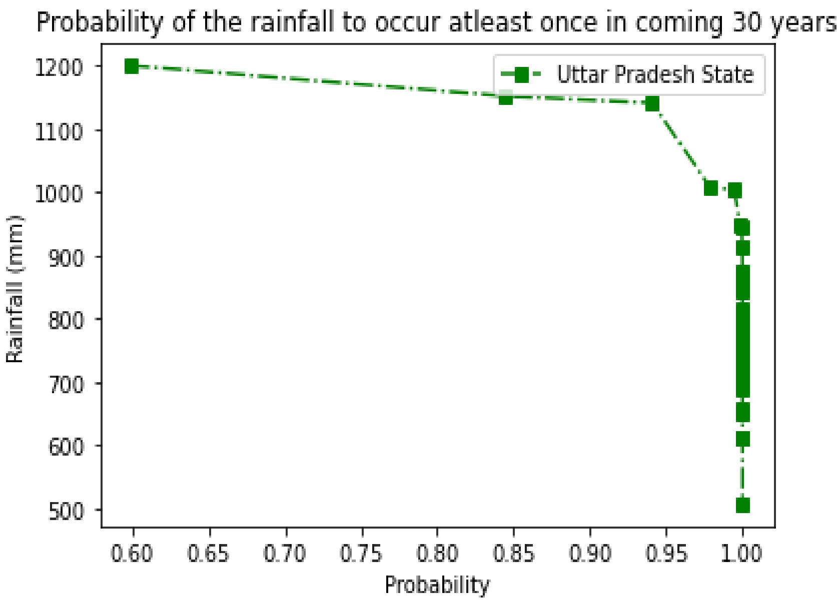


Fig 5.11: probability of rainfall to occur atleast once in 30 years in Uttar Pradesh

II **ASSAM STATE :**

The Indian meteorological agency provided 30 years of annual rainfall data for Assam (1990 to 2020), and the frequency of rainfall over the past 30 years is displayed in the form of graphs generated with Python Pandas. Using Python Pandas, the return period and probability of obtaining 30 years of rainfall in 2021, as well as the probability of receiving the maximum rainfall once per 30 years, were calculated and graphed.

(a) Annual rainfall data analysis for past 30 years using python panda's

In the year 1993, Assam had the most rainfall, with 2776mm. In the year 2020, Assam received 1651mm of rain, which resulted in the deaths of 343 people due to flooding. Assam faced major floods in 1998,1993, 2002, 2004 and 2012 with a rainfall of 2374mm, 2776mm , 2249mm, 2691mm, 2268mm respectively.

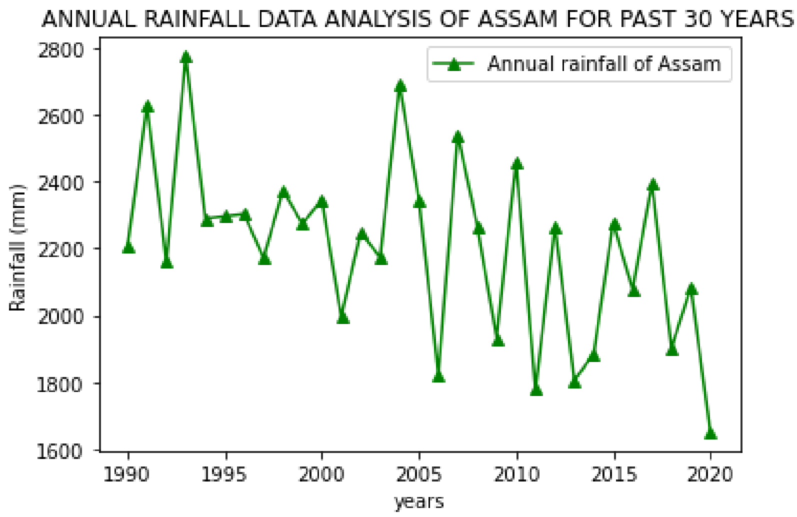


Fig 5.12: Annual rainfall of Assam

(b) Return period of the rainfall data:

According to Weibull's equation, the return time for receiving the greatest rainfall of 2776mm, which occurred in the year 1993, is 32 years, while the return period for receiving 1651mm, which occurred in the year 2020, is 1.03 years.

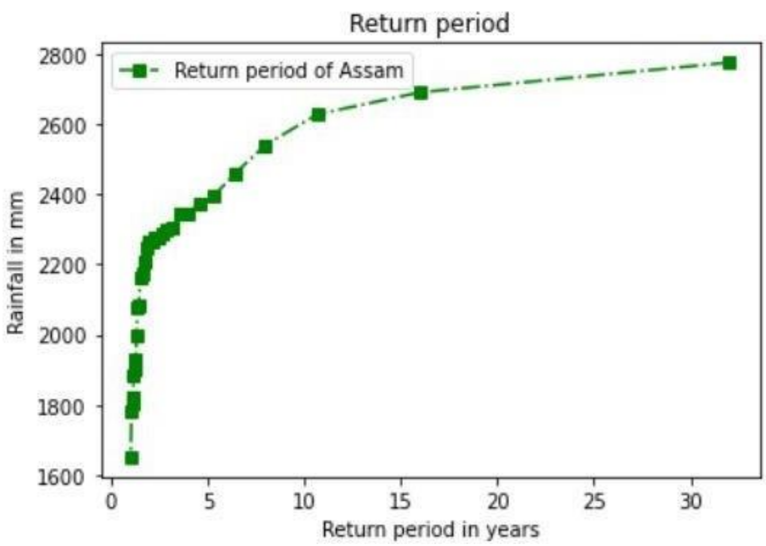


Fig 5.13: Return period of Assam

(c) Probability of the rainfall to occur in the present year :

According to Weibull's equation, the probability of receiving the greatest rainfall of 2776mm, which occurred in the year 1993, is 0.03, while the probability of receiving 1651mm, which occurred in the year 2020, is 0.97.

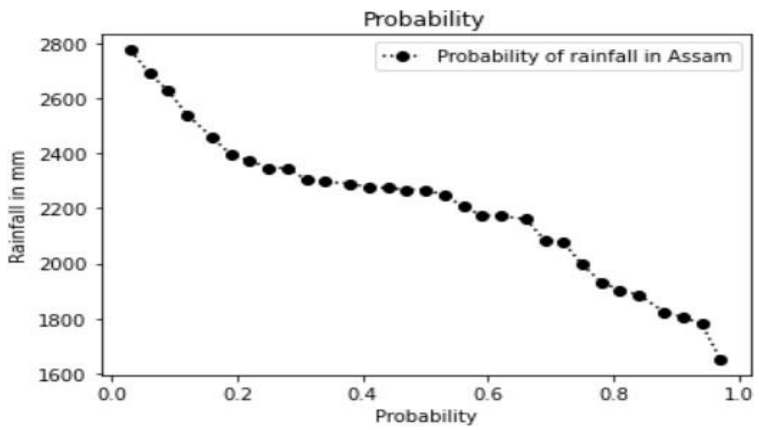


Fig 5.14: probability of rainfall in Assam

(d) Probability of the rainfall to occur atleast once in coming 30 years :

The probability of receiving the maximum rainfall of 2776mm once in the next 30 years, which occurred in 1993, is 0.5, while the probability of receiving 1651mm once in the next 30 years, which occurred in 2020, is 1.

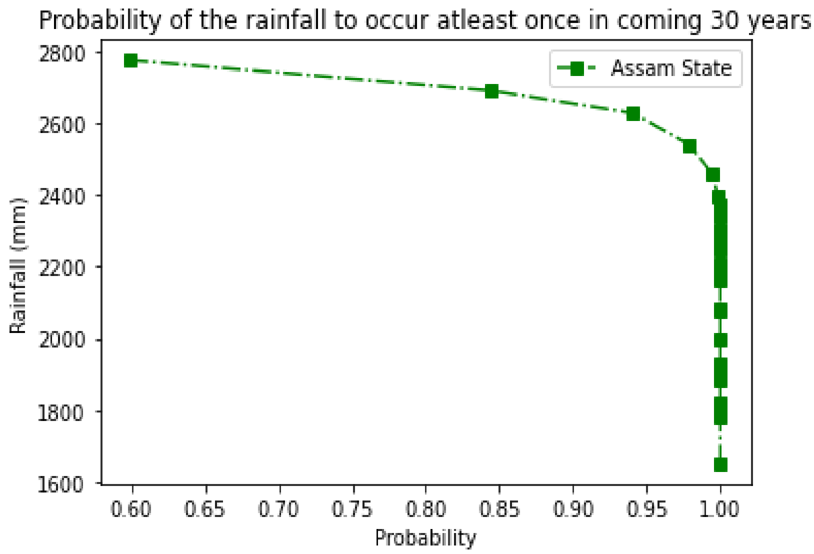


Fig 5.15: Probability of rainfall to occur atleast once in 30 years in Assam

III.KERALA STATE :

Annual rainfall data of 30 years (1990-2020) were given by the Indian weather service, where the rainfall frequency in the course of the last 30 years is shown in graphs created using Python Pandas. The return duration and probability of 30 years of rainfall by 2021 was computed and graphed using Python Pandas, together with the possibility of getting the maximum precipitation once in the 30 years.

(a) Annual rainfall data analysis for past 30 years using python panda's

Kerala received 3518.9mm of rainfall in 2018, which is the most rainfall in the last 30 years and resulted in catastrophic flooding in 13 of the state's 14 districts, according to rainfall data. Kerala had around 2227.9mm of rainfall in the year 2020, with a number of lives lost. The lowest rainfall occurred in the year 2016, with 1837.4mm.

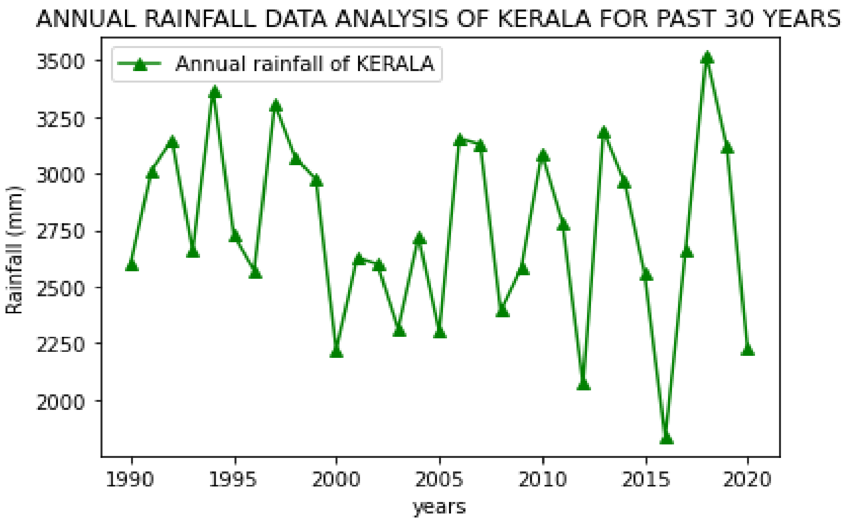


Fig 5.16: Annual rainfall of Kerala

(b) Return period of the rainfall data :

In 2018, the greatest rainfall of 3518.9mm was registered in Kerala, which has never happened since 1961, 3518.9mm of prevailing return period is 32 years. Kerala has registered 2227.9 mm of precipitation in 2020 on the basis of the return time of Weibull's equation of 2227.9 mm of precipitation is 1.14 years. The return period from the lowest rainfall in 2016 of 1837.4mm is 1.03 years.

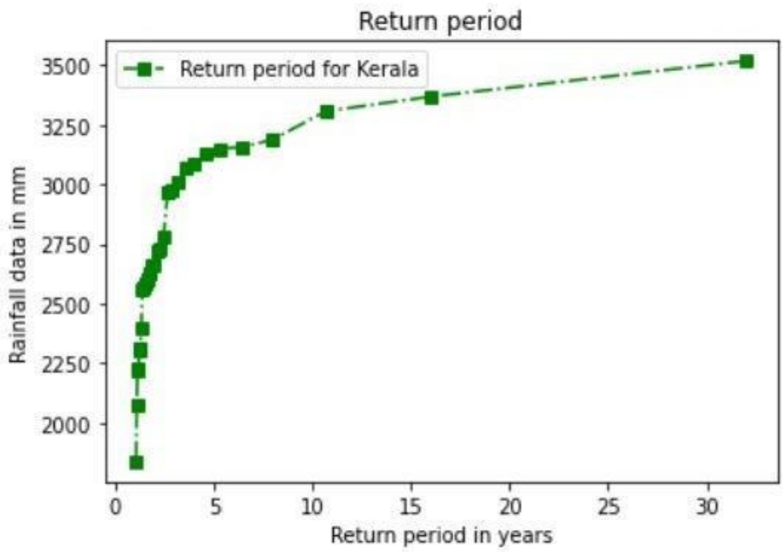


Fig 5.17: Return period of Kerala

(c) Probability of the rainfall to occur in the present year :

Kerala had the greatest rainfall of 3518.9mm in 2018, a record that has not been broken since 1961. The probability of receiving 3518.9mm of rainfall is 0.03 percent. Kerala received 2227.9mm of rainfall in 2020, and based on Weibull's equation, the probability for receiving 2227.9mm rainfall is 0.88. The probability for the lowest rainfall of 1837.4mm in 2016, which occurred in 2016, is 0.97.

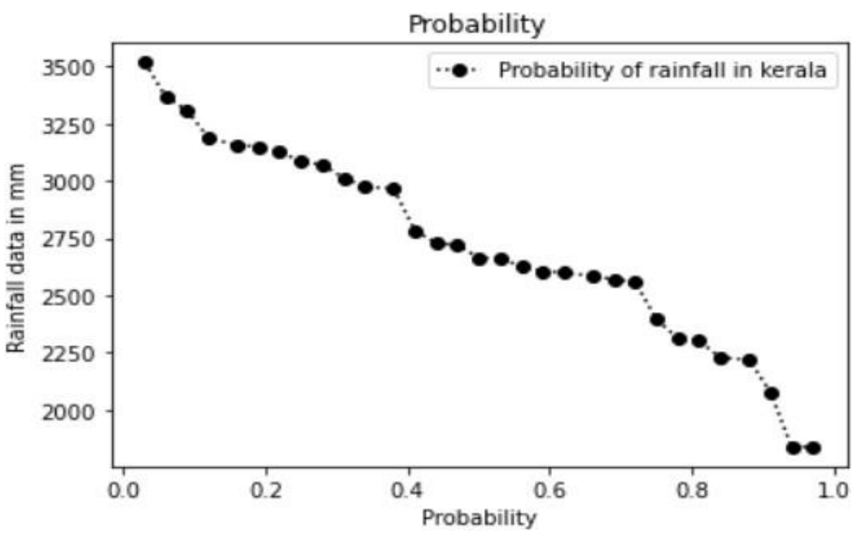


Fig 5.18: Probability of rainfall in Kerala.

(d) Probability of the rainfall to occur atleast once in coming 30 years:

Kerala had the greatest rainfall of 3518.9mm in 2018, which has never happened since 1961. The chance of receiving 3518.9mm of rainfall once in the next 30 years is 0.59. Kerala received 2227.9mm of rainfall in 2020; the likelihood of receiving 2227.9mm rainfall once in the next 30 years is 1. The probability of receiving the lowest rainfall of 1837.4mm once in the next 30 years, which occurred in 2016, is 1.

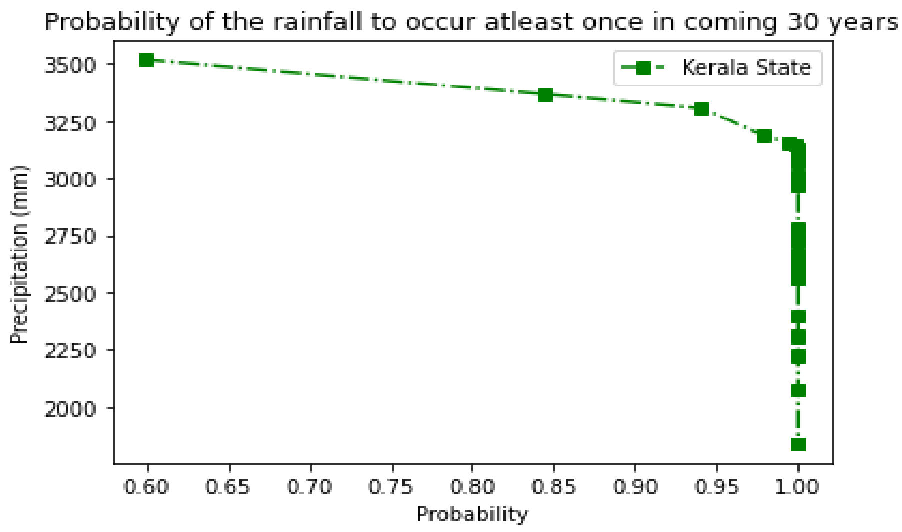


Fig 5.19: Probability of rainfall to occur atleast once in 30 years in Kerala

IV BIHAR STATE:

The Indian Meteorological Agency provides 30 years of annual precipitation data in Bihar (1990-2020). The frequency of rainfall in the last 30 years is shown in the form of a graph generated by Python Pandas. Using Python Pandas, he calculated and plotted the return period and probability of obtaining 30-year precipitation in 2021, and the probability of obtaining maximum precipitation every 30 years.

(a) Annual rainfall data analysis for past 30 years using python panda's

Bihar set the record for highest rainfall of 1,522mm in 1997 and caused great loss of life and economy. In 2020, Bihar's rainfall reached 1,275mm and more than 8.36 million people were affected in 16 districts. The flood has reportedly killed 27 people. In 2018, Bihar recorded the lowest rainfall of 806mm.

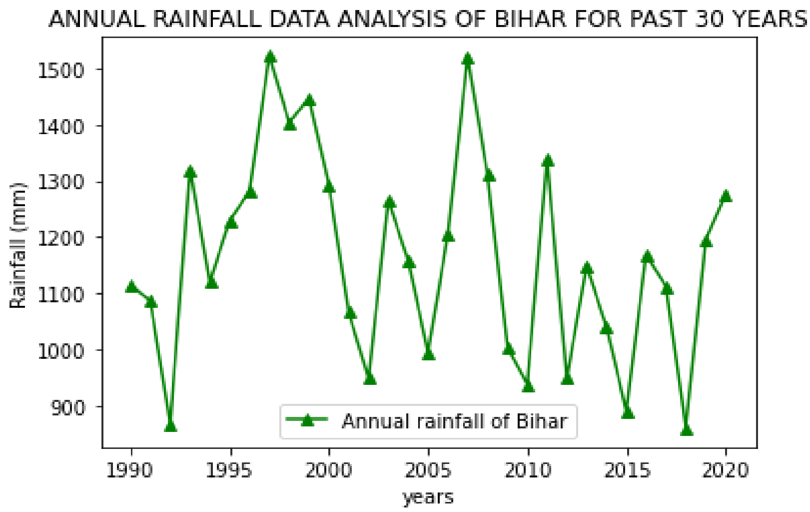


Fig 5.20: Annual rainfall of Bihar

(b) Return period of the rainfall data:

The highest rainfall in Bihar in 1997 was 1522 mm, and the return period of 1522 mm was 32 years. The registered rainfall in Bihar in 2020 is 1,275 mm, and the return period for obtaining 1,275 mm of rainfall is 3.2 years. The return period of obtaining the lowest rainfall of 860 mm in 2016 is 1.03 years.

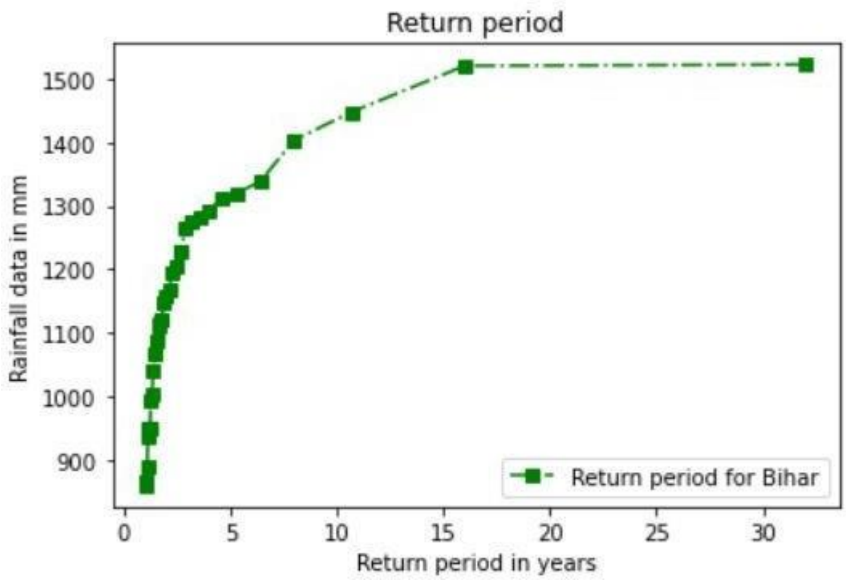


Fig 5.21: Return period of Bihar

(b) Probability of the rainfall to occur in the present year:

Bihar had the greatest rainfall in 1997, with 1522mm, and the chance of receiving 1522mm is 0.03 percent. In the year 2020, Bihar received 1275mm of rainfall, with a chance of 1275mm rainfall of 0.31. The likelihood of receiving the year's lowest rainfall of 860mm, which occurred in 2016, is 0.97.

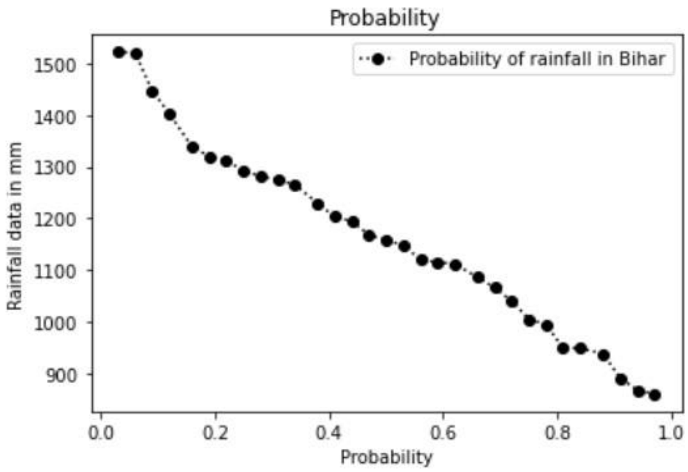


Fig 5.22: Probability of rainfall in Bihar

(d) Probability of the rainfall to occur atleast once in coming 30 years:

In 1997, Bihar had the most rain, at 1,522 mm. In the next 30 years, there is a 0.59 chance of receiving 1,522 mm of rain. In 2020, Bihar will experience 1,275 mm of rain, with a 0.99 chance of obtaining 1,275 mm in the following 30 years. The chances of the lowest rainfall of 806 mm occurring once in the next 30 years in 2018 are 1 in 30.

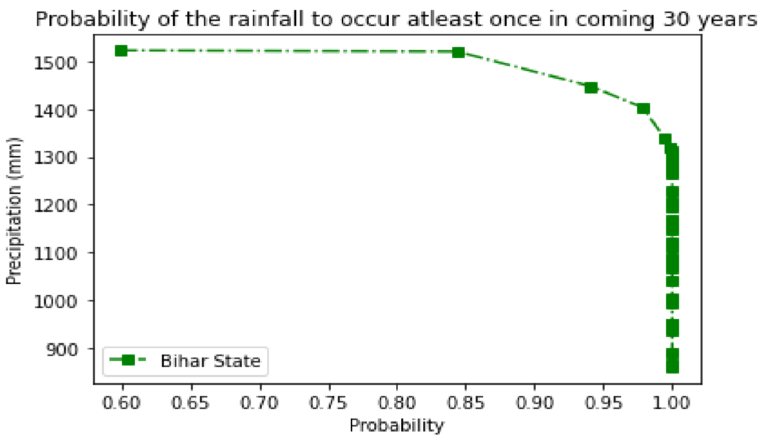


Fig 5.: Probability of rainfall to occur atleast once in 30 years in Bihar

5.2 Discussion

ASSAM STATE:

- This state his about of 78,438 km^2
- The population as per 2020 census was 3,60,24,656 citizens.
- Accurately 149 number of deaths occurred due to floods in 2020.
- The flooding began just before harvest and has caused destruction to more than 267,203 hectares of crops and more than 45,000 domesticated animals have been forced to flee or be abandoned.
- In the year 1993, Assam had the most rainfall, with 2776mm. In the year 2020, Assam received 1651mm of rain, which resulted in the deaths of 343 people due to flooding.
- Assam faced major floods in 1998,1993, 2002, 2004 and 2012 with a rainfall of 2374mm, 2776mm , 2249mm, 2691mm, 2268mm respectively.
- The return time for receiving the greatest rainfall of 2776mm, which occurred in the year 1993, is 32 years, while the return period for receiving 1651mm, which occurred in the year 2020, is 1.03 years.
- The probability of receiving the greatest rainfall of 2776mm, which occurred in the year 1993, is 0.03, while the probability of receiving 1651mm, which occurred in the year 2020, is 0.97.
- The probability of receiving the maximum rainfall of 2776mm once in the next 30 years, which occurred in 1993, is 0.5, while the probability of receiving 1651mm once in the next 30 years, which occurred in 2020, is 1.

BIHAR STATE:

- This state his about of 4,006 km^2
- Where the population as per 2020 census was 12,84,58,570 citizens.
- Accurately 27 number of deaths occurred due to floods in 2020.
- Bihar set the record for highest rainfall of 1,522mm in 1997 and caused great loss of life and economy.

- In 2020, Bihar's rainfall reached 1,275mm and more than 8.36 million people were aff ected in 16 districts. The flood has reportedly killed 27 people. In 2018, Bihar recorded the lowest rainfall of 806mm.
- The highest rainfall in Bihar in 1997 was 1522 mm, and the return period of 1522 mm was 32 years.
- The registered rainfall in Bihar in 2020 is 1,275 mm, and the return period for obtaining 1,275 mm of rainfall is 3.2 years.
- The return period of obtaining the lowest rainfall of 860 mm in 2016 is 1.03 years.
- Bihar had the greatest rainfall in 1997, with 1522mm, and the chance of receiving 1522mm is 0.03 percent
- In the year 2020, Bihar received 1275mm of rainfall, with a chance of 1275mm rainfall of 0.31.
- The probability of receiving the years lowest rainfall of 860mm,which occurred in 2016 is o.97
- In 1997, Bihar had the most rain, at 1,522 mm. In the next 30 years, there is a 0.59 chance of receiving 1,522 mm of rain.
- In 2020, Bihar will experience 1,275 mm of rain, with a 0.99 chance of obtaining 1,275 mm in the following 30 years
- The chances of the lowest rainfall of 806 mm occurring once in the next 30 years in 2018 are 1 in 30.

KERALA STATE:

- This state his about of 38,863 km^2
- Where the population as per 2020 census was 3,46,78,294 citizens.
- Accurately 132+ deaths occurred due to floods in 2020.
- In kerela floods are caused due to unnatural increase in rainfall was caused by a mons oon surge, which was aided by a strong Somali Current or Somali Jet and a low-pressu re on the Bay of Bengal which dragged strong monsoon winds towards the Western C oast of India.

- Kerala received 3518.9mm of rainfall in 2018, which is the most rainfall in the last 30 years and resulted in catastrophic flooding in 13 of the state's 14 districts, according to rainfall data.
- Kerala had around 2227.9mm of rainfall in the year 2020, with a number of lives lost. The lowest rainfall occurred in the year 2016, with 1837.4mm.
- In 2018, the greatest rainfall of 3518.9mm was registered in Kerala, which has never h appened since 1961, 3518.9mm of prevailing return period is 32 years.
- . Kerala has registered 2227.9 mm of precipitation in 2020 on the basis of the return time of Weibull's equation of 2227.9 mm of precipitation is 1.14 years. The return period from the lowest rainfall in 2016 of 1837.4mm is 1.03 years.
- Kerala had the greatest rainfall of 3518.9mm in 2018, a record that has not been broken since 1961.now the probability of receiving 3518.9mm of rainfall is 0.03
- the probability for receiving 2227.9mm rainfall is 0.88. The probability for the lowest rainfall of 1837.4mm in 2016, which occurred in 2016, is 0.97.
- Kerala had the greatest rainfall of 3518.9mm in 2018, which has never happened since 1961. The chance of receiving 3518.9mm of rainfall once in the next 30 years is 0.59.
- The probability of receiving 2227.9mm rainfall once in the next 30 years is 1
- The probability of receiving the lowest rainfall of 1837.4mm once in the next 30 years, which occurred in 2016, is 1.

UTTAR PRADESH STATE:

- This state his about of 2,43,290 km^2
- Where the population as per 2020 census was 23,15,21,022 citizens.
- Accurately 149 number of deaths occurred due to floods in 2020
- The flood situation is improving in the state. There are 922 flood-hit villages; 571 among them are marooned
- From 1990 to 2020, Uttar Pradesh has seen the highest rainfall of approximately 1200mm in 2020, affecting 1,090 villages in 16 districts of Uttar Pradesh, and the lowest rainfall of around 507mm in 2014.

- the return period for receiving 1200mm of rainfall is 32 years, while the return period for receiving the smallest amount of rainfall, 507mm, which occurred in 2014, is 1.04 years.
- In the year 2020, Uttar Pradesh had 1200mm of rain. The probability of receiving 120 0mm of rainfall is 0.03. the probability of receiving the lowest rainfall, 507mm, which occurred in 2014, is 0.97.
- The probability of receiving 1200mm of rainfall once in the next 30 years, as occurred in 2020, is 0.59, while the probability of receiving the lowest rainfall of 507mm once in the next 30 years is 1.

CHAPTER:6
CONCLUSIONS

6.1. Achievements of objectives:

The primary aim of the project is to calculate and develop the graphs for the return period, probability for the states which are heavily flooded in the year 2020 by using python software

- PYTHON softwate was studied and explained before beginning of the project
- The general features of the each state is presented clearly in study area
- India has Major floods in the state Assam,bihar, uttarpradesh, kerala in the year 2020 and we have used a very dynamic software called python panda's which offers good libraries to input 30 years rainfall data of 4 states.
- The probability and return period of four states have been calculated using weibull's formula and these will be helpful to estimate the occurrence of rainfall.
- All these studies will be helpful for designing the hydraulic structures and helps to take certain precautions when the flood occurs.
- The graphs which represents the return period of the different rainfalls of the states are developed in the python.
- The probability of the different mm of rainfall to occur in the present year are calculated using python and the graphs are also developed as it is done in developing the graphs of the return period
- The probability of the rainfall to occur atleast once in coming 30 years is also calculated for the four states and graphs are developed in python

6.2. Precautions to be taken for the floods in the future:

- Flooding or flash flooding may occur in your region. Be aware of changing weather and flood conditions, and be ready to evacuate to higher ground if necessary.
- Flooding is happening or is soon to happen. Avoid low-lying locations and evacuate if necessary.
- A flash flood is occurring or about to occur. Seek higher ground immediately.
- Receive alerts, cautions, and public safety information before, during, and after emergencies to keep you informed.

- Find out whether your property is in a flood-prone or high-risk area. Explore the Federal Emergency Management Agency’s (FEMA) flood maps.

6.3. Future Enhancement :

- In recent years there has been increasing demand from the engineering organization in india for detailed information of rainfall to design the local drainage works.
- The return period helps us to estimate the frequency of the certain amount of rainfall that is going to occur in the future
- By knowing the probability and return period, early warning system can be provided to floods so that perfect preventive measures are taken which decreases the damages of the livelihood and infrastructure

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A Major Project Report

On

EVALUATION OF ELECTROCOAGULATION AND REVERSE OSMOSIS PROCESS IN THE REMOVAL OF DYE FROM PLASTIC WASTE WATER

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

by

B. SUKANYA LAXMI - (17K81A0169)

M. RAHUL CHOWDARY - (18K85A0128)

M. NITIN SAI GOUD - (17K81A01B2)

P. PRAKASH REDDY - (18K85A0131)

Under the Guidance of

Dr. D. NARESH KUMAR (PhD)

Assistant Professor

DEPARTMENT OF CIVIL ENGINEERING

ST. MARTIN'S ENGINEERING COLLEGE

(An Autonomous Institute)

Dhulapally, Secunderabad – 500 100

JUNE 2021

ST. MARTIN'S ENGINEERING COLLEGE

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(Approved by A.I.C.T.E, New Delhi, Affiliated to JNTU Hyderabad)

Dhulapally, Secunderabad, Telangana (India)-500100

BONAFIDE CERTIFICATE

This is to certify that the project entitled ***EVALUATION OF ELECTROCOAGULATION AND REVERSE OSMOSIS PROCESS IN THE REMOVAL OF DYE FROM PLASTIC WASTE WATER,*** is being submitted 1.**Ms. B. Sukanya Laxmi (17K81A0169), 2. Mr. M. Rahul Chowdary (18K85A0128), 3. Mr. M. Nitin Sai Goud (17K81A01B2), 4.Mr. P. Prakash Reddy (18K85A0131)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN** CIVIL ENGINEERING is recorded of Bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

Signature of Guide

Dr. D. NARESH KUMAR
Assistant professor
Department of Civil Engineering

Signature of HOD

Ms. SANDHYA KIRAN J.K.
Asst. professor &head of dept.
Department of Civil Engineering

Internal Examiner

External Examiner

Place:

Date:

DECLARATION

We, the students of **Bachelor of Technology** in **Department of Civil Engineering**, of the Academic Year:2017 - 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project entitled **EVALUATION OF ELECTROCOAGULATION AND REVERSE OSMOSIS PROCESS IN THE REMOVAL OF DYE FROM PLASTIC WASTE WATER** is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been carried by taking care of Engineering Ethics. The result embodied in this project report has not been submitted in any university for award of any degree.

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ABSTARCT

Electrocoagulation (EC) is a powerful and environmentally friendly technology for the treatment of plastic dye, reactive dyes and etc..EC is one of the attractive methods for treating wastewater because it is simple, economic and less sludge production technology.

DC current is to be supplied for the treatment of the water. Different cathodes and anodes are to be used in the process. Effects of various operating parameters like pH, the nature of water , plastic dye concentration, initial concentration of water, density of water, exposed area of electrodes, material of electrodes, temperature of solution and their optimum ranges for dye removal from the waste water are different parameters which decide the current to be induced for the water treatment and the plastic dye removal from the water.

Technological advancements have resulted in a greater water demand by various industries. In addition, there is an increase in quantum of waste water, with diversified pollutants generated and discharged from these industries.

Hence, treatment of waste water generated from industries before release into the environment has become a grand challenge. Plastic processing industry is one among the most polluting industries that discharge 15% of dyes used in dyeing and finishing processes, which are toxic to the environment.

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TDS : TOTAL DISSOLVED SOLIDS

TSS : TOTAL SUSPENDED SOLIDS

AED : ACTUAL ELECTRODE DISSOCIATION

TED : THEORETICAL ELECTRODE DISSOCIATION

CRE : COLOUR REMOVAL EFFICIENCY

SRT : SOLID RETENTION TIME

BOD : BIOLOGICAL OXYGEN DEMAND

COD : CHEMICAL OXYGEN DEMAND

INTRODUCTION

Water is a one of the natural resources product in this planet. It is travel from hilly terrain to plain land and finally reaches oceans. Runoff water polluted from human activities, leachate releases from industries, expanding and intensifying food production etc., In general wastewater is classified based on their origin, such as domestic sewage, commercial sewage, industrial sewage, or storm sewage. Domestic or residential wastewater comes from general living processes like bathing, toilet flushing, laundry, dishwashing, floor washing etc. Commercial wastewater comes from non-domestic sources, such as beauty salon, taxidermy, furniture refinishing, musical instrument cleaning. Industries generates high concentrated wastewater they are making steel material, plastic material, oil production, vehicle repair shops, food production etc., storm sewage know as drains receive water from street gutters on most motorways, freeways and other busy roads, as well as towns in areas with heavy rainfall that leads to flooding, and coastal towns with regular storms.

Industrial wastewater is a dangerous hazardous compare to three sewages, it releases harmful gases, oil, leachate and chemicals on river, oceans, soil, and air. Based on production industrial wastewater divided two types they are production process and disposal way. Manufacturing unit releases lot of wastewater while making of products, cleaning, washing and packing. Unnecessary products, waste materials releases into adjacent rivers, oceans and drains. Most of the river basins in India and elsewhere are closing or closed and experiencing moderate to severe water shortages, brought on by the simultaneous effects of agricultural growth, industrialization and urbanization. Current and future fresh water demand could be met by enhancing water use efficiency and demand management. Thus, wastewater/low quality water is emerging as potential source for demand management after essential treatment.

Major cities in India generated sewage per day is 38354 million litres (MLD) but to treat this sewage in treatment plant is only of 11786 MLD. Mostly large scale industries invest most and efforts to treat this sewage only 60%. Performance of state owned sewage treatment plants, for treating municipal waste water, and common effluent treatment plants, for treating effluent from small scale industries, is also not Most of the river basins in India and elsewhere are closing or closed and experiencing moderate to severe water shortages, brought on by the simultaneous effects of agricultural growth, industrialization and urbanization. Current and future fresh water demand could be met by enhancing water use efficiency and demand management. Thus, wastewater/low quality water is emerging as potential source for demand management after essential treatment. An estimated 38354 million litres per day (MLD) sewage is generated in major cities of India, but the sewage treatment capacity is only of 11786 MLD. Similarly, only 60% of industrial waste water, mostly large scale industries, is treated.

Waste water generation in India:

India accounts for 2.45% of land area and 4% of water resources of the world but represents 16% of the world population. Total utilizable water resource in the country has been estimated to be about 1123 BCM (690 BCM from surface and 433 BCM from (ground), which is just 28% of the water derived from precipitation. About 85% (688 BCM) of water usage is being diverted for irrigation (Figure 1), which may increase to 1072 BCM by 2050.

Major source for irrigation is groundwater. Annual groundwater recharge is about 433 BCM of which 212.5 BCM used for irrigation and 18.1 BCM for domestic and industrial use (CGWB, 2011). By 2025, demand for domestic and industrial water usage may increase to 29.2 BCM. Thus water availability for irrigation is expected to reduce to 162.3 BCM. With the present population growth-rate (1.9% per year), the population is expected to cross the 1.5 billion mark by 2050. Due to increasing population and all round development in the country, the per capita average annual freshwater availability has been reducing since 1951 from 5177 m3 to 1869 m3, in 2001 and 1588 m3, in 2010. It is expected to further reduce to 1341 m3 in 2025 and 1140 m3 in 2050. Hence, there is an urgent need for efficient water resource management through enhanced water use efficiency and waste water recycling.

Waste water generation in Telangana:

1,781 million liters estimated sewage is generated each day in greater Hyderabad area, including the twin cities of Hyderabad and Secunderabad. 772 million liters Amount of sewage that is treated in various Sewage Treatment Plants in the city (43%). The rest of the sewage (57%) is released untreated, mostly in the Musi river (Fig.1.1), turning it into a foul stinking slurry that flows through the city or into the Hussain Sagar.

Sewage treatment in Telangana scarcely meets the requirements, going by a recent technical report prepared by the Central Pollution Control Board (CPCB). As per the National Inventory of Sewage Treatment Plants-2021, wide gap prevails between the amount of sewage generated and that being treated in the State. For an estimated sewage generation of 2660 million litres per day (MLD) in the State, only 706 MLD is being actually treated, as per the report, which amounts to 26.5%.

Figure: 1.1 Sewage water travel and river water travel at musi river channel in Hyderabad

While the installed capacity of sewage treatment plants (STPs) is 901 MLD across the State, only 842 MLD is operational. Of the operational capacity, the actual utilisation is only 706 MLD. All the operational STPs are not fully compliant with the norms, as apparent from the water quality parameters. Of the 842 MLD, only 637 MLD capacity has been found to be compliant. A total 24 MLD capacity is non-compliant and 35 MLD is under construction Of the total installed capacity in 37 STPs, Amberpet treatment plant alone constitutes 339 MLD, which is found to be compliant though its actual utilisation is only 300 MLD. The STP at Nagole on river Musi constitutes 172 MLD more, which is only partially compliant, with Biochemical Oxygen Demand (BOD) shooting past the stipulated limits. Of the two STPs on the Musi at Attapur with the capacities of 23 MLD and 51 MLD respectively, only the latter is fully compliant. The STP on Khajaguda lake too is only partially compliant, while two STPs in Pragathi Nagar Lake, and Krishnakanth Park respectively are non-operational. Much of the total capacity exists within the city limits, with only 164 MLD installed outside the city encompassing Hyderabad and Rangareddy districts.

Environmental degradation and sustainability:

Environmental degradation is a process through which the natural environment is compromised in some way, reducing biological diversity and the general health of the environment. The primary cause of environmental degradation is human disturbance. Environmental changes are based on factors like urbanization, population and economic growth, increase in energy consumption and agricultural intensification. The degradation has adverse impacts on humans, plants, animals and micro-organisms.

The goal of environmental sustainability is to conserve natural resources and to develop alternate sources of power while reducing pollution and harm to the environment. Sustainable development means using our resources in a manner that they should also be preserved for our future generation. It prevents the environmental degradation by using sustainable development Environmental degradation is the main factor reducing sustainability. This chapter introduces the environmental degradation processes (i.e. desertification, pollution, land degradation, snow ablation and glacier retreat, dams and resettlement) and their relationships to environmental sustainability.

The elasticities of environmental degradation and poverty are found to be negative and significant. These results suggest that if the level of water pollution increases 1%, condition of human development deteriorates by 0.08%. If the level of poverty increases by 1%, the quality of human development worsens by 0.18%.

There is a significant increase in the urban population in developing countries like India and consequently, this has thrown up a major challenge to Urban Local Bodies (ULBs) entrusted with the task of waste management. In India, less than 20% of the wastewater generated is getting treated. Recent studies indicate that the supply is roughly equal to the demand for the country, hiding wide regional variations with acute shortages in many parts. Since economic growth implies increased water use, the water situation can be expected to worsen rapidly. Even though water resources are not scarce from the perspective of total available water volumes, the precipitation is highly variable in time and space. In addition, the untreated or partially treated wastewater from human settlements is polluting the existing freshwater bodies, creating shortage of freshwater for different uses. Moreover, many studies have shown that centralized treatment plants are not a sustainable solution for countries like India, where the power supply is rarely continuous, and operation and maintenance are not secured. Hence, it will be advisable to treat the wastewater near to the point of generation and reuse it so that the environment is protected and reliable source of water supply is provided. Innovative decentralized wastewater treatment plants aiming not only at treating the wastewater but also providing other benefits such as the reuse of water, energy reuse or nutrient reuse depending on the local context are the need of the day water treatment systems. Any sustainable wastewater management system should be oriented toward the 3R concept, i.e., reduce, recycle, and reuse. However, the selection of technologies/management strategies will be depending on the economic status of the society. An integrated wastewater management system is the base for a sustainable development in urban and peri-urban areas. It is important to quantify and characterize the amount of wastewater for

(i) developing effective strategies to treat the wastewater.

(ii) applying different technologies, i.e., anaerobic, followed by aerobic and physicochemical.

(iii) using the treated wastewater in a sustainable way taking into account the risks involved, e.g., using treated wastewater for toilet flushing, and landscaping.

Historically, water scarcity has been a major problem in many regions of the world. Natural waters, and to a greater extent, sewage, must be treated before use, reuse, or being discharged. There are many pollutants that compromise water quality, and affect both the human being and the natural environment. Some of the most important threats come from industrial wastewater due to the toxicity of heavy metals, persistent organic compounds, etc.

However, urban wastewater, apparently easily treated by well-established methods for decades, is generating an increase in eutrophication events with direct consequences such as massive deaths of aquatic organisms, biodiversity reduction, red tides, etc. Current trends, including predicted population growth and ever more intensive consumption of natural resources, will only increase the need for improved excreta and wastewater management.

Effects of waste water on environment:

Wastewater is all around us. From the water running down your shower drain to the runoff that comes from wet roads, this is a byproduct of our modern lifestyle.

Groundwater and water tables: Both bodies of freshwater and saltwater are polluted every day by untreated wastewater. Numerous parts of the world are currently suffering from water scarcity., which means clean water is of the utmost importance. When wastewater is discharged on these dry lands, it can seep into the underground water tables and well sources. Because we need to draw from these natural bodies of water for generations to come, this can render entire water supplies useless for people in multiple locations.

Natural ecosystems: Every ecosystem relies on water in some regard. And when water is contaminated by sewage, toxic chemicals, or any number of other man-made forms of waste, those ecosystems are put at serious risk. Not only is that, but surface and underground water connected, always. Reckless disposal of waste can contaminate a far wider range of animals and environments.

Preserving the environment involves developing processes for treating contaminated water to ensure sustainable growth of urban areas and protection of natural areas. We consider wastewater treatment as water use because it is so interconnected with the other uses of water. Much of the water used by homes, industries, and businesses must be treated before it is released back to the environment. Nature has an amazing ability to cope with small amounts of water wastes and pollution, but it would be overwhelmed if we didn't treat the billions of gallons of wastewater and sewage produced every day before releasing it back to the environment. Treatment plants reduce pollutants in wastewater to a level nature can handle.

Sustainable use of wastewater:

Collecting and exploiting waste water is both technically feasible and financially justifiable. By 2025, absolute water scarcity will be a daily reality for an estimated 1.8 billion people. In a world where vital resources are increasingly scarce, nations cannot afford to flush them down the drain. But that is exactly what we do. After we use water in our homes and businesses, it is washed away, and takes many valuable resources with it.

Waste water is rich in carbon and nutrients and – if collected and treated properly – it could provide new water, fertiliser, energy,effectively recover nutrients and bioenergy, and produce ―new water‖ that can be reused. But more than 80% of all waste water still currently flows into natural ecosytems, polluting the environment and taking valuable nutrients and other recoverable materials with it.

If properly managed, the water we have already used stops being an environmental hazard and becomes an affordable and sustainable source of energy, nutrients, and other recoverable materials.

More sustainable sanitation and wastewater management could yield vast economic. Many of these benefits come in the form of savings of costs linked to inadequate sanitation and wastewater management – most notably in health care, but also in terms of lost economic productivity, reduced ecosystem services and others. In India, for example, the estimated economic savings available through providing adequate sanitation and environmental friendly.

Using wastewater irrigation in agriculture is one way to achieve this. Wastewater can be easily collected or pumped directly from a nearby water source. It can then be used to irrigate crops and fields.

Use of waste water in irrigation:

High nutrient content – Wastewater has a naturally high nutrient content which reduces or even eliminates the need for expensive chemical fertilisers. This helps to support people in poorer communities by reducing agricultural running costs.

Environmentally friendly – Using wastewater to irrigate crops and farmland is a sustainable practice that helps to reduce water wastage and conserve water supply.

Higher production of crops – Irrigation allows farmers to grow more pastures and crops by providing access to water. Particularly at times when it would otherwise be hard to achieve good plant growth. Having access to water throughout the year also lengthens the growing season. In addition, irrigation allows farmers to grow crops in areas that would otherwise be considered too dry. This resource can irrigate gardens and agricultural fields, or replenish surface water and groundwater. Water recycling is an environmentally and economically viable solution to help conserve our water resource.

Use of waste water in electricity generation:

Energy production: The world needs more energy to support growing populations and expanding cities. Using waste for energy is a cheap, renewable and readily available form of energy for many cities. Since sewage treatment plants can use biogas generated from their own sludge to power their operations, it allows them to be energy self-sufficient. This ensures that a sewage plant's primary function -- removing pollutants and disease-causing pathogens -- is not interrupted by surrounding power outages.

Emissions reductions: Methane makes up 16 percent of global greenhouse gas emissions, and it's extremely potent—about 30 times more powerful a greenhouse gas than carbon dioxide. Sludge-to-energy systems harness this methane for energy instead of letting it escape into the atmosphere, where it would fuel climate change. Although methane releases carbon dioxide when harnessed for energy, the net emissions are negligible if methane-rich biogas is being used in place of fossil fuels.

Waste management: Many developing countries lack the infrastructure needed to properly manage solid waste and sludge. In these areas, this toxic, foul-smelling waste is often dumped directly onto land or nearby waters, where it can endanger public health. In China, for example, over 70 percent of municipal solid waste and sludge is land filled or dumped—sometimes illegally. A sludge-to-energy approach provides a solution.

Economic benefits: Sludge-to-energy systems reduce the need for more costly and polluting forms of power, such as fossil fuels. In addition, those who operate waste-to-energy operations can directly benefit financially from selling the gas and solid digestate.

Plastic industry

In this research we are focusing on the dye remove from plastic industries, Plastics are inexpensive, lightweight and durable materials which can readily be moulded into a variety of products that have a wide range of applications. They are mainly highly polymerized compounds consisting of carbon and hydrogen, made from substances such as petroleum and natural gas. Crude gasoline produced by refining crude oil is used as the raw material for making plastics. Plastics are divided into two main types according to how they behave when heated; thermoplastics and thermosetting plastics. Thermoplastics undergo strong molecular motion when heated, which causes them to soften. They harden when cooled, and repeated heating and cooling allows them to be moulded into a variety of different shapes. This group of plastics includes, among others, PET, Low Density Polyethylene (LDPE), Polyvinylchloride (PVC), High Density Polyethylene (HDPE), Polypropylene (PP) and Polystyrene (PS) [1]). Thermosetting plastics undergo relatively weak molecular motion but once softened by heat and treated they undergo a chemical reaction which causes them to form a high molecular weight 3D matrix structure meaning, once they have set they cannot be softened again by heat [2]. According to [3], manufacturing is by far one of the main drivers to improve a nation's economy. It is a priority which many countries should consider in order to improve the living standards of its people. The purpose of the research was to address the obstacles facing plastic recycling and manufacturing companies from the sustainable perspective. Sustainability is founded on three aspects, economic, environmental and social aspects. According to a sustainable system is a system that is appropriate to the local conditions in which it operates, from a technical, social, economic, financial, institutional, and environmental perspective, and capable to maintain itself over time without reducing the resources it needs. It was important to conduct a research on the major obstacles to sustainability in the plastic industry as the focus of sustainability is resource utilization for future generations. Background of the study Several million tonnes of plastics are produced and used as packaging materials and consumer products every year. 50 per cent of plastics are used for single-use disposable applications such as packaging and only 20% and 25 % are for long term infrastructure. If 50% of manufactured plastics are converted into disposable products, it means huge amount of waste is generated from plastics. Considering that energy is consumed during the production of plastics from virgin materials, this also means that huge amount of energy is also consumed. Recycling has become a key factor in the supply chain. It has been receiving considerable attention due to its main environmental benefits which are acknowledged throughout the world and make it one of the most successful and cleanest waste-recovery processes. A number of studies have been conducted in the plastic industry with particular focus on plastic recycling. The research looked at the challenges and opportunities in plastic recycling focusing on the production and disposal of packaging plastic waste. The researchers found that, significant challenges still exist from both technological factors and from economic or social behaviour issues relating to the collection of recyclable wastes and substitution for virgin materials. The review further focused on the various recycling methods of plastic solid waste and energy recovery in response to the current waste generation rates and production technologies. The researchers concluded that, it is very important to consider recycling and energy recovery methods in plastic manufacturing and converting facilities. The researchers further highlighted that, many tertiary and quaternary technologies appear to be robust to warrant further research and development in the near future. Conducted a study on plastics recycling and waste management in the US. The findings of the research indicated that while new technologies have been developed, the amounts of materials been recycled would have reached a plateau and in the absence of additional legislative mandates, further progress in recycling of plastics might be slower. Have focused on plastic recycling with an emphasis on the different types of plastic waste. Even though the plastic waste types might be different, they have all looked at the technical aspect of managing this waste. Having highlighted the different technologies available to treat this waste type, they all point out that challenges still exist in managing this waste type. The fact that challenges still exist in managing plastic waste, this research will investigate the obstacles preventing sustainable recovery and recycling of plastics in the Zambian context. In contrast few studies have been conducted on the challenges facing plastic recycling and manufacturing industries from the sustainable aspect. Highlighted the challenges facing the plastic manufacturing industry as collection, sorting, lack of incentives by manufacturers to use recycled plastics, few and far away markets and weak environmental controls. According to a study on a number of challenges facing the plastic industry were highlighted; market share, costs and capacity, quality and demand, legislations and environmental concerns.

Types of plastic colourant :

Several methods are available for delivering colour for use in moulding plastics, including Master batches, Cube Blends and Pre-colours. Master batches (Concentrates):

The most common method used by moulders, master batches consist of concentrated pigments dispersed into a polymer carrier resin. During moulding the master batch is let down into natural resin as it is feed into the press at a predefined ratio to achieve the desired colour. Master batches are the most economical method to colour plastics and can be provided in small volumes. Depending on the carrier selected, the same masterbatch may be used to colour several different resins, or be chosen for maximum compatibility and processing ease. Colour matches can be performed in just 3 days, and master batch production orders can be delivered with short 5 to 10 days lead times.

Cube Blends (Salt & Pepper Mixes):

Cube blends are colour systems that feature a master batch dry blended with natural polymer that are ready to use. This method can be utilized by moulders who lack metering equipment at the press. Mixing is carefully controlled by RTP Company eliminating the risks associated with self-blending that can cause variations in colour.

Pre-coloured Resins:

Processors without experience handling custom colour matches often select pre-coloured resins for their ease-of-use. Engineering resins that require high master batch let down ratios also benefit from pre-colouring because pigments are completely polymerized into a resin package and is used by moulders as supplied. Custom colour matches can be performed in just 5 days and pre-coloured resin production orders can be delivered with short 5to10 day lead times.

Coloured Specialty Compounds:

Colour enhances and adds value to custom engineered compounds formulated to meet specific physical requirements. Masking the hues of various additives isn’t just a matter of adding more pigment, colouring specialty compounds must be achieved without altering the physical properties the material was designed to provide for renowned. Colour in specialty compounds can be for identification purposes or custom matched to a specific target. Colour can also provide compounds with a cosmetic quality appearance or an eye catching special effect look.

Coloured Pellets, Coloured Compounds

Unlike master batches, they are set at the same concentration (hue) as the final products (Fig. 1.0). Therefore, there is no need to mix them with natural pellets. They also have no trouble mixing and an ease of stably in producing the desired colour. However, the cost is higher than other products.

Fig1.2 Black colour nylon compound granules in pellet form

Dry Colour

Plastic colorants in powder form are produced by mixing pigments with metal soaps and such like (Fig.1.1). They are the most inexpensive colorants, because there is no trouble with production. However, they have several weak points in handling, such as scattering easily, easily dirtying machinery and materials, and difficulties in measurement.

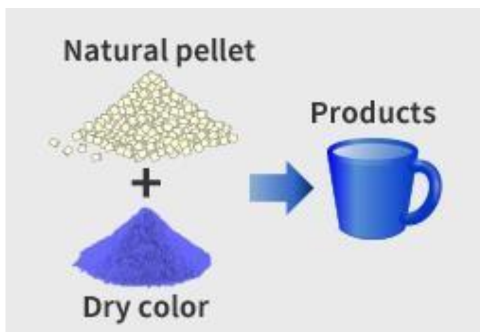


Fig 1.3 Plastic products formed by dry plastic colorants

Paste Colours, Liquid Master batch

Plastic colorants in a liquid form (fig 1.2). Paste Colours are different from Liquid Master batch in terms of viscosity (fig 1.3). Paste Colours are mainly used when the base resin is in a liquid form such as vinyl chloride. Liquid Master batch is used in the case that a customer wants to colour products lightly, such as semi-transparent colour overseas.

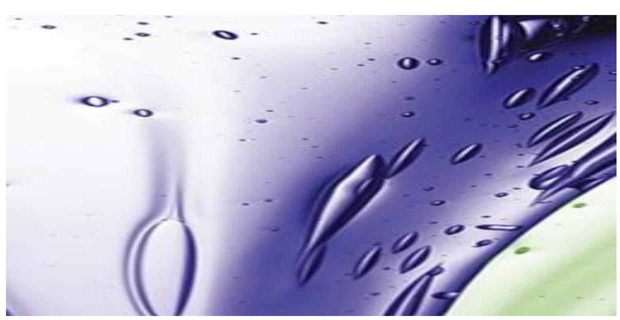


Fig. 1.4 Liquid form of plastic colourants

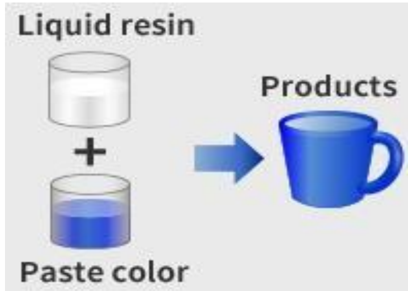


Fig 1.5 Plastic products formed by liquid plastic colorants

Treatment Methods

These contaminants in wastewater are removed by physical, chemical and biological operations and these operations occur in a variety of combinations in treatment systems. In the past, different methods for this treatment were used and through evolution and advancement of technology, developed methods have been advocated. Treatment methods are aimed at the removal of suspended material, biodegradable organics (BOD), disease-causing pathogenic micro- organisms, and nutrients such as nitrogen and phosphorous. It is necessary to understand their standard operating procedures separately. The physical treatment approach requires physical forces like screening, mixing, flocculation, sedimentation, filtration for operation as chemical treatment approach bases on chemical reactions unlike the biological treatment approach which applies biological activities like settling.

Concluding, the consequence of poor sanitation practices like improper fecal wastewater disposal is the ill effects of the urban population and the enormous investment of the state to maintain the health of its population. Conversely, effective waste water treatment technologies are available to elude the undesirable consequences but they are expensive and have no direct economic returns and hence many local authorities are not interested in implementing those methods. Therefore, in this paper, a cheap, simple and conventional wastewater treatment process is presented which comprises of the principles, ideas and design.

Types of plastic

There are various types of plastics to be mixed with plastic colourants. Thermoplastic (mold by melting in heat) plastics which are often used for daily necessities and are divided into two categories—crystalline and non-crystalline (table 1.0). Each of features a variety of properties, which must be taken into consideration when designing products. For example, polyethylene (PE) that is strongly resistant to heat and chemicals among crystalline plastics is used for films and buckets. Highly transparent and durable polyethylene terephthalate (PET) is used for plastic bottles and egg cartons.

Example of plastics

Classification	Material type	Abbreviations	Character	Product example
Crystalline plastic	Polyethylene	PE	Strong against heat and chemicals	Film, bucket, etc.
	Polyethylene terephthalate	PET	High transparency and strong	PET bottle, egg pack, etc.
Amorphous plastic	Polyvinyl chloride	PVC	Hard to burn and strong	Hose, electric wire, etc.
	ABS resin	ABS	Opaque, resistant to cracking and heat	Furniture, PC, etc.

Table1.1 Different types of plastics and their properties

Industrial wastewater treatment plants

Dissolved air flotation systems are widely used at oil refineries, chemical plants and paper mills Disposal of wastewaters from an industrial plant is a difficult and costly problem. Most petroleum refineries, chemical and petrochemical plants have onsite facilities to treat their wastewaters so that the pollutant concentrations in the treated wastewater comply with the local and/or national regulations regarding disposal of wastewaters into community treatment plants or into rivers, lakes or oceans. Constructed wetlands are being used in an increasing number of cases as they provided high quality and productive on-site treatment. Other industrial processes that produce a lot of waste-waters such as paper and pulp production has created environmental concern, leading to development of processes to recycle water use within plants before they have to be cleaned and disposed.

Industrial wastewater treatment plants are required where municipal sewage treatment plants are unavailable or cannot adequately treat specific industrial wastewaters. Industrial wastewater plants may reduce raw water costs by converting selected wastewaters to reclaimed water used for different purposes. Industrial wastewater treatment plants may reduce wastewater treatment charges collected by municipal sewage treatment plants by pre-treating wastewaters to reduce concentrations of pollutants measured to determine user fees.

Although economies of scale may favor use of a large municipal sewage treatment plant for disposal of small volumes of industrial wastewater, industrial wastewater treatment and disposal may be less expensive than correctly apportioned costs for larger volumes of industrial wastewater not requiring the conventional sewage treatment sequence of a small municipal sewage treatment plant. An industrial wastewater treatment plant may include one or more of the following rather than the conventional primary, secondary, and disinfection sequence of sewage treatment:

An oil-water separator, for removing separate phase oil from wastewater. A clarifier, for removing solids from wastewater A roughing filter, to reduce the biochemical oxygen demand of wastewater. A carbon filtration plant, to remove toxic dissolved organic compounds from wastewater. An advanced electrodialysis reversal (EDR) system with ion-exchange membranes. Agricultural wastewater treatment plants

Agricultural wastewater treatment for continuous confined animal operations like milk and egg production may be performed in plants using mechanized treatment units similar to those described under industrial wastewater; but where land is available for ponds, settling basins and facultative lagoons may have lower operational costs for seasonal use conditions from breeding or harvest cycles. Many farms generate nonpoint source pollution from surface runoff which is not controlled through a treatment plant. Farmers can install erosion controls and implement nutrient management plans to control runoff pollution.

Leachate treatment plants are used to treat leachate from landfills. Treatment options include: biological treatment, mechanical treatment by ultrafiltration, treatment with active carbon filters, electrochemical treatment including electrocoagulation by various proprietary technologies and reverse osmosis membrane filtration using disc tube module technology.

Membrane filtration

A membrane is a thin layer of semi-permeable material that separates substances when a driving force is applied across the membrane. Membrane processes are increasingly used for removal of bacteria, microorganisms, particulates, and natural organic material, which can impart color, tastes, and odors to water and react with disinfectants to form disinfection byproducts.

As advancements are made in membrane production and module design, capital and operating costs continue to decline. The membrane processes discussed here are microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO).

Microfiltration:

Microfiltration is loosely defined as a membrane separation process using membranes with a pore size of approximately 0.03 to 10 micronas (1 micron = 0.0001 millimeter), a molecular weight cut-off (MWCO) of greater than 1000,000 daltons and a relatively low feed water operating pressure of approximately 100 to 400 kPa (15 to 60psi) Materials removed by MF include sand, silt, clays, Giardia lamblia and Crypotosporidium cysts, algae, and some bacterial species. MF is not an absolute barrier to viruses. However, when used in combination with disinfection, MF appears to control these microorganisms in water.

There is a growing emphasis on limiting the concentrations and number of chemicals that are applied during water treatment. By physically removing the pathogens, membrane filtration can significantly reduce chemical addition, such as chlorination.

Another application for the technology is for removal of natural synthetic organic matter to reduce fouling potential. In its normal operation, MF removes little or no organic matter; however, when pre-treatment is applied, increased removal of organic material can occur. MF can be used as a pre-treatment to RO or NF to reduce fouling potential. Both RO and NF have been traditionally employed to desalt or remove hardness from groundwater.

Ultrafiltration:

Ultrafiltration has a pore size of approximately 0.002 to 0.1 microns, an MWCO of approximately 10,000 to 100,000 daltons, and an operating pressure of approximately 200 to 700 kPa (30 to 100 psi). UF will remove all microbiological species removed by MF (partial removal of bacteria), as well as some viruses (but not an absolute barrier to viruses) and humic materials. Disinfection can provide a second barrier to contamination and is therefore recommended. The primary advantages of low-pressure UF membrane processes are compared with conventional clarification and disinfection (post-chlorination) processes are:

• No need for chemicals (coagulants, flocculants, disinfectants, pH adjustment)

• Size-exclusion filtration as opposed to media depth filtration

• Constant quality of the treated water in terms of particle and microbial removal

• Process and plant compactness

• Simple automation

However, fouling can cause difficulties in membrane technology for water treatment.

Nanofiltration:

Nanofiltration membranes have a nominal pore size of approximately 0.001 microns and an MWCO of 1,000 to 100,000 daltons. Pushing water through these smaller membrane pores requires a higher operation pressure than either MF or UF. Operating pressures are usually near 600 kPa (90psi) and can be as high as 1,000 kPa (150psi). These systems can remove virtually all cysts, bacteria, viruses, and humic materials. They provide excellent protection from DBP formation if the disinfectant residual is added after the membrane filtration step.

Because NF membranes also remove alkalinity, the product water can be corrosive, and measures, such as blending raw water and product water or adding alkalinity, may be needed to reduce corrosivity. NF also removes hardness from water, which accounts for NF membranes sometimes being called ―softening membranes.‖ Hard water treated by NF will need pretreatment to avoid precipitation of hardness ions on the membrane. However, more energy is required for NF than MF or UF.

Reverse osmosis:

Reverse osmosis can effectively remove nearly all inorganic contaminants from water. RO can also effectively remove radium, natural organic substances, pesticides, cysts, bacteria and viruses. RO is particularly effective when used in series with multiple units. Disinfection is also recommended to ensure the safety of water. Some of the advantages of RO are:

• Removes nearly all contaminant ions and most dissolved non-ions,

• Relatively insensitive to flow and total dissolved solids (TDS level and suitable for small systems with a high degree of seasonal fluctuation in water demand,

• RO operates immediately, without any minimum break-in period,

• Low effluent concentration possible,

• Bacteria and particles are also removed, and

• Operational simplicity and automation allow for less operator attention and make RO suitable for small system applications.

• Some of the limitations of RO are:

• High capital and operating costs,

• Managing the wastewater (brine solution) is a potential problem,

• High level of pretreatment is required in some cases,

• Membranes are prone to fouling and

• Produces the most wastewater at between 25-50 percent of the feed.

Membrane materials:

Normally, membrane material is manufactured from a synthetic polymer, although other forms, including ceramic and metallic ―membranes,‖ may be available. Almost all membranes manufactured for drinking water are made of polymeric material, since they are significantly less expensive than membranes constructed of other materials.

Membranes constructed of polymers that react with oxidants used in drinking water treatment should not be used with chlorinated feed water. Mechanical strength is another consideration, since a membrane with greater strength can withstand larger trans-membrane pressure (TMP) levels, allowing for greater operational flexibility and the use of higher pressures.

Membranes with bi-directional strength may allow cleaning operations or integrity testing to be performed from either feed or filtrate side of the membrane. Membranes with a particular surface charge may remove particulate or microbial contaminants of the opposite charge due toelectrostatic attraction. Membranes can also be hydrophilic (water attracting) or hydrophobic (water repelling). These terms describe how easily membranes can be wetted, as well as its ability to resist fouling to some degree.

MF and UF membranes may be constructed from a wide variety of materials, including cellulose acetate, polyvinylidene fluoride, polyacrylonitrile, polypropylene, polysulfone, polyethersulfone, or other polymers. Each of these materials has different properties with respect to the surface charge, degree of hydrophobicity, pH and oxidant tolerance, strength and flexibility.

NF and RO membranes are generally manufactured from cellulose acetate or ployamide materials, and their various advantages and disadvantages. Cellulose membranes are susceptible to biodegradation and must be operated within a narrow, pH range of 4 to 8 but they do have some resistance to continuous low-level oxidants.

Chlorine doses of 0.5 mg/L or less may control biodegration and biological fouling without damaging the membrane. Polyamide membranes, by contrast, can be used under a wide range of pH conditions and are not subject to biodegradation. Although these membranes have very limited tolerance for strong oxidants, they are compatible with weaker oxidants such as cholramines. These membranes require significantly less pressure to operate and have become the predominate material used for NF or RO applications.

Membrane modules:

Membrane filters are usually manufactured as flat sheet stock or as hollow fibers and then formed into on of several different types of membrane modules. Module construction typically involves potting or sealing the membrane material into an assembly, such as with hollow-fiber module. These types of modules are designed for long-term use over the course of a number of years. Spiral-wound modules are also manufactured for long-term use, although these modules are encased in a separate pressure vessel that is independent of the module itself.

Hollow-Fiber Modules:

Most hallow-fiber modules used in drinking water treatment applications are manufactured for MF or UF membranes to filter particulate matter. These modules are comprised of hollow-fiber membranes, which are long and very narrow tubes that may be constructed of membrane materials described previously. The fibers may be bundled in one of several different arrangements.

Fibers can be bundled together longitudinally, potted in a resin on both ends, and encased in a pressure vessel. These modules are typically mounted vertically, although horizontal mounting may be used. These fibers can be similar to spiral-wound modules and inserted into pressure vessels independent of the module itself. These modules (and the pressure vessels) are mounted horizontally. Bundled hollow fibers can also be vertically and submerged in a basin that does not need a pressure vessel.

A typical hollow-fiber module may consist of several hundred to over 10,000 fibers. Although dimensions vary by manufacturer, approximate ranges for hollow-fiber construction are:

• Outside diameter 0.5 – 2.0 mm

• Inside diameter 0.3-1.0 mm

• Fiber wall thickness 0.1-0.6 mm

• Fiber length 1-2 meters

Hollow-fiber membrane modules may operate in an ―inside-out‖ or ―outside-in‖ mode. In insideout mode, feed water enters the center of the fiber (lumen) and is filtered radially through the fiber wall. Filtrate is then collected from outside the fiber. During outside-in operation, feed water passes from outside the fiber to the inside, where filtrate is collected in the center of the fiber.

Hollow Fiber Cross-Section Photomicrograph:

When a hollow-fiber module is operated in an inside-out mode, pressurized feed water may enter the center of the fiber at either end of the module, while filtrate exits through a port located at the center or end of the module. In outside-in mode, feed water typically enters the module through an inlet port located in the center and is filtered into the center of the fiber, where the filtrate exits through a port at one end of the module. Most hollow-fiber systems operate in direct filtration mode and are periodically backwashed to remove the accumulated solids.

Spiral-Wound Modules:

Spiral-wound modules were developed to remove dissolved solids, and are most often associated with NF/RO processes. The basic unit is a sandwich of flat membrane sheets called a ―leaf‖ wound around a central perforated tube. One leaf consists of two membrane sheets placed back to back and separated by a spacer called permeate carrier. Layers of the leaf are glued along three edges, while the unglued edge is sealed around the perforated central tube.

Feed water enters the spacer channels at the end of the spiral-wound element in a path parallel to the central tube. As feed water flows through the spacers, a portion permeates through either of the two surrounding membrane layers and into the permeate carrier, leaving behind any dissolved and particulate contaminates that are rejected by the membrane.

Filtered water in the permeate carrier travels spirally inward toward the central collector tube, while water in the feed spacer that does not permeate through the membrane continues to flow across the membrane surface, becoming increasingly concentrated with rejected contaminates. This concentrate stream exits the element parallel to the central tube through the opposite end from which the feed water entered.

Waste stream disposal:

Waste stream disposal is a significant problem in many areas. Unlike conventional treatment processes, in which approximately 5 to 10 percent of the influent water is discharged as waste, membrane processes produce waste streams as much as 15 percent of the total treated water volume. Because little or no chemical treatment is used in a membrane system, the concentrate stream usually contains only the contaminates found in source water (although at much higher concentrations), and concentrate can sometimes be disposed of in the source water. Other alternatives include deep well injection, dilution and spray irrigation, or disposal in municipal sewer. These alternatives are usually necessary for NF wastes, which usually contain concentrated organic and inorganic compounds. Disposal must be carefully considered and applicable discharge regulations must be respected.

Membrane integrity testing:

One of the most critical aspects of employing membrane technology is ensuring that the membranes are intact and continuing to provide a barrier between the feedwater and the permanent or product water. There are several different methods that can be employed to monitor membrane integrity, including turbidity monitoring, particle counting or monitoring, air pressure testing, bubble point testing, sonic wave sensing, and biological monitoring.

Chemical Cleaning Agents:

Proprietary cleaning chemicals are available, and these specialty cleaning agents may be useful when more conventional chemicals are ineffective. For example, enzymatic cleaners have been effective at dissolving organic contaminants. Chemical cleaning options are limited for membranes that cannot tolerate oxidants and/or extreme pH levels. A chemical cleaning regimen may be specified by the manufacturer based on site-specific source water quality.

For MF/US systems, it is common to recycle as much as 90 % of the cleaning chemicals for reuse, thus reducing the volume of chemical waste as well as the cost associated with cleaning. Recycling cleaning solutions is less common with NF/RO systems, since used cleaning solutions accumulate dissolved constituents with repeated use, diminishing effectiveness of the cleaning agents.

Category	Chemicals commonly used	Typical Target Contaminants
Acid	Citric acid ($C6\ H8\ O7$) Hydrochloric acid (HCL)	Inorganic scale
Base	Caustic (NaOH)	Organics
Oxidants/ Disinfectants	Sodium Hypochlorite (NaOCl) Chlorine ($Cl2$) gas Hydrogen Peroxide ($H2O$)	Organics; Biofilms
Surfactants	Various	Organics; Inert Particles

Table1.2: Commonly used chemicals

Membrane bioreactors (MBRs) are a further development of the conventional activated sludge process (ASP), where the secondary clarifier is replaced by a membrane filtration. Membranes with pore sizes of 0.1–0.4mm are typically used. One advantage of this process is the complete removal of suspended solids (SS), including bacteria. However, the pore sizes of the membranes are too large to separate single molecules or ions. As the MLSS (mixed liquor suspended solids) is independent of the sedimentation behaviour of the sludge, it can be increased significantly.

Two main configurations of MBRs can be established. At the so called immersed or submerged membranes, the fouling control is achieved by an air scour at the membrane surface by an additional coarse bubble ―cross flow‖ aeration. The necessary shear velocity is caused by the movement of the bubbles close to the membrane surface. This kind of membrane is applied in municipal and industrial wastewater treatment and can be placed either inside the aeration tank or in an external filtration tank. At tubular side stream membranes, the fouling control is achieved by a high water velocity across the filtration channel. This configuration is used for industrial wastewater treatment only.

Design of MBRs :

As the MBR is an activated sludge process, the same generally accepted design regulations for the conventional ASP can be applied for MBR design. The F/M-ratio is one, or the key, design parameter and as high MLSS can be achieved the resulting tank volumes are smaller. The aeration equipment has to be adapted to the resulting high specific volumetric oxygen rates.

The hydraulic load and the achievable flux are the key parameters for the design of the membrane surface, whereby the membranes have to permeate the maximal flow. As membranes are still a relevant expense factor, strategies to avoid or cut peak flows might pay off.

For the design of the configuration, maintenance and membrane cleaning facilities, it is important to specify the type of membrane and membrane module as early as possible. Overall, in MBRs the automation level is higher compared to conventional wastewater treatment plants due to back flush, cleaning procedures, etc.

Pre-treatment :

The wastewater needs to be carefully pre-treated before entering the MBR plant and there must not be any emergency bypass, so that only pre treated wastewater will enter Figure 1 Options of membrane configurations P. Cornel and S. Krause 38.

It is advisable to remove abrasive or sharp edged materials which can damage the membranes, as well as fibers or hairs which can clog the membrane (modules), and lead to a dramatic and rapid decrease of the flux. Screens, or even better sieves, with mesh sizes ,0.5 mm have proved suitable . Further, a grease trap should be installed, because oil and grease may influence the flux of the membranes negatively. The hydraulic equalisation is of importance, because the costly membrane surface has to be designed according to the maximum inflow.

Aeration tank :

General.

The use of membranes to separate the biomass leads to some changes in the design and operation of the plant. As already mentioned, the MLSS in MBRs can usually be raised to approximately 10 to 15 g/L for immersed membranes and up to 30 g/L for tubular side stream membranes.

The aeration tank design is (as in the conventional ASP process) based on the load (F/M-ratio). Higher MLSS and similar F/M as in conventional activated sludge plants result in smaller aeration tank volumes. However, a minimum hydraulic retention time (HRT) should be observed, at least 4 h in municipal MBR.

Recirculation.

The filtration leads, locally, to an increase of the sludge concentration whereby the sludge needs to be returned to the aeration tank. In case of configuring the membranes inside the aeration tank, the mixing due to the oxygen input and the fouling control by coarse bubbles is usually sufficient. If the membranes are located outside of the aeration tank, in general, a recycle rate of 4 to 5 is sufficient.

Sludge production.

Our experiences with a municipal MBR show that the surplus sludge production is in the same range as conventional ASP plants. Furthermore, it can be shown that MBR can be simulated by the activated sludge model ASM 1 and ASM 3 , both by IWA. Thus, in principal, the biodegradation of organic compounds does not differ from conventional plants.

Sludge characteristics and oxygen transfer.

The sludge characteristic differs from conventional activated sludge, mainly due to the higher MLSS. The sludge viscosity increases with increasing MLSS. The viscosity of the MBR sludge is non-Newtonian, i.e. it decreases at higher shear stress. The higher viscosity may lead to a lower a-value (¼ ratio of the aeration coefficient kLa under process condition to the clean water aeration coefficient) which is approximately 0.5 ^ 0.1 at MLSS content of approximately 12 g/L. a-values of two municipal full scale MBRs are shown. It is obvious that the a-value decreases at increasing MLSS.

Membranes.

The design of the membranes surface area is important for economic efficiency. The flux depends on the membranes, the modules, the trans membrane pressure, the wastewater composition and on fouling/scaling. For the design, the net flux is the important parameter which characterises the overall flow rate including breaks and back flushes. For industrial wastewater in general, pilot tests have to be performed. The resulting flux is often as low as 8 –15 (20) L/(m2 h) for immersed membranes and up to 120 L/(m2 h) for tubular membranes.

Fouling can be controlled by reducing the flux, which results in higher membrane surface area and higher energy demand, by increasing the crossflow resulting in higher energy demand again and/or regular cleaning of the membranes.

Membrane cleaning :

The membranes require regular cleaning to remove membrane fouling and keep the flux/- pressure (or permeability ¼ flux divided by the pressure in L/(m2 h bar)) loss in a given range. Overall, different cleaning procedures have been established and will be described in the following :

backwash with permeate: ―in situ‖, automatically every few minutes mainly; hollow fibre membranes only

chemical enhanced backwash: ―in situ‖ or ―on air‖; chemicals such as acids or oxidizing agents; automatic control mode, e.g. daily

maintenance cleaning: ―in situ‖, ―ex situ‖ or ―on air‖; chemicals such as NaOCl, citric acid (0.5%) etc.; e.g. weekly

intensive cleaning: ―ex situ‖, e.g. different chemicals, 35 8C, 1–2 times per year

Typical chemicals used for cleaning are acids such as nitric, sulphuric, hydrochloric acids or weak acids such as citric acid to remove scaling, and oxidizing agents Cleaning specific terms for immersed membranes , a-values in dependence of MLSS for municipal full-scale MBRs sodium hypochlorite or peroxide, eventually in combination with caustic soda, to adjust the pH.

Frequency, as well as type and concentration of chemicals, depend strongly on wastewater composition, membrane and module type and are not standardised so far. In contrast, cleaning strategies are a focus of research with regard to avoiding the use of chlorinated products (AOX-formation) and to reduce the so-called ―aging‖ of membranes caused by the use of oxidizing chemicals which corrode the membranes. Some commercial agents with unknown formula are also offered.

Energy demand:

The energy demand of MBRs is higher compared to conventional AS systems, mainly due to the additional energy demand for fouling control. Immersed membranes require approximately 0.4 –1 kWh/m3 for coarse bubble aeration, the energy demand for tubular side stream membranes ranges from 1 to 4 kWh/m3. Air cycling (Zenon), or stacking of the membrane modules, are attempts to use the coarse bubble energy more efficiently. The energy consumption for maintaining the under pressure is almost neglectable with values around 0.01 kWh/m3 depending on the trans membrane pressure. The energy demand for oxygen supply depends on the COD load and on the MLSS, as the a-value is affected (see above). Comparing an MBR with MLSS of 12 g/L and thus a a of 0.5 with a conventional system with an a-value of 0.7, the aeration energy is by the factor of 1.4 (0.7/0.5 ¼ 1.4) higher. For municipal stabilization plants with a typical specific aeration energy demand of 0.3 to 0.4 kWh/m3 thus by 0.12 to 0.16

kWh/m3 higher. Due to high salt content and a wide span of COD concentrations, a value for industrial wastewater applications is not possible.

In wastewater treatment, micro- and ultra-filtration membranes are used for the separation of the activated sludge (biomass) from the treated water. This offers the advantages of a complete removal of solids and bacteria, as well as most of the viruses, namely those attached to the suspended solids. Compared to the conventional activated sludge process (CAS) this technology allows a much higher biomass concentration (MLSS) whereby the reactor volume and the footprint decreases. With increasing MLSS, the viscosity of the sludge increases, which leads to reduced oxygen transfer rates. Depending on the type of membrane and membrane module, the pre-treatment has to be more sophisticated to prevent clogging and sludging of the modules.

Due to fouling and scaling, the flux through the membranes will decrease with time. The decrease depends on the water quality as well as on the measurements taken to minimize fouling. Mainly, three strategies are available: lowering the flux, increasing the ―crossflow‖ and cleaning of the membranes. Different strategies including backwash and chemical cleaning ―*in situ*‖, ―on air‖ and ―*ex situ*‖ can be applied. It has been proven more effective to apply preventive regular cleaning.

Besides the energy demand for oxygen supply – which is typically in the range of 0.3 kWh/m^3 for municipal wastewater – the energy for fouling prevention is substantial. Immersed membranes need approximately 0.4 to 1 kWh/m^3 for the coarse bubble aeration, whereas tubular modules require 1 to 4 kWh/m^3 pump energy.

MBRs will be used in future wherever high quality effluent is required, because of a sensitive receiving water body or due to the fact of water reuse as process water. MBRs are a perfect pre-treatment in industrial applications when further treatment with nanofiltration or reverse osmosis is considered.

The technique is advanced and can be applied both in municipal and industrial wastewater treatment. Higher operational costs must be balanced by superior effluent quality (table 1.1).

Process	Phenol inlet (mg.l^-1)	Phenol removal (g)	COD Intel(mg.l-1)	COD removal (g)
Electrochemical	1520	>90	1475-6545	35-15
Electro-coagulation	nd	nd	4850	52
UASB reactors	nd	nd	5000	70
CAC reactors	720-1420	70-74	10256-26211	32-65
Fungal laccase	3700	65	43000	5.3
Pleurotus	3400	69-76	140000	nd
MBR	5410	>92	1500-5300	81-87

Table: 1.3 Different chemicals removal amount using different wastewater treatments

Industrial MBRs − food and beverage sector :

The food and beverage (F&B) sector produces both finished products for consumption and intermediate products destined for further processing.

The sector is diverse and includes dairy, maltings, breweries, distilleries, wineries, soft drinks, cereals, potato chips, salads and produce, coffee, confectionery, edible oils, meat and poultry processing and various other prepared foods.

The sector is heavily reliant on good quality water, which is the principal ingredient in all beverages and a number of foods. However, most water is used for ancillary processes including washing, cooling, heating, cooking and conveying, plus cleaning and sanitising of equipment and to provide site utilities.

Food and beverage effluent characteristics :

Effluent generated in the F&B industry is typically high in organic loading, with BOD and COD concentrations that can be 5−100 times higher than for domestic wastewater.

The TSS also varies from negligible to very high concentrations, and may contain FOG (fats, oils and grease), e.g. from meat, fish, dairy and vegetable oil production. They may also contain high levels of ammonia and/or phosphorus if large quantities of phosphoric acid are used in the process, such as for vegetable oil de-gumming or cleaning operations. Equally, some F&B

wastewater can be deficient in N and P and require nutrient balancing. However, they are generally readily biodegradable with COD/BOD ratios ranging from ~0.4−0.5 for bakery products to >0.8 for poultry processing.

Membranes use in the food and beverage sector :

Membranes use in the F&B industry predates MBRs, having been used for process waters rather than effluent treatment. The implementation of membranes and in particular MBR technology for industrial effluent treatment has only occurred since the mid−late 1990s. Market penetration has followed the same pattern as for municipal wastewater for much the same reasons − declining MBR costs, increasing freshwater supply costs, increasingly stringent legislation, improved technology design and reliability, and spatial restrictions, among others.

Industrial MBRs − petroleum sector :

The petroleum industry comprises three elements: exploration, refining, and petrochemical, where refining and petrochemical production may be combined. Exploration concerns the abstraction of mineral oil and gases from underground reservoirs, which generates produced water (PW) as the main effluent. Refining mainly concerns the separation of the crude oil into useful fractions, and petrochemical operations are those involving chemical modification of these fractions into further products. It is only in the latter two areas that MBRs have been implemented, the largest industrial MBRs installed worldwide being associated with refining.

Treating refinery wastewater :

Refinery wastewater quality varies significantly according to the process cycles. Its treatment is generally based on classical activated sludge treatment, usually with an initial flotation sequence to remove the oil.

The simplest flotation device is the American Petroleum Institute (API) separator, the 'workhorse' in any refinery for the separation of oil/water and solids, which allows both settlable solids and large oil droplets (>150 µm) to be removed by up to 90%. This primary step is then often followed by clarification. This may comprise corrugated plate separators preceded by coagulation/flocculation and followed by either dissolved air flotation (DAF) or induced gas/air flotation (IGF/IAF). These technologies target much smaller oil droplets − 10-25 µm − and reduce the suspended oil concentration to around 25−50 µm.

Flotation, along with the increasingly employed electro-coagulation process, is most effective (in terms of % removal) for high suspended oil concentrations, such as those arising in the desalter effluent. Such effluents, along with the spent caustic, also have a considerably higher salt content than the remaining effluent streams.

It is therefore desirable to treat these three streams separately from the remaining low-TDS streams to allow both pre-treatment for oil removal and segregated biological treatment of high-TDS effluent. Since segregation is rarely employed, significant shock loads arise in refinery effluents from dissolved salt and oil, in particular from sub-optimal electrical coalescence (grid technology) or intermittent discharge of the mud wash from the desalter.

Electrocoagulation:

Electrocoagulation (EC) is a technique used for wastewater treatment, wash water treatment, industrially processed water, and medical treatment. Electrocoagulation has become a rapidly growing area of wastewater treatment due to its ability to remove contaminants that are generally more difficult to remove by filtration or chemical treatment systems, such as emulsified oil, total petroleum hydrocarbons, refractory organics, suspended solids, and heavy metals. There are many brands of electro coagulation devices available and they can range in complexity from a simple anode and cathode to much more complex devices with control over electrode potentials, passivation, anode consumption, as well as the introduction of ultrasonic sound, ultraviolet light and a range of gases and reactants to achieve so-called Advanced Oxidation Processes for refractory or recalcitrant organic substances.

Treatment of wastewater and wash water by EC has been practiced for most of the 20th century with increasing popularity. In the last decade, this technology has been increasingly used in the United States, South America and Europe for treatment of industrial wastewater containing metals.[3] It has also been noted that in North America EC has been used primarily to treat wastewater from pulp and paper industries, mining and metal-processing industries. A large one-thousand gallon per minute cooling tower application in El Paso, Texas illustrates electrocoagulations growing recognition and acceptance to the industrial community. In addition, EC has been applied to treat water containing foodstuff waste, oil wastes, dyes, output from public transit and marinas, wash water, ink, suspended particles, chemical and mechanical polishing waste, organic matter from landfill leachates, defluorination of water, synthetic detergent effluents, and solutions containing heavy metals.

Coagulation is one of the most important physio-chemical reactions used in water treatment. Ions (heavy metals) and colloids (organic and inorganic) are mostly held in solution by electrical charges. The addition of ions with opposite charges destabilizes the colloids, allowing them to coagulate. Coagulation can be achieved by a chemical coagulant or by electrical methods. Alum [$Al_2(SO_4)_3 \cdot 18H_2O$] is such a chemical substance, which has been widely used for ages for wastewater treatment. The mechanism of coagulation has been the subject of continual review. It is generally accepted that coagulation is brought about primarily by the reduction of the net surface charge to a point where the colloidal particles, previously stabilized by electrostatic repulsion, can approach closely enough for van der Waals forces to hold them together and allow aggregation. The reduction of the surface charge is a consequence of the decrease of the repulsive potential of the electrical double layer by the presence of an electrolyte having opposite charge. In the EC process, the coagulant is generated *in situ* by electrolytic oxidation of an appropriate anode material. In this process, charged ionic species—metals or otherwise—are removed from wastewater by allowing it to react with an ion having an opposite charge, or with floc of metallic hydroxides generated within the effluent.

Electro coagulation offers an alternative to the use of metal salts or polymers and polyelectrolyte addition for breaking stable emulsions and suspensions. The technology removes metals, colloidal solids and particles, and soluble inorganic pollutants from aqueous media by introducing highly charged polymeric metal hydroxide species. These species neutralize the electrostatic charges on suspended solids and oil droplets to facilitate agglomeration or coagulation and resultant separation from the aqueous phase. The treatment prompts the precipitation of certain metals and salts. In its simplest form, an electro coagulation reactor is made up of an electrolytic cell with one anode and one cathode. When connected to an external power source, the anode material will electrochemically corrode due to oxidation, while the cathode will be subjected to passivation.

An EC system essentially consists of pairs of conductive metal plates in parallel, which act as monopolar electrodes. It furthermore requires a direct current power source, a resistance box to regulate the current density and a multimeter to read the current values. The conductive metal plates are commonly known as "sacrificial electrodes." The sacrificial anode lowers the dissolution potential of the anode and minimizes the passivation of the cathode. The sacrificial anodes and cathodes can be of the same or of different materials. The arrangement of monopolar electrodes with cells in series is electrically similar to a single cell with many electrodes and interconnections. In series cell arrangement, a higher potential difference is required for a given current to flow because the cells connected in series have higher resistance. The same current would, however, flow through all the electrodes. In contrast, in parallel or bipolar arrangement the electric current is divided between all the electrodes in relation to the resistance of the individual cells, and each face on the electrode has a different polarity.

During electrolysis, the positive side undergoes anodic reactions, while on the negative side, cathodic reactions are encountered. Consumable metal plates, such as iron or aluminum, are usually used as sacrificial electrodes to continuously produce ions in the water. The released ions neutralize the charges of the particles and thereby initiate coagulation. The released ions remove undesirable contaminants either by chemical reaction and precipitation, or by causing the colloidal materials to coalesce, which can then be removed by flotation. In addition, as water containing colloidal particulates, oils, or other contaminants move through the applied electric field, there may be ionization, electrolysis, hydrolysis, and free-radical formation which can alter the physical and chemical properties of water and contaminants. As a result, the reactive and excited state causes contaminants to be released from the water and destroyed or made less soluble.It is important to note that electrocoagulation technology cannot remove infinitely soluble matter. Therefore, ions with molecular weights smaller than Ca^{+2} or Mg^{+2} cannot be dissociated from the aqueous medium.

Careful selection of the reaction tank material is essential along with control of the current, flow rate and pH. Electrodes can be made of iron, aluminum, titanium, graphite or other materials, depending upon the wastewater to be treated and the contaminants to be removed. Temperature and pressure appear to have only a minor effect on the process.In the EC process the water-contaminant mixture separates into a floating layer, a mineral-rich flocculated sediment, and clear water. The floating layer is generally removed by means of an overflow weir or similar removal method. The aggregated flocculent mass settles either in the reaction vessel or in subsequent settling tanks due to gravitational force.Following removal to a sludge collection tank, it is typically dewatered to a semi-dry cake using a mechanical screw press. The clear, treated (supernatant) water is typically then pumped to a buffer tank for later disposal and/or reuse in the plant's designated process.

Influence on temperature and pH variations on the performance of the system:

The initial temperature of the stick water received for processing is typically about 45 – 47o C. When diluted (and at this stage all our experiments involved batch processing only) the temperature drops to typically 27 – 29o C. Temperature measured at the outlet of the electrocoagulation chamber is typically about 30o C. The temperature of the incoming stick water varies during the day and depends on the particular operation currently taking place in the rendering plant. There are also temperature variations experienced through the seasonal temperature fluctuation. These relatively small temperature variations have been found to have no practical bearing on the performance of the system. The experience from other electrocoagulation applications suggests the same conclusion of the temperature variations being of no particular importance.

Problem Statement:

The need for small scale domestic wastewater treatment plant increases, due to the scarcity or shortage of water availability, high level of domestic waste discharge into surrounding walls due to increase of population day by day, which increase the load on treatment plant coupled with lack of compliance to health, safety and environmental policy. These have led to the loss of lives and properties including aquatic lives. Hence the wastewater treatment plant is needed to make the wastewater useful to the environment.

SCOPE OF THE PROJECT:

Performance of state owned sewage treatment plants, for treating municipal waste water, and common effluent treatment plants, for treating effluent from small scale industries, is also not complying with prescribed standards. Thus, effluent from the treatment plants, often, not suitable for household purpose and reuse of the waste water is mostly restricted to agricultural and industrial purposes complying with prescribed standards. Thus, effluent from the treatment plants, often, not suitable for household purpose and reuse of the waste water is mostly restricted to agricultural and industrial purposes.

Water recovery and reuse, motivated primarily by cost savings, water scarcity (and regulatory requirements relating to water conservation), security supply, and, strategic corporate planning. Key issues surrounding the water recycling in the sector concern the maintenance of hygiene and food safety standards using effective control measures. Since effluent reuse plants based on the two-stage electrocoagulation−RO within the sector have been established since the early noughties, the initial reticence associated with water recycling has now largely been replaced with widespread acceptance. A final disinfection stage (chemical and/or UV) is normally sufficient to meet the required strict quality assurances for treated water reuse in the F&B sector. The aim of this research is to share the experiences with the MBR process, to elaborate the differences to the conventional activated electro coagulation process and to present a possible technical solution for the design of the electrocoagulation−RO process.

OBJECTIVE OF THE PROJECT:

This project is designed to provide a comprehensive study to establish guidelines for this application.

The objectives of the project are as follows:

- To identify conditions under which a certain number of wastewaters can be connected to a single small-scale wastewater treatment plant (economical, technical& social ability).
- To design a model for this wastewater treatment plant.
- To make wastewater into reusable.
- To reduce the load on the treatment plant.
- Reduce water-borne disease and acidic nature of water.
- To enhance aquatic lives.
- To identify conditions under which a certain number of wastewaters can be connected to a single small-scale wastewater treatment plant (economical, technical& social ability).
- To investigate the influence of operational parameters in decolourisation of plastic dyeing waste water.
- To develop an electrode for electro-coagulation process to achieve less applied current and operation cost.

OUTCOME OF THE PROJECT :

- After performing the electrocoagulation test on the color dye water it has been observed that the CRE% was different for different electrodes.
- Among these three electrodes i.e., Fe,Al,TiO_2/Al the result was more in TiO_2/Al electrodes.

- At TiO_2/Al electrode the dye removal was up to 74.23 to 96.85%.
- The rest dye present in water can be removed using reverse osmosis technique.

2. LITERATURE REVIEW

1. **Poonam Barge 1 (2014)**, The wastewater temperature has a decisive on the biological processes of wastewater treatment and thus on SRT and OUR. It has been clear from the above expression that as the temperature of wastewater increases there is a decrease in the absolute value of SRT and OUR, therefore the specific value of aeration tank volume will increase considerably. Also, expressions above regarding the oxygen transfer rate, efficiency, capacity are very important factors in the dimensioning of an activated sludge process plant.
2. **Hassen T. Dorrah (2015),** The goal of most fish farmers is to maximize production and profits while holding labour and management efforts to the minimum. In most pond culture operations, aeration offers the most immediate and practical solution to water quality problems encountered at higher stocking and feeding rates. Aeration means the addition of oxygen to the water. This process is accomplished either by exposing the water to air or by introducing air into the water. In this paper, a new design and sizing of a dissolved air aeration system for aquaculture pond are suggested and control of dissolved oxygen of the aquaculture system is achieved using the FLC technique. The results show the high performance of the control subsystem.
3. **Riya Rose Poly Parambi (2015)**, Aeration was done on sample wastewater at different flow rates of 1.5L/min, 3L/min, and 4L/min. It was found that as flow rates increased the percentage of removal of the above constituents also increased. The period of aeration can also be varied in addition to the airflow rate. Different periods of aeration such as 24 hrs. 48 hrs. 72 hrs. were adopted. The percentage removal of different parameters also varied with the change in the period. It was found that as the period of aeration increases, there was more reduction in the parameters. Optimum removal was possible at a flow rate of 4L/min for a detention period of 72 hours. BOD, COD, Turbidity was found to be removed by 95.88%, 95.71%, and 37.72% respectively.
4. **M. K. Stenstrom And D. Rosso (2010),** Aeration systems are key to the success of any biological process. They consume the most energy of any part of an aerobic process and the potential energy savings warrants close attention to design and maintenance details. The recent work at standardization of methodologies (ASCE standards) has taken a lot of the guesswork out of the design process. A key aspect of any design is its practicality and workability. One does not want to force the plant operators to operate in a certain way or

region because of an inflexible aeration system.

5. **M. Sundin (2010),** In conventional wastewater treatment plants the aeration of the biological treatment process is often one of the largest energy consumers. As a part of making the Kappala wastewater treatment plant (WWTP) in Stockholm Sweden, more energy-efficient a full-scale optimization experiment of the dissolved oxygen (DO) control in the aerobic tanks has been performed. In the strategy tested, each aerated zone was separately controlled and the spatial DO profile changed into a structure that avoids unnecessarily high DO levels. By using ammonium- and DO- feedback controllers the strategy became more sensitive to changes of influent load. The strategy gave a reduction of the total airflow of 18% and with preserved treatment efficiency. a modified version of this strategy has then been implemented to the plant as the conventional DO control system and the results are similar to those in the preceding experiments.
6. **Ibrar Zahid et. At. (2016),** the Reduction of water elements concentration in domestic wastewater by using kikar charcoal and rice husk and activated carbon material filters more impurities such as COD, TDS, TSS, Turbidity, and colour than the kikar charcoal.
7. **Revathi H U and Sadashiva Murthy B M (2016),** Domestic wastewater is treated by laying non-woven geotextile layered filter media removes maximum impurities like COD, TDS, BOD, and also it provides more flexibility and control of degradation than the normal sand filters 2016**.**
8. **Islamuddin Imran Ahmad Nusrat Ali Neha Muntaz (2016),** Domestic wastewater contaminants are treated by using multimedia filter process with low- cost natural adsorbent materials such as activated carbon, sugarcane bagasse and wheat husk it removes more contaminates like BOD, COD, TSS, Turbidity, TDS, Alkalinity and hardness than the single media filter process and it is also economical.
9. **Neena Sunny, Smruthi Krishna, Devika Ghosh, Dias George, Aswin Kumar M. S. (2019),** Domestic wastewater is treated by preparing two multimedia filters beds by using natural absorbance first one made with laterite soil and activated carbon and another one with sawdust and sugarcane bagasse. The second multimedia filter was found to the most effective with high percentage removal of COD.
10. **Kiran Kumar, Sachin S. Patavardan, Sarita Labo, And Rechard Gonsalves (2018),** Removal of cupric ions(copper) from wastewater by using dried orange peel and by maintaining proper pH, temperature, concentration and dosage of dry orange peel for

removing copper. After the study, it was absolved, that the orange peel is best for removal of copper from the wastewater.

11. **Hassan Hans Badreddine (2004),** A wastewater treatment plant includes a treatment chamber or reactor containing a plurality of buoyant sludge carriers. In the base of the treatment, the chamber is a biofilm collection chamber is a hollow shaft with an air injection device arranged at the foot thereof. In use, wastewater is the introduction into the treatment chamber through an inlet and is caused to circulate the treatment chamber through the pumping action of the shaft and air injector. Treated was passes through the biofilm collection chamber to an outer settlement chamber having an outlet for treated water.
12. **Jeevan B Gowda; G Aishwarya, B A Kanchan Garg (2018),** The study has been proposed to modelling and design of wastewater treatment plant for households. The steps include a collection of grey water, designing, settling up the plant, using methods of treatment such as sedimentation, filtration aeration. After treating necessary tests conducted according to BIS. The result of the tests on different parameters being within the permissible limits according to CPCB. The treated water is fit reuse for flushing, street cleaning, irrigation& other non-portable uses.It reduces the load on STPS and increases its working efficiency.
13. **Tanveer Mehedi Adyel, Syed Hafizur Rahman, Mohammad Moniruz Zaman, Hossain Md. Sayem, Mala Khan, Md. Abdul Gafur, and S. M. Nazrul Islam (2013)** : Has used effluents of disposal from Electro-Coagulated Metal Hydroxide (EMHS) as a partial substitute of clay in the manufacturing of construction building materials like Building Blocks. Different number of batches of normal and pressurized building blocks (NBBS and PBBS;) were prepared using up to 50% EMHS with clay and heated at a particular temperature. EMHS proportion in the mixture and firing temperature were two main factors determining the quality of Building Block. There were no deformation or uneven surfaces in Building blocks at any of the examined heating temperature. More weight loss and shrinkage of Building Block were noticed at higher heating temperature and EMHS proportion. Higher compressive strength and lower water adsorption were found at lower EMHS content and higher firing temperature.
14. **E-S. Z. El-Ashtoukhy, A.A. Mobarak and Y. O. Fouad (2016)** : Used a recycle batch reactor (RBR) with aluminium electrodes, in which the efficiency of electrocoagulation to treat reactive blue 19 dye effluent was investigated. In a cell an anode consisting of an array of horizontal aluminium cylinders embedded between an upper and a lower aluminium

screen cathode. The inner side of these tubes are used as a heat exchanger to control the reaction temperature if needed. The efficiency of color and COD removal depends on different parameters, such as current density, flow rate, initial dye concentration, electrolyte concentration and pH were noted. By increasing the current density and the electrolyte concentration the efficiency of color and COD removal increases. Inversely, a higher flow rate and a higher initial dye concentration decreased the removal rate. The pH of the waste needed to be neutral or nearly neutral to accomplish a high efficiency. A color removal of 97.4% and COD removal of 93% were achieved under optimum operating conditions.

15. **Guohua Chen and Yung-Tse Hung (2008)** : has done electrochemical treatment process in treating wastewaters from textile, catering, petroleum, tar sand and oil shale wastewater, carpet wastewater , municipal sewage, chemical fibre wastewater, oil–water emulsion, oily wastewater clay suspension, nitrite, and dye stuff from wastewater. Arrangement of the Electrodes Usually, an anode is installed at the bottom, whereas a stainless steel screen cathode is fixed at 10–50 mm above the anode, Fig. Experimental investigations focus mostly on the behaviours of anodic materials, the effect of cathodic materials was not investigated extensively, although, Azzam et al. have found a considerable influence of the counter electrode material in the anodic destruction of 4-Cl phenol. Direct Anodic Oxidation EO of pollutants can also occur directly on anodes by generating physically adsorbed «active oxygen» or chemisorbed (active oxygen) . This indicates that effective oxidation of pollutants on these anodes occurs only at very low current densities or in the presence of high concentrations of chlorides or metallic mediators.

16. **Markandeya, S.P. Shukla and D. Mohan (2017)** : observed that the pH of the solution had immense bearing on the rate of decomposition when a non-biodegradable azo dye orange II was effectively mineralized with iron and hydrogen peroxide. Some drawbacks can also be associated with membrane separation as it cannot be easily staged and fails to operate at above room temperature. Coagulation helps to overcome the factors that promote the stability of a given system. Coagulation is completed in a very short duration whereas flocculation requires more time to complete. Various researcher primed starch-based polymers by a cross linking reaction of starch-enriched flour using epichlorohydrin as a cross linking agent. One of the most important characteristics of an adsorbent is the quantity of solute it can be accumulated which was usually calculated from the adsorption isotherms. Multi-component adsorption studies of dye systems : Activated carbon Basic blue 41, basic

red 18, remazol reactive yellow, Tea leaves Methylene blue Langmuir and Freundlich isotherm, kinetics Shukla et al. Sawdust Methylene blue Langmuir and Freundlich isotherm, Shukla et al. Cellulose based Methyl violet, amido black 10B Langmuir and Freundlich isotherm Annadurai et al. Langmuir isotherm assumes that the adsorption takes place at specific homogeneous sites within the adsorbent. Linear form of Langmuir isotherm was presented as Example.

17. **Femina Patel, Panchami Patel, Nirali Patel, Sanjay Patel (2014)** : Oxidation process Chemical methods include use of oxidizing agents such as ozone, hydrogen peroxide and permanganate to change the chemical composition of compound or group of compounds. Oxidation methods may differ in the way in which hydrogen peroxide is activated. Ozone is recognized widely because of its high reactivity and good removal efficiencies with dyes but it is also been reported that ozone is not efficient with non-soluble disperse and vat dyes which react slowly and take longer reaction time, advanced oxidation process using an H2O2/Ultraviolet system is an emerging technology for handling large volumes of textile wastewater. In the coagulation process chemicals are dispersed in wastewaters rapidly, thus changing the characteristics of the particles which are suspended in the dye wastewater so that they aggregate to form flocs that settle down rapidly. Most methods are non-destructive and just transfer the organic pollutants from water to another phase, thereby causing secondary pollution. All the methods have their own advantages and dis-advantages, therefore their selection will be predicted based on characteristics of wastewater like type and concentration, pH, toxic compounds and salinity. The most common combination is that of biological oxidation and physical-chemical treatment methods.
18. **N.Dharmesvar (2005)**:optimised electro coagulation techniques to remove color from C.I Basic Red 46 (BR46) and C.I Basic Blue 3 (BB3).These dyes are used in a blanket factories. they utilized iron and steel plates as anode and as cathode.In each run 250 ml of dye solution was decanted into the electrolytic cell, by applying optimun current densities of 60-80 A/m2 could remove high percentage of colour from dye solution .80% COD reduced from dye solution by adding NaCl in this EC process.
19. **H.Chenik(2013)**: studied the efficiency of electrocoagulation or electroflotation in removing colour from real textile wastewater by using aluminum and iron electrodes in an innovative pilot external-loop airlift reactor of 150 L. The reactor was designed to operate in batch and

continuous modes. The real effluent contained 90% of disperse dye and 10% of reactive dye. The treatment of these discharges was easy using electrodes of iron rather than aluminum. The optimal initial pH was 10 for both aluminum and iron electrodes. By using iron electrodes, the maximum decolourisation efficiency and COD reduction efficiency reached respectively 96% and 65 % for 90 minutes of treatment during the treatment.

20. **S.M.D Islam (2016)** Study was done to investigate the water quality of Shitalakya river for phytoplankton abundance, diversity and the effect of pollutants on the phytoplankton growth well as the primary productivity. The water collected was mostly alkaline with ph 7.01-8.2 and when electricity is passed through it to Electric conductivity there was a Fluctuation of the pH.And it has been found that pollutants in water effect the phytoplankton diversity and the ecosystem.
21. **Deepak Pant and Lakhveer Singh (2020)**:study says about the contaminants removal from pharmaceutical wastewater by electro coagulation process. This contaminats are threat for human health and the environment.The pharmaceutical wastewater poses high COD concentration ranging from 4,014 to 40,000 mg/L and high sanity. Using electro coagulation contaminates were removed from pharmaceutical water up to 72% for COD reduction and improvement of BOD: COD proportion by 0.18 to 0.3. The colloidal pharmaceutical contaminaants were removed from water by Electro coagulation process in form of floc because of the cathodic reaction.
22. **Luba and Lech(2020):** study says about the process of industrial-type wastewater purification carried-out through continuous anodic dissolution of aluminum alloy sacrificial anode for artificially aerated Cu-Al alloy galvanic (macro-corrosion) cells and synthetically prepared wastewater solutions. Electrochemical experiments were performed by means of a laboratory size electrolyzer unit, where the electrocoagulation process along with surface-induced electrooxidation phenomena were examined for wastewater containing Acid Mixture and Disperse Red 167 dyes in the process.
23. **Kim et al., 2002)**. They investigated the effects of different operating parameters including current density, number of electrodes, electrolyte concentration, electrode gap, dye concentration, pH of solution, and the inlet flow rate on decolourisation using the continuous electrocoagulation process.However, the removal mechanism has not been considered in the study by the authors. The results showed that removing dye using Al electrodes was more efficient than Fe electrodes. It is because of low absorption capacity of ferrous ions which is

caused by the iron sacrificial anode. Also, the power consumption for electrocoagulation increased proportionally when the current density,electrode gap, and concentration of electrolyte in the solution were increased. The dye removal efficiency was reported to be between 60 and 98.5%

24. **Int. J. Electrochem. Sci., Vol. 13, (2018)**...He introducedApplication of Modified Electrocoagulation for Efficient Color Removal from Synthetic Methylene Blue Wastewater forDyes are used extensively in textiles, printing, paper making, food processing and other industries, as well as everyday life. Consequently large quantities of dye-containing wastewater are produced throughout the world [1]. For instance, it has been reported that about 12% of synthetic dyes are used for textiles and of this 20% will be released into the ecosystem, with toxicity to microorganisms and humans [2]. Most of these dyes are contain the structures of benzene ring and azo, which are resistant to degradation [3]. The major characteristics of many of the industrial dye wastewaters are high organic concentration, strong color, high-salt content and low biodegradability and removal rate [4, 5]. The release of dyes into water bodies is highly undesirable, resulting in reduced photosynthetic activity [6]. Accordingly, it is essential to develop effective methods for removal of color and toxicity prior to discharge.Biological processes may be used for treatment of dye contaminated effluents but dyes tend to inhibit bacterial development [5]. Other processes, such as coagulation and adsorption [7, 8], photocatalytic degradation [2, 9, 10] and ozone oxidation [11, 12], micro-electrolysis [13, 14], advanced biological oxidation [8] and membrane separation technology [15, 16] have also been developed to treat this wastewater. However, these approaches have significant disadvantages, such as relatively high costs and the production of large amounts of enriched sewage mud.
25. **William Perren, Arkadiusz Wojtasik, and Qiong Cai(2013)-**The EC reactor was run for 60 min with water property measurements taken at every 5 mininterval from 0 to 20 min, then followed by further sampling at 30, 45, and 60 min. Temperature and conductivity we recontinually monitored using a Mettler Toledo Five Easy Plusconductivity meter (calibrated using 0.1 g/L of KCl calibrating solution). pH was measured at each interval using ±0.5accuracy pH indicator sticks (Fisher Scientific). Current andvoltage readings were taken from the power supply readout ateach sample time.As EC progressed, the wastewater analogue became visiblymore turbid due to the formation of a polymeric floc structurethought to be Al(OH)3. Mixing at 60 rpm dispersed these flocsrelatively easily

throughout the vessel, and some microbeadswere visibly seen attached to the flocs. After 16 h settlement followed the EC process, the contents of the reactor settled.The formed floc blanket sank to the bottom of the reactor and took with it most of the contained microbeads. The remaining liquid bulk was visibly more clear and free of microbeads compared to that of the original samples.The removal of microbeads was tracked by taking samplesfrom the reactor during the EC operation. A representative 20mL of sample was extracted from the bulk of the liquid by a 20mL plastic syringe. The samples then underwent gravityfiltration through Grade 1 Whatman filter papers and thenwere dried at 20 °C for 16 h. The number of microbeads, Nt,for each dried sample was counted. The estimated bulkconcentration for the particle diameter.

26. **F. Ihan, M. Gonnulu(2008)-**In this paper, treatment of leachate by electrocoagulation (EC) has been investigated in a batch process. The sample of leachate was supplied from Odayeri Landfill Site in Istanbul. Firstly, EC was compared with classical chemical coagulation (CC) process via COD removal. The first comparison results with 348 A/m2 current density showed that EC process has higher treatment performance than CC process. Secondly, effects of process variables such as electrode material, current density (from 348 to 631 A/m2), pH, treatment cost, and operating time for EC process are investigated on COD and NH4-N removal efficiencies. The appropriate electrode type search for EC provided that aluminum supplies more COD removal (56%) than iron electrode (35%) at the end of the 30 min operating time. Finally, EC experiments were also continued to determine the efficiency of ammonia removal, and the effects of current density, mixing, and aeration. All the findings of the study revealed that treatment of leachate by EC can be used as a step of a joint treatment.

27. **Vanitha Katheresan, Jibrail Kansedo, Sie Yon Lau(2001)-**Efficiency of Various Recent Wastewater Dye Removal Method Dye effluents released from numerous dye-utilizing industries are harmful towards the environment and living things. Consequently, existence of dye effluent in environmental water bodies is becoming a growing concern to environmentalists and civilians. A long term sustainable and efficient dye effluent treatment method should be established to eliminate this issue. Dye wastewater should be treated first before release to minimize its negative impacts towards the environment and living things. However, due to lack of information on efficient dye removal methods, it is difficult to decide on a single technique that resolves the prevailing The textile industry (54%) releases

the highest amount of dye effluent, contributing to more than half of the existing dye effluents seen in the environment around the world. The dyeing industry (21%), paper and pulp industry (10%), tannery and paint industry (8%) and the dye manufacturing industry (7%) too are known to produce high amounts of dye effluents from various associated processes [32, 85].

3. METHODOLOGY

The process extracting colour dye from plastic waste water is divided into following steps.

1.Preparation of sample:

In the preparation of sample we are using Dye powder (Black CA powder), glass flask, water, weighing machine , glass stirrer.

- In plastic making industry the colour dye is used to make the colourless plastic coloured for the appearance .
- In this process colour dye powder is taken and certain amount of powder is mixed into .
- For the sample preparation 1 liter of water is mixed with the dye powder i.e.,Black CA powder.
- Five samples are used for the testing at different concentrations like 0.1,0.2, 0.3, 0.4 & 0.5.
- 10 grams of dye powder is mixed with 1 liter of water for making 0.1% concentrated dye water.
- 20 grams of dye powder is mixed with 1 liter of water for making 0.2% concentrated dye water.
- 30 grams of dye powder is mixed with 1 liter of water for making 0.3% concentrated dye water.
- 40 grams of dye powder is mixed with 1 liter of water for making 0.4% concentrated dye water.
- 50 grams of dye powder is mixed with 1 liter of water for making 0.5% concentrated dye water.
- Thus, obtained dyes are tested and the chemical and physical properties of the plastic dye water are to be tested and treated .

2. Testing of sample:

- The five samples prepared are tested for knowing the properties like pH, TSS, TDS.
- pH of dye water sample : Here the pH of of the dye water is known using pH meter that is the hydrogen ion concentration of the water is known.
- The pH of the water sample lies between 9-11.

- TSS of the dye water sample : Here the TSS of the dye water sample that is the quantity of Total Suspended Solids present in the water sample is known.
- The TSS of the water sample lies between 50-350 mg/L.
- TDS of the dye water sample : Here the TDS of the dye water sample that is the quantity of Total Dissolved Solids present in the water is known.
- The TDS of the water sample lies between 150-400 mg/L.
- BOD of the dye water sample : Here the BOD of the dye water sample that is the Biological Oxygen Demand of water is known.
- The BOD of the water sample lies between 100-400.
- COD of the dye water sample : Here the COD of the dye water sample that is the Chemical Oxygen Demand of water is known.
- The COD of the water sample lies between 400-1400.
- Thus the properties of the plastic dye water sample are calculated and further treated using Electrocoagulation and Reverse osmosis techniques.

3. Preparation of Electrode:

Electrode:

An electrode is a solid electric conductor that carries electric current into non-metallic solids, or liquids, or gases, or plasmas, or vacuums. Electrodes are typically good electric conductors, but they need not be metals.

Cathode and Anode:

- In an electrochemical cell, reduction and oxidation reactions take place at the electrodes. The electrode at which reduction takes places is called the cathode. Oxidation takes place at the anode.
- Whether an electrode operates as a cathode or anode depends on the direction the cell is operating in.
- If a cell is switched from operating galvanically (i.e. outputting energy like a battery) to electrolysis (energy is input to the cell) then its cathode will become its anode and vice versa.

Standard Electrode diameters:

2.6 mm	(3/32")
3.2 mm	(1/8")
4.0 mm	(5/32")
5.0 mm	(3/16")
6.4 mm	(1/4")

Table5.1: Standard sizes of Electrodes

- Electrodes are supplied in lengths of 350mm (14") and are boxed in 5.0kg (11 lb) plastic, sealed boxes.

Materials of Electrode:

- Some of the most prominent alloys and materials used as electrode materials are copper, graphite, titanium, brass, silver, and platinum.

4. Electrode Model:

- In this experiment we are using three types of Electrodes they are
  1. Fe Electrode
  2. Al Electrode
  3. TiO2/Al electrode.

Aluminium Electrode: Aluminium is a silvery grey metal that possesses many desirable characteristics. It is light, nonmagnetic and non-sparking. It stands second among metals in the scale of malleability, and sixth in ductility. It is extensively used in many industrial applications where a strong, light, easily constructed material is needed. Elemental Aluminium although it has only 60% of the electrical conductivity of copper, it is used in electrical transmission lines because of its light weight. Pure aluminium is soft and lacks strength, but alloyed with small amounts of copper, magnesium, silicon, manganese, or other elements it imparts a variety of useful properties.

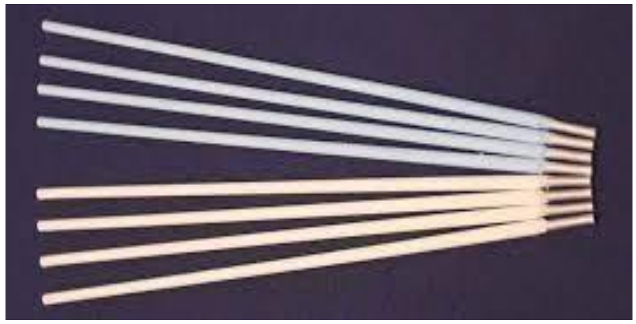


Fig 5.1: Aluminium Electrode

Titanium dioxide coated with Aluminium Electrode: Titanium is a non-ferrous metal with excellent corrosion resistance, good fatigue properties, and a high strength-to-weight ratio. Titanium's excellent corrosion properties result in the use of titanium for electrochemical processes such as electroplating, electrophoresis, electro deposition, electroforming, electro-hydrolysis, electro chlorination, electro fluorination, and electrolysis.

The electrochemical behaviour of a titanium–aluminium hybrid electrode in aqueous solutions of electrolytes containing halide ions (F^- and Cl^-) was studied. The effects of current density, solution composition, and ratio of the working surface area of titanium and aluminum on the anodic dissolution rate of a Ti–Al hybrid electrode and its electrochemical characteristics were revealed. The joint anodic dissolution of aluminum and titanium in the aqueous media under study made it possible to obtain precursors of the highly disperse oxide system Al_2O_3–TiO_2. Data of X-ray and electron-microscopic analysis confirmed the results obtained.

Iron Electrode: Iron is unstable as an oxygen evolution electrode in alkaline media. Thus, relatively expensive nickel-based electrodes are used in industrial alkaline water electrolysis. We show that an iron substrate can be rendered stable and electrocatalytically active for the oxygen evolution reaction by nano-scale surface modification with nickel. The electrocatalytic activity of such a surface-modified iron electrode is comparable to the recently-reported nickel-based catalysts. The electrocatalytic activity is due to a 50-nanometer layer of a high-surface area α-nickel hydroxide on the iron electrode. The nickel modification renders the iron electrode electrically-conductive, prevents dielectric breakdown, and thus endows anodic stability. The electrocatalytic activity is unchanged even after 1000 hours of continuous operation. The temperature of preparation is critical, as excessive dehydration of the hydroxide layer results in nickel ferrite formation and a drastic reduction in electrocatalytic activity. We report significant insight into the surface chemical composition and structure of the catalyst layer by X-ray Absorption Spectroscopy, Photoelectron Spectroscopy, and Transmission Electron Microscopy. Electrochemical kinetics analysis suggests that surface hydroxo-intermediates react with the Hydroxide ions from the solution to evolve oxygen. Thus, the surface-modified iron substrates present an opportunity for improving the performance and reducing the cost of alkaline water electrolysis systems.

Fig 5.2: Iron Electrode

5. Electrolysis Process:

- Electrolysis of water is a popular method used for different applications in various industries, mainly in the food industry, metallurgy, power plants and many others.
- It involves passing an electric current through the water which results in the decomposition of water into hydrogen and oxygen.
- Electrolysis involves the charge carriers, for the current to flow. So, water with a very small amount of ions is a bad conductor of electricity.
- In the electrolysis of water, electrodes are inert solids like Aluminium, Ferrous, Titanium Platinum and etc whereas electrolyte is a solute in a solution and the product is a gas.
- Salts are 100%dissociate into cations and anions in water and hence increase the ionic concentration for increasing conductivity. But the cations and anions from the salt also will be attracted towards the electrodes.
- Salts containing lesser standard electrode potentials than hydrogen and hydroxide ions are suitable for the electrolysis of water.
- Electro-catalysts are substances that accelerate electrochemical reactions without being consumed in the reaction like a catalyst in chemical reactions.

- Catalysts take the reaction through a different path of lower activation energy. High surface area, larger activation centres are the ability of the catalyst in increasing the reactivity.
- The electrolytic cell used for the electrolysis of water is the electrolyzer. Depending on the transporter of the electrolyte, electrolyzer can be divided into three types.,

  1)Polymer Electrolyte Membrane (PEM) Electrolyzer

  2)Alkaline Electrolyzers

  3)Solid Oxide Electrolyzer

Electro Coagulation:

- Electrocoagulation is a process of destabilising suspended, emulsified or dissolved contaminants in an aqueous medium by introducing electrical current into the medium.
- The electrical current provides the electromotive force causing the chemical reactions.
- Electrocoagulation, the passing of the electrical current through water, has proven very effective in the removal of contaminants from water.

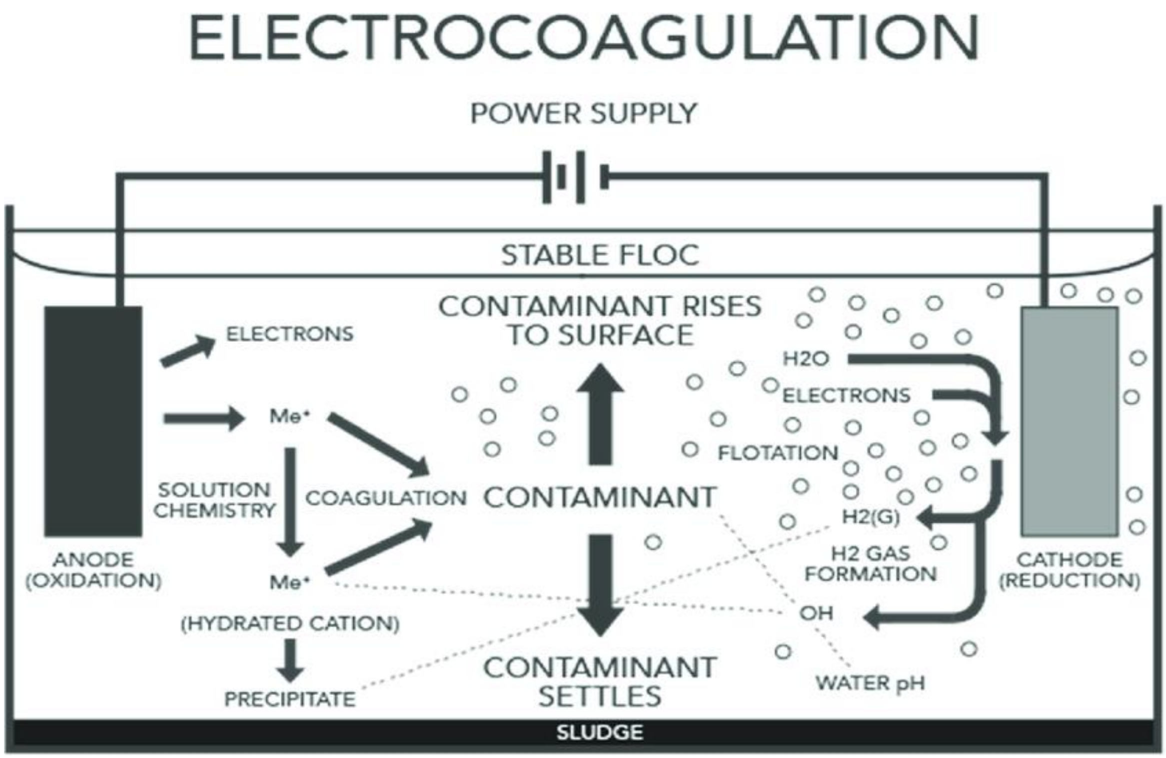


Fig 5.3: Electrocoagulation process

- Electrocoagulation systems have been in existence for many years using a variety of anode and cathode geometries, such as plates, balls, fluidised bed spheres, wire mesh, rods, and tubes.

- Several distinct electrochemical processes occur during the electrocoagulation process independently.
- Some of the electrochemical process occuring
    1. Seeding resulting from the anode reduction of metal ions that become new centres for larger, stable, insoluble complexes.
    2. Emulsion breaking resulting from oxygen and hydrogen ions reacting with emulsified substances and forming water insoluble material.
    3. Halogen completing - as the metal ions bind themselves to halogens resulting in formation of large insoluble complexes and isolating pesticides, herbicides, chlorinated PCBs, etc.
    4. Bleaching by oxygen species produced in the reaction chamber and providing oxidization of chemical substances and also reducing bio-hazards through oxidisation of bacteria, viruses, etc.
    5. Electron flooding of the water affects the polarity of water, allowing colloidal materials to precipitate. The electrons create osmotic pressure rupturing cell walls of bacteria, cysts, and viruses.
    6. Oxidation and reduction reactions are forced to their natural end point. Electrocoagulation can speed up the natural processes occurring in wet chemistry .
- Using Electrocoagulation the induced pH or the intital pH present can be typically shifted towards neutral.
- Advantages of the Electrocoagulation process:
    1. Treats multiple contaminants
    2. Sludge minimization
    3. Capital cost significantly less than conservative technologies
    4. Operating cost significantly less than conservative technologies
    5. Low power requirements
    6. Generally no chemical additions
    7. Low maintenance
    8. Minimal operator attention and
    9. Consistent and reliable results.

After the treated wastewater leaves the electrocoagulation chamber, the destabilised colloids are allowed to flocculate and then separated in an integrated system. The sludge can be further de-watered using a filter press, settling pond, or other de-watering technique.

6. Testing of sample:

- After completion of the electrocoagulation process the samples should once again tested for knowing the properties like pH, TSS, TDS, BOD & COD.
- This test is done after the extraction of the color dye using electrocoagulation process.

7. Reverse Osmosis process:

Reverse osmosis (RO) is a water purification process that uses a partially permeable membrane to separate ions, unwanted molecules and larger particles from drinking water. In reverse osmosis, an applied pressure is used to overcome osmotic pressure, a colligative property that is driven by chemical potential differences of the solvent, a thermodynamic parameter. Reverse osmosis can remove many types of dissolved and suspended chemical species as well as biological ones (principally bacteria) from water, and is used in both industrial processes and the production of potable water. The result is that the solute is retained on the pressurized side of the membrane and the pure solvent is allowed to pass to the other side. To be "selective", this membrane should not allow large molecules or ions through the pores (holes), but should allow smaller components of the solution (such as solvent molecules, i.e., water, H2O) to pass freely.

In the normal osmosis process, the solvent naturally moves from an area of low solute concentration (high water potential), through a membrane, to an area of high solute concentration (low water potential). The driving force for the movement of the solvent is the reduction in the Gibbs free energy of the system when the difference in solvent concentration on either side of a membrane is reduced, generating osmotic pressure due to the solvent moving into the more concentrated solution. Applying an external pressure to reverse the natural flow of pure solvent, thus, is reverse osmosis. The process is similar to other membrane technology applications.

Reverse osmosis differs from filtration in that the mechanism of fluid flow is by osmosis across a membrane. The predominant removal mechanism in membrane filtration is straining, or size exclusion, where the pores are 0.01 micrometers or larger, so the process can theoretically achieve perfect efficiency regardless of parameters such as the solution's pressure and concentration. Reverse osmosis instead involves solvent diffusion across a membrane that is either nonporous or uses nanofiltration with pores 0.001 micrometers in size. The predominant removal mechanism is from differences in solubility or diffusivity, and the process is dependent on pressure, solute concentration, and other conditions.

Reverse osmosis is most commonly known for its use in drinking water purification from seawater, removing the salt and other effluent materials from the water molecules.

History:

Process of osmosis through semipermeable membranes was first observed in 1748 by Jean-Antoine Nollet. For the following 200 years, osmosis was only a phenomenon observed in the laboratory. In 1950, the University of California at Los Angeles first investigated desalination of seawater using semipermeable membranes. Researchers from both University of California at Los Angeles and the University of Florida successfully produced fresh water from seawater in the mid-1950s, but the flux was too low to be commercially viable[4] until the discovery at University of California at Los Angeles by Sidney Loeb and Srinivasa Sourirajan[5] at the National Research Council of Canada, Ottawa, of techniques for making asymmetric membranes characterized by an effectively thin "skin" layer supported atop a highly porous and much thicker substrate region of the membrane. John Cadotte, of FilmTec Corporation, discovered that membranes with particularly high flux and low salt passage could be made by interfacial polymerization of m-phenylene diamine and trimesoyl chloride. Cadotte's patent on this process[6] was the subject of litigation and has since expired. Almost all commercial reverse-osmosis membrane is now made by this method. By 2019, there were approximately 16,000 desalination plants operating around the world, producing around 95 million cubic metres per day (25 billion US gallons per day) of desalinated water for human use. Around half of this capacity was in the Middle East and North Africa region.

In 1977 Cape Coral, Florida became the first municipality in the United States to use the RO process on a large scale with an initial operating capacity of 11.35 million liters (3 million US gal) per day. By 1985, due to the rapid growth in population of Cape Coral, the city had the largest low-pressure reverse-osmosis plant in the world, capable of producing 56.8 million liters (15 million US gal) per day (MGD).

Disinfection:

Post-treatment consists of preparing the water for distribution after filtration. Reverse osmosis is an effective barrier to pathogens, but post-treatment provides secondary protection against compromised membranes and downstream problems. Disinfection by means of ultraviolet (UV) lamps (sometimes called germicidal or bactericidal) may be employed to sterilize pathogens which bypassed the reverse-osmosis process. Chlorination or chloramination (chlorine and ammonia) protects against pathogens which may have lodged in the distribution system downstream, such as from new construction, backwash, compromised pipes, etc.

Disadvantages:

Household reverse-osmosis units use a lot of water because they have low back pressure. As a result, they recover only 5 to 15% of the water entering the system. The remainder is discharged as waste water. Because waste water carries with it the rejected contaminants, methods to recover this water are not practical for household systems. Wastewater is typically connected to the house drains and will add to the load on the household septic system. A reverse-osmosis unit delivering 19 liters (5.0 U.S. gal) of treated water per day may discharge between 75 and 340 liters (20 and 90 U.S. gal) of waste water daily.[30] This has a disastrous consequence for mega cities like Delhi where large-scale use of household RO devices has increased the total water demand of the already water-parched National Capital Territory of India.[31]

8. Membranes:

- Most commonly used RO membranes are typically composed by a thin film composite membrane consisting of three layers: a polyester support web, a microporous polysulfone interlayer and an ultra think polyamide barrier layer on the top surface.
- Thin film composite membranes are packed in a spiral wound configuration. Such element contains from one to more than 30 sheets, depending on the element diameter and element type.
- In membrane systems the elements are placed in series inside of a pressure vessel.
- The concentrate of the first element becomes the feed to the second element and so on. The permeate tubes are connected with interconnectors (also called coupler), and the combined total permeate exits the pressure vessel at one side of the vessel.

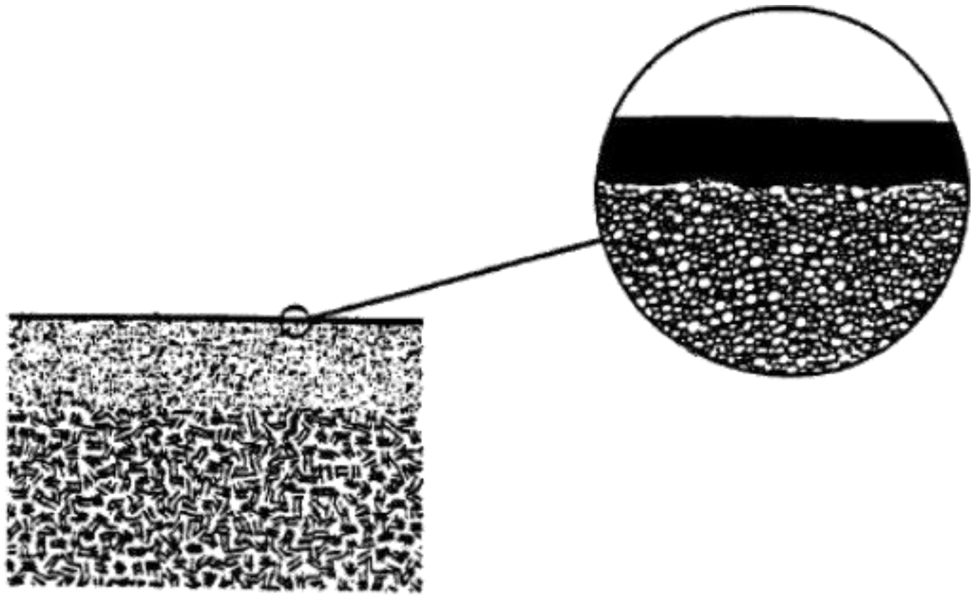


Fig 5.4:Schematic cross-section of a Filmtec thin film composite membrane

- The membranes are wound around a perforated permeate pipe.
- Two membrane sheets are glued together on three sides, only with an opening towards the permeate pipe. The feed water flows across the membrane surface from one side to the other. Due to the high pressure in the vessel, a part of the water penetrates the membrane and this permeate water can only leave the PV through the permeate pipe, while the rest of the water - now more concentrated - leaves on the other side of the membrane , just flowing across the sheet.

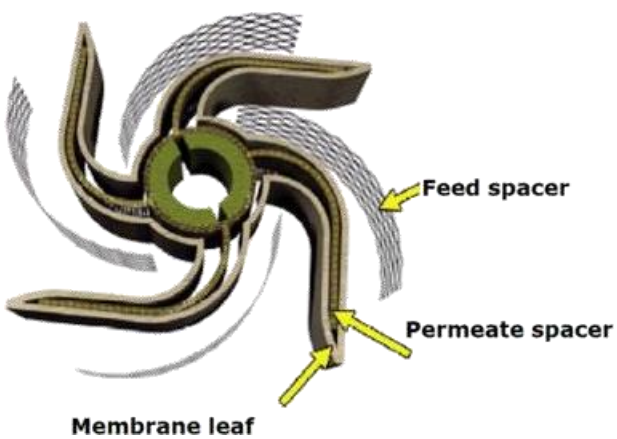


Fig 5.5: Transversal cut of a membrane

9. Filter:

After testing the water then we should filter water by using Reverse osmosis process, by filtering the water we can completely extract the colour dye from plastic waste water.

10. Testing of sample:

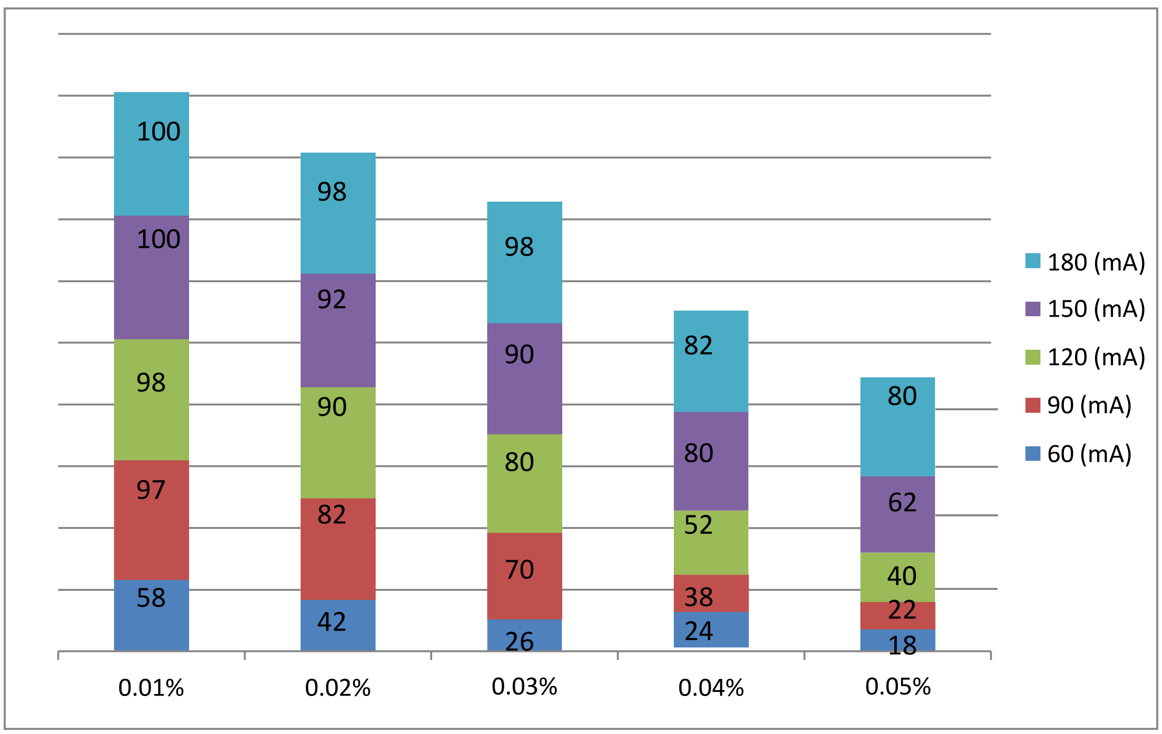
- After completion of both Electrocoagulation and Reverse osmosis process we should now test the plastic waste water to knowing the properties like pH, TSS, TDS.
- This test should be conducted after Reverse osmosis process.

4. RESULTS:

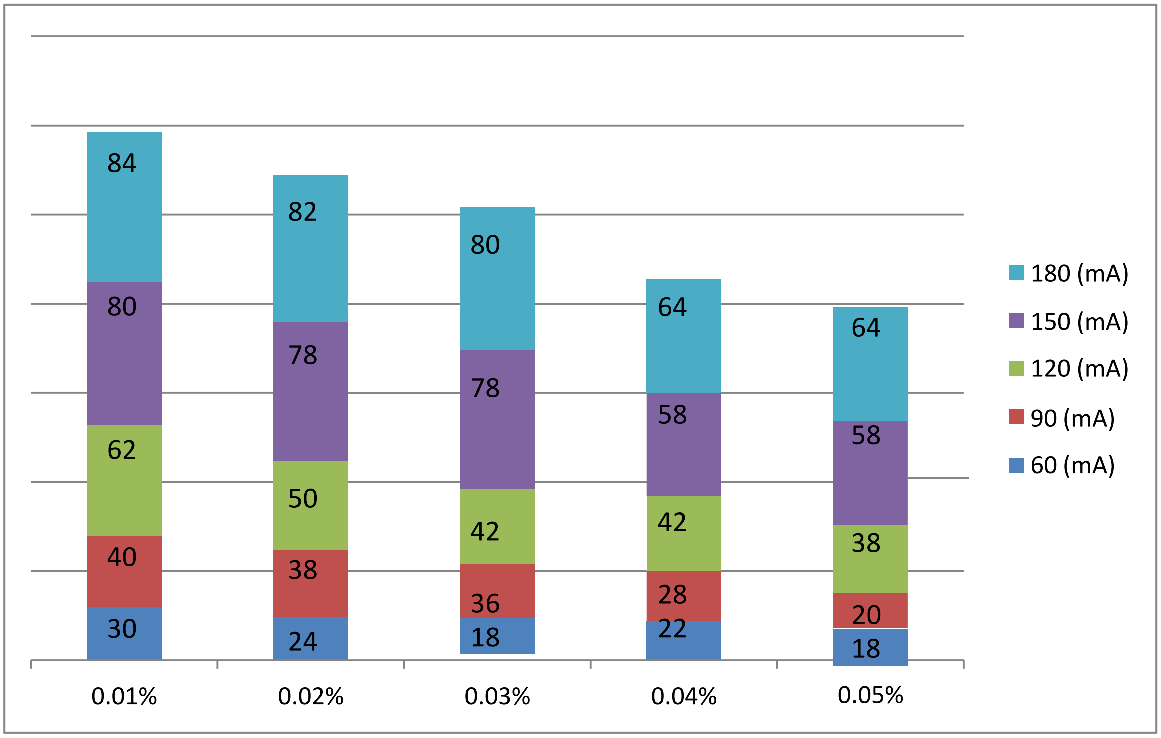
Analysis of Experimental Data:

- The rate of electrochemical reaction occurring on the surface of the electrode in the EC process is controlled by the applied current that influences the electrode potential.
- Also, at a constant pH the current density determines the rate of coagulant generation (anodic dissolution), floc size and the release of gas bubbles in the cathode during electrolysis as per Faraday's law.
- Experiments were conducted with varying applied current 60, 90, 120, 150 and 180mA to determine the CRE.
- The experimental results showed that the efficiency of colour removal at currents 60 – 180mA (0.05% initial dye concentration) was found to increase from 14.21 to 68.22% with Al electrode, 15.61 to 79.41% using Fe electrode and higher CRE with TiO_2/Al (74.23 to 96.85%)

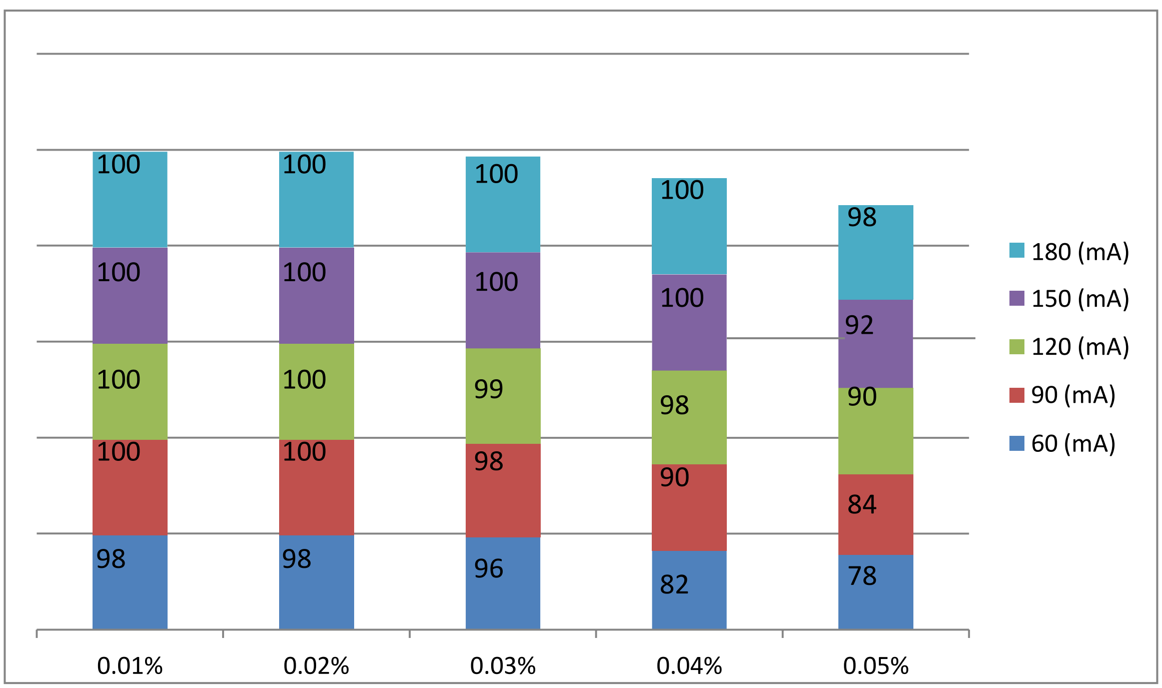
Interpreting Experimental Results:



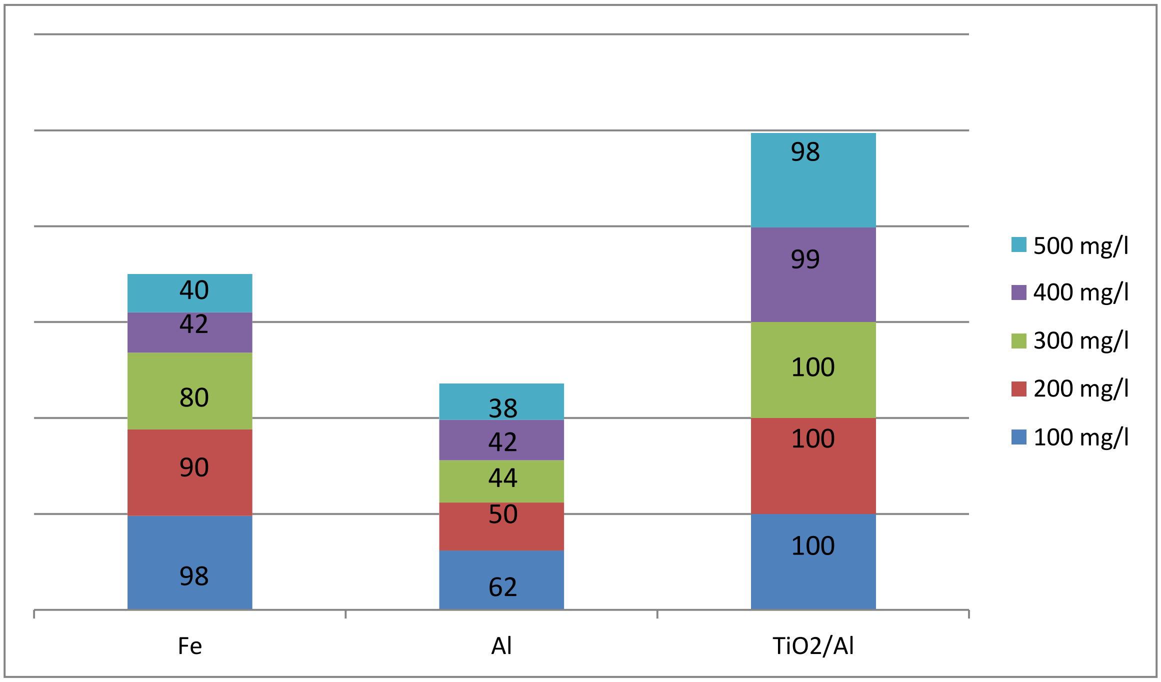
Graph6.1: Result of Fe Electrode applied with current to extract dye from water



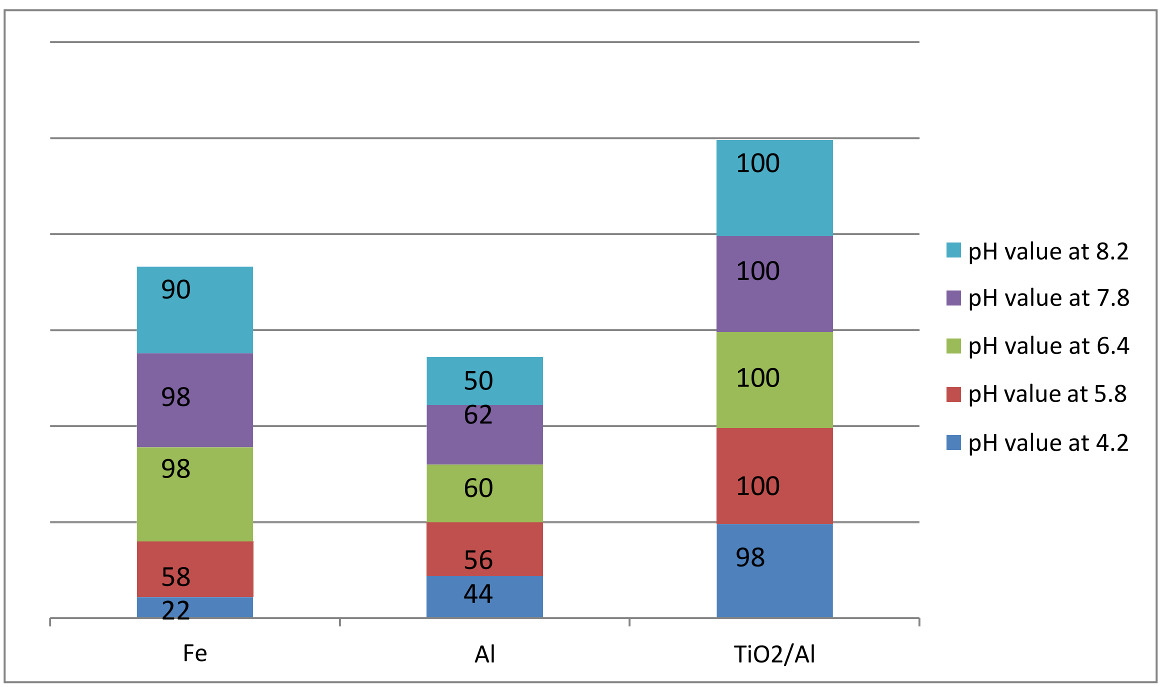
Graph 6.2: Result of Al Electrode applied with current to extract dye from water



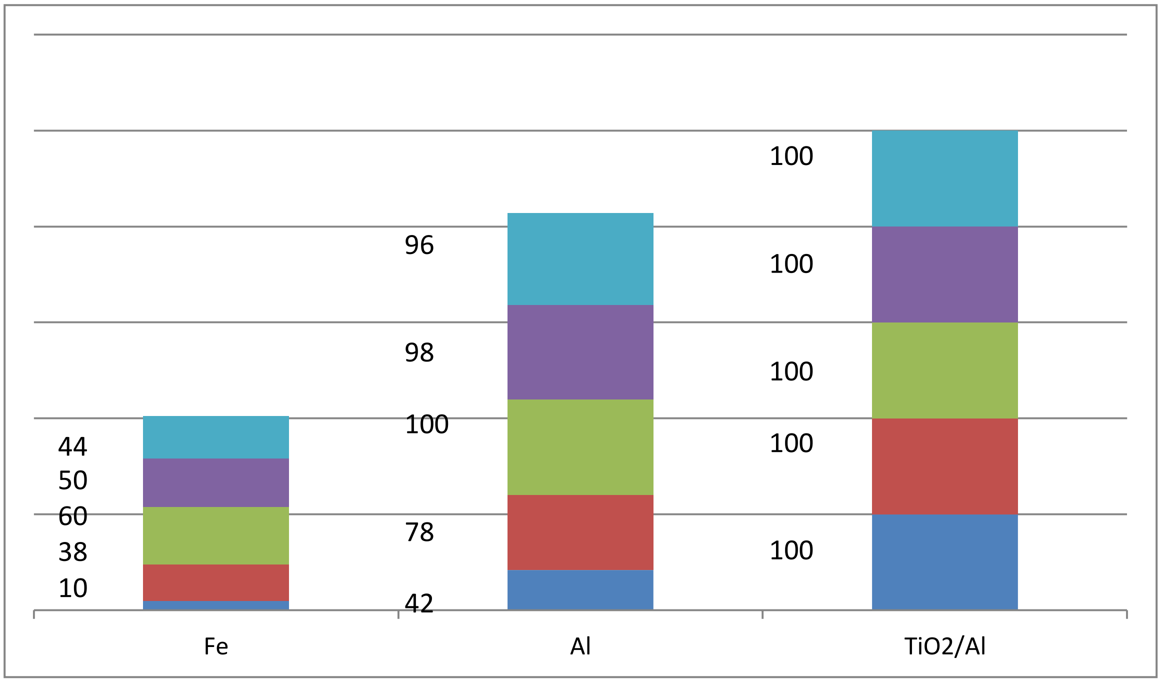
Graph 6.3:Result of TiO2/Al Electrode applied with current to extract dye from water



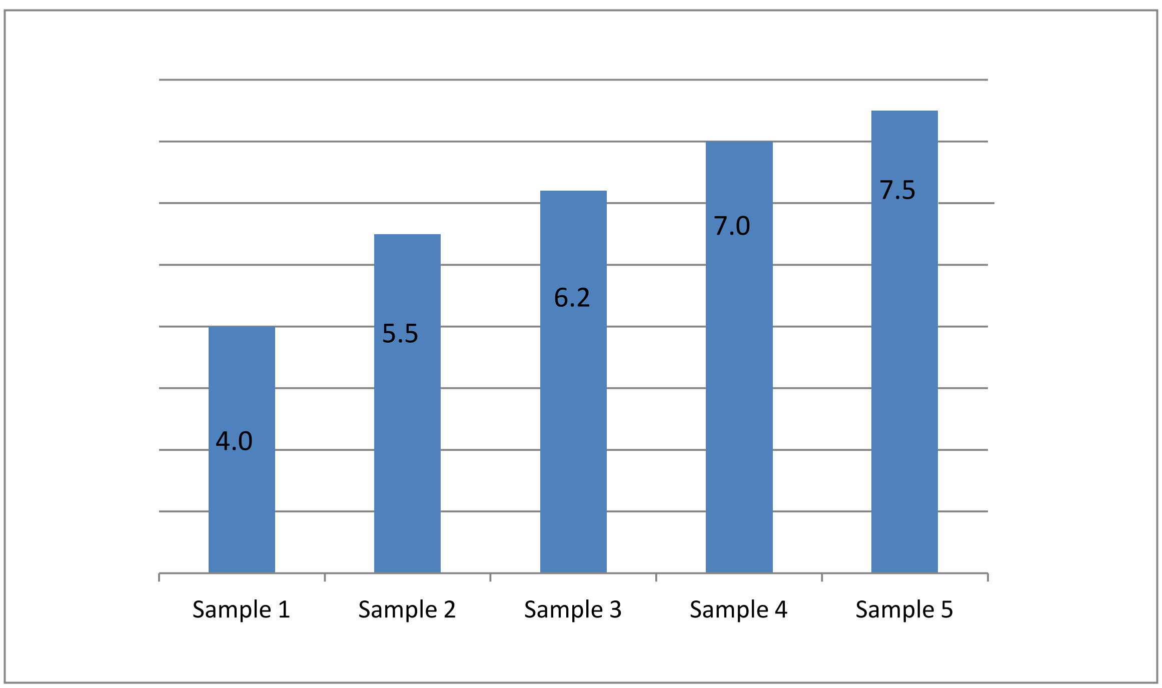
Graph 6.4:Initial dye concentration V/S CRE [120 mA AND 7.5 pH]



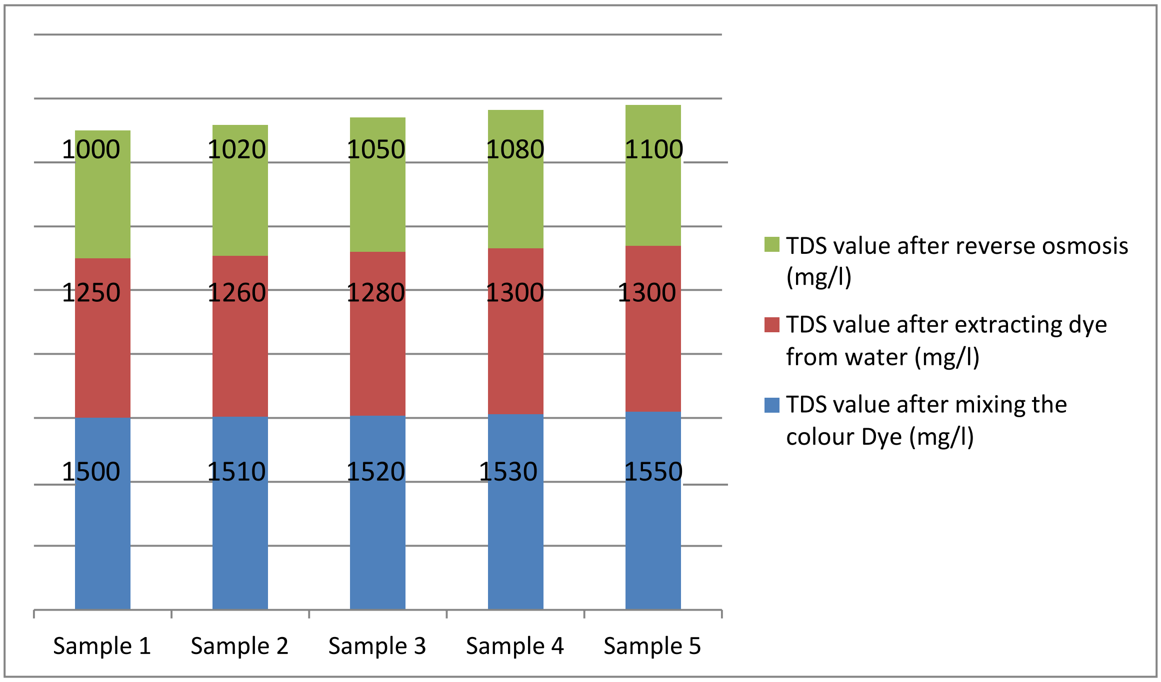
Graph 6.5: Effect of pH on CRE



Graph 6.6: Effect of Nacl on Concentration of CRE



Graph 6.7:pH after Reverse osmosis



Graph 6.8: Result of the TDS

5. CONCLUSION AND FUTURE ENHANCEMENT:

CONCLUSION:

- India generates 38,354 million litres per day (MLD) . From that 78% of the waste water generated remains untreated and is disposed of in rivers, groundwater or lakes.
- The two main sources of water contamination are sewage and industrial waste. From this both a majority amount of waste is non degradable which results in the pollution of water by different contaminates like plastic , colour dyes , styrofoam, faecal waste, pharmaceutical waste and etc..which in result leads to water pollution.
- The plastic dye is one of the waste produced from plastic industry which when untreated results in the accumulation and blanket of sludge forms on the river bed resulting in disturbance of ecosystem of the river and leads to water pollution, water scarcity and also leads to different ill effects on human health , marine life.
- So, the treatment of this water is necessary so has to stop this pollution this can be effectively done using the electro coagulation process. This helps in decrease of the pollution upto huge extent and helps in maintaining the quality of water.
- The analysis on effect of various operational parameters such as the initial dye concentration, applied current, electrolysis time, pH.
- The electrolyte concentration revealed that they had an influence on the CRE.
- When the initial dye concentration was increased from 0.01% to 0.05%, the CRE decreased from 95.5 to 40.91% with Fe, 64.43 to 34.53% using Al and 99.98 to 97.65% with TiO2/Al.
- CRE was found to increase with increase in other operational parameters such as the applied current and electrolysis (reaction) time as it was directly proportional to the anodic dissociation of the ions leading to the formation of more hydroxides species.
- The removal efficiencies with Fe and TiO2/Al electrodes were NaCl was used as the electrolyte with an optimum of 3% for all the electrodes.
- The results achieved with the TiO2/Al electrode are best results compared to Fe electrode and Al electrode.

- By using electrocoagulation process we concluded that extraction of colour dye from waste water is effected by CRE.
- Increase in CRE eventually decreases in extraction of colour dye.
- In previous extraction of colour dye from plastic waste water was done by electrocoagulation process, for this project we are further adding Reverse osmosis process after electrocoagulation.
- By filtrating the water by membranes using Reverse osmosis process we can completely extract the colour dye from plastic waste water.

FUTURE ENHANCEMENT:

- When we refine large amount of water at a same time the cost will be economical feasible.
- Before to extract color dye from water we used electrode method. But we added reverse osmosis process to the electrodcoagulation process to extraxt color dye from water.
- For small scale industries this method will give more profit.
- By this process we can extract any color dye from water.
- By using this process we can restrict the environmental pollution.

PUBLICATIONS

CONFERENCE :

- Naresh kumar .D, Sukanya laxmi .B, Rahul chowdhary .M, Nitin sai goud .M, Prakash reddy .P,(2021) ―Evaluation of electrocoagulation and reverse osmosis process in the removal of dye from plastic waste water‖, International Conference on computing for Sustainable Development in Civil Engineering

(ICCSDC 2021), St. Martins Engineering college, secunderabad, 24th and 25th June 2021.

JOURNAL :

- To be communicated.

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A Major Project Report
on

EXPERIMENTAL INVESTIGATION ON LIGHTWEIGHT CONCRETE CONTAINING OIL PALM KERNEL SHELL AS REPLACEMENT OF COARSE AGGREGATE AND BINDING MATERIAL WITH FLY ASH

SUBMITTED TO

Jawaharlal Nehru Technological University Hyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

by

Mr. G. Sri Hari	**-**	**(17K81A0181)**
Mr. K. Krishna Vamshi	**-**	**(18K85A0126)**
Mr. K. Abhinav Raj	**-**	**(17K81A0187)**
Mr. M. Mahinder	**-**	**(18K85A0122)**

Under The Guidance of

Mr. G. Siva Vignan
Assistant Professor

DEPARTMENT OF CIVIL ENGINEERING
ST. MARTIN'S ENGINEERING COLLEGE
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Dhulapally, Secunderabad - 500 100

JUNE 2021

ST. MARTIN'S ENGINEERING COLLEGE

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Dhulapally, Secunderabad, Telangana (India)-500100

BONAFIDE CERTIFICATE

This is to certify that the project entitled Experimental Investigation on Lightweight Concrete Containing Oil Palm Kernel Shell as Replacement of Coarse Aggregate and Binding Material with Fly Ash is being submitted by 1.**Mr. Gouduperu Sri Hari (17K81A0181) 2.Mr. Kancherla Krishna Vamshi (18K85A0126) 3.Mr. Kota Abhinav Raj (17K81A0187) 4.Mr. Moyya Mahinder (18K85A0122)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN** Civil Engineering is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

Signature of Guide

Mr. G. Siva Vignan
Assistant Professor
Department of Civil Engineering

Signature of HOD

Prof. SANDHYA KIRAN J.K.
Head of the Department
Department of Civil Engineering

Internal Examiner

External Examiner

Place:

Date

DECLARATION

We, the student of **Bachelor of Technology** in Department of 'Civil Engineering', session: 2017 - 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled Experimental Investigation on Lightweight Concrete Containing Oil Palm Kernel Shell as Replacement of Coarse Aggregate and Binding Material with Fly Ash is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

Mr. Gouduperu Sri Hari	(17K81A0181)
Mr. Kancherla Krishna Vamshi	(18K85A0126)
Mr. Kota Abhinav Raj	(17K81A0187)
Mr. Moyya Mahinder	(18K85A0122)

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1. Gouduperu Sri Hari

2. Kancherla Krishna Vamshi

3. Kota Abhinav Raj

4. Moyya Mahinder

ABSTRACT

Concrete is the most used construction material in the world and the second most consumed substance in the world after water. Concrete flexibility and increase in population have resulted in the high use of the material for the construction of shelters, infrastructures, and workplaces among other, thereby contributing to the high cost of the material. There is a worry in the construction industry about the depletion of natural resources from which concrete is produced soon. This high demand for concrete has also increased the price of the material making it almost impossible for low-income earners to own houses and leaving many homeless. Also, increased in population has increased agricultural activities across the globe in order to tackle the problem of food insecurity amongst which include palm farming. The negative effect of these increased agricultural activities is the high environmental pollution as wastes from these activities are openly burned in many instances as a mean of disposal, releasing a significant amount of carbon dioxide (CO2) in the atmosphere. These concerns have prompted research towards waste materials that could be used as alternatives to those conventional materials for concrete production while at the same time minimizing the high environmental pollution. Through these efforts, it was discovered that Oil Palm Kernel Shell (OPKS), the by-product of palm farming, can partially replace coarse aggregate to produce structural concrete. Similarly, it was discovered that Fly Ash (FLA), a waste from the quarrying, can be used as an Ordinary Portland to replace portion of the cement in concrete production. However, limited information was found on the combine effect of OPKS and FLA as partial replacements for coarse aggregate and Ordinary Portland cement respectively on normal concrete. It was the aim of this research to investigate the effect of OPKS and FLA on normal weight concrete (NWC) as partial replacements for coarse aggregate and Ordinary Portland cement (OPC) respectively. Effects were determined in terms of concrete workability, density, water absorption, compressive strength, and Flexural strength. Four mixes were designed in which OPKS was varied at 0%, 10%, 20%, 30% and 40% and FLA at 5% in a mix ratio of 1:1.05:2.38 for cement, fine aggregate, and coarse aggregate respectively with a constant free water to cement ratio of 0.40. Batching was by volume and a total of 45 cubes and 45 cylinders were casted. Specimens were cured for 7, 14 and 28 days. It was found out that OPKS and FLA use in concrete reduce workability, density and increase water absorption, compressive strength and flexural strength at 28 days of curing. However, the resulting concrete was satisfactory for structural used.

Keywords: Oil Palm Kernel Shell, Fly Ash, Compressive strength, Flexural strength.

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LIST OF ABBREVIATIONS

S. No	Full form	Short form
1	Oil Palm Kernel Shell	OPKS
2	Oil Palm Kernel Shell Concrete	OPKSC
3	Treated Oil Palm Kernel Shell	TOPKS
4	Non-Treated Oil Palm Kernel Shell	NTOPKS
5	Ordinary Portland Cement	OPC
6	Coarse Aggregate	CA
7	Fine Aggregate	FA
8	Fly Ash	FLA

CHAPTER-1

INTRODUCTION

1.1 Overview of the Project

There were numerous trial works directed to improve the property of the substantial by putting new materials, regardless of whether it is regular material or reused materials or manufactured materials in the substantial blend. Countless horticultural squanders were arranged in a large portion of tropical nations particularly in Asia for nations like India, Thailand, Philippines and Malaysia. On the off chance that the waste can't be arranged as expected it will prompt social and natural issues. The significant expense of customary structure material is a central point influencing lodging conveyance in India. This has required investigation into elective materials of development. The current examination manages the different qualities of the fundamental elements of cement for example concrete, oil palm shell (OPKS, total fine and coarse.

Lightweight concrete, like typical weight concrete, is a combination of water, Ordinary Portland Cement (OPC), and total. Light-weight total substantial uses an assortment of totals with lower thickness than ordinary weight concrete. LWA can be isolated into two classes.

- Those happening normally and are prepared to utilize just with mechanical treatment, i.e., squashing and sieving.
- Those delivered by warm treatment from either normally happening materials or from modern results, squander materials, and so on.

In this investigation, oil palm shell is utilized as light weight total Production of lightweight concrete is an innovation pointed toward lessening dead burden on structures and to diminish the general expense of the construction. Practically all LWACs are fireproof. Moreover, contingent up-upon the densities and strength, the substantial can be effectively cut, nailed, penetrated, and etched with conventional carpentry apparatuses. The utilization of farming waste as totals can give an option in contrast to traditional strategies for creation of lightweight totals. Structural lightweight concrete is a significant and adaptable material in present day development. It enjoys numerous benefits of dead burden decrease, high warm protection. On the off chance that floors, and dividers are comprised of light weight concrete, it prompts economy of construction. It likewise brings down power utilization for outrageous climatic condition due to having property of low warm conductivity. The utilization of lightweight concrete is acquiring wide acknowledgment in building development, clearly because of the extensive decrease in mass. Decrease in weight by the utilization of light weight total is favoured particularly for structures worked in seismic zones. Decreased dead burden by utilizing lightweight total outcomes in decrease of seismic tremor harms to structures. The concrete substance is a conspicuous factor in the physical/mechanical and strength properties of lightweight total cements. These days lightweight concrete is ordinarily utilized in precast and prestressed parts. Lightweight substantial offers plan adaptability and generous expense investment funds by giving less dead burden, improves seismic underlying reaction, better fire rating, diminished story stature, more modest size primary individuals, lower establishment cost, and less building up steel. The profoundly permeable microstructure of lightweight total gives it low thickness and better protection and make that the substantial made with lightweight substantial display lower warm conductivity than that of typical weight concrete. Subsequently, lightweight concrete gives more effective fire assurance than thick total as it is less responsible to spalling and has a higher warm protection. Lightweight substantial assumes a significant part in primary designing and its utilization is consistently expanding. It is characterized as a kind of substantial which remembers a growing specialist for that it builds the volume of combination. Furthermore, primarily it is lighter than ordinary cement with dry thickness of 300kg/m3 up to 1840kg/m3. The decrease in weight by utilization of lightweight substantial will be beneficial, particularly for building structures. Primary lightweight concrete has a set up thickness (unit weight) on the request for 1440 to 1840 kg/m3 contrasted with ordinary weight concrete with a thickness in the scope of 2240 to 2400 kg/m3. For primary applications the substantial strength ought to be more noteworthy than 17 MPa. The substantial blend is made with a lightweight coarse total. Now and again, a bit or the whole fine total might be a lightweight item. There are different classes of non-underlying lightweight concretes with lower thickness made with 3 other total materials and higher air voids in the concrete glue framework, for example, in cell concrete. These are normally utilized for their protection properties. The above properties centre around primary lightweight concrete.

Lightweight concrete is characterized as a substantial that has a thickness, after stove drying, that isn't bigger than 2000 kg/m3, absolute or halfway delivered with permeable design total. These days, the utilization of lightweight concrete is expanding, for primary applications, yet additionally for different purposes, for example, restoration or asphalt filling. The use of lightweight concrete on asphalts is expanding, basically because of the lower self-weight contrasted with the conventional concrete, making conceivable the lessening of stacking in the design. In any case, one of the serious issues that substantial has is the time that it takes to dry out, which means, the time that the water removes to come from the substantial, postponing the covering and causing oddities on this one. Since, the drying interaction is moderate, it is important to realize the water content that is satisfactory in the substantial so there isn't any issue when a covering, that is touchy to dampness, is applied. This paper has the point of realizing the water substance of cement, all through time, to gauge how long it requires to dry contingent upon the lightweight total utilized.

1.2 Statement of the problem

The high demand for concrete is the result of the increase needs for shelters, workplaces, and infrastructures as the population increases. This has resulted in an increase in the prices of constituent materials thereby making total construction cost very high. Global Construction Perspective (2015) reported that global construction had reached 8.7 trillion United States Dollars (USD) in 2012 and is expected to rise to 15 trillion USD by 2025. The cost of concrete together with the high quantity needed is one of the reasons for this high construction cost globally. This explains why many low-income earners especially in Africa are without shelters and are homeless because they cannot afford these high costs thereby impeding on Africa's agenda for 2063 which include poverty reduction. Also, the high demand for concrete is leading to the gradual depletion of natural resources. According to Ismail (2009), the usage of concrete is around 10 billion tons per year, which is equivalent to 1 ton per every living person. Following this trend, Africa with a population of 1.2 billion and is said to double by 2050 according to the Population Reference Bureau (PRB, 2016), it can therefore be stated that by 2050 Africa alone will be using around 2.4 billion tons of concrete per year. This will then lead to a very high demand of these materials leading to a total depletion of natural resources thereby causing geographical instability and damage to the environment. Again, increased demand for concrete has increased production activities for cement. Cement production is expensive, requires high energy, reduces natural resources, and emits large amount of CO2. United States Geological Survey (USGS, 2015) stated that the world cement production for the year 2012 was 3.7 billion tons. According to Lun (2015), approximately 4.9 million Kilo Joules (KJ) of energy is required to produce a ton of cement. Therefore producing 5 3.7 billion tons of cement will required around 1.8 trillion KJ of energy. Also, cement production emits a large quantity of CO2. Shivaram (2014) stated that producing a ton of cement will generate approximately a ton of CO2. Therefore, to produce 3.7 billion tons of cement will also generate approximately 3.7 billion tons of CO2. According to Trend in Global CO2 Emission (TGCE, 2015), cement production accounts for roughly 8% of global CO2 emissions. Increase in population has also led to increase agricultural activities across the glober. Production of oil continues to increase on a yearly basis. It was reported by Food and Agriculture Organization of the United Nations (FAO, 1996), that Africa consumes a total of 11.6 million tonnes of milled OPKS per year. Mehta (2015) reported that approximately 20 tonnes of fly ash are obtained for 100 tonnes of quarrying. Therefore, production of 11.6 million tonnes of milled OPKS produces approximately 2.32 million tonnes of husks as waste. This waste is disposed by open burning thereby polluting the environment. Therefore, with these problems as a result of increase in population, there is an urgent need for research towards low-cost construction and to find means by which waste materials can be utilize.

1.3 Objectives of study

1.3.1 General Objective

To investigate the effect of Oil Palm Kernel Shells (OPKS) and Fly Ash (FLA) on the physical and mechanical properties of Normal Weight Concrete (NWC).

1.3.2 Specific Objectives

- To determine the characteristics of Oil Palm Kernel Shells, Normal Weight Aggregate, Fine Aggregate, Fly Ash, and Ordinary Portland Cement.
- To determine the effect of Oil Palm Kernel Shells as partial replacement of coarse aggregate in normal weight concrete.
- To determine the effect of Fly Ash as partial replacement of Ordinary Portland Cement in normal weight concrete.
- To determine the effect Oil Palm Kernel Shells and Fly Ash as partial replacements of coarse aggregate and Ordinary Portland Cement respectively on the physical and mechanical properties of normal weight concrete.

1.3.3 Justification

Increase in population has increased the need for shelters, workplaces, and infrastructures. With the cost of concrete being very high, low-income earners are unable to own their own shelters or afford rents for them. Therefore, finding low-cost materials to replace these conventional materials use for concrete production significantly reduces the cost of concrete and hence total construction cost. Hence, finding low-cost materials will enables even low-income earners shelters at affordable costs.

Also, with an increase in the consumption of concrete on a yearly basis, fear that the natural resources might get depleted in the long run is another major concern. Therefore, using waste to substitute these natural resources reduces the high demand on them thereby leading to a boost in resource preservation. Also, this minimizes the high pollution level associated with the processing of these natural resources. For instance, it was reported that cement production accounts for roughly 8% of the global CO_2 emissions and requires huge amount of energy. Hence, the use of waste in concrete production minimizes some of these pollutions.

Again, with an increased in agricultural activities across the globe and Africa in Panicular, increased number of wastes are anticipated from these activities. With poor waste management being a major issue in Africa, it can be seen that environmental pollutions will be on the increase all across the continent. Therefore, incorporating some of these wastes in the production of concrete will help to minimize some of these pollutions leading to a safer environment.
Therefore, this research is significant as it addressed some of Africa's main challenges. That is, by combining OPKS and FLA to substitute coarse aggregate and OPC in the production of concrete, the cost is significantly reduced and hence total construction cost. Also, the incorporation of OPKS and FLA in concrete production reduces the high demand on the natural resources boosting resources preservation, reduction in environmental pollution, and a better mean of waste management.

1.4 Scope of the study

The Study was involved with the determination of the effect of OPKS and FLA on the physical and mechanical properties of NWC. Physical properties considered for the concrete produced were in terms of workability, concrete density, and water absorption. Mechanical properties were in terms of compressive and flexural strengths. Characterization of OPKS and coarse aggregate were in terms of Aggregate Crushing Value (ACV), Aggregate Impact Value (AIV), water absorption, specific gravity, bulk density, loose density, and Particle Size Distribution (PSD). FLA and OPC were characterized in terms of chemical properties, PSD, and specific gravity. Concretes with OPKS and FLA were compared with NWC. Determination of the mechanical properties was at 7, 14 and 28 days of curing. The design mix used in this study was 1:1.05:2.38 for cement, fine aggregate and coarse aggregate and a water to cement ratio of 0.40 for all concretes.

1.5 Background of the study

Concrete is the most common construction material used in almost every construction all around the world. It is environmentally friendly and very easy to produce. Its applications include buildings, roads, bridges, dams, retaining structures, stadiums, airports, among others, thereby increasing its demand on the daily basis and an increase in the price of the material. It is the second most consumed substance on Earth after water (Smith & Maillard, 2007). According to Ismail (2009), its usage is around 10 billion tons per year, which is equivalent to 1 ton per every living person. This high production and consumption of concrete is due to the continuous increase in the global population. According to the Population Reference Bureau

(PRB, 2016), Africa has a population of 1.2 billion and it is estimated to double by 2050. Increase in population hence leads to an increase in the demand for the basic needs of mankind which include shelter, workplace, and infrastructure.

The most expensive constituent of concrete is cement. It is one of the active ingredients of concrete used as a binding agent. The high need for concrete has increased the demand for cement thereby making it the most expensive constituent. According to the United States Geological Survey (USGS, 2015), the world cement production for the year 201 I was 3.6 billion tons and that by 2012, the production was increased to 3.7 billion tons. From these statistics, it can therefore be seen that demand of cement continues to increase on a yearly basis. What this means is that, more natural resources and energy are needed to produce cement leading to the depletion of resources and emission of high amount of Carbon dioxide (CO2) in the atmosphere. According to the Trend in Global CO_2 Emission (TGCE, 2015), cement production accounts for roughly 89r of the global CO_2 emissions. Also, the Cement Sustainability Initiative (CSI)/European Cement Research Academy (ECRA, 2009), stated that the grinding of clinker with additives to produce cement requires only electricity and accounts for about 38' o of total electricity used.

Aggregates are also used in concrete production and account for about 60-80 percent of the total volume of concrete depending on the mix design. Extraction and crushing of these natural aggregates usually involve stripping, drilling, and blasting, and impact crushing causing pollution and environmental instability. Again, the high demand of concrete has resulted in an increased in aggregate production leading to increase environmental pollution and a total depletion of the natural resource causing geographical instability to the environment.

On the other hand, increase in population has not only resulted in the need for more shelters and infrastructures, but also the problem of food insecurity. This problem of food insecurity has led to an increased in agricultural activities across the world due to the strategic planning policies for food security of many countries.

There is a steady increase in palm production across the African continent. According to the Global Palm Oil Conference (2015), world production of palm oil and palm kernel oil has grown rapidly in recent decades: from about 2 million metric tonnes in 1961 to over 56 million tonnes in 2012. Main drivers behind this growth are the high productivity of oil palms, the development of applications beyond their traditional food use, and the production of biodiesel. The World Bank has therefore estimated that world consumption of palm oil will double by 2020 to about 112 million tonnes (Global Palm Oil Conference, 2015). Similarly, Budu and Sarpong (2013) stated that the consumption of palm oil and other palm products is expected to increase in West Africa and in other parts of the continent as the population grows. Hence, this high increase in Palm farming across the world and Africa has resulted in high pollution across the continent as the by-product is openly burn as a mean of disposal.

Hence, increase in population requires more shelters and infrastructures as well as increase in agricultural activities. With cement and aggregates being the main constituents of concrete, there are worries that the natural resources will be depleted soon. Also, with palm farming on the increase, there is high pollution of wastes from these activities. Addressing some of these problems have been a major challenge in the engineering field. However, as a mean of mitigating some of these problems, engineers are now focusing on producing low-cost concrete by incorporating wastes produced from agricultural activities. With low-cost concrete produced from wastes, more shelters can be built at affordable cost while at the same time reducing the high pollution cause by those wastes. According to the British Standards for concrete, concrete materials should satisfy the requirement for the safety, structural performance, durability, and appearance of the finished structure, taking full account of the environment to which, it will be subjected (BS 5328, 1997). With this as a guide, Oil Palm Kernel Shell (OPKS), waste from the palm oil manufacturing process, was found to have satisfied the provisions of BS 5328 making it suitable for concrete production as a replacement for coarse aggregate in terms of its crushing value, impact value, density, specific gravity, and size. With the fact that OPKS is a waste, its replacement for coarse aggregate brings about a significant reduction in the cost of concrete, preservation of the natural resource, and a better way of managing waste leading to a safer environment. Also, Fly Ash (FLA), waste from the quarrying process was found to be a good pozzolana for concrete production replacing a portion of cement as it satisfied pozzolana requirements of ASTM C618 (2005) in terms of its physical and chemical properties. As with the OPKS, FLA replacement for cement also brings about a reduction in cement demand, boost in resource preservation, and minimizes the high pollution associated with the production of cement.

1.5.1 Types of Lightweight Concrete Based on Density and Strength

- Low density concrete
- Moderate strength concrete
- Structural concrete

1.5.1.1 Low Density Concrete

These are employing chiefly for insulation purposes. With low unit weight, seldom exceeding 800 kg/m³, heat insulation value is high. Compressive strength is low, regarding from about 0.69 to 6.89 N/mm2.

1.5.1.2 Moderate Density Concrete

The use of these concrete requires a fair degree of compressive strength, and thus they fall about midway between the structural and low-density concrete. These are sometimes designed as 'fill' concrete. Compressive strength is approximately 6.89 to 17.24 N/mm² and insulation values are intermediate.

1.5.1.3 Structural Concrete

Concrete with full structural efficiency contain aggregates which fall on the other end of the scale, and which are generally made with expanded shale, clay, slates, slag, and fly-ash. Minimum compressive strength is 17.24 N/mm².Most structural LWC can produce concrete with compressive strength in excess of 34.47 N/mm².Since the unit weight of structural LWC are considerably greater than those of low-density concrete, insulation efficiency is lower. However, thermal insulation values for structural LWC are substantially better than Normal weight concrete.

1.6 Uses of Lightweight Concrete

- Screeds and thickening for general purposes especially when such screeds or thickening and weight to floors roofs and other structural members.
- Screeds and walls where timber has to be attached by nailing.
- Casting structural steel to protect it's against fire and corrosion or as a covering for architectural purposes.
- Heat insulation on roofs.
- Insulating water pipes.
- Construction of partition walls and panel walls in frame structures.
- Fixing bricks to receive nails from joinery, principally in domestic or domestic type construction.
- General insulation of walls.
- Surface rendered for external walls of small houses.
- It is also being used for reinforced concrete.

1.7 Advantages of Lightweight Concrete

- Reduced dead load of wet concrete allows longer span to be poured un-propped. This save both labour and circle time for each floor.

- Reduction of dead load, faster building rates and lower haulage and handling costs. The eight of the building in term of the loads transmitted by the foundations is an important factor in design, particular for the case of tall buildings.
- The use of LWC has sometimes made it possible to proceed with the design which otherwise would have been abandoned because of excessive weight. In frame structures, considerable savings in cost can be brought about by using LWC for the construction floors, partition, and external cladding.
- Most building materials such as clay bricks the haulage load is limited not by volume but by weight. With suitable design containers much larger volumes of LWC can haul economically.
- A less obvious but nonetheless important characteristics of LWC is its relatively low thermal conductivity, a property which improves with decreasing density in recent years, with the increasing cost and scarcity of energy sources, more attention has been given the formerly to the need for reducing fuel consumption while maintaining, and indeed improving, comfort conditions buildings. The point is illustrated by fact that a 125 mm thick solid wall of aerated concrete will give thermal insulation about four times greater than that of a 230 mm clay brick wall.

1.8 Application of lightweight concrete

The primary use of light weight concrete is to reduce the dead load of the concrete structure, which then allows the structural designer to reduce the size of the column, footing and other load bearing elements. Structural lightweight concrete mixture can be designed to achieve similar strength as normal weight concrete. The same is true for the other mechanical and durability performance requirements. Structural lightweight concrete provides a more efficient strength to weight ratio in structural elements. Lightweight Concrete is used when. structural concerns require. Lightweight Concrete is ideal for roof deck repairs, stair pan fill, elevated floor slabs or overlays on existing floor decks. It can also be used for appliance platforms, curbs, down spout gutters, balconies, floors, fishponds, walls, setting posts, castings, steps, or virtually any job that would normally be done with standard weight concrete. Use it where ease in lifting and carrying is important. Lightweight Concrete also offers slower temperature transfer rates than standard weight concrete, resulting in improved insulation factors.

Now a days with the advancement of technology, lightweight concrete expands its uses, for example, in the form of perlite with its outstanding insulating characteristics. It is widely used as loose-fill insulation in masonry construction where it enhances fire ratings, reduces noise transmission, does not rot and termite resistant. It is also used for vessels, roof decks and other applications. The use of high strength, high performance lightweight concrete (HSLWC) can result in longer span lengths and lighter weight girders. Previous research at the Georgia Institute of Technology (Georgia Tech) showed that HSLWC bridge girders can be constructed with 10,000 psi (69 MPa) compressive strength concrete with a very low permeability, while achieving up to a 20% decrease in shipping weight.

1.9 ORGANIZATION OF CHAPTERS

The dissertation has been divided into five chapters including Introduction. Chapter 1 consists of general introduction, overview of previous literatures is given in chapter 2, study area, components of the Polavaram Project are explained in chapter 3, present irrigation and cropping pattern are presented in chapter 4, chapter 5 consists of conclusion and scope of future work.

Chapter 1 presents the brief introduction about the behavioural aspects of oil palm kernel shell concrete. The objectives and scope of the study has also been presented and it gives an overview of the project in this chapter.

Chapter 2 presents literature reviews of the previous work of pioneer investigators. This chapter includes previous work already carried out in oil palm kernel shell concrete.

Chapter 3 presents the study area of the Experimental Investigation on Lightweight concrete by using Argo-waste and also highlights the major components of the project such as water absorption, specific gravity of oil palm kernel shell etc.

Chapter 4 presents the results and discussions on the sample of the OPKSC which show its compressive strength, and flexural strength.

Chapter 5 includes the concluding remarks and future scope if the research works. Previous works carried out by other investigators have been cited in references are provided at the last.

CHAPTER – II

REVIEW OF RELATED LITERATURE

U.J. Alengraram, M.z. Jummat, H. Mahmud (2008), have presented the work, "*Influence of cementitious materials and aggregate content on Palm shell concrete*" and found the below: This paper reports the impact of cementitious materials, fine and coarse total substance on usefulness and compressive strength of palm part shell concrete. cementitious material was added 10% silica ash as extra cementitious material and 5% fly debris as concrete substitution on weight of concrete. The impact of fluctuating fine total and palm piece shell substance on functionality and compressive strength has been considered.

Payam Shafigh, Mohd Zamin Jumaat, Hilmi Mahmud (2010), have made a study on "*Mix design and mechanical properties of oil palm shell lightweight aggregate concrete: A review*" and stated the below:

Oil palm shell (OPKS) is a type of farming strong waste in the tropical systems. Exploration during the most recent twenty years shows that OPKS can be utilized as a lightweight total for delivering primary lightweight total cement. The thickness of OPKS concrete is around 20 - 25% lower than typical weight concrete. For the most part, mechanical properties of OPKS concrete are somewhat lower than different sorts of lightweight total cement. It appears to be that from the synopsis and investigation of the current data concerning OPKS concrete and contrasting it and other lightweight total substantial apparently critical accomplishments can be achieved.

Payam Shafigh, Mohd Zamin Jumaat, Hilmi Mahmud (2011), have presented the work, "*Oil palm shell as a lightweight aggregate for production high strength lightweight concrete*" and found the below:

oil palm shell (OPKS) is a farming strong waste beginning from the palm oil industry. In this examination old OPKS was utilized for creation of high strength lightweight concrete (HSLC). The thickness, air content, functionality, 3D shape compressive strength and water assimilation were estimated. The impact of five kinds of restoring conditions on 28-day compressive strength was considered. The test outcomes showed that by joining limestone powder and without it, it is feasible to create the OPKS concretes with 28-day compressive strength of around 43–48 MPa and dry thickness of around 1870–1990 kg/m3. The compressive strength of OPKS HSLC is delicate to the absence of restoring. The water ingestion of these concretes is in the scope of good concretes.

U. Johnson Alengram, Baig Abdullah Al Muhit, Mohd Zamin bin Jumaat (2012), have presented the work, "*Utilization of oil palm kernel shell as lightweight aggregate in concrete – A review*" and found the below:

This paper audits past research completed on the utilization of oil palm bit shell (OPKS) as lightweight total (LWA). OPKS is a waste material acquired during the extraction of palm oil by pounding of the palm nut in the palm oil plants. It is quite possibly the most plentifully delivered squander materials in Southeast Asia and Africa; OPKS has been tested in research as lightweight totals (LWAs) to create lightweight concrete (LWC) since 1984 and today there are numerous specialists working around here. In this paper the physical and mechanical properties of OPKS are summed up alongside mechanical, solidness and useful properties and primary conduct of OPKS concrete (OPKSC). Late papers on frothed and fiber supported OPKSC are additionally included. It is seen from the outcomes that OPKSC has similar mechanical properties and underlying conduct to ordinary weight concrete (NWC). Late examination on the utilization of squashed OPKS shows that OPKSC can be created to medium and high strength concrete. Maintainability issues joined with higher malleability and total interlock attributes of OPKSC contrasted with NCW has brought about numerous analysts leading further examination on the utilization of OPKS as LWA.

Muhammad Aslam, Payam Shafigh, Mohd Zamin Jumaat (2016), have made a study on "*Oil-palm by-products as lightweight aggregate in concrete mixture: a review*" and stated the below:

The utilization of modern waste as a development material to assemble earth reasonable constructions has a few functional and monetary benefits. Oil-palm-heater clinker is a waste material acquired by consuming off strong squanders during the interaction of palm oil extraction. The exploration performed during the most recent twenty years concerning the utilization of oil-palm-evaporator clinker as a lightweight total to deliver underlying lightweight total concrete is summed up in this paper. The physical, compound, and mechanical properties of oil-palm-heater clinker total and the mechanical properties and primary execution of oil-palm-evaporator clinker concrete are tended to, examined, and contrasted and typical weight concrete. The survey of the writing showed that relying upon the wellspring of oil-palm-evaporator clinker the gravity of this total is 15–35% not exactly ordinary weight totals and it tends to be utilized as a lightweight total for making underlying lightweight total concrete. Concretes containing oil-palm-kettle clinker as coarse and fine totals have the 28-day compressive strength in the scope of 17–47 MPa, with a thickness in the scope of 1440–1850 kg/m3. While concretes containing oil-palm-heater clinker as coarse total and typical sand as fine total have the 28-day compressive strength in the scope of 15–35 MPa with a thickness in the scope of 1800–2000 kg/m3. Incomplete supplanting of oil palm shell with oil-palm-evaporator clinker in oil palm shell lightweight concrete could altogether improve (about 40%) the compressive strength of the substantial. The exploration holes are additionally recognized in this examination to investigate the imaginative lightweight concrete dependent on the monetary and natural plan factors.

S.M. Alamgir Kabir, U. Johnson Alengaram, Mohd Zamin Jumaat, Sumiani Yusoff, Afia Sharmin, Iftekhair Ibnul Bashar (2016), have made a study on "*Performance evaluation and some durability characteristics of environmentally friendly palm oil clinker based geopolymer concrete*" and have inferred the following results:

Seven substantial blends were planned with changing coarse total substance to create eco-accommodating geopolymer concrete while different boundaries were kept steady. The mechanical properties and some sturdiness qualities of lightweight geopolymer concrete were explored and revealed. The most noteworthy compressive strength accomplished was 41.5 MPa at 28 days where 100% POC (9–14 mm) was utilized as coarse total. POC in geopolymer concrete improves the compressive durability contrasted with OPKS geopolymer concrete because the permeable POC total expanded the firmness and improved the bond with mortar in concrete as the infilling impact of mortar into the pores fortifies the bond and upgrades the break development obstruction. Geopolymer concrete has lower slim sorptivity, the utilization of magnesium sulfate answer for sulfate opposition test showed irrelevant effect on geopolymer concrete because of the inborn idea of alumino silicate gels in geopolymeric materials. The outcomes show that by using POC and OPKS primary evaluation lightweight geopolymer concrete can be created.

Ramappa Ramesh Nayaka, U. Johnson Alengaram, Mohd Zamin Jumaat, Sumiani Binti Yusoff, Mohammed Fouad Alnahhal (2011), have published a technical paper entitled, "*High volume concrete replacement by environmentally friendly industrial by-product palm oil clinker powder in concrete – lime masonry mortar*" and have found the below:

Concrete lime-based mortar is incredibly mainstream for a wide scope of development all throughout the planet and rationing normal assets utilized in the creation of such material is vital. Recognizable proof of elective materials from palm oil based mechanical side-effects empowered analysts to utilize palm oil clinker powder (POCP) as a concrete substitution material; in this exploration work, POCP was utilized as concrete substitution material in workmanship mortar. The physical, synthetic properties and SEM of POCP were broke down to explore the possibility of using POCP as concrete swap for up to 80%. Considering the practicality study, last mortar blends were arranged using 40% of POCP. Further examinations were continued new, mechanical and bond properties of mortar. The solidified properties for mechanical execution and ultrasonic heartbeat speed (UPV) examined in water and air relieved systems show that up to 40% of concrete could be supplanted to acquire the essential compressive strength of 12.4 MPa for concrete lime mortar. Further, POCP ground to a greater number of cycles minorly affected the mechanical properties. The examination on the likely utilization of POCP as concrete substitution affirmed the probability through energy saving, financially savvy and cleaner climate.

Ming Kun Yew, Hilmi Bin Mahmud, Bee Chin Ang, Ming Chian Yew (2014), have published a technical paper entitled, "*Effects of Oil Palm Shell Coarse Aggregate Species on High Strength Lightweight Concrete*" and have found the below:
The target of this examination was to research the impacts of various types of oil palm shell (OPKS) coarse totals on the properties of high strength lightweight concrete (HSLWC). Unique and squashed OPKS coarse totals of various species and age classifications were researched in this investigation. The exploration zeroed in on two OPKS species (dura and tenera), in which the coarse totals were taken from oil palm trees of the accompanying age classes (3–5, 6–9, and 10–15 years of age). The outcomes showed that the functionality and dry thickness of the oil palm shell concrete (OPKSC) increment with an increment in age class of OPKS species. The compressive strength of example CD3 increments fundamentally contrasted with example CT3 by 21.8%. The most extreme reachable 28-day and 90-day compressive strength is 54 and 56 MPa, individually, which is inside the reach for 10–15-year-old squashed dura OPKS. The water retention was resolved to be inside the reach for great concrete for the various types of OPKSC. Also, the ultrasonic heartbeat speed (UPV) results showed that the OPKS HSLWC accomplish great condition at 3 years old days.

CHAPTER - III

RESEARCH METHODOLOGY & MATERIALS

3.1 Materials

3.1.1 Cement

Cement is a substance that is used in construction as a binder for bonding mineral fragments into a compact whole. According to the Energy Technology Systems Analysis Programme (ETSAP, 2010), global cement production has grown steadily from less than 200 million tonnes in 1950 to more than 2500 million tonnes in 2006. There are different types of cements with different properties and performance. BS EN 197-1 (2000) stated that the choice of cement, especially the type and/or strength class, based on the requirements for durability largely depends on the exposure and type of construction in which it is incorporated. The most common type of cement used in construction is the Ordinary Portland Cement (OPC).

The manufacture of OPC involves two stages, notably, clinker production and cement grinding. In the clinker production stage, raw materials are fed to the kiln system to produce clinker. These materials are crushed, grounded, and mixed to obtain a homogenous blend. During this process, significant amount of carbon dioxide (CO2) is released to the atmosphere. Shivaram (2014) stated that producing a tone of cement will generate approximately a ton of CO2. This stage ends with the cooling of the clinker in a cooler system. In the second stage, the clinker is grounded with the addition of other minerals to obtain cement with desired properties such as setting time and strength grade.

According to Cement Sustainability Initiative/European Cement Research Academy (CSI/ECRA, 2009), the grinding of clinker with additives to produce cement requires only electricity (no heat) and accounts for about 38'7o of total electricity used. Table 3-1 shows the physical, chemical, and mechanical properties of Portland cement. As can be seen from table, Portland cement contains over 609ºc of lime (calcium oxide) which makes cement sound and also provides strength to the cement, it is the excess of this lime that reacts with pozzolana in the presence of moisture to produce cementitious properties.

Table 3-1: Physical, Chemical and Mechanical properties of Portland cement (salas et al., 2009)

Chemical Composition (%)		**Physical properties**		**Mineralogical composition (%)**	
SiO_2	21.27	Density (Kg/m^3)	3050	C_3S	53.29
Al_2O_3	4.63	Blaine fineness (m^2/kg)	377	C_2S	20.79
Fe_2O_3	3.96			C_4AF	12.05
CaO	63.05			C_3A	5.56
MgO	1.56	**Compressive strength (MPa)**		Free CaO	0.54
Na_2O	0.16	1 day	10.1		
K_2O	0.18	3 days	23.3		
SO_3	1.75	7 days	36.0		
P. F	2.25	28 days	46.7		

3.1.2 Aggregate

Aggregate is a collective term for the mineral materials such as sand, gravel and crushed stone that are used with a binding medium to form concrete. Aggregate may be defined as an inert filler material in concrete. It is a granular material, such as sand, gravel, crushed stone, and iron blast-furnace slag, used with a cementing medium to form a hydraulic cement concrete or mortar (ACI 318, 1995). According to Gambhir (2013), the reasons of using aggregate in the construction of concrete are due to the economic reasons, volume stability and durability of concrete. As shown in Table 3-2, aggregates can be classified according to the production method, petrological characteristics, unit weight, and according to the particle sizes. Depending on the mix design, aggregate may occupy about 70 – 80 percent of the total volume of concrete. Generally, fine aggregates include particles that pass through 4.75mm sieve and retain on a 0.075mm sieve such as river sand. Their functions include filling the voids between the coarse aggregate while holding them in suspension, producing workable and uniform concrete mixtures. On the other hand, coarse aggregate are those particles retain on a 4.75mm sieve and use as an inert filler material.

Table 3-2: General classification pf aggregates

No.		Classification Type	Examples
1.	**According to production method:**		
	a.	Natural Aggregates (no change in their natural state except for crushing, grading, or washing	Sand, gravel, crushed stone, lime rock.
	b.	By-product aggregates	Blast-furnace slags and cinders, fly ash
	c.	Processed aggregates (heat treated0	Perlite, burnt clays, shales, processed fly ash
	d.	Colored Aggregates	Glass, ceramics, manufactured marble
2.	**According to Petrological Characteristics**		
	a.	Igneous Rocks	Quartz, granite, basalt, obsidian, pumice, tuff
	b.	Sedimentary Rocks	Sandstone, limestone, shale
	c.	Metamorphic Rocks	Marble, slate, schist
3.	**According to Unit Weight**		
	a.	Normal Weight Aggregates	Sand, gravel and crushed. rock
	b.	Light Weight Aggregates	Slag, slate
	c.	Heavy Weight Aggregates	Hemotite, barite magnetite, steel and iron punching’s
4.	**According to Particle Size**		
	a.	Fine Aggregate	Sand
	b.	Coarse Aggregate	gravel

3.1.3 Oil Palm Kernel Shell

Oil Palm kernel shells (OPKS) also known as Oil Palm Shells (OPKS), shown in Figure 3-1, are the by-product of palm oil and palm kernel oil production, and are fractions of shells that result from the cracking of the nuts. OPKS is obtained as crushed pieces, the sizes of which vary from fine aggregates to coarse aggregates, after the crushing of palm kernel to remove the seed, which is used in the production of palm kernel oil (Olutoge, 2010). Oil Palm kernel shells are hard, flaky and of irregular shape (Oti and Kinuthia, 2015). There is no single type of shape that can be used to describe the palm kernel shell. The shape depends on the pattern of breaking during the nut cracking. It is usually composed of many shapes among which are roughly parabolic or semi-circular shapes, flaky shapes and other irregular shapes (Okafor, 1988). OPKS are hard in nature and do not deteriorate easily when used for concrete and therefore, do not contaminate or leach to produce toxic substances (Basri et al., 1999). OPKS may consists of about 65 to 70% of medium size particles in the range of 5 to 10 mm based on the method of cracking the nut (Alengaram et al., 2010).

Fig 3-1: Crushed oil palm kernel shells of different sizes

OPKS physical and mechanical properties make it suitable for so many applications. It can be used as an aggregate for concrete production (Okafor, 1988; Okpala, 1990; Osei and Jackson, 2012). Okoroigwe et al. (2014) used OPKS as a sorbent material for industrial water treatment and stated that the physical and chemical properties of the material make it suitable for the purpose. OPKS can also be used in road construction. However, for heavily trafficked roads, OPKS replacement for aggregate of stone dust and bitumen in 10% blend with asphalt is recommended (Ndoke, 2006). OPKS is also used in the preparation of pozzolana, a cement substitute material that has been developed by the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana (FAO Rome, 2002). Also, Oti and Kinuthia (2015) used OPKS ash to produce concrete and stated that the potential to replace up to 509a Portland cement with OPKS ash burnt at oven temperature of 750°C is more feasible. Also, a recent study has shown that OPKS can be used as a partial replacement for sand in sandcrete block production. Blocks produced from OPKS aggregates are heavier, denser and stronger than the traditional sandcrete blocks when the OPKS aggregate content do not exceed 109c (Dadzie and Yankah, 2015).

3.1.3.1 Characteristics of Oil Palm Kernel Shells

OPKS has both physical and mechanical properties suitable for use as coarse aggregate in concrete. According to Okoroigwe et al. (2014), the material physical and chemical properties determined using standard methods showed that it can fill useful applications in light weight construction as material filler and as sorbent material for industrial water treatment. The shell has a 24-hour water absorption capacity range of 21 — 33to (Shafigh et al., 2010). Okpala (1990) stated that the indirect compressive strength of OPKS aggregate was 12.1 MPa with a standard deviation of about 2 MPa. The material bulk density ranges from 572 to 620 kg/m’ (Itam et al., 2016; Okafor, 1988; Alengaram et al., 2010). The material has been found to have a specific gravity of 1.34 (Williams et al., 2014). Properties of OPKS given by researchers summarized in Table 3-3, show that the material possesses desired characteristics that rendered it necessary to be used as coarse aggregate for concrete production.

Table 3-3: Properties of oil palm kernel shell

Author	Specific Gravity	Bulk Density (kg/m^3)	Shell Thickness (mm)	Water Absorption for 24 hr. (%)	Fineness Modulus	Aggregate Impact Value (%)
Okafor, 1988	1.37	589	-	27.3	-	6.0
Okpa1a, l990	1.14	595	-	21.3		
Alengaram et al., 2010	1.27	620	3.0	25.0	6.24	3.91
Shafigh et al., 2010	1.22			18.73	5.72	
Itam et a1., 2016	1.21	572		25.64		6.65

3.1.4 Physical properties for treated OPKS.

Maximum grain size of OPKS aggregate used in present study is 12 mm whereas Malaysian OPKS has 13 mm. Bulk density of OPKS aggregate is 350–480 kg/m3 and this is the reason for lower density of concrete. Water absorption of OPKS used in this study and Malaysian OPKS are similar. Thickness of OPKS used in this research is 3 mm whereas Malaysian OPKS ranges from 0.3 to 8 mm. Flakiness index and elongation index are similar for OPKS aggregates used in this research and Malaysian OPKS but higher than conventional aggregates.

3.2 Oil Palm Kernel Shell Concrete

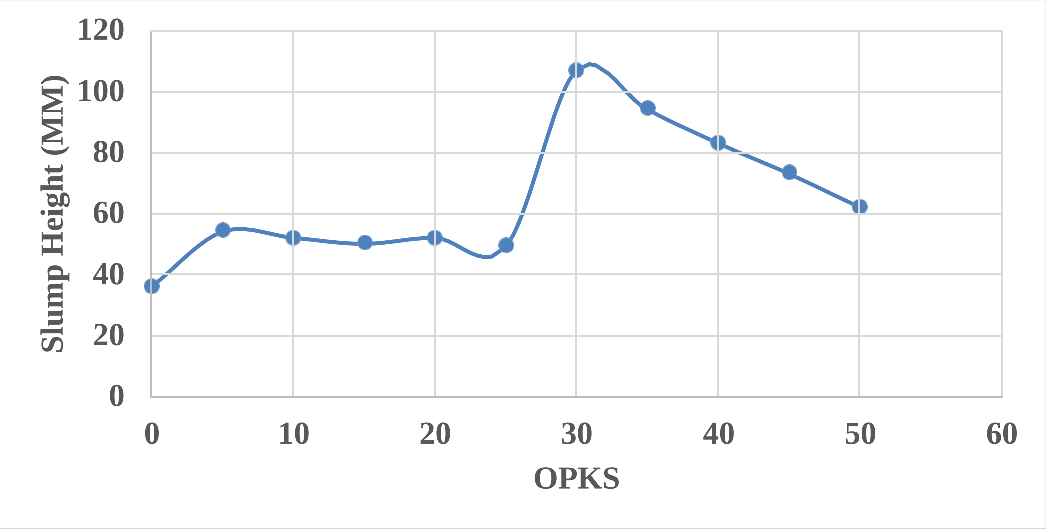
Oil Palm Kernel Shell concrete (OPKSC) is a concrete produce by substituting coarse aggregate partially with OPKS. Depending on the mix design, it can be classified as either Structural Light Weight Concrete (SLWC) or an Insulating Light Weight Concrete when the 28-day compressive strength is below 17 MPa. According to the American Concrete Institute (ACI), Structural Light Weight Concrete is defined as a concrete made with low density aggregate that has an air-dry density of not more than 115 lb/ft" (1840 kg/m") and a 28-day compressive strength of more than 2,500 psi/17 MPa (ACI 1 l6R, 2000). BS 5328 (1997) defined SLWC as hardened concrete having an oven dried density not greater than 2000 kg/m3. Okafor (1988) suggested that the use OPKS as a full replacement of coarse aggregate cannot produce concrete with compressive strength above 30 MPa and that OPKS is suitable for concrete grade 25 and below compared to conventional coarse aggregates. However, in latter research, Alengaram et al. (2010) increased the 28-days compressive strength to 36-38 MPa by incorporating silica fume while Shafigh et al. (2011) developed a new method to produce high strength OPKS concrete of 28-days compressive strength of 53MPa by using crushed OPKS. Osei and Jackson (2012), studied OPKS as Coarse Aggregates in Concrete and ascertained the possibility to replace coarse aggregate up to 100 percent but recommended that batching by volume should be used for better results. The mechanical and structural properties of OPKSC have been compared with normal weight concrete (NWC) by many researchers to show the effectiveness of OPKSC (Alengaram et al., 2013).

3.3 Physical properties of oil palm kernel shell concrete

Physical properties of NWC are the same for OPKSC. Main physical properties of concern for OPKSC include those of workability, density, and water absorption of the concrete.

3.3.1 Workability of Palm Kernel Shell Concrete

The most important property of fresh concrete is its workability defined as the ease with which concrete is mixed, transported, placed, compacted, and finished without segregation. Slump test is a standard test for determining the workability of concrete. It is used to calculate the variation in the uniformity of mix of a given proportion and to measure the consistency of the concrete. Workability of OPKSC is dependent on the water to cement ratio and the content of OPKS. As can be seen in Graph 3-2, Danashmand and Saadatian (2011) performed a slump test on OPKSC for different percentages of OPKS (Oil Palm Shell-OPKS -as on the figure) content as a partial replacement for coarse aggregate with a constant water cement ratio of 0.40 and showed that with increase in OPKS content, the workability of the concrete reduces. Also, according to Alengaram et al. (2008), higher OPKS content in the mix combined with the irregular and angular shapes of the OPKS result in poor workability. This poor workability might be due to the friction between the angular surfaces of the OPKS panicles and lower fine content.



Graph 3-2: Slump Test for different percentage of OPKS content (Danashmand and Saadatian, 2011).

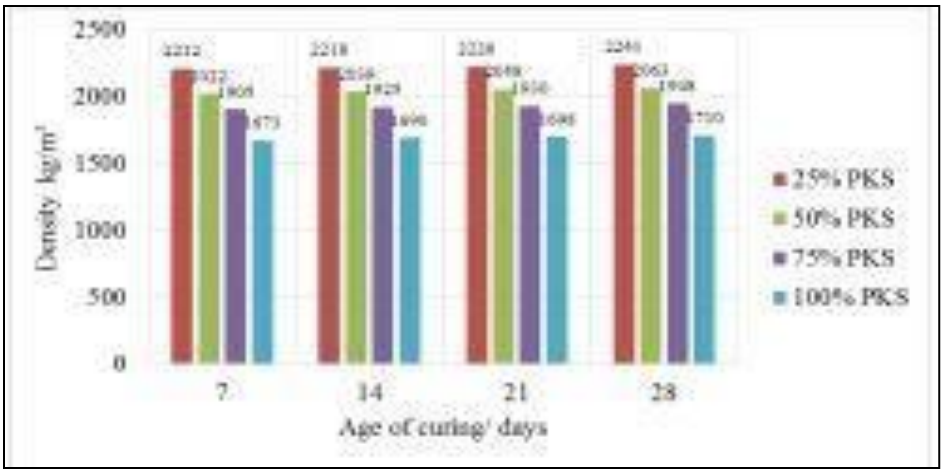
A reduction in OPKS content and a subsequent increase in fine aggregate content increases workability as can be seen from reports by different researchers summarized in Table 3-4.

Table 3-4: Slump of OPKSC by researchers for different mixes

Author	**w/c**	**Mix Proportion**	**Slump (mm)**
Abdullah 1984	0.6 0.4	1:1.5:0.5 1:2:0.6	200 260
Okafor 1988	0.48 0.65	1:1.7:2.08 1:2.1:1.12	8 50
Okpala 1990	0.5 0.6 0.7 0.5 0.6 0.7	1:1:2 1: 1:2 1: 1:2 1:2:4 i: 2:4 1:2:4	30 63 Collapse 3 28 55
Mahmud et a1. 2009	0.35	1:1:0.8	160

3.3.2 Density of Palm Kernel Shell Concrete

For structural applications of Light Weight Concrete (LWC), the density is often more important than the strength (Rossignolo et al., 2003). The density of concrete is study in terms of bulk density, fresh density, and dry density. According to Okafor (1988), the fresh density of OPKSC is in the range of 1753 — 1763 kg/m’ depending on the mix proportion, water to cement ratio, and also the use of sand. Mannan and Ganapathy (2001), based on the mix proportion also reported the fresh density of OPKSC in the range of 1910 1958 kg/m’. Alengaram et al., 2008, reported the fresh density of OPKSC to be approximately 1880 kg/m’ by incorporating l0'7o silica fume and 5to fly ash by weight with a cement: sand: aggregate: water ratio of 1: I.2:0.8:0.35. Usually, the fresh density of OPKSC is about 100 - 120 kg/m3 lower than the saturated density of LWC (Alengaram et al., 2013). As shown on Graph 3-3, Osei and Jackson (2015) showed that the dried density of OPKSC reduces with an increase in OPKS content but increases with curing time.



Graph 3-3: Densities of hardened OPKSC at different curing age (Osei and Jackson, 2015)

3.3.3 Water Absorption of Palm Kernel Shell Concrete

Pore distribution

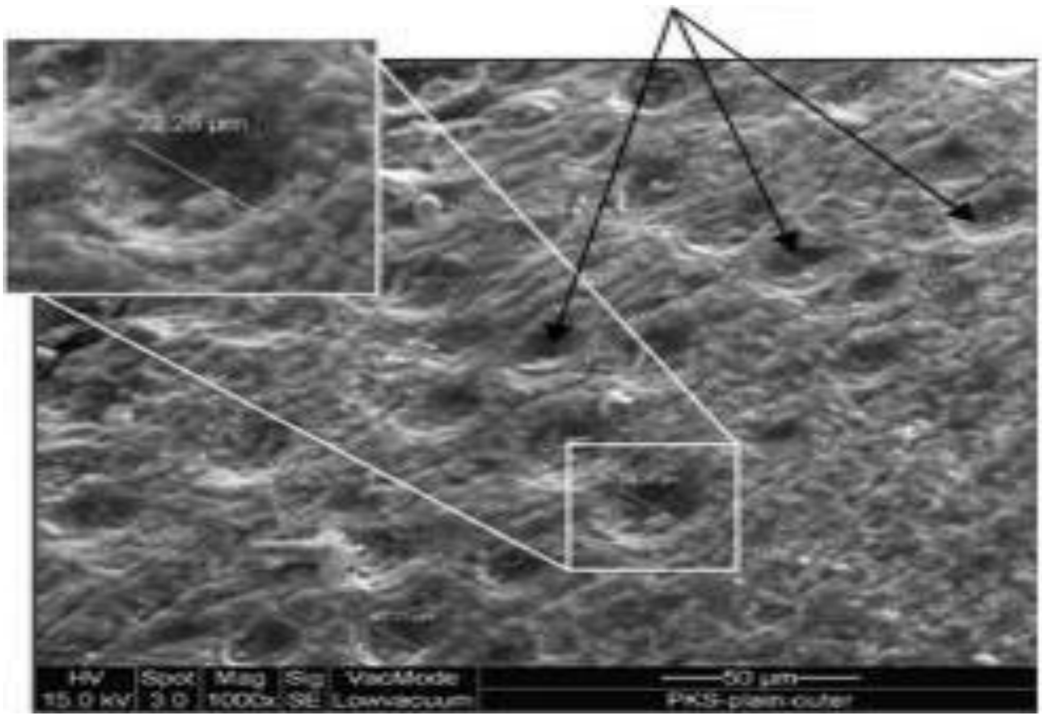


Figure 3-4: Pores of the outer surface of OPKS (Alengaram et al., 2011).

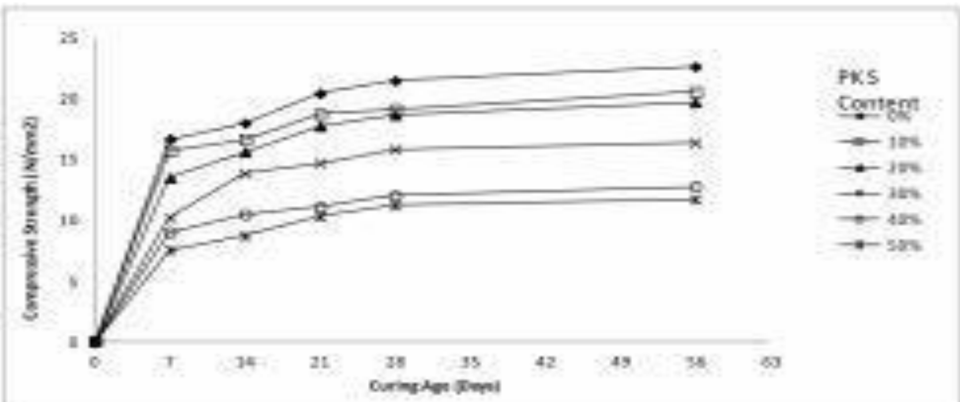
According to Basheer et al. (2001), water absorption is the transport of liquids in porous solids caused by surface tension acting in the capillaries. Water absorption for LWC such as expanded polystyrene concrete and pumice aggregate concrete is in the range of 3 69r according to Babu and Babu (2003), and 14 22% according to Guduz and Ugur (2005) respectively. For OPKSC, Teo et al. (2007) showed that the water absorption is 11.23' o and 10.64' o for air dry curing and full water curing respectively. This high-water absorption for OPKSC can be explained by the analysis of the OPKS structure. Alengaram et al. (201 I) examined the structure of the OPKS using a scanning electron microscope and it was observed that tiny pores in the range of 16 - 24qm exist on the convex surface of the OPKS as shown in Figure 3-4, which are responsible for the high-water absorption of OPKSC.

3.4 Mechanical properties of oil palm kernel shell concrete

The mechanical properties of OPKSC are dependent on the mixed design chosen. According to Shetty (2005), mix design methods that apply to normal weight concrete are generally difficult to use with lightweight aggregate concrete. Abdullah (1996) suggested that trial mixes are necessary to achieve a good mix design for OPKSC. Also, Osei and Jackson (2012), after batching by weight and by volume for OPKSC, concluded that batching by volume gives better mechanical properties than batching by weight.

3.4.1 Compressive Strength of Oil Palm Kernel Shell Concrete

The compressive strength is the most used parameter to describe the quality of concrete in practice (Weigrink et al., 1996). All other mechanical parameters such as flexural strength, splitting tensile strength and modulus of elasticity directly depend on the compressive strength of the concrete (Alengaram et al., 2013). As shown in Graph 3-5, Ikponmwosa et al., (2014), Daneshmand and Saadatian (201 I), and Olutoge et al. (2012), all reported that the compressive strength of OPKSC is dependent on the amount of OPKS aggregate in the concrete and that the strength increases with curing age.



Graph 3-5: Compressive strength of OPKSC with curing age (Ikponmwosa et al., 2014)

Depending on the mix design, percentage of OPKS aggregate, and method of curing, different grades of OPKSC have been reported by researchers. Table 3-5 shows the compression strength of OPKSC by various researchers. Okpala (1990) reported a 28-day compressive strength of 22.2 MPa using a water to cement ratio of 0.5 and a mix design of 1: 1: 2 (cement: sand: aggregate). Shafigh et al. (2011), incorporated steel fibers using a water to cement ratio of 0.38 and a design mix of 1: 1.736: 0.72 (cement: sand: aggregate) and reported a 28-day compressive strength in a range of 39.34 — 44.95 MPa.

Table 3-5: The compressive strength of OPKSC at 28 — day

Author	**Water/Cement** Ratio	**Mix Proportion**	**Compressive Strength at 28** days (MPa)
Okafor, 1988	0.48	1: 1.7: 2.08	23
Okpala, 1990	0.5	1: 1: 2	22.2
Alengaram et al., 2010	0.35	1: 1.2: 0.8	37.41
Shafigh et al., 2011	0.38	1: 1.736: 0.72 (+steel fibers)	39. 34– 44.95

3.4.2 Suitability of oil palm kernel shells in concrete

OPKS has been experimented in research as light weight aggregate (LWA) to produce light weight and low-cost concrete since 1984 (Alengaram et al., 2013). According to Shafigh et al. (2010), research over the last two decades has shown that OPKS can be used as a lightweight aggregate for producing low cost and structural lightweight concrete. Also, it has been reported by Yap et a1. (2013), that OPKS is a suitable replacement for coarse aggregate to produce high strength LWC with 28 days compressive strength up to 53 MPa.

Okafor (1988) tested the physical properties of the shell, the compressive, flexural, and tensile splitting strength of the OPKS concrete. Three mixes of widely different water to cement ratio were used with 1009c coarse aggregate replacement with OPKS. The properties tested were compared with those of similar concrete specimens made with crushed granite as coarse aggregate. The results showed that the material is suitable to produce concrete grade 25 and below. Similarly, Williams et al. (2014), produced some concrete with 1009c replacement of coarse aggregate using OPKS at a mix design of I:2:4 (cement: sand: coarse aggregate) and a water to cement ratio of 0.65. The results showed that the compressive and flexural strength improved with age of curing, though the compressive and flexural strength of OPKSC were low as compared to that of the NWC. They concluded that OPKS can be used for concrete production as lightweight aggregate and therefore can be used to produce LWC. The properties of OPKS fresh concrete are however excellent, very workable, consistent, and easily placed. Therefore, with the above information, the OPKS is suitable to produce low structural concrete by replacing coarse aggregate.

3.5 Fly Ash

The combustion of coal at high temperatures and pressures in power stations produces different types of ash. The 'fine' ash fraction is carried upwards with the flue gases and captured before reaching the atmosphere by highly efficient electrostatic precipitators. This material is known as fly ash. It is composed mainly of extremely fine, glassy spheres and looks like cement. The coarse ash fraction falls into the grates below the boilers, where it is mixed with water and pumped to lagoons. This material, known as bottom ash, has a gritty, sand-like texture. The use of fly ash and bottom ash in construction has been established for decades. Applications range from providing the cementations material in concrete, to use as a simple fill material or a lightweight aggregate in the manufacture of blocks. Using fly ash makes a positive contribution to the environment. Fly ash is used in many applications to replace naturally occurring aggregates and minerals, which can reduce significantly the demand for normal aggregates (granite). Fly ash is also used as a component in the production of flowable fill, which is used as self-levelling, self-compacting backfills material in lieu of compacted earth or granular fill. Flowable fill includes mixtures of Portland cement and filler material and can contain mineral admixtures, such as fly ash. Filler material usually consists of fine aggregate (in most cases, sand), but some flowable fill mixes may contain approximately equal portions of coarse aggregate and fine aggregates.

3.5.1 Properties of fly ash

Studies by Khairul Nizar. (2007) have shown that the physical and chemical properties of FLA are dependent on the soil chemistry and climatic conditions. Similarly, studies made by Mohd Mustafa Al Bakri Abdullah. (2014) also showed that the differences in the physical and chemical properties of FLA may be due to waste produce during quarrying. Therefore, properties of FLA largely depend on chemistry, climatic conditions, and internal grain structure applied during the cooling of molten.

3.5.1.1 Chemical Properties of Fly Ash

The chemical compositions of FLA from various locations are presented in Table 3.6. Fly ash consists primarily of oxides of silicon, aluminum iron and calcium. Magnesium, potassium, sodium, titanium, and sulfur are also present to a lesser degree. When used as a mineral admixture in concrete, fly ash is classified as either Class C or Class F ash based on its chemical composition. American Association of State Highway Transportation Officials (AASHTO) M 295 [American Society for Testing and Materials (ASTM) Specification C 618] defines the chemical composition of Class C and Class F fly ash.

- Class C ashes are generally derived from sub-bituminous coals and consist primarily of calcium alumino-sulfate glass, as well as quartz, tricalcium aluminate, and free lime (CaO). Class C ash is also referred to as high calcium fly ash because it typically contains more than 20 percent CaO.
- Class F ashes are typically derived from bituminous and anthracite coals and consist primarily of an alumino-silicate glass, with quartz, mullite, and magnetite also present. Class F, or low calcium fly ash has less than 10 percent CaO.

Table 3-6: The Chemical composition of fly ash

Compounds	Fly Ash Class F	Fly Ash Class C	Portland Cement
SiO_2	55	40	23
Al_20_3	26	17	4
Fe_2O_3	7	6	2
CaO (Lime)	9	24	64
MgO	2	5	2
SO_3	1	3	2

3.5.1.2 Physical Properties of Fly Ash

3.5.1.2.1 Colour

Fly ash can be tan to dark gray, depending on its chemical and mineral constituents. Tan and light colors are typically associated with high lime content. A brownish colour is typically associated with the iron content. A dark gray to black colour is typically attributed to an elevated unburned carbon content. Fly ash colour is usually very consistent for each power plant and coal source.

3.5.1.2.2 Size and Shape

Fly ash is typically finer than Portland cement and lime. Fly ash consists of silt-sized particles which are generally spherical, typically ranging in size between 10 and 100 micron (Figure 1-2). These small glass spheres improve the fluidity and workability of fresh concrete. Fineness is one of the important properties contributing to the pozzolanic reactivity of fly ash.

3.6 Test on cement

The following tests are performed in the concrete technology laboratory to determine the properties of cement and the results are shown in the Table 3-7.

- Normal consistency test
- Fineness of cement
- Specific gravity of cement
- Initial and final setting time
- Soundness of cement

3.6.1 Normal consistency test

Take 250gm of cement and weight carefully and add 20% water in it. Care should be taken that mixing time is not less than 3min and gauging shall be counted from the time of adding water. Fill the paste in the mould. The excess paste to trim off and vibration are given to remove air bubbles. Fix the 10mm dia. plunger in the moving rod and bring down in touch with the paste. Release the plunger. Repeat the procedure till it penetrate 33-34mm from the top & note down the water percentage.

Observations and Calculations:

Table 3-7 Normal Consistency

Cement	% Of Water added	Penetration
250 grams	27 X (250/100)	33
	28 X (250/100)	25
	29 X (250/100)	15
	30 X (250/100)	10
	31 X (250/100)	7

Result: The percentage of water for normal consistency for the given sample of Cement is 31.67%.

3.6.2 Fineness of Cement

Weigh approximately 300g of cement to the nearest 0.01g and place it on the sieve. Agitate the sieve by swirling, planetary and linear movements, until no more fine material passes through it. Weigh the residue and express its mass as a percentage w1, the quantity first placed on the sieve to the nearest 0.3 percent. Gently brush all the fine material off the base of the sieve. Repeat the whole procedure using a fresh 300g sample to obtain w2. Then calculate R as the mean of w1 and w2 as a percentage, expressed to the nearest 0.1 percent. When the results differ by more than 1 percent absolute, carry out a third sieving and calculate the mean of the three values.

<u>Observation and Calculations</u>:

Fineness of cement = W1+W2+W3/ avg x10= weight retain on sieve/total weight

Table 3-8 Fineness of Cement

S. No	Weight of cement (grams)	Weight of residue formed (grams)	Fineness of cement (%)
1	300	20	6.67
2	300	30	5.29
3	300	30	7.0

Fineness of Cement= (5.29+6.67+7.0)/3 = 6.32%

Result: The finesse of cement is 6.32%, which is less than 10%.

3.6.3 Specific gravity of cement

Object: To determine the specific gravity of cement using Le Chatelier Flask or Specific Gravity Bottle.

Apparatus:

- Le Chatelier Flask or Specific Gravity Bottle-100ml gm.
- Balance capable of weighing accurately 0.1gm.

Procedure:

- Weigh a clean and dry Le Chatelier Flask or Specific Gravity Bottle with its stopper (W1).
- Place a sample of cement up to half of the flask (about 50 gm.) and weigh with its stopper (W2). • Add kerosene (polar liquid) to cement in flask till it is about half full.
- Mix thoroughly with glass rod to remove entrapped air. Continue stirring and add more kerosene till it is flush with the graduated mark.
- Dry the outside and weigh (W3). Entrapped air may be removed by vacuum pump.
- Clean it refills with clean kerosene flush with the graduated mark wipe dry the outside and weigh (W4).

Calculations:

Where W1 =weight of empty flask = 120 gm

W2=weight of flask + cement = 220 gm.

W3=weight of flask + cement + kerosene = 510 gm.

W4=weight of flask + kerosene = 442 gm.

Specific Gravity = (W2-W1)/ [(W2-W1) - (W3-W4)]

= (220-120)/ [(220-120) - (510-442)]

= 100/32

= 3.142

= 3.14

Result: The Specific Gravity of cement is **3.14**

3.6.4 Initial and final setting time

Take about 500gms of cement. Add water of standard consistency. To make cement paste. To make the surface of the cement paste is till smooth and Level. The whole assembly kept in vicat's apparatus.

Bring the needle in the rod gently near the surface of the test block and release it quickly allowing it to penetrate the block and note the time. Repeat the procedure till the needle fails to penetrate the test block by 5mm to 7mm from the bottom of the mould. Generally, the initial setting time of cement is not less than 30min.

Observation:

1. Quantity of cement = 250 grams.
2. Water for standard Consistency = 31.67%

Observation Table:

Table 3-9 Initial and Final Setting Time

Cement	Percent of water Added	Time (sec)	Penetration (mm)
250 grams	0.85 * 31% of weight of cement	5	0
		10	0
		15	0
		20	0
		25	3
		30	5
		35	6
		40	10

Result:

(a) The initial setting time of the cement sample is found to be 44 minutes.

(b) The final setting time of the cement sample is found to be 600 Minutes.

3.6.5 Soundness of Cement

1. Before Performing the test, calculate the standard consistency of cement to find out the water required to obtain the normal consistency (P).
2. Now add 0.78 times of water to the cement to give a paste of standard consistency (0.78P).
3. Lightly apply oil to the Lechatelier mould and place it on a glass plate.
4. Now pour the cement paste into mould and close the mould using lightly oiled glass plate and to avoid misplacement place a weight on it.
5. Then submerge the whole assembly for 24Hrs in water bath at a temperature of 27C.
6. Remove the entire apparatus from water and then calculate the distance separating two indicator points using measuring scale and note it as L1.
7. Again, submerge the whole assembly in a water bath at a temperature of boiling point for 3hours.
8. After completion of 3hours remove the assembly from the bath and measure the distance between two indicator points and note it as L2.

Calculations:

Soundness/expansion of cement = L2-L1

L1=Measurement taken after 24 hours of immersion in water at a temp. of 27 $\pm 20^{o}$ C =12 mm

L2=Measurement taken after 3 hours of immersion in water at boiling temperature =18 mm

Result: Soundness of Cement = 6 mm

Table 3-10: Test results of cement

S. No.	Parameter	Result
1	Normal consistency test	31%
2	Fineness of cement	6.32%
3	Specific gravity of cement	3.14
4	Initial setting time	44 min
5	Final setting time	600 min
6	Soundness of cement	6 mm

3.7 Tests on Aggregates

The following tests are performed in the concrete technology laboratory to determine the properties of fine aggregate, coarse aggregate, oil palm shell aggregate and the results are shown in Table 3.11.

- Specific gravity of fine aggregate
- Specific gravity of coarse aggregate
- Specific gravity of oil palm shell aggregate
- Water absorption test for oil palm shell
- Bulk unit weight of oil palm shell
- Fineness modulus of oil palm shell
- Los Angeles abrasion test (oil palm shell)
- Aggregate impact test (oil palm shell)
- Aggregate crushing strength test (oil palm shell)

Table 3-11: Test results of aggregates

S. No	Parameter	Result
1	Specific gravity of fine aggregate	2.64
2	Specific gravity of coarse aggregate	2.66
3	Specific gravity of oil palm shell aggregate	1.6
4	Water absorption of oil palm shell	28%
5	Bulk unit weight of oil palm shell	672.56 kg/m3
6	Fineness modulus of oil palm shell	6.08
7	Los Angeles abrasion value (oil palm shell)	4.90%
8	Aggregate impact value (oil palm shell)	7.51%
9	Aggregate crushing value (oil palm shell)	8.00%

3.8 Methodology

3.8.1 Introduction

Literature reviews related to the Oil palm kernel shell (OPKS) were collected and based on the literature survey preliminary works were performed. Works like collection of OPKS was performed. Materials required for concrete such as coarse aggregate, fine aggregate, cement were collected. Basic tests were conducted on fine aggregate, coarse aggregate, cement, Oil palm kernel shell, to check their suitability concrete making. The properties of fine and coarse aggregates sieve analysis of fine and coarse aggregates, tests on cement are found out. The Study aims to investigate the strength related properties of concrete of M30 grade. The proportions of ingredients of the control concrete of grade M30 had determined by mix design as per IS code. Moulds were prepared to cast he specimen. Mould of size 150mm*150mm*150mm and prism mould 100*100*500 were cast with desired of partially replacement (0%, 10%, 20%, 30%, 40%, and 50%) of coarse aggregate simultaneously 5% constant partially replacement of fly ash with binding material. Casted Samples were tested after 7days and 28 days of curing Compressive strength and split tensile strength test and flexural strength was performed using casted concrete. Results were obtained and conclusion was arrived.

3.8.2 METHODOLOGY FLOW CHART

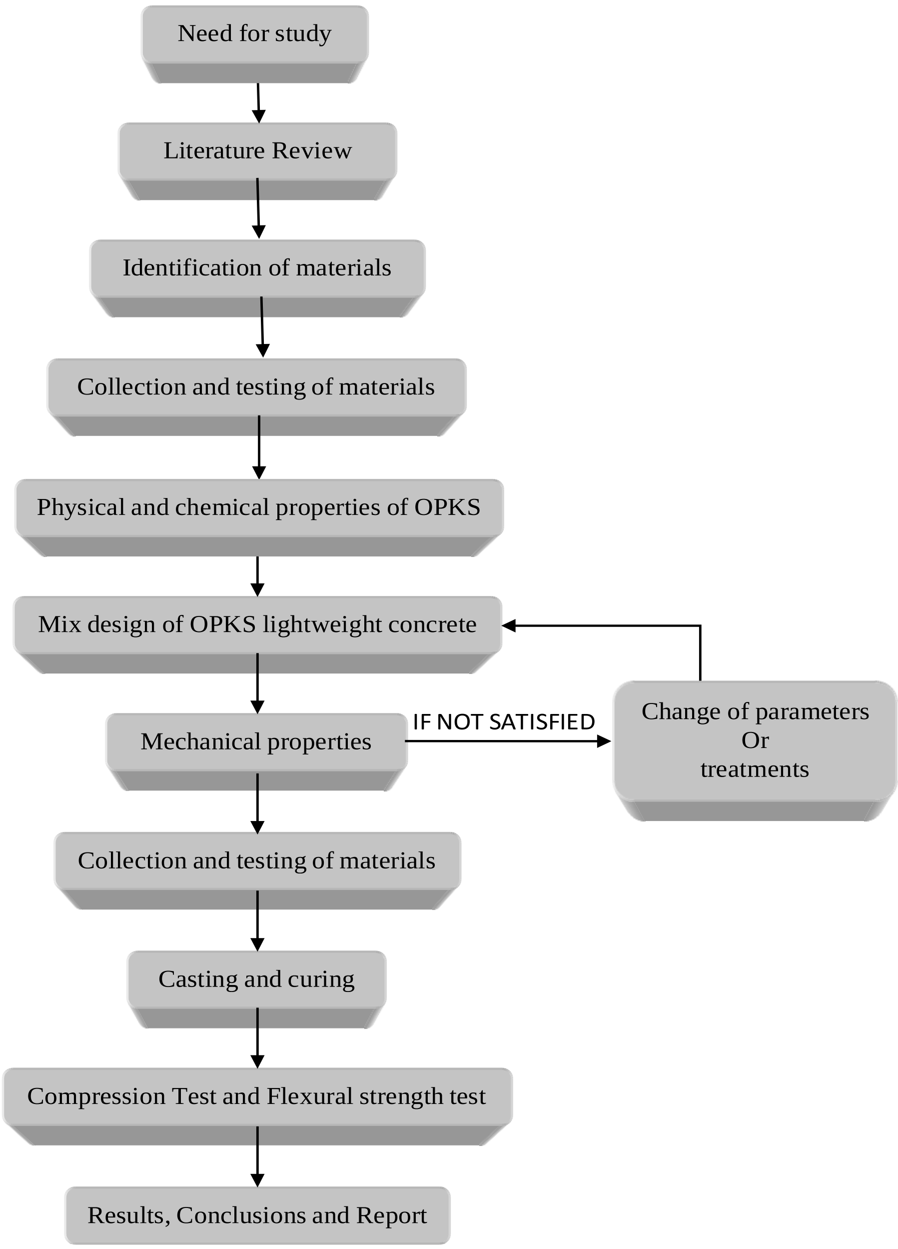


Figure 3-6 shows the flow chart for the activities adopted for the research from start up to the completion.

3.9 Preparation of samples

3.9.1 Mix Proportion

After several trial mixes for a targeted strength, the mix ratio of 1:1.05:2.38 was adopted for cement,sand, and coarse aggregate respectively by volume with a constant free water to cement ratio of 0.40 in accordance with BS 1881-125 (1983). This mix ratio was used to produce twelve types of concretes as shown in Table 3-12. The control concrete consisted of cement, sand, and coarse aggregate all at 1009c, while the rest had varied amount of OPKS and FLA to determine their effect on the concrete properties.

Table 3-12: Experimental matrix used in the research.

OPKS	**FLA 5%**		
0%	0%OPKS + 0%FLA	0%OPKS + 0%FLA	0%OPKS + 0% FLA
10%	10%OPKS + 5%FLA	10%OPKS + 5%FLA	10%OPKS + 5%FLA
20%	20%OPKS + 5%FLA	20%OPKS + 5%FLA	20%OPKS + 5%FLA
30%	30%OPKS + 5%FLA	30%OPKS + 5%FLA	30%OPKS + 5%FLA
40%	40%OPKS + 5%FLA	40%OPKS + 5%FLA	40%OPKS + 5%FLA

3.9.2 Mixing, Casting, Curing of Concrete

3.9.2.1 Mixing

Mixing was done manually in accordance with the provisions of BS 1881-125 (1983). All mixing was done on a tray using shovels and trowels as shown in Figure 3-7.

Figure 3-7: Tray used for the mixing of concrete.

3.9.2.2 Casting

Concrete was casted in forms of cubes and prisms with full compaction to expel entrapped air. Concrete was placed in three layers and compaction was made at each layer placement using a mechanical vibrator. Each mix casted a total of 9 cubes and 9 prisms bringing the total to45 cubes and 45 cylinders for the five mixes. The cubes had a dimension of 150 X 150 X l50mm and prism of l00mm in breadth and depth and 500mm long.

3.9.2.3 Curing

Cubes and cylinders were open air cured for 24hrs after casting and then demolded for water curing for 7, 14 and 28 days prior to testing in accordance with BS 1881 11 I (1983). Method of water curing used was by immersing specimens in curing tanks as shown in Figure 3-8.

Figure 3-8: Curing of concrete by immersion.

3.10 MATERIALS CHARACTERISTICS

The objective of these tests was to determine the characteristics of OPKS, Coarse Aggregate, FLA, OPC, and fine aggregate for their use as constituents for concrete production. Samples of OPKS and coarse aggregate were classified in terms of particle size distribution, aggregate impact value, aggregate crushing value, 24hrs water absorption, bulked density, and the specific gravity of the materials. Fine aggregate was classified in terms of particle size distribution, 24hrs water absorption, and the fineness modulus of the material. FLA and OPC were classified in terms of their physical and chemical properties.

3.10.1 Particle Size Distribution

The particle size distribution (PSD) or sieve analysis were performed for OPKS, coarse aggregate, and fine aggregate in order to the determine the grading of each material in accordance with BS 812-103 (1990). Sieving was done by hand. The dried residue was placed on the top of the coarsest sieve and shaken for sufficient time to separate the test sample into the size fractions determined by the sieve apertures used. After sieving, each sieve, starting with the coarsest sieve was shaken separately over a clean tray until not more than a trace passed. Light brushes were used on the underside of the sieve to clear sieve opening. The material retained on each sieve was weighed and calculated as a percentage of the original mass and the mass passing each sieve was calculated as a cumulative percentage of the total sample mass.

3.10.2 Specific Gravity and Water absorption.

The specific gravity and water absorption tests in accordance with BS 812-2 (1995) were also done for both OPKS, coarse aggregate, and fine aggregate. Samples were immersed in water for 24 hours and then dried with a cloth to removed films of water while the aggregate still had a damp appearance. The aggregate was weighed, and mass recorded (mass A). A glass vessel/jar (Pycnometer) containing the sample and filled with water was also weighed and recorded (mass B). The vessel was then filled with water only and was weighed and the mass recorded (mass C). The sample was then placed on a clean tray and oven dried at a temperature of l05'C for 24 hours. The sample was cooled after oven drying and the mass weighed and recorded (mass D). The specific gravity and water absorption were then calculated using Equations 3-1 and 3-2 respectively.

$$\text{Specific Gravity} = \frac{D}{A - (B - C)} \qquad \text{Equation 3-1}$$

$$\text{Water Absorption} = \frac{100\,(A - D)}{D} \qquad \text{Equation 3-2}$$

Where A - is the mass of the saturated surface – dry aggregate.

B - is the mass of vessel containing sample and filled with water.

C - is the mass of vessel filled with water only.

D - is the mass of the oven-dried aggregate in air.

3.10.3 Aggregate Crushing Value

The aggregate crushing value (ACV) test was conducted for both the OPKS and coarse aggregate in accordance with BS 812 (1990). Aggregates passing a l4mm test sieve and retained on a 10mm test sieve were used. The resulting l4mm to l0mm fraction was divided to produce three test specimens. Each test specimen was dried by heat at a temperature of l05°C for a period of 3 hours and then cooled at room temperature before testing.

The cylinder of the test apparatus was placed in position on a baseplate and the test specimen added in three layers of approximately equal depth, each layer being subjected to 25 strokes from the tamping rod distributed evenly on the surface of the layer and dropping from a height approximately 50mm above the surface of the aggregate. The apparatus with the specimen was placed in position between the platens of the testing machine and loaded at a uniform rate until the required loading of 400KN was reached in 10 minutes. The load was released, and the crushed material removed in a clean tray of known mass. The mass of the crushed aggregate

(M_1) was then determined, and specimen was then sieved using a 2.36mm test sieve. Passed and retained masses were recorded as M_2 and M_3 respectively. ACV was then calculated and expressed as a percentage using equation 3-3. The average ACV was computed from the three results obtained.

$$\mathbf{ACV} = \frac{\mathbf{M_2}}{\mathbf{M_1}} \mathbf{(100)} \text{ -------------------- } \textbf{Equation 3-1}$$

3.10.4 Aggregate Impact Value

The aggregate impact value (AIV) was also done for both OPKS, and coarse aggregate as specified in BS 882 (1992). Aggregates passing a l4mm test sieve and retained on a l0mm test sieve were used. The resulting l4mm to l0mm fraction was divided to produce three test specimens. Each test specimen was oven dried at a temperature of l05°C for a period of 3 hours and then cooled at room temperature before testing.

The impact machine was then rested on the floor such that it was rigid and the hammer guide column vertical. The specimen was placed in the cup and compacted by 25 strokes of the tamping rod. The cup was fixed firmly in position on the base of the machine and the hammer adjusted to about 380mm above the upper surface of the aggregate in the cup. The hammer was then made to fall freely on the aggregate for about 15 times. The aggregate was removed to a clean tray of known mass and the weight of the aggregate measured as M1. The specimen was then sieved using a 2.36mm test sieve until no significant amount was passed. Fractions of passed and retained were weighed and recorded as M2 and M3 respectively. The AIV for each test specimen was then calculated as a percentage using Equation 3-4, and the average AIV computed.

$$\boldsymbol{AIV} = \frac{M2}{M1} \mathbf{(100)} \qquad \textbf{Equation 3 — 4}$$

3.10.5 Hydrometer Analysis of Fly Ash

Hydrometer analysis is a widely used method for obtaining an estimate of the distribution of particle sizes from No. 200 (0.075 mm) sieve to around 0.0lmm. Analysis was done in accordance with BS 1377 -2 (1990). Sample mass of 50g was used for the analysis. This sample was then placed in a wide-mouth conical flask and then l00ml of sodium hexametaphosphate added. The mixture was shaken until all the particles were in suspension. It was then further mixed in a mixing machine for about 5 minutes until the materials were further broken down into individual particles. The suspension was then transferred from the flask to a 75µm sieve and washed with 500ml of distilled water. The suspension that passed through the sieve was transferred to a 1L measuring cylinder up to the 1L graduation mark. This suspension was used for the sedimentation analysis. The material retained on the 75µm sieve was oven-dried and re-sieved on relevant sieves upon cooling while recording the mass retained on each sieve down to the 75µm sieve. Material that passed the 75µm sieve was added to the measuring cylinder.

For the sedimentation analysis, a separate solution was prepared in a 1L measuring cylinder consisting of 100ml of the sodium hexametaphosphate and diluted with distilled water up to the 1L graduation mark. The suspension was mixed in the measuring cylinder by placing the palm of one hand over the open end of the cylinder and turned vigorously end-over-end about 60 times within 2 minutes. The cylinder was quickly placed on the table after mixing and timing for sedimentation was started. The hydrometer was then immersed in the suspension and was allowed to float freely. Hydrometer readings were taken at the upper ring of the meniscus after a period of 0.5min., 1min., 2min. and 4 minutes without removing the hydrometer. The hydrometer was then removed after 4 minutes and was rinsed with distilled water and was placed in the dispersant solution cylinder and reading taken at the top of the meniscus as R_0. The hydrometer was reinserted into the suspension cylinder and readings recorded for the periods of 8min, 15min, 30min, 1hr, 2hrs, 4hrs, and 24hrs from the start of the sedimentation while withdrawing and reinserting the hydrometer after each reading. The temperature of the suspension was also recorded after every subsequent reading.

The true hydrometer reading Rr was calculated from Equation 3-5.

Hydrometer reading Rh) = R'h + Cm----------------------------- Equation 3 – 5

Where Rh' is the observed hydrometer reading, and Cm is the meniscus correction faction (Cm=0.5).

The modified hydrometer reading, Rd, was calculated using Equation 3-6.

Modified hydrometer reading (Rd) = R'h – R'o -----------------Equation 3 – 6

Where Ro' is the hydrometer reading at the upper rim of the meniscus in the dispersant solution.

3.10.6 Chemical Analysis of Fly Ash and Cement

The chemical characteristics of FLA and OPC were determined at the Ministry of Mining in India. The objective of this test was to determine the chemical composition of these materials, especially the silica content of FLA as it defines the criterion for a good pozzolana and the calcium oxide (CaO) content of the OPC, before their use in concrete production. Several methods were used to determine these chemicals composition. The Atomic absorption spectroscopy method was used to determine $Al2O_3$, CaO, $Fe2O_3$, MgO, MnO_2 and CuO contents in the sample; Flame photometry method, used to determine Na and K content in the sample; loss on ignition (LOI), was used to determine the organic content in the samples. The LOI was done by igniting a known mass of the sample in a furnace and heated gradually up to a temperature of l000'C. This temperature was maintained for 30 minutes after which it was allowed to cool and weighed. The LOI was expressed as a percentage of the original sample weight.

3.10.7 Testing of oil palm kernel shells as coarse aggregate partial replacement in normal weight concrete

The objective of this test was to determine the impact of OPKS on concrete when used as a partial replacement for coarse aggregate. To determine this impact, OPKS was varied at 0%, 10%. 20%, 30% and 40% as coarse aggregate replacement in the production of concrete producing a total of 45 cubes and 45 prisms at each percentage. The effect of OPKS was determined in terms of workability of concrete, density, water absorption, compressive strength, and splitting tensile strength.

3.10.8 Testing of fly ash as ordinary Portland cement partial replacement in normal weight concrete

The objective of this test was to determine the impact of FLA on concrete when used as a partial replacement for OPC. To determine this impact, FLA was varied at 5% for OPC, producing a total of 45 cubes and 45 prisms for each mix. The effect was determined in terms of workability of concrete, density, water absorption, compressive strength, and flexural strength.

3.10.9 Testing of palm kernel shells and fly ash as partial replacements of coarse aggregate and ordinary Portland cement respectively on the physical and mechanical properties of normal weight concrete

The objective of this test was to determine the combined effect of OPKS and FLA on concrete. Five mixes of concrete were produced by varying OPKS at 0%, 10%, 20%, 30% and 40% and FLA at 5% for coarse aggregate and OPC respectively. Physical properties studied were in terms of workability, density, and water absorption of the concrete. Mechanical properties were determined in terms of compressive and flexural strengths.

3.10.10 Workability

The workability of the concrete was determined through slump test. The slump measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. Slump test was conducted in accordance with provision of BS 1881-102 (1983) as shown in Figure 3-9.

Figure 3-9: Determination of slump as per BS 1881-102 (1983)

3.10.11 Water Absorption Test

The water absorption test was conducted on hardened concrete for all mixes. Three cube specimens of each concrete mix were cured for 28 days before testing. After the 28 days curing, the specimens were placed in a drying oven of temperature 100°C for a period of 72hrs conforming to specification of BS 1881-122 (1983). Upon removal from the oven, the specimens were cooled for 24hrs. After cooling, specimens were weighed and immediately immersed completely in a tank of water for 30 minutes. Specimens were removed from the tank and dried with a cloth to remove bulk of the water from the surface and then weighed. Water absorption was then calculated as the increase in mass resulting from immersion and was expressed as a percentage of the mass of the dry specimen.

3.10.12 Compressive Strength Test

For the determination of the compressive strength, 3 cube specimens of 150 X 150 X l50mm of each mix were tested at 7 and 28 days of curing using a Universal Testing Machine (UTM) as specified in BS 188 l -115 (1983) shown Figure 3-10. The compressive strength for each cube was calculated by dividing the maximum load applied to it by the cross-sectional area according to BS 1881-116 (1983).

Fig 3-10 Compressive test of cubes

3.10.13 Density of Concrete Test

The concrete density was determined by dividing the mass of each cube by its volume as specified by BS 1881-144 (1983). Specimens were cured in water in accordance with BS 81 — 111 (1983) for more than 3 days and were therefore assumed to be saturated to a constant mass for the test. The specimen was weighed on the scale balance and masses recorded in kilogram (kg). The volume of each specimen was calculated in cubic meter (m3) and the density was computed in kilogram per cubic meter (kg/m3).

CHAPTER-IV

RESULTS AND DISUSSION

4.1 Introduction

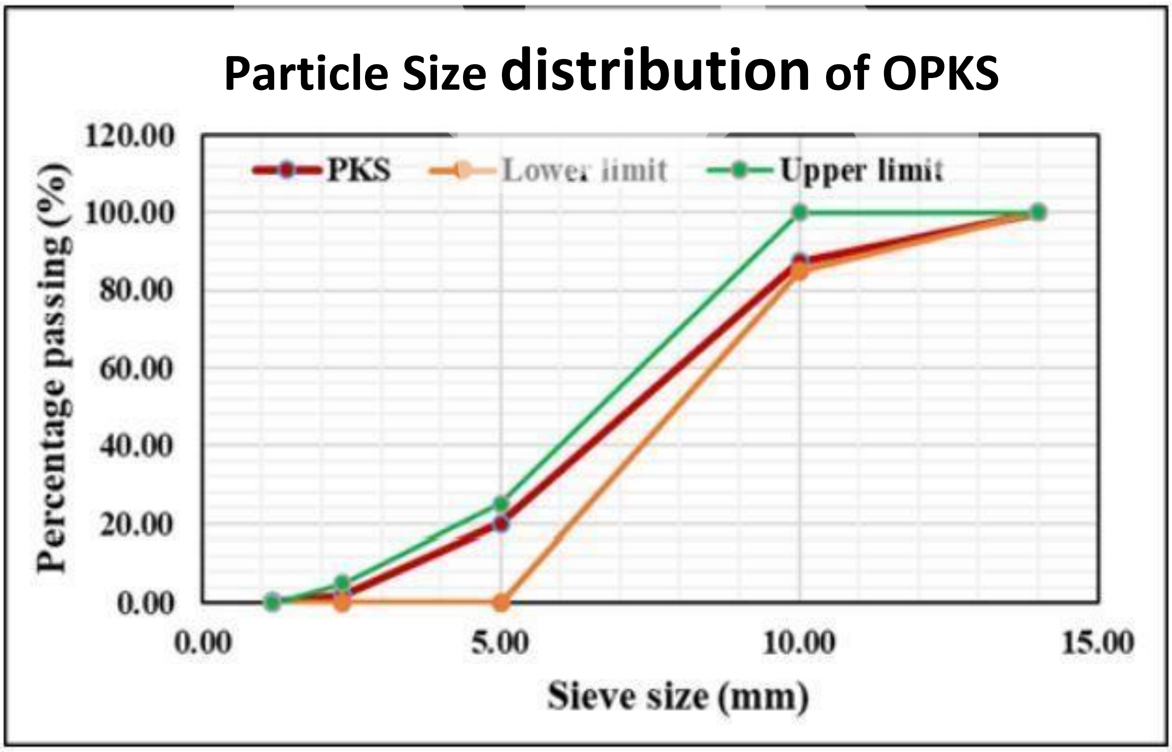
This chapter focuses on the results and discussion of findings obtained from investigating the effect of OPKS and FLA on the physical and mechanical properties of NWC as partial replacements for coarse aggregate and OPC respectively. These effects are discussed in terms of workability, density, water absorption, compressive strength, and flexural strength. The characteristics of OPKS, FLA, OPC, Coarse Aggregate and Fine aggregates are also presented and discussed in this chapter.

4.1.1 Materials characteristics

Characterization of OPKS and coarse aggregate were in terms of PSD, water absorption, specific gravity, ACV, AIV, and bulk density. FLA was characterized in terms of specific gravity, particle size distribution (hydrometer analysis), and chemical composition. Fine aggregate was characterized in terms of PSD, water absorption, specific gravity, and fineness modulus.

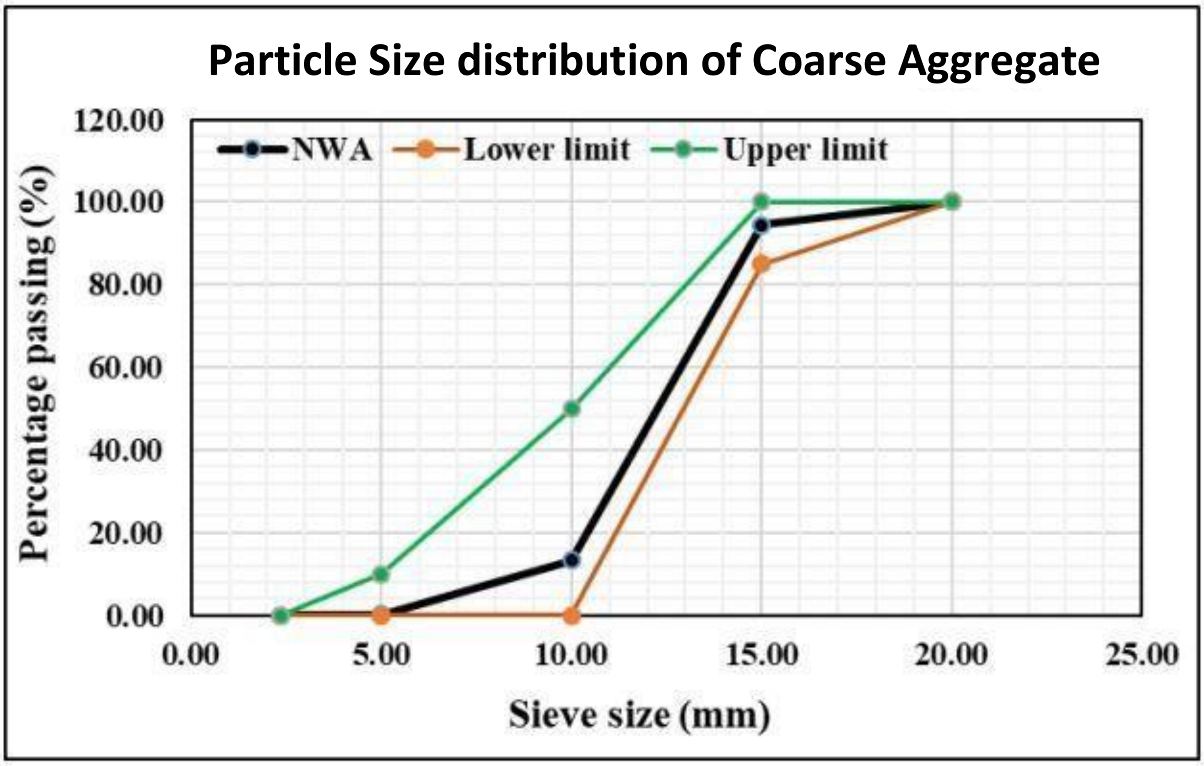
4.1.2 Characteristics of Oil Palm Kernel Shells, Coarse Aggregate, and Fine aggregate

4.1.2.2 Particle Size Distribution of Oil Palm Kernel Shells and Coarse Aggregate



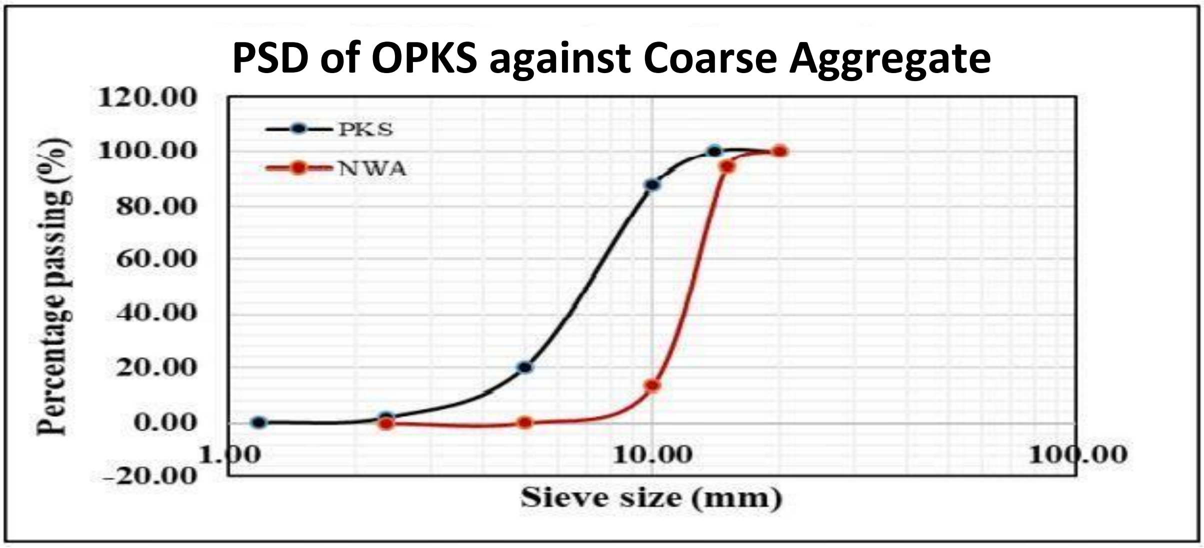
Graph 4-1: Particle Size Distribution of OPKS

Results for the particle size distribution of PKS and coarse aggregate are presented in Graph 4-1 and 4-2 respectively. Graph 4-3 shows the particle size distribution of PKS and coarse aggregate. The maximum aggregate size for PKS was 10mm and 14mm for coarse aggregate as shown on Table 4 -1.



Graph 4-2: Particle Size Distribution of coarse aggregate

From Graph 4-1, about 60% of the PKS were between 5 mm – 10mm and about 20% were below 5mm. Also, Graph 4-2 shows that about 70% of the coarse aggregate was between 10mm – 15mm while less than 30% was below 10mm. From Graph 4-3, the particle sizes of PKS and coarse aggregate were between 5mm – 15mm which represented about 90% of the total aggregate.



Graph 4-3: Particle Size Distribution of PKS and coarse aggregate

Hence it can be said that the PKS used in this research was finer than the coarse aggregate and therefore its substitution for coarse aggregate will increase the surface area of the aggregate which might lead to a high demand of cement paste for proper bonding. Holding all factors constant, PKS substitution for coarse aggregate will produce less workable concrete due to the increase surface area of PKS. With poor workability, compaction might also be poor which might lead to the production of concrete with voids that could reduce concrete strength, density, and durability as it may also result in increased level of water absorption.

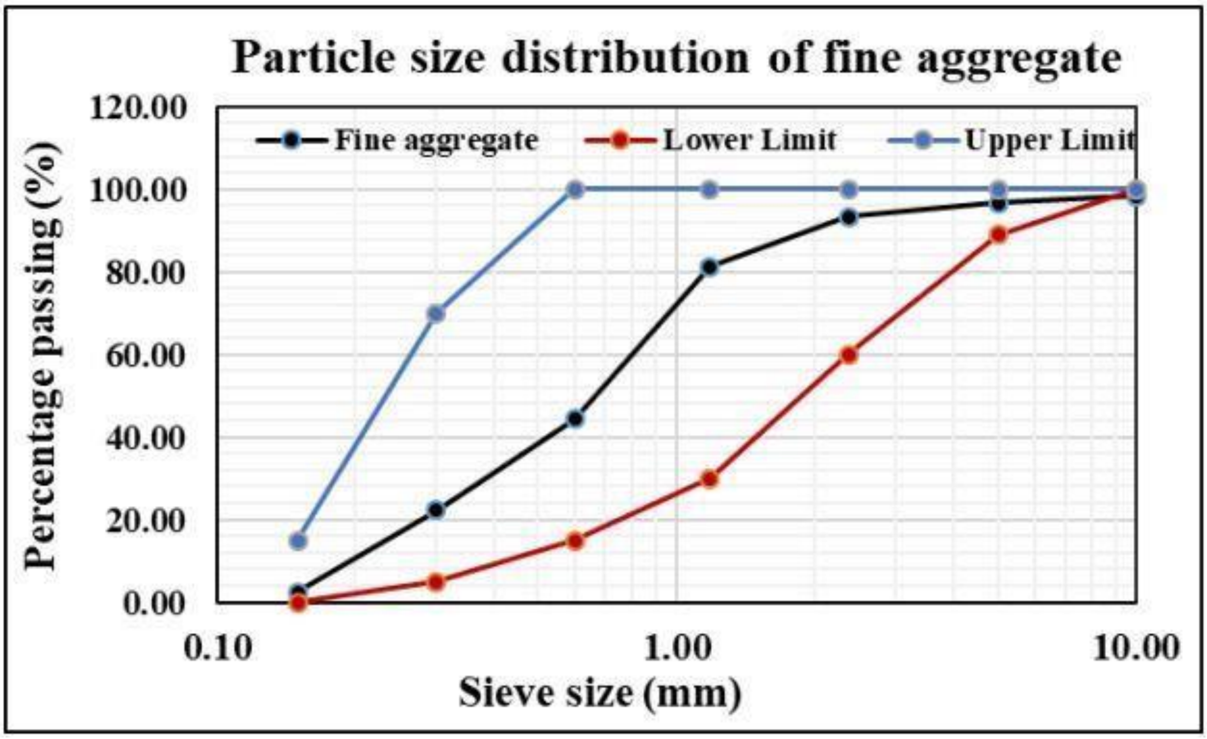
Table 4-1: Characteristics summary of OPKS, Coarse aggregate, and fine aggregate

Characteristic	OPKS	Coarse aggregate	Fine aggregate
Maximum aggregate size (mm)	10	14	5
Specific Gravity	1.40	2.58	2.44
24 hr water absorption (%)	30.44	2.92	6.53
Bulk density (kg/m^3)	582.982	1,366.23	1,665.00
Loose Density (kg/m^3)	514.389	1,255.40	1,523.58
Aggregate Crushing Value, ACV (%)	2.15	17.42	-
Aggregate Impact Value, AIV (%)	4.63	7.635	-
Fineness modulus	-	-	2.68

Also from the figure, the coarse aggregate used was single size aggregate as about 80% of the aggregate was retained on sieve no. 10mm. Hence, the likely implication could be the formation of voids in the mixed due to the lack of smaller sizes to fill the voids. However, to avoid this situation, a large portion of fine aggregate is required to fill up those voids in order to produce durable concrete with less voids.

4.1.2.3 Particle size distribution of fine aggregate

The fine aggregate used was well graded as particles range from 0.15mm – 5mm in sizes. Hence, from Graph 4-4, the grading of the aggregates satisfied the requirements of BS 882 (1992), hence indicating uniformity in the concrete. Graded aggregate contributes to the quality of the concrete better than non-graded aggregate. Graded aggregate 46 also increases the density of the concrete and reduces water permeability. It also leads to workable concrete with less voids and improves durability.



Graph 4-4: Particle Size Distribution of fine aggregate

Also, the figure shows that the particle size distribution satisfied ASTM C33 requirement for graded aggregate which requires that the fine aggregate be less the 45% retained on any one sieve. Too much material on one sieve means gap – grading, which will increase the cement – paste demand in the mix. ASTM C33 also suggested that the fineness modulus be kept between 2.3 and 3.1. This is since a 'very fine' fine aggregate will increase water demand of the mix, while a 'very coarse' fine aggregate could compromise workability. Hence, the fineness modulus obtained was 2.68 which shows that the material was not very fine and not very coarse either, and therefore suitable to produce concrete with high workability and finish-ability.

4.1.2.4 Water Absorption of OPKS, Coarse Aggregate, and Fine Aggregate

The 24 hours water absorption for PKS, coarse aggregate, and fine aggregate obtained were 30.4%, 2.9%, and 6.5% respectively. Of the three aggregates, OPKS had the highest percentage of water absorption. This high-water absorption of the OPKS can be attributed to the presence of micro tiny pores on the convex surface of the material. Though seems high but still lower than other aggregates' water absorption such as pumice aggregates which have a 24hrs water absorption of 37% according to Hossain and Khandaker (2004).

Hence, it can be said that the high-water absorption of OPKS could lead to poor concrete. workability as the quantified water for a given concrete workability might be absorbed by the OPKS. This situation leads to poor compaction of concrete by creating voids that could. compromise concrete strength and durability.

Also, due to absorptive characteristic of OPKS, using OPKS in concrete might serve as internal reservoirs as the absorbed water is stored in the concrete and hence enhance the gradual development of concrete strength as it is known that concrete strength continues to develop in the presence of moisture.

4.1.2.5 Specific Gravity of OPKS, Coarse Aggregate and Fine Aggregate

The specific gravity for OPKS, coarse aggregate, and fine aggregate recorded were 1.4, 2.58, and 2.44 respectively. From these results, OPKS can be characterized as a light-weight aggregate (LWA) because Popovics (1992) stated that aggregates with specific gravity less than 2.4 are classified as LWA. Therefore, for this research, OPKS was considered as an LWA.

Thus, due to the fact that OPKS has been determined to be a lightweight aggregate, batching by weight will therefore mean that for the same masses of OPKS and coarse aggregate, the volume of OPKS will be about twice that of the coarse aggregate in the mix. This increases the surface area of OPKS in the mix and increases the demand for cement paste. Hence, if the w/c ratio is held constant, concrete produced with OPKS will have poor workability and strength than the concrete produced with the coarse aggregate. It can therefore be said that batching by volume works better than by weight for OPKS aggregate and therefore batching by volume was adopted for this research.

Also, the low specific gravity of OPKS might lead to the production of concrete with density below 2000kg/m3. This might also cause the reduction in compressive strength as concrete density contributes significantly to the compressive strength. On the other hand, the low density of OPKS concrete could bring about significant savings in construction cost as supporting members for the concrete can be of smaller sections because of the reduction in the dead load.

4.1.2.6 Aggregate crushing value of palm kernel shells and coarse agg.

The ACV for OPKS and coarse aggregate were 2.15% and 17.42% respectively. BS 812 (1990) gave the maximum recommended ACV for aggregates for concrete production to 30%. This means that aggregate with higher ACV have poor resistance to compressive load while those with low ACV have good resistance to compressive load. Hence, from the results obtained, OPKS has a lower ACV than the coarse aggregate and is therefore expected to perform better when being crushed under a gradually applied compressive load. In other words, it can be said that the material is more ductile than the coarse aggregate, and that the material can sustain stress without abrupt failure.

4.1.2.7 Aggregate Impact Value of Palm Kernel Shells and Coarse Aggregate

The AIV for OPKS and coarse aggregate were 4.6% and 7.6% respectively. BS 882 (1992) specified limit for AIV for aggregates which are adequate for concrete with good impact resistance is 25%. As with the ACV, this also means that aggregate with higher AIV have weak impact resistance while those with low AIV have good impact resistance. Therefore, from the results obtained, OPKS showed better impact resistance than the coarse aggregate.

Hence, it can be said that OPKS is tougher than the coarse aggregate and can prevent crushing, degradation, and disintegration when stockpiled, fed through, and compacted with rollers without causing construction and performance problems. Table 4-1 shows the characteristic summary of OPKS, coarse aggregate, and fine aggregate used in the research.

4.1.3 Characteristics of Fly Ash and Ordinary Portland cement

The characteristics of FLA and OPC were determined in terms of their physical and chemical properties. The physical properties determined included, particle size distribution, specific gravity, and bulk density.

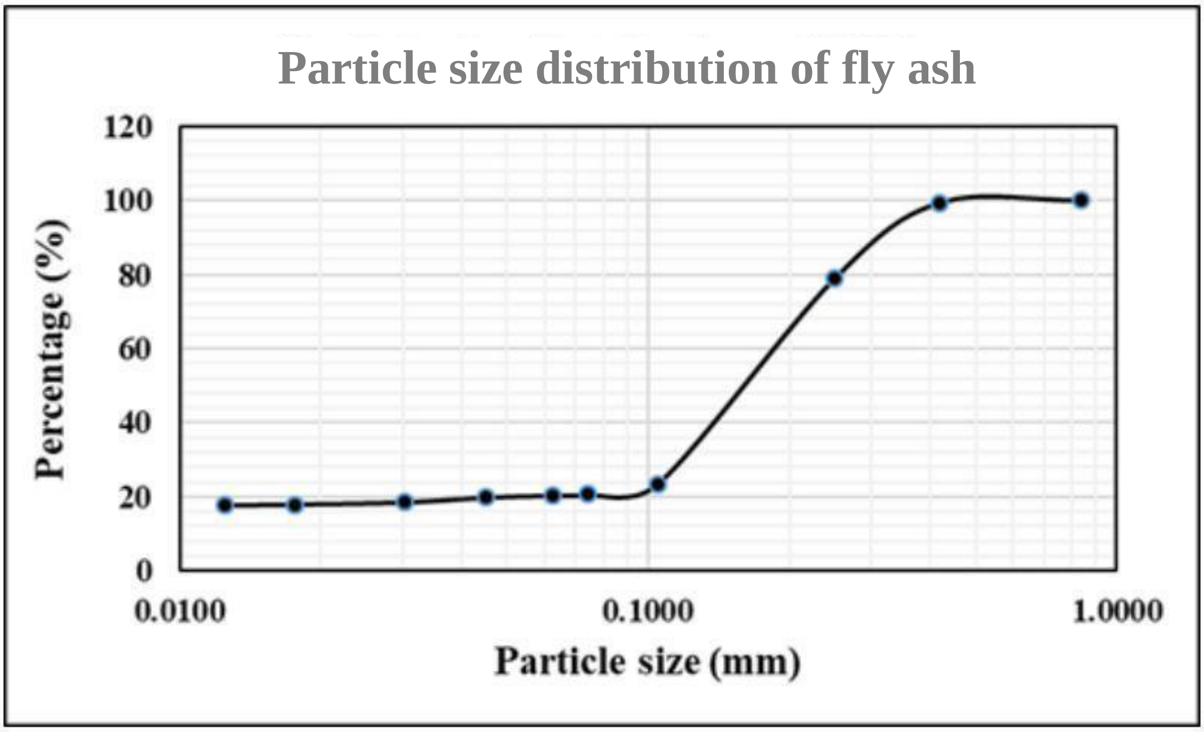
4.1.3.1 Physical Properties of Fly Ash and Ordinary Portland Cement

Table 4-2: Physical properties of FLA and OPC

Property	FLA	OPC
Specific Gravity	1.77	3.11
Bulk Density (kg/m^3)	355.79	1396.67
Loose Density (kg/m^3)	267.59	1165.36
Mean particle size (mm)	0.15	-
Colour	Grey	Grey

As shown in Table 4 – 2, the specific gravity of FLA and OPC used were 1.77 and 3.11 respectively, and hence it be said that the FLA used in this research was treated as a lightweight material since the specific gravity was below 2.4. However, though a lightweight, the material will not float in water since the specific gravity is greater than 1 and therefore mixing of the concrete can easily be achieved. Again, the low specific gravity of FLA can contribute significantly to the reduction of concrete density thereby bring a significant reduction in construction cost. On the other hand, if batching is done by weight and all other factors are held constant, for the same masses of FLA and OPC, the volume of FLA will be twice that of OPC as the specific gravity of OPC is almost twice that of FLA.

Also, the bulk density of FLA is just about 25% that of OPC. Hence it can be said that the OPC is about 4 times denser than the FLA, and therefore FLA can be said to contain more pores than the OPC. The most likely implication could be reduction of concrete workability as the quantified water for a particular workability will be absorbed into those pores.



Graph 4-5: Particle size distribution of FLA

Graph 4-5 shows the particle size distribution of FLA using hydrometer analysis. It can be seen that about 50% of the particles were between 0.25mm (250µm) to 0.1mm (100µm), about 15% between 0.01mm (10µm) to 0.1mm (100µm), and about 15% below 0.01mm (10µm). The inclusion of particle sizes up 0.25mm was since natural fly ash was considered for this research and hence no further grinding was done.

4.5 Effect of oil palm kernel shells and fly ash as partial replacement of coarse aggregate and ordinary Portland Cement respectively on the physical and mechanical properties of normal weight concrete

The effect of PKS and FLA as partial replacements of coarse aggregate and OPC respectively have been investigated and the results are presented and discussed in this section. Effect on the mechanical properties was in terms of compression and flexural tests, while effect on physical properties was in terms of workability, density of concrete, and water absorption.

4.5.1 Workability test results

4.5.1.1 Slump results

For each mix we have conducted the slump test and results are shown in Table 4-3. the slump value directly proportional to workability, as slump value increases then the workability also increased. Generally, slumps are classified in to three types they are,

- Collapse slump: In this slump the concrete collapses completely.
- Shear slump: In this slump the top portion of the concrete shears off and slips sideways.

- True slump: In this slump the concrete simply subsides, keeping shaping.

Table 4-3: slump cone results

Mix (percentage of replacement with oil palm shell)	Slump value (mm)
0%	**105**
10%	**102**
20%	**94**
30%	**97**
40%	**99**

Table 4-4: slump ranges

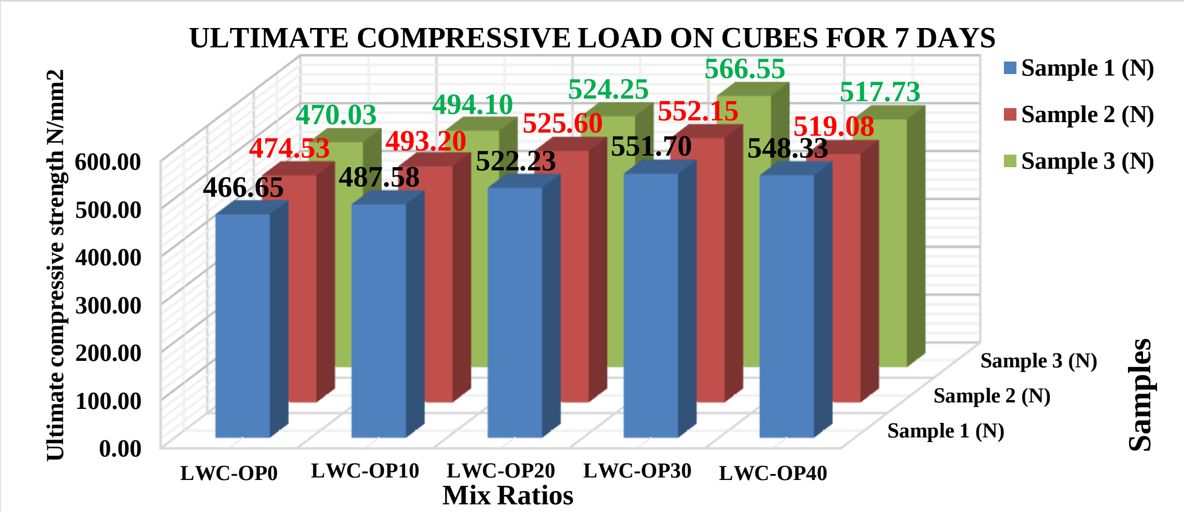
Slump Range	Workability
10 - 50mm	Low workability
50 – 100mm	Medium workability
Above 100mm	High Workability

4.5.2 Compressive strength results

The compressive strengths of the casted specimens were determined by the compressive test machine and are tabulated as follows:

Table 4-5: Ultimate compressive load on cubes for 7 days

S.No.	Mix Ratios	Sample 1 (N)	Sample 2 (N)	Sample 3 (N)	Average (N)
1	**LWC-OP0**	466.65	474.53	470.03	470.40
2	**LWC-OP10**	487.58	493.20	494.10	491.63
3	**LWC-OP20**	522.23	525.60	524.25	524.03
4	**LWC-OP30**	551.70	552.15	566.55	556.80
5	**LWC-OP40**	548.33	519.08	517.73	528.38



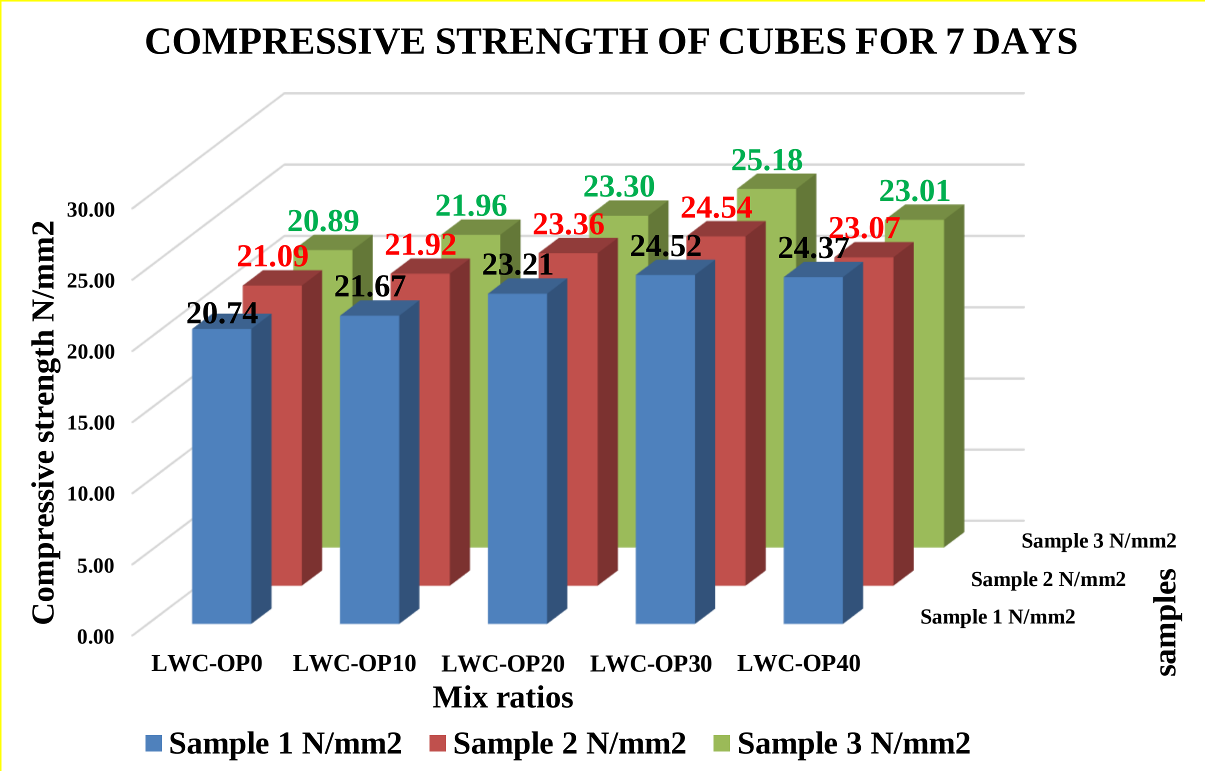
Graph 4-6: Ultimate compressive load on cubes for 7 days

- The above graph shows ultimate load that had been applied on three samples on each for every mix ratio.

$$\textbf{Flexural strength (N/mm2)} = \frac{\textbf{Failure load (in N) * Effective span of beam}}{\textbf{(Width of the specimen * Depth of the specimen)}}$$

Table 4-6: Compressive strength of cubes for 7 days

S. No.	Percentage of Replacement	Compressive strength (N/mm2)	Average compressive strength (N/mm2)
1	**LWC-OP0**	20.74	**20.091**
		21.09	
		20.89	
2	**LWC-OP10**	21.67	**21.85**
		21.92	
		21.96	
3	**LWC-OP20**	23.21	**23.29**
		23.26	
		23.30	
4	**LWC-OP30**	24.52	**24.75**
		24.54	
		25.18	
5	**LWC-OP40**	24.37	**23.48**
		23.07	
		23.01	



Graph 4-7: Compressive strength of cubes for 7 days

Table 4-7: Ultimate compressive load on cubes for 14 days

S. No.	Mix ratios	Sample 1 (N)	Sample 2 (N)	Sample 3 (N)	Average (N)
1	**LWC-OP0**	677.48	683.33	660.83	673.88
2	**LWC-OP10**	630.23	702.90	709.20	680.78
3	**LWC-OP20**	723.38	730.13	723.60	725.70
4	**LWC-OP30**	765.45	770.85	776.03	770.78
5	**LWC-OP40**	722.25	740.25	732.60	731.70

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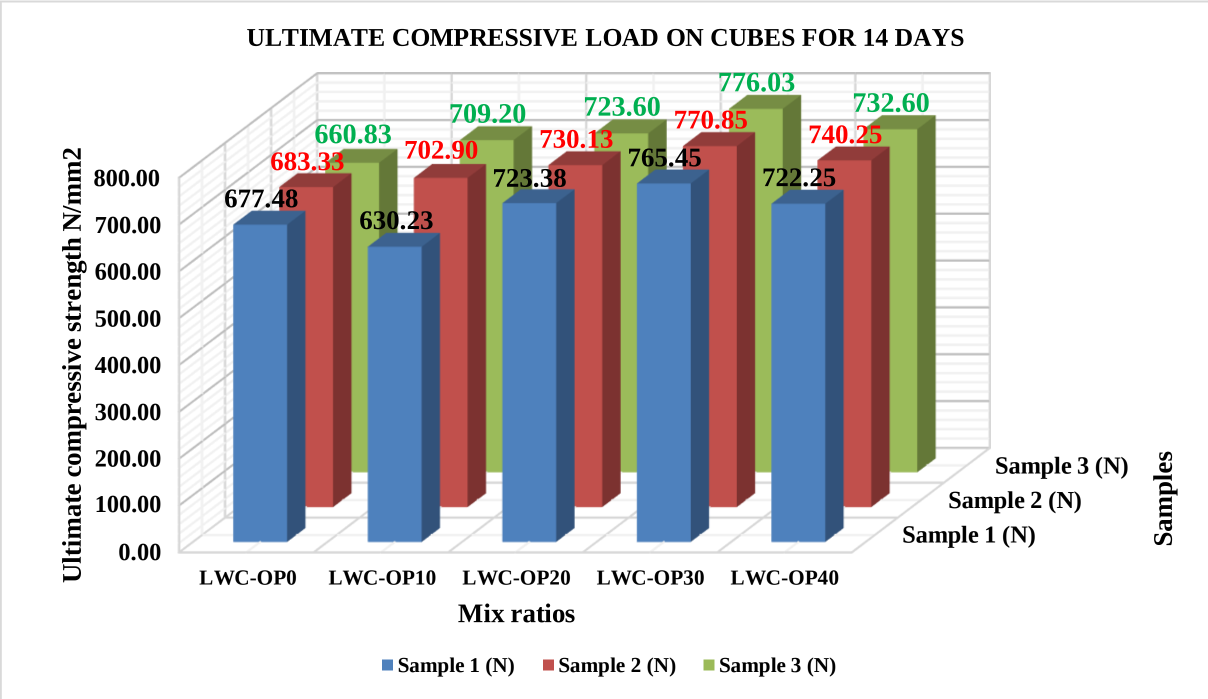
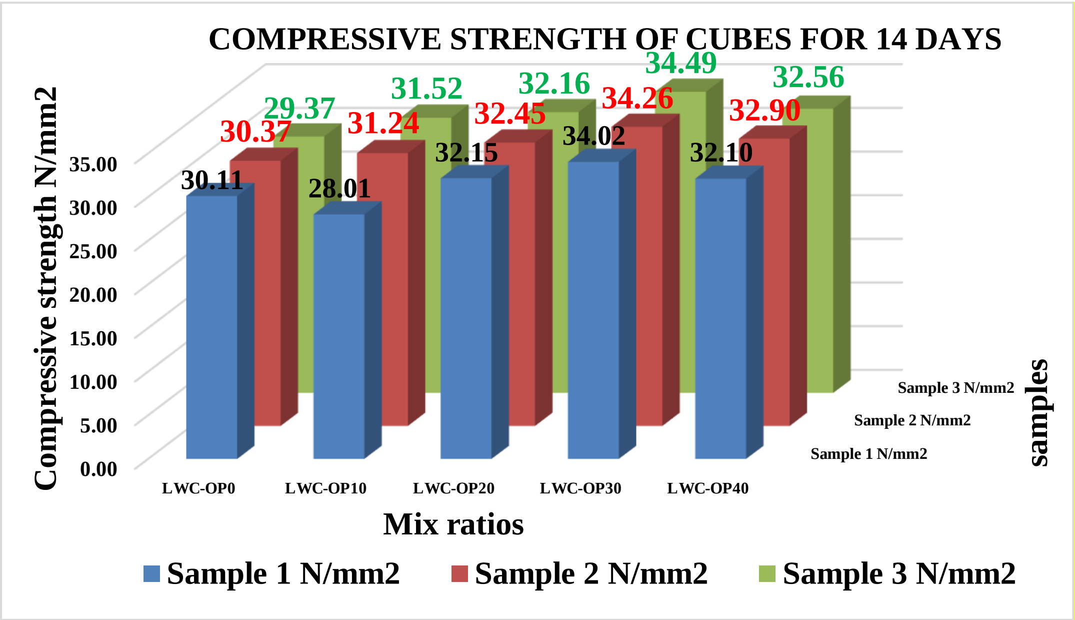


Graph 4-8: Ultimate compressive load on cubes for 14 days

Table 4-8: Compressive strength of cubes for 14 days

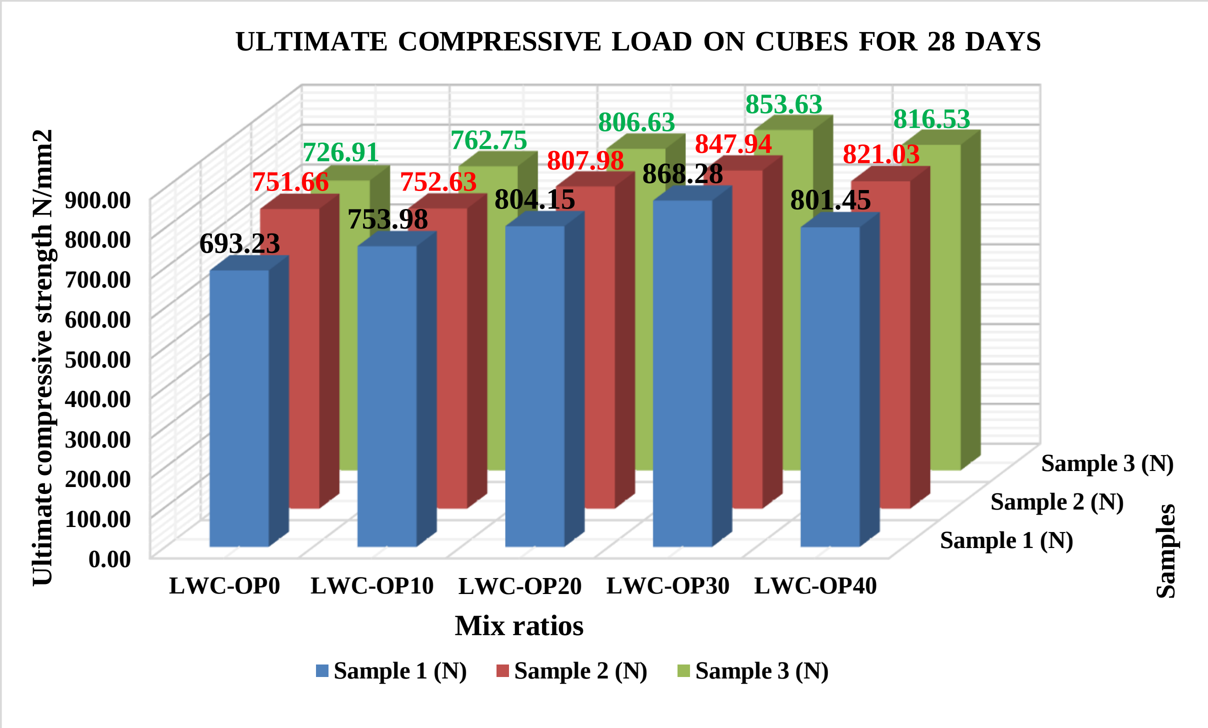
S. No.	Percentage of Replacement	Compressive strength (N/mm2)	Average compressive strength (N/mm2)
1	LWC-OP0	30.11	29.95
		30.37	
		29.37	
2	LWC-OP10	28.01	30.26
		31.24	
		31.52	
3	LWC-OP20	32.15	32.25
		32.45	
		32.16	
4	LWC-OP30	34.02	34.26
		34.26	
		34.49	
5	LWC-OP40	32.10	32.52
		32.90	
		32.56	



Graph 4-9: Compressive strength of cubes for 14 days

Table 4-9: Ultimate compressive load on cubes for 28 days

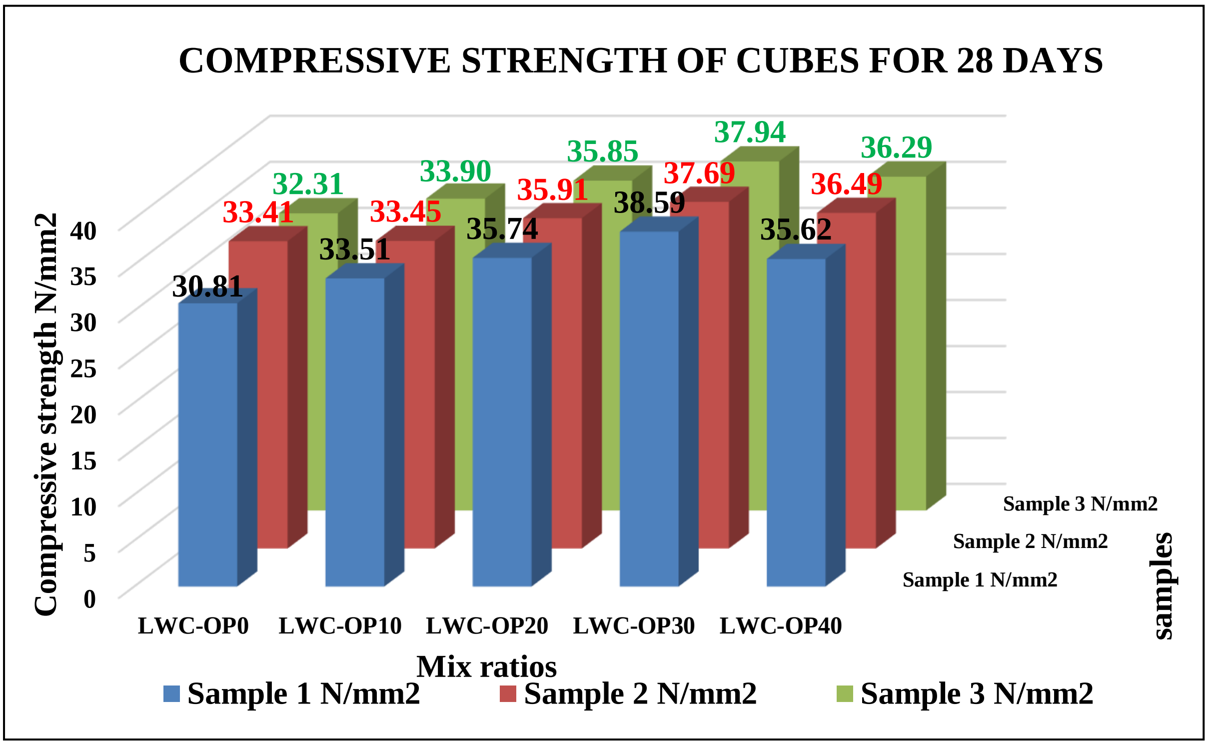
S. No.	Mix	Sample 1 (N)	Sample 2 (N)	Sample 3 (N)	Average (N)
1	**LWC-OP0**	693.23	751.66	726.91	723.93
2	**LWC-OP10**	753.98	752.63	762.75	756.45
3	**LWC-OP20**	804.15	807.98	806.63	806.25
4	**LWC-OP30**	868.28	847.94	853.63	856.61
5	**LWC-OP40**	801.45	821.03	816.53	813.00



Graph 4-10: Ultimate compressive load on cubes for 28 days

Table 4-10: Compressive strength of cubes for 28 days

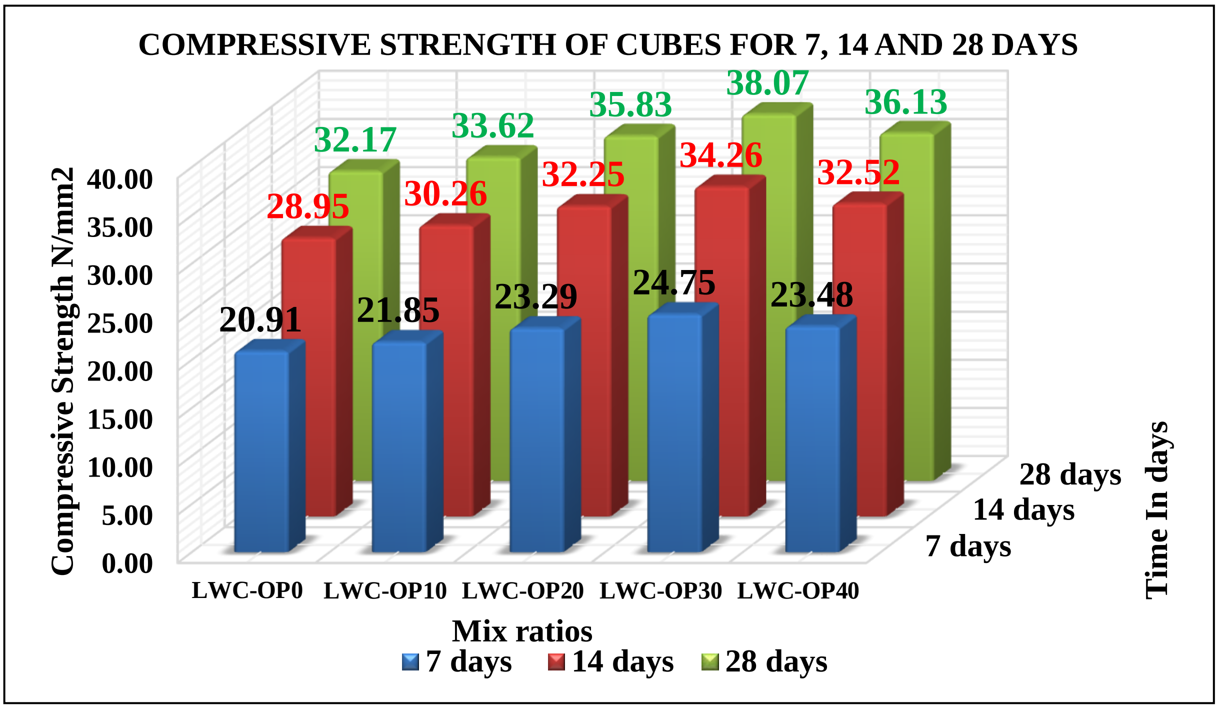
S. No.	Percentage of Replacement	Compressive strength (N/mm2)	Average compressive strength (N/mm2)
1	LWC-OP0	30.81	32.17
		33.41	
		32.31	
2	LWC-OP10	33.51	33.62
		33.45	
		33.90	
3	LWC-OP20	35.74	35.83
		35.91	
		35.85	
4	LWC-OP30	38.59	38.07
		37.69	
		37.94	
5	LWC-OP40	35.62	36.13
		36.49	
		36.29	



Graph 4-11: Compressive strength of cubes for 28 days

Table 4-11: Compressive strength of cubes for 7, 14 and 28 days

S.No.	Mix	7 days	14 days	28 days
1	**OPKSC0**	20.91	28.95	32.17
2	**OPKSC10**	21.85	30.26	33.62
3	**OPKSC20**	23.29	32.25	35.83
4	**OPKSC30**	24.75	34.26	38.07
5	**OPKSC40**	23.48	32.52	36.13



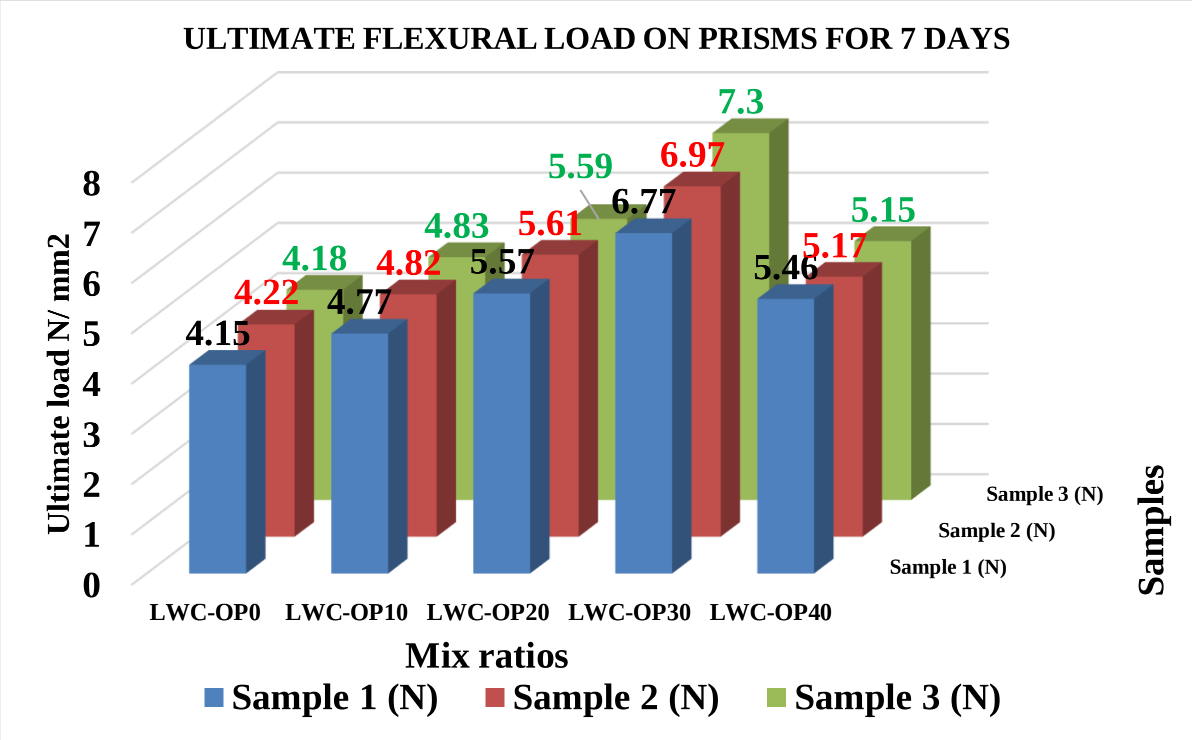
Graph 4-12: Compressive strength of cubes for 7,14 and 28 days

- As graphs are clearly representing that after reduction of water absorption of oil palm kernel shell, raise in strength along with increase of replacing.
- Comparing to all the compressive strength after 28 days, LWC-OPKS30 obtained higher compressive strength which is above 38.07 N/mm^2 for 28 days of curing.
- But after LWC-OPKS30 drastic fall of compressive strength of a cube.

4.5.3 Flexural strength of prism

Table 4-12: Ultimate flexural load on prisms for 7 days

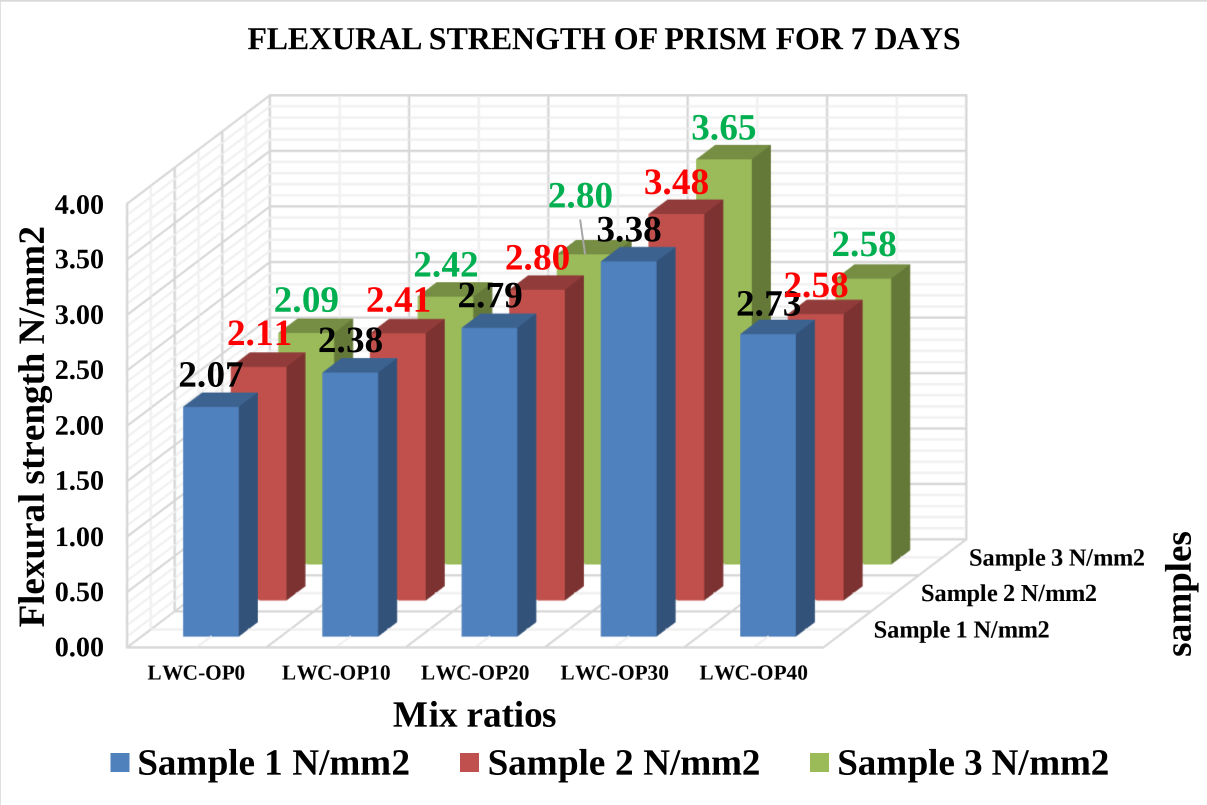
S.No.	Mix	Sample 1 (N)	Sample 2 (N)	Sample 3 (N)	Average (N)
1	LWC-OP0	4.15	4.22	4.18	4.18
2	LWC-OP10	4.77	4.82	4.83	4.81
3	LWC-OP20	5.57	5.61	5.59	5.59
4	LWC-OP30	6.77	6.97	7.30	7.01
5	LWC-OP40	5.46	5.17	5.15	5.26



Graph 4-13: Ultimate flexural load on prisms for 7 days

Table 4-13: Flexural strength of prism for 7 days

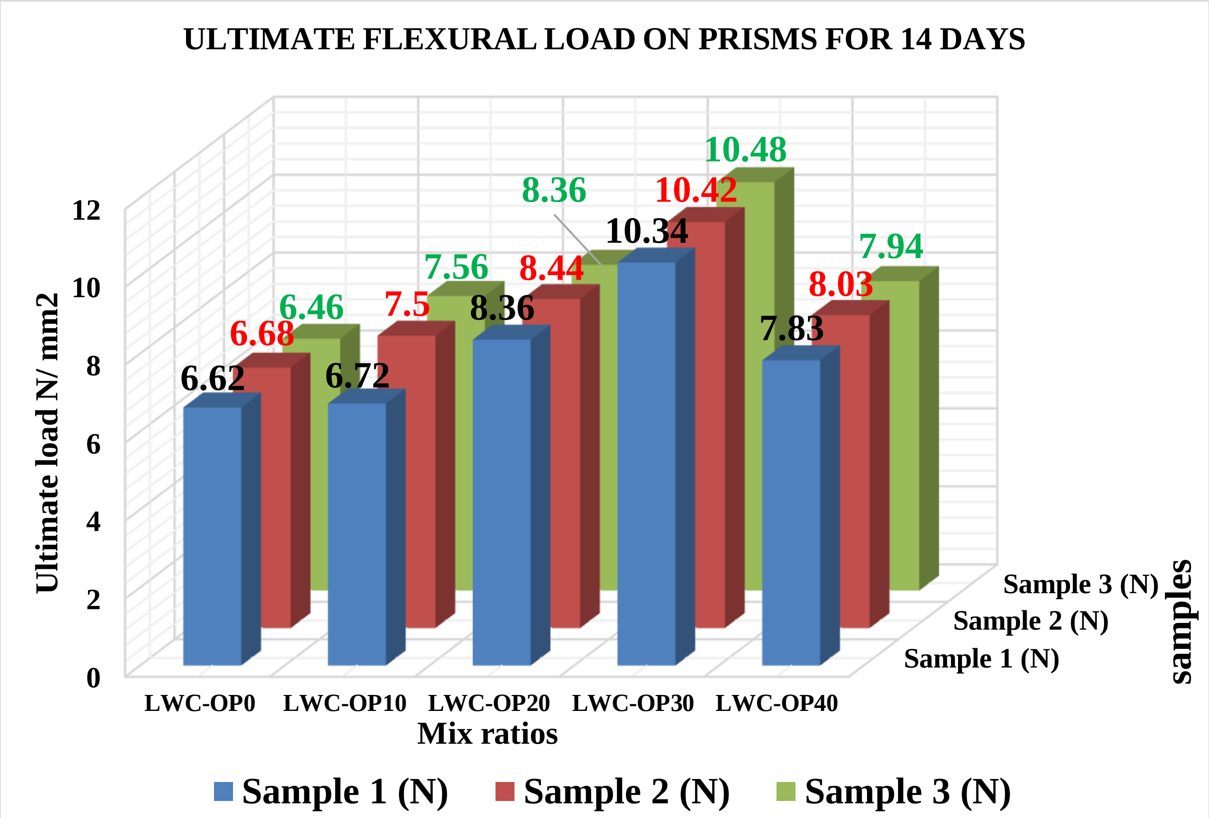
S. No.	Percentage of Replacement	Compressive strength (N/mm2)	Average compressive strength (N/mm2)
1	LWC-OP0	20.74	20.091
		21.09	
		20.89	
2	LWC-OP10	21.67	21.85
		21.92	
		21.96	
3	LWC-OP20	23.21	23.29
		23.26	
		23.30	
4	LWC-OP30	24.52	24.75
		24.54	
		25.18	
5	LWC-OP40	24.37	23.48
		23.07	
		23.01	



Graph 4-14: Flexural strength for 7 days

Table 4-14: Ultimate flexural load on prisms for 14 days

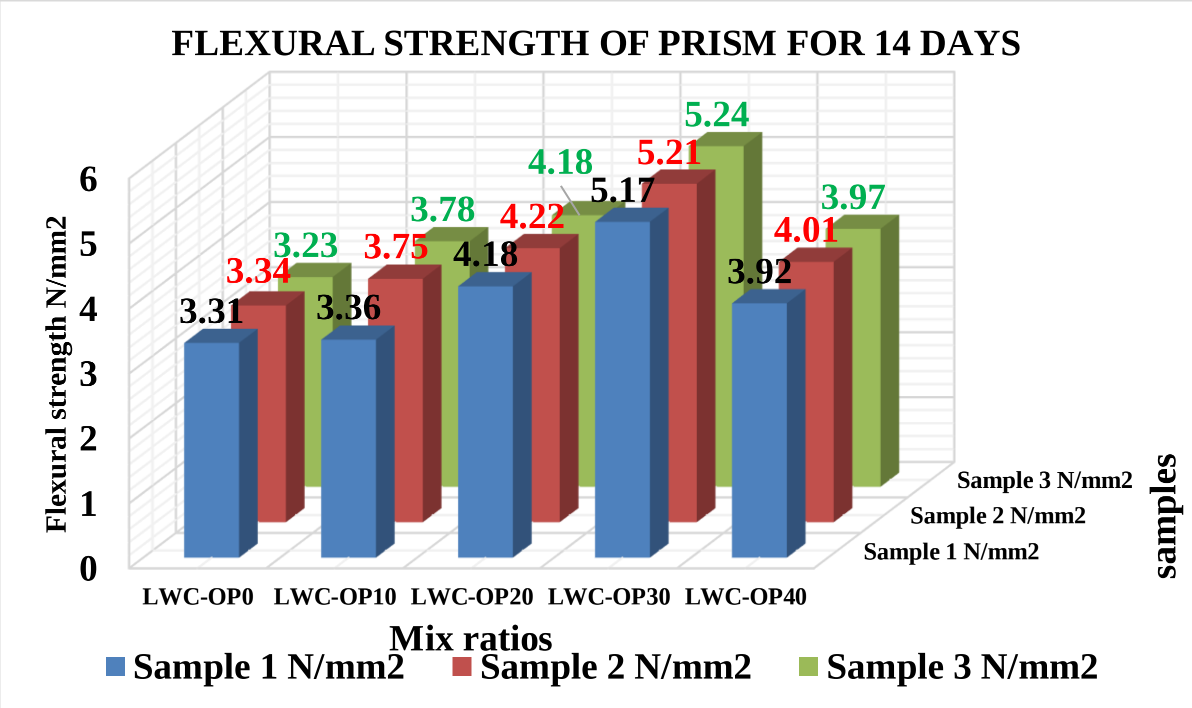
S.No.	% Of substitute	Sample 1 (N)	Sample 2 (N)	Sample 3 (N)	Average (N)
1	**LWC-OP0**	466.65	474.53	470.03	470.40
2	**LWC-OP10**	487.58	493.20	494.10	491.63
3	**LWC-OP20**	522.23	525.60	524.25	524.03
4	**LWC-OP30**	551.70	552.15	566.55	556.80
5	**LWC-OP40**	548.33	519.08	517.73	528.38



Graph 4.15: Ultimate flexural load on prisms for 14 days

Table 4-15: Flexural strength of prism for 14 days

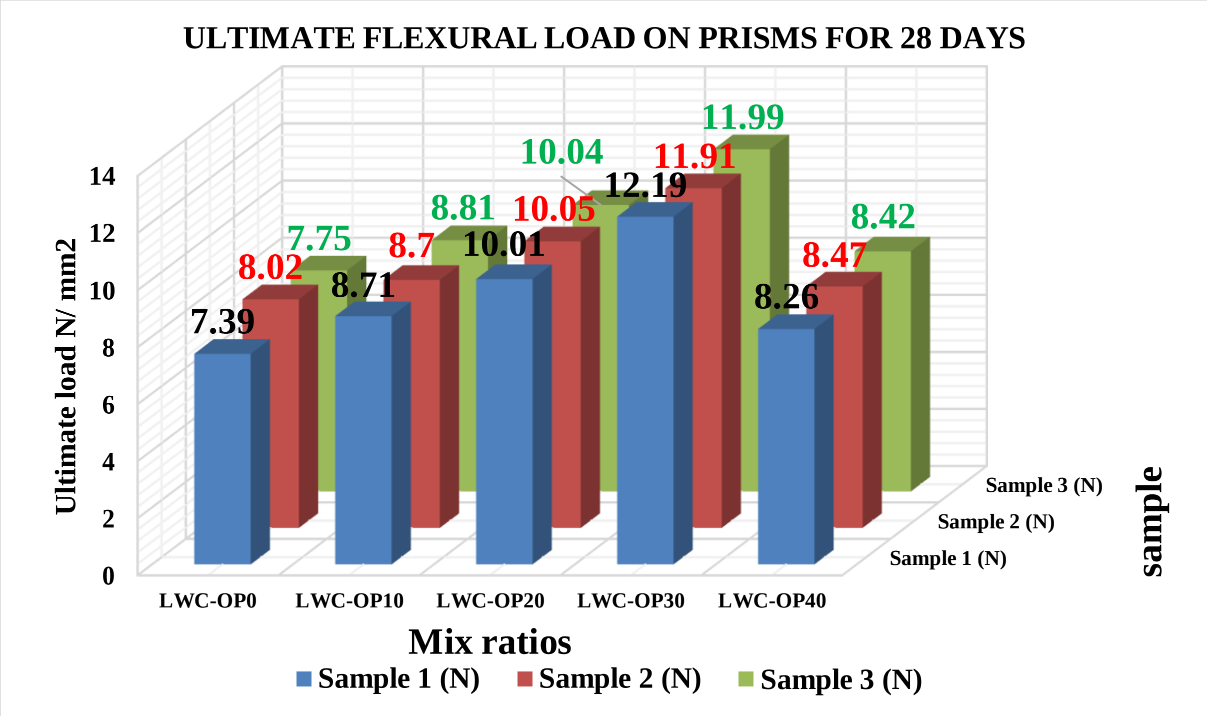
S. No.	Percentage of Replacement	Compressive strength (N/mm2)	Average compressive strength (N/mm2)
1	LWC-OP0	20.74	20.091
		21.09	
		20.89	
2	LWC-OP10	21.67	21.85
		21.92	
		21.96	
3	LWC-OP20	23.21	23.29
		23.26	
		23.30	
4	LWC-OP30	24.52	24.75
		24.54	
		25.18	
5	LWC-OP40	24.37	23.48
		23.07	
		23.01	



Graph 4-16: Flexural strength of prism for 14 days

Table 4.16: Ultimate flexural load on prisms for 28 days

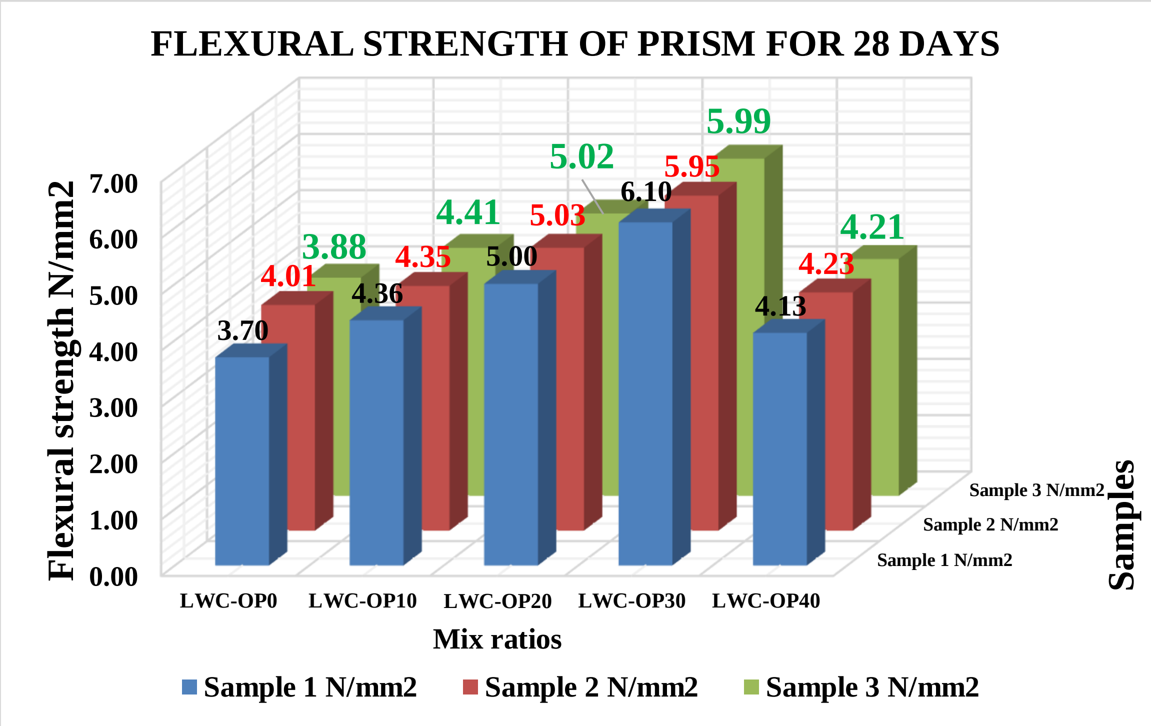
S.No.	% Of substitute	Sample 1 (N)	Sample 2 (N)	Sample 3 (N)	Average (N)
1	**LWC-OP0**	466.65	474.53	470.03	470.40
2	**LWC-OP10**	487.58	493.20	494.10	491.63
3	**LWC-OP20**	522.23	525.60	524.25	524.03
4	**LWC-OP30**	551.70	552.15	566.55	556.80
5	**LWC-OP40**	548.33	519.08	517.73	528.38



Graph 4-17: Ultimate flexural load on prisms for 28 days

Table 4-17: Flexural strength of prism for 28 days

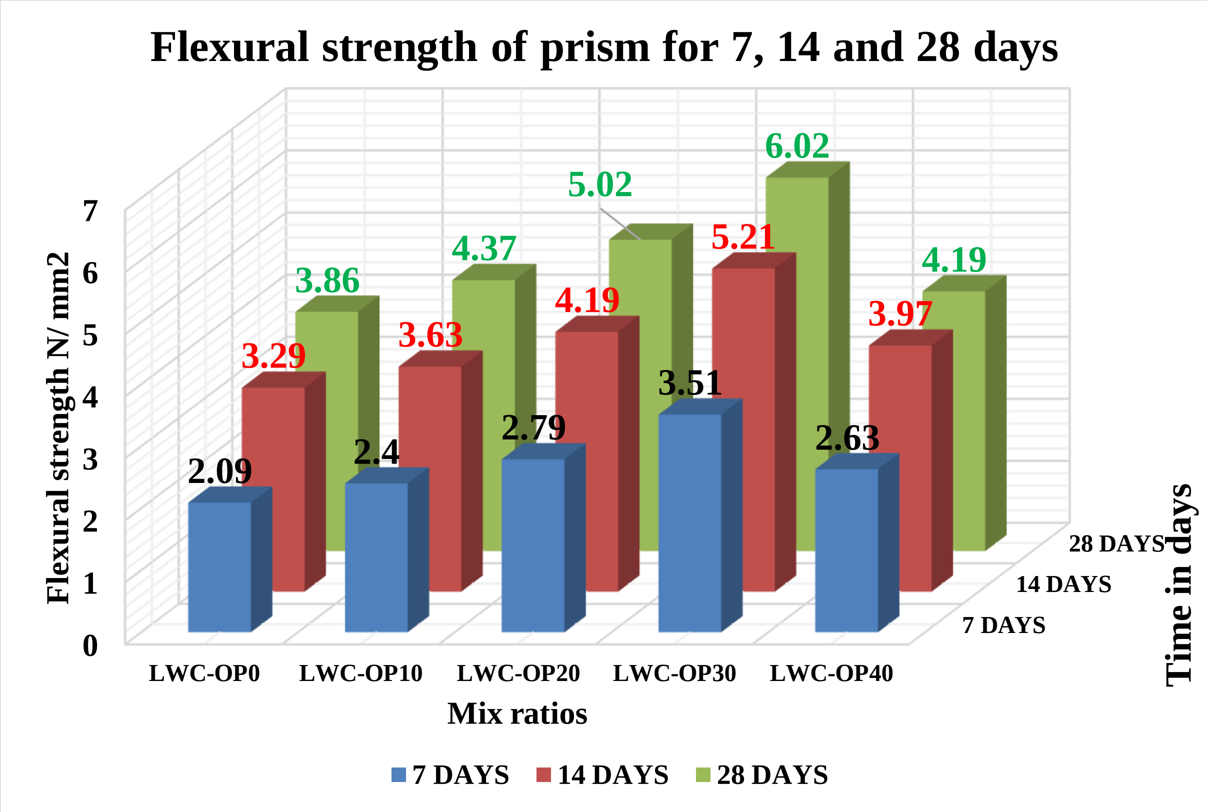
S. No.	Percentage of Replacement	Compressive strength (N/mm2)	Average compressive strength (N/mm2)
1	LWC-OP0	20.74	20.091
		21.09	
		20.89	
2	LWC-OP10	21.67	21.85
		21.92	
		21.96	
3	LWC-OP20	23.21	23.29
		23.26	
		23.30	
4	LWC-OP30	24.52	24.75
		24.54	
		25.18	
5	LWC-OP40	24.37	23.48
		23.07	
		23.01	



Graph 4-18: Flexural strength of prism for 28 days

Table 4-18: Flexural strength of prism for 7, 14 and 28 days

S.No.	Mix	7 days	14 days	28 days
1	**LWC-OP0**	4.18	6.59	7.72
2	**LWC-OP10**	4.81	7.26	8.74
3	**LWC-OP20**	5.59	8.39	10.03
4	**LWC-OP30**	7.01	10.41	12.03
5	**LWC-OP40**	5.26	7.93	8.38



Graph 4-19: Flexural strength results for 7, 14 and 28 days

- As graphs are clearly representing that after reduction of water absorption of oil palm kernel shell, raise in strength along with increase of replacing.
- Comparing to all the compressive strength after 28 days, LWC-OPKS30 obtained higher compressive strength which is above 38.07 N/mm^2 for 28 days of curing.
- But after LWC-OPKS30 drastic fall of compressive strength of a cube.

CHAPTER - V

CONCLUSION & FUTURE ENHANCEMENT

5.1 Conclusions

The concluding remarks are obtained from the comparative study of strength using different percentage of replacements with OPKS. Based on the above results the following conclusions may be drawn.

- By and large, OPKS total was established to be a decent replacer of coarse total in the creation of lightweight cement are inclined to high water ingestion pace of 24–25%. Thus, Operations are coated with water repellent covering. This aides in keeping up the water assimilation rate to 6%.
- More utilization of water by NTOPKS total prompts higher water concrete proportion about 20% high, which influences the usefulness and toughness of the NTOPKS concrete. The effect of functionality is unmistakably noticed, as the compressive strength is 40–half lower in NTOPKS concrete than the TOPKS concrete.
- The strength of 10%,20%,30% and 40% OPKS concrete with an expansion of 5% fly debris to all blend proportions, tests delivered lightweight cement with compressive strength coming to up to limit of 38.07 N/mm2 and least of 33.62 N/mm2 for 28 days which fulfils the prerequisite for underlying light weight concrete.
- Concrete with the 30% substitution gives most elevated at all tests, for example, pressure test and flexural test. 40% substitution gives least compressive strength, malleable and flexural strength with more decrease in weight of cement.
- In any case, the strength of the substantial is relying upon the two factors for example measure of OPKS and relieving period.
- At long last, from the outcomes we can presume that 10% substitution test is considered as fractional lightweight cement, since its Density more than 2000kg/m3.
- 40% examples additionally consider full light weight concrete, yet the outcomes are not fulfilling so they considered as non-primary light weight concrete.

5.2 Future Enhancement

- Further studies on the durability performance of OPKS, Glass powder and Rice husk ash concrete should be carried out especially for aggressive environments due to the fact that PKS is a biodegradable material.
- The use of superplasticizers in OPKS and Rice husk ash concrete should be investigated as they might improve on concrete engineering properties.

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A Major Project Report

On

EXPERIMENTAL INVESTIGATION ON PARTIAL REPLACEMENT OF COARSE AGGREGATE WITH CERAMIC WASTE AND STEEL FIBER AS REINFORCING AGENT IN CONCRETE

SUBMITTED TO

JawaharlalNehruTechnologicalUniversityHyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

CIVIL ENGINEERING

By

Ms. B. Kalpana (18K85A0117)

Mr. U. Vamshi Krishna (17K81A01A5)

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Assistant Professor

DEPARTMENT OF CIVIL ENGINEERING

ST.MARTIN'S ENGINEERING COLLEGE

(An Autonomous Institute)

Dhulapally, Secunderabad – 500 100

JUNE 2021

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BONAFIDE CERTIFICATE

This is to certify that the project entitled EXPERIMENTAL INVESTIGATION ON PARTIAL REPLACEMENT OF COARSE AGGREGATE WITH CERAMIC WASTE AND STEEL FIBER AS REINFORCING AGENT IN CONCRETE, is being submitted by **1.Ms. B.Kalpana(18K85A0117), 2.Mr. U.Vamshi Krishna(17K81A01A5), 3.Ms. V.Rajeswari(17K81A01A5) ,4.Mr. M.Susheel Kumar (18K85A0116)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN CIVIL ENGINEERING** is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

Signature of Guide
Mrs. A.Sravani
Assistant Professor
Department of Civil Engineering

Signature of HOD
Ms. Sandhya Kiran J.K
Head of the Department
Department of Civil Engineering

Internal Examiner

External Examiner

Place:

Date:

DECLARATION

We, the student of **Bachelor of Technology** in Department of Civil Engineering', session: 2017 – 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled EXPERIMENTAL INVESTIGATION ON PARTIAL REPLACEMENT OF COARSE AGGREGATE WITH CERAMIC WASTE AND STEEL FIBER AS REINFORCING AGENT IN CONCRETE is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

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ABSTRACT

Construction industry is consuming the planet's resources at a very rapid rate, as the industry is growing at an increasing speed to meet the demands of the economy, it's consumption requirements are getting bigger, expensive and putting a lot of stress on the environment waste disposed in landfills and is not recycled. Even a small portion of it recycled may lead to considerable deduction in the effects. Fibre in concrete is generally used to control the plastic shrinkage, dry shrinkage cracking and permeability. In recent times steel fibre reinforced concretehas become more frequent substitute for steel reinforced concrete because the tensile strength andflexural strength of concrete is increased due to addition of steel fibre in concrete.

In this project, we are proposing to use used or broken ceramic tiles as a partial replacementto the coarse aggregate which forms the bulk of the concrete, and addition of steel fibre for additional reinforcement to concrete. Ceramic waste is not only from the construction industry it is also coming from the manufacturing sector. These ceramic waste materials are almost non- recyclable and are very inert to environmental elements. These will meet the conditions of aggregatein strength, durability and inertness. They are also of lower density and good insulation material.

For this project ceramic waste which varying sizes will be partially replaced in place of coarse aggregate by 5%, 10% and 15% and addition of 2% of steel fibre by weight of cement for a mix of M25 grade concrete. All kinds of experimental investigations will be done on the concrete and the variations in compression strength, tensile strength, flexural strength of the concrete will be noted and a report will be submitted.

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CHAPTER 1

INTRODUCTION

1.1 OVER VIEW OF THE PROJECT

Construction industry play vital role in development of infrastructure of any region. Concrete is being used as prime material for construction which makes concrete most consumed manmade material on earth. Concrete consist natural aggregates (Fine and Coarse) and binder (mostly cement). Consumption of natural resources increasing proportionately to civilization development and unbalanced consumption of natural resources will lead to their exhaustion. Cement industry is one of the largest producer of greenhouse gases like CO2. Cement industry contribute about 6% of Global CO2 emission.

For the production of per ton cement 1.57 tons of clinker consumed which contain mainly Limestone, clay and shale etc. and its source is nature. Industrial wastes have continued to increase due to the continuous demand of resources use by humans for different activities. Some of these wastes are hazardous. Some wastes or by-product have been successfully utilized as alternative construction material. Ceramic waste have a potential to be utilized as a partial replacement of construction materials. The ceramic industry has a long history, the first instance of functional pottery vessels being used for storing water and food, to be around since 9,000 or 10,000 BC. In 2008 India was the 24th larger ceramic trading nation in the world and India imports ceramic of worth US$ 317.5 million. India produced approx. 600 million square meters ceramic in 2011-12 which increase to approx. 750 million square meters in 2015-16.

A ceramic is an inorganic, non-metallic, solid material it’s raw material contains clay minerals such as kaolinite and alumina, modern ceramic materials contains silicon carbide and tungsten carbide. Ceramic materials have been used for a long time for multiple uses like making goods such as tableware (crockery, cutlery etc.), sanitary ware and high voltage electric insulators. Ceramics are normally used as a building materials too. Ceramic floor, tiles and various clay building brick are example of it. This paper presented a review of the use of ceramic materials in construction industry as partial replacement of conventional materials and cement focus on concrete making.

1.1.2 CONCRETE

Concrete is stuff composed of fine and coarse aggregate bonded together with fluid cement (cement paste) that hardens over time. Most frequently within the past a lime- based cement binder, like lime putty, but sometimes with other hydraulic cements, sort of calcium aluminates cement or with cement to make cement concrete.

When aggregate is mixed with dry cement and water, the mixture forms fluid slurry that's easily poured and molded into shape. The cement reacts with the water and other ingredients to make a troublesome matrix that binds the materials together into a durable stone-like material that has many uses.

The technology of using concrete was adopted earlier on large-scale by the normal Romans, and thus the most important an element of concrete technology was highly utilized within the empire. The Colosseum in Rome was built largely of concrete and thus the dome of the pantheon is that the World’s largest unreinforced concrete structure. After the collapse of empire within the mid-18th century, the technology was re-pioneered because the usage of concrete has become rare. Today, the widely used simulated material is concrete in terms of tonnage

1.1.3 PROPERTIES OF CONCRETE

Different properties of concrete:

- Grades (M20, M25, and M30 etc.)
- Compressive strength
- Characteristic Strength
- Tensile strength
- Durability
- Creep
- Shrinkage
- Unit weight
- Modular Ratio
- Poisson’s ratio

1.1.4 GRADES OF CONCRETE

Concrete is known by its grade which is designated as M15, M20 etc. in which letter M refers to concrete mix and number 15, 20 denotes the specified compressive strength (f_{ck}) of 150mm cube at 28 days, expressed in N/mm^2.

Thus, concrete is known by its compressive strength. M20 and M25 are the most common grades of concrete, and higher grades of concrete should be used for severe, very severe and extreme environments.

1.1.5 Compressive strength of concrete

Like load, the strength of the concrete is also a quality which varies considerably for the same concrete mix. Therefore, a single representative value, known as characteristic strength is used.

1.1.6 Characteristic strength of concrete

It is defined as the value of the strength below which not more then 5% of the test results are expected to fall (i.e. there is 95% probability of achieving this value only 5% of not achieving the same)

The characteristic strength of concrete in flexural member is taken as 0.67 times the strength of concrete cube.

1.1.7 Tensile strength of concrete

The estimate of flexural tensile strength or the modulus of rupture or the cracking strength of concrete from cube compressive strength is obtained by the relations

$$f_{cr} = 0.7\ f_{ck}\ \text{N/mm}^2$$

The tensile strength of concrete in direct tension is obtained experimentally by split cylinder. It varies between 1/8 and 1/12 of cube compressive strength.

1.1.8 Creep in concrete

Creep is defined as the plastic deformation under sustained load. Creep strain depends primarily on the duration of sustained loading. According to the code, the value of the ultimate creep coefficient is taken as 1.6 at 28 days of loading.

1.1.9 Shrinkage of Concrete

The property of diminishing in volume during the process of drying and hardening is termed Shrinkage. It depends mainly on the duration of exposure. If this strain is prevented, it produces tensile stress in the concrete and hence concrete develops cracks.

1.1.2 Modular ratio

Short term modular ratio is the ratio of modulus of elasticity of steel to the modulus of elasticity of concrete.

Short term modular ratio = E_s

/ E_c Es = modulus of elasticity of steel (2 x 10

5 N/mm^2)

Ec = modulus of elasticity of concrete (5000 *($\sqrt{f_{ck}}$) N/mm^2)

As the modulus of elasticity of concrete changes with time, age at loading etc the modular ratio also changes accordingly. Taking into account the effects of creep and shrinkage partially IS code gives the following expression for the long term modular ratio.

Long term modular ratio (m) = 280/ (3f_{cbc})

Where, f_{cbc} = permissible compressive stress due to bending in concrete in N/mm^2.

1.1.2.1 Poisson's ratio

Poisson's ratio varies between 0.1 for high strength concrete and 0.2 for weak mixes. It is normally taken as 0.15 for strength design and 0.2 for serviceability cri

CERAMIC WASTE IN CONSTRUCTION

In the present construction world, the solid waste is increasing day by day from the demolitions of constructions. There is a huge usage of ceramic tiles in the present constructions are going on and it is increasing in day by day construction field. Ceramic products are part of the essential construction materials used in most buildings. Some common manufactured ceramics include wall tiles, floor tiles, sanitary ware, household ceramics and technical ceramics. They are mostly produced using natural materials that contain high content of clay minerals. However, despite the ornamental benefits of ceramics, its wastes among others cause a lot of nuisance to the environment. And also in other side waste tile is also producing from demolished wastes from construction. Indian tiles production is 100 million ton per year in the ceramic industry, about 15%- 30% waste material generated from the total production. This waste is not recycled in any form at present, however the ceramic waste is durable, hard and highly resistant to biological, chemical and physical degradation forces so, we selected these waste tiles as a replacement material to the basic natural aggregate to reuse them and to decrease the solid waste produced from demolitions of construction. There are some researchers are also going on solid waste from construction to reuse them again in the construction to reduce the solid waste and to preserve the natural basic aggregates. These researches promotes to use the recycled aggregates in the concrete mix and they got good result when adding some extent percentages of recycled aggregates in place of natural coarse aggregate.

ENVIRONMENTAL AND ECONOMIC BENEFITS OF TILE AGGREGATE CONCRETE

The usage of tile aggregate as replacement to coarse aggregate in concrete has the benefits in the aspects of cost and reduction of pollution from construction industry. The cost of concrete manufacturing will reduce considerably over conventional concrete by including ceramic tile aggregate since it is readily available at very low cost and there-by reducing the construction pollution or effective usage of construction was

FIBRE REINFORCED CONCTETE

Fibre reinforced concrete may be defined as a composite material made with Portland cement, aggregate, and incorporating discrete discontinuous fibres. Plain, unreinforced concrete is a brittle material, with a low tensile strength and a low strain capacity. The role of randomly distributes discontinuous fibres is to bridge across the cracks that develop provides some post- cracking “ductility”. If the fibres are sufficiently strong, sufficiently bonded to material, and permit the fibre reinforced concrete to carry significant stresses over a relatively large strain capacity in the post-cracking stage.

Steel Fiber Reinforced Concrete

A number of steel fiber types are available as reinforcement. Round steel fiber the commonly used type are produced by cutting round wire in to short length. The typical diameter lies in the range of 0.25 to 0.75mm. Steel fibers having a rectangular c/s are produced by silting the sheets about 0.25mm thick. Fibre made from mild steel drawn wire. Conforming to IS: 280-1976 with the diameter of wire varying from 0.3 to 0.5mm have been practically used in India. Round steel fibers are produced by cutting or chopping the wire, flat sheet fibers having a typical c/s ranging from 0.15 to 0.41mm in thickness and 0.25 to 0.90mm in width are produced by silting flat sheets. Deformed fiber, which are loosely bounded with water-soluble glue in the form of a bundle are also available. Since individual fibers tend to cluster together, their uniform distribution in the matrix is often difficult. This may be avoided by adding fibres bundles, which separate during the mixing process.

Figure 1: Steel fibre

ADVANTAGES

- Reinforcing concrete with Steel fibres results in durable concrete with a high flexural and fatigue flexural strength, improved abrasion, spalling and impact resistance.
- The elimination of conventional reinforcement, and in some cases the reduction in section thickness can contribute to some significant productivity improvements. Steel fibres can deliver significant cost savings, together with reduced material volume, more rapid construction and reduced labour costs.
- The random distribution of Steel fibres in concrete ensures that crack free stress accommodation occurs throughout the concrete. Thus micro cracks are intercepted before they develop and impair the performance of the concrete.
- Steel fibres are a far more economical design alternative.

DISADVANTAGES

- Steel fibres will not float on the surface of a properly finished slab, however rain damaged slabs allow both aggregate and fibres to be exposed and will present as aesthetically poor whilst maintaining structural soundness.
- Fibres are capable of substituting reinforcement in all structural elements
- (including primary reinforcement), however, within each element there will
- be a point where the fibre alternative's cost saving and design economies are diminished.
- Strict control of concrete wastage must be monitored in order to keep it at a minimum. Wasted concrete means wasted fibres.

1.2 OBJECTIVE OF STUDY

- To obtain alternative coarse aggregate from ceramic waste tile pieces.
- The use of ceramic waste and steel fiber in concrete is an effective measure in reducing the cost of concrete, increasing its strength and keeping the environment clean by maintaining waste management and reducing the use of raw materials.
- To obtain a tensile strength in a concrete.
- To use ceramic waste material in construction methodology.
- To compare the compressive strength of ceramic waste used as Coarse Aggregate for Constructional Concrete with the Conventional concrete.
- To study the behavior of fresh and hardened concrete reinforced with ceramic waste coarse aggregate.
- To reduce the environmental and ecological challenge associated with ceramic waste.

1.3 SCOPE OF STUDY

According to our research the major source of pollution in India has renovating their housed regularly and construction of house are rapidly increasing. Growth of population, increasing urbanization, rising standards of living due to technological innovations have contributed to an increase both in the quantity and variety of solid wastes generated by industrial, mining, domestic and agricultural activities. Globally The estimated quantity of wastes generation was 56 million tones in the year. To find the possibilities of reducing the amount of ceramic waste as it will create an eco-friendly environment as well as it used in construction.

1.4 PROBLEM STATEMENT

Solid waste management is the most pressing environmental challenge faced by urban and rural areas of India. India, with population exceeding 134 crores, is one of the largest producers of solid waste. There is rapid growth in the population and the increase in population comes with increase in waste generation. India generates around 62 12 million tons of solid waste annually, out of which only 20-30% is collected. The waste are disposed in open spaces, road sides and within residential buildings. Increasing in the renovation of the construction industry and re-construction. There are construction stages that does not require normal concrete or heavy load and alternatively lightweight can be used on the building or structure. The continuous rise in construction industry and cost of building materials over the years in India and the world at large, forced researchers to look for ways of addressing the problem. ceramic waste which is one of the non-bio-gradable materials as stated earlier causes a lot of environmental pollution, and there is the need to find solution to such menace. It was reported that recycling of waste materials can be economical and as a consequence reduces pollution and contamination. The problem with cement concrete are in terms of low tensile strength, permeability to liquids, corrosion of reinforcement, prone to biological or chemical attack, poor freeze/thaw resistances. Research and Development has a new dimension in the use of affordable local building materials in addressing the concrete drawbacks, such as the use of ceramic waste and other admixtures to improve the performance of concretes. Research has been carried out in advanced countries, on the use of ceramic waste materials in concrete, but only few were reported in India. The study also evaluates differences in compressive strength and density based on variable addition of granulated waste plastic in the cement based composite respectively.

CHAPTER-2

LITERATURE SURVEY

General:

Being the main component of structure, many researches are done on concrete to boost its properties in every possible manner to develop a sustainable concrete mass. The concrete are often strengthened only by the replacement of its ingredients by better ones. Not only replacing by some material but using stuff makes the environment friendly at the identical time more suitable to construction. During this aspect lot of researches are done on using the tile aggregate in concrete which may be stuff directly from industry or indirectly from demolition of a structure. The current study is concentrated only on the literature associated with usage of tile aggregate in concrete as a replacement to coarse aggregate. The small print of literature review is given below.

LITERATURE REVIEW

Falah A. Almottiri (2011)[1]: (Physical Properties of Steel Fiber Reinforced Cement Composites Made with Fly Ash) The study is conducted on the structural behaviour of steel fibres reinforced fly ash concrete under the compression as well as flexure. It was observed that the use of steel fibre in fly ash containing concrete improved its structural properties like flexural tensile strength. Enhancement of flexural tensile strength and compressive strength obtained by increasing thepercentage of fly ash up to 30% as well as by adding 1% of steel fibre in concrete.

M. Ramli and E. ThanonDawood (2011)[2]: (Contribution of Hybrid Fibers on the properties of high strength concrete having high workability) An experimental study was conducted on high strength flow able mortar which was reinforced with different percentage of steel fibres to determine the physical properties of concrete. The load-deflection curve under a static flexural load were established and from that the results indicate that if the fibre content is increased up to 1.75%, not only the flexural strength but also the toughness indices are increased. Also the experimental results showed that by increasing the steel fibres, the density, compressive strength and static modulus of elasticity are increased.

Prashant Y. Pawade, Nagarnaik P. B and Pande A. M. (2011)[5]: (Performance of steel fiber on standard strength concrete in compression) The experimental investigation was carried out with the incorporation of steel fibers, silica fume and cement had been shown that a strong composite was produced with superior crack resistance, improved ductility and strength behavior. The experimental results were compared with the mathematically modeled expressions. Regression analysis was of large number of experimental results were carried out and from that the statistical model was prepared. All the properties of concrete such as compressive strength and modulus of elasticity were increased by addition of steel fibers.

Dr. Mrs. S. A. Bhalchandra and Pawase Amiat Bajirao (2012) [6]: (Steel Fiber Reinforced Concrete & Its Properties) The experimental study was carried out on the steel fibre reinforced self-compacting concrete (SFRSCC) by addition of different content of steel fibres. The results showed that split tensile strength found to be increased with the addition of steel fibres and the optimum fibre content for increasing the split tensile strength was found to be 1.75%. When the results were compared for SFRSCC and normal Self Compacting Concrete (SCC) the increase in compressive strength was found to be 25.75% and flexural strength as 19.47%.

Vikrant S. Vairagade and Kavita S. Kene (2012)[7]: (Introduction to Steel Fiber Reinforced Concrete on Engineering Performance of Concrete) The review study was carried out for the introduction of steel fibres to obtain steel fibre reinforced concrete in sustainable and long-lasting concrete structures. The study found that the workability can be adequate to the concrete by introducing the super plasticizer without affecting the other properties.

Mazen Musmar (2013)[8]: (Tensile strength of steel fiber reinforced concrete) The study had shown that the addition of steel fibres in a concrete improved many mechanical properties of concrete such as tensile strength, impact strength and toughness. The resulting concrete material possesses higher tensile strength, consolidated response and ductility. From the experimental data it had been proved that concrete compressive strength, fibre content and the fibre aspect ratio are the major effectual parameters for specifying the tensile strength of fibre content.

Amit Rana (2013)[10]: (Some Studies on Steel Fiber Reinforced Concrete) This experimental study included finding out the optimum quantity of steel fibres required to achieve the maximum strength for the M25 grade of concrete. It showed that with the increase in steel fibre content in concrete the flexural strength was increased in large content. The result showed that at 1% of steel fibres content flexural strength of 6.46 N/mm^2 while it was observed that the flexural strength of 5.36 N/mm^2 was obtained for 0% of steel fibres.

Julia García-González, Desirée Rodríguez-Robles, Andrés Juan-Valdés, Julia Ma Morán-del Pozo and M. Ignacio Guerra-Romero (2014)[9]: (Pre-Saturation Technique of the Recycled Aggregates: Solution to the Water Absorption Drawback in the Recycled Concrete Manufacture) The study concentrates on the ceramic waste from industries in Spain. The concrete design is done as per the Spanish concrete code and the recycled ceramic aggregates met all the technical requirements imposed by current Spanish legislation. The ceramic aggregates are replaced up to 100% replacement of coarse aggregate. Appropriate tests were conducted to compare the mechanical properties with conventional concrete. The ceramic ware aggregate concrete was exhibited a feasible concrete properties as like the normal gravel concrete.

Md Daniyal and Shakeel Ahmad (2015) [10]:(Application of Waste Ceramic Tile Aggregates in Concrete) A large quantity of ceramic materials goes into wastage during processing, transporting and fixing due to its brittle nature. The crushed waste ceramic tiles were used in concrete as a replacement for natural coarse aggregates with 10%, 20%, 30%, 40% and 50% of substitution in concrete. The study states that the use of ceramic tile aggregate in concrete enhances its properties and it has been observed an increase in both compression and flexural strength.

Aruna D (2015)[11]:(Studies On Usage Potential Of Broken Tiles As Part Replacement To Coarse Aggregates In Concretes) For tile waste based concrete, coarse aggregates were replaced by 20mm down size, tile wastes by 0% , 5%, 10%, 15%, 20% and 25% and also the cement is partially replaced by fly-ash. The average maximum compressive strength of roof tile aggregate concrete is obtained at a replacement of 25%. A reduction of 10-15% of strength is observed compared to conventional concrete at 25% of roof tile aggregate replacement. The workability of roof tile waste concrete is in the range of medium. Overall, the replacement of tiles in concrete is satisfactory for small constructions.

Parminder Singh and Dr. Rakesh Kumar Singla (2015)[12]: (Utilization of waste ceramic tiles as coarse aggregate in concrete)

A research paper on utilization of ceramic waste tiles from industries. A partial replacement to coarse aggregate has been studied. Three different grades of concrete has been prepared and tested. The results are not appropriate with the conventional but considering the strength properties, it is advisable to use ceramic tile aggregate in concrete. It is finally concluded that, about 20% of ceramic tile usage in M20 grade of concrete is preferable.

Wadhah M. Tawfeeq (2016) [13]: (Partial replacement of ceramic tiles waste in concrete) This study investigated the effects of using crushed tiles (CT) as coarse aggregates in the concrete mix. The technology of concrete recycling is well established in the U.S. Recycling of Portland cement Concrete, as well as asphaltic concrete, has been shown to be a cost-effective alternative for road, street and highway construction. It includes not only the water content and tiles but also the gravel/sand ratio. They concluded that as the water cement ratio decrease, the compressive strength increases. The paper consists of replacement of crushed tiles to 50% and 100% only. The results show that replacement of crushed tiles as coarse aggregate below 50% will have considerable properties.

Prof. Shruthi H. G. (2016) [14]: (Reuse of ceramic waste as aggregate in concrete)
Ceramic tiles were obtained from manufacturing industries, from construction and demolition sites, this cause's environmental pollution. The utilization of crushed tile as a coarse aggregate in concrete would also have a positive effect on the economy. study, Ceramic tile waste were used in concrete as a replacement for natural coarse

aggregate with 0%, 10%, 20% and 30% of the substitution and M20 grade concrete were used. The concrete moulds were casted and tested for Compressive Strength and Split Tensile Strength after a curing period of 3, 7 & 28 days. The results indicate that, the maximum compressive strength is obtained for the 30% replacement of ceramic tile aggregate with natural coarse aggregate.

P. Rajalakshmi (2016) [15]: (Study of partial replacement of coarse aggregate byMosaic tile chips)

Use of ceramic waste will ensure an effective measure in maintaining environment and improving properties of concrete. The replacement of aggregates in concrete by ceramic wastes will have major environmental benefits. In ceramic industry about 30% production goes as waste. The ceramic waste aggregate is hard and durable material than the conventional coarse aggregate. It has good thermal resistance. The durability properties of ceramic waste aggregate are also good. This research studied the fine aggregate replacement by ceramic tiles fine aggregate accordingly in the range of 10% and coarse aggregate accordingly in the range of 30%, 60%,100% by weight of M-30 grade concrete. This paper recommends that waste ceramic tiles can be used as an alternate construction material to coarse and fine aggregate in concrete irrespective of the conventional concrete; it has good strength properties i.e., 10% CFA and 60% CCA being the maximum strength.

Paul O. Awoyera (2016) [16]: (Characterization of ceramic waste aggregate concrete)

The usage of ceramic tiles in concrete was observed in this paper. In this, both the coarse and fine aggregates are replaced with ceramic fine and ceramic coarse aggregates obtained from construction sites of Ota, Lagos and Nigeria in various percentages. The ceramic fine and coarse aggregates are replaced in conventional concrete individually and the strength parameters are studied. Finally, it states that usage of ceramic waste in concrete gives considerable increase in strength compared to conventional concrete.

N.Naveen Prasad (2016) [17]: (Partial Replacement of Coarse aggregate by Crushed Tiles and Fine aggregate by Granite Powder to improve the Concrete Properties) Crushed waste tiles and Granite powder were used as a replacement to the coarse aggregates and fine aggregate. The combustion of waste crushed tiles were replaced in place of coarse aggregates by 10%, 20%, 30% and 40% and Granite powder was replaced in place of fine aggregate by 10%, 20%, 30% and 40% without changing the mix design. M25 grade of concrete was designed to prepare the conventional mix. Without changing the mix design different types of mixes were prepared by replacing the coarse aggregates and fine aggregate at different percentages of crushed tiles and granite powder. Experimental investigation is carried out. The workability of concrete increased with increase in granite powder and it has been observed that the compressive strength is maximum at 30% of coarse aggregate replacement.

Batriti Monhun and R. Marwein (2016) [18]: (A Review Paper On Utilisation Of Ceramic Waste In Concrete)

The ceramic waste adopted is broken tiles. Ceramic waste concrete (CWC)made with these tiles at 0%, 15%, 20%, 25% and 30%.

M20 grade concrete is adopted; a constant water cement ratio of 0.48 is maintained for all the concrete mixes. The characteristics properties of concrete such as workability for fresh concrete, also Compressive Strength, Split Tensile Strength are found at 3, 7 and 28 days. The paper suggests that the replacement of waste tile aggregate should be in the range of 5-30% and also it is suitable to ordinary mixes like M15 and M20.

CHAPTER-3

MATERIALS AND METHODOLOGY

3.1 Materials

- Ordinary Portland Cement of 53 Grade cement conforming to IS:169-1989
- Fine aggregate and coarse aggregate conforming to IS: 2386-1963.
- Water
- Crushed ceramic waste
- Steel fiber
- Conplastsp430 superplasticizer

3.1.1 Portland cement

Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete, mortar, stucco, and non-specialty grout. It was developed from other types of hydraulic lime in England in the late 19th century by Joseph Aspdin, and usually originates from limestone. It is a fine powder, produced by heating limestone and clay minerals in a kiln to form clinker, grinding the clinker, and adding 2 to 3 percent of gypsum. Several types of Portland cement are available. The most common, called ordinary Portland cement (OPC).

Figure 2: Portland cement

3.1.2 Fine aggregate and coarse aggregate:

Fine aggregate is the essential ingredient in concrete that consists of natural sand or crushed stone. The quality and fine aggregate density strongly influence the hardened properties of the concrete.

Figure 3: Fine aggregate

The concrete or mortar mixture can be made more durable, stronger and cheaper if you made the selection of fine aggregate on basis of grading zone, particle shape and surface texture, abrasion and skid resistance and absorption and surface.Coarse-grained aggregates will not pass through a sieve with 4.75 mm opening.

Those particles that are predominantly retained on the 4.75 mm (No. 4) sieve and will pass through 3-inch screen are called coarse aggregate. The coarser the aggregate, the more economical the mix. Larger pieces offer less surface area of the particles than an equivalent volume of small pieces. Use of the largest permissible maximum size of coarse aggregate permits a reduction in cement and water requirements. Using aggregates larger than the maximum size of coarse aggregates permitted can result in interlock and form arches or obstructions within a concrete form. That allows the area below to become a void, or at best, to become filled with finer particles of sand and cement only and results in a weakened area.

Figure 4. Coarse aggregate

3.1.3 Water

Water is one of the most important elements in construction and is required for the preparation of mortar, mixing of cement concrete and for curing work etc. The quality of water used has a direct impact on the strength of the motor and cement concrete in the construction work. The water used for curing and mixing must be free from high quantities of alkalis, acid, oils, salt, sugar, organic materials, vegetable growth, etc that might be deleterious to bricks, concrete or iron.

Impurities in water can cause metal corrosion, introduce unwanted silt and clay into the concrete, adversely affect the hardening process of concrete and also reduce the strength by even 25%. Thus the need to ensure the quality of water used during construction is vital.

3.1.4 CRUSHED CREAMIC WASTE

Various products of ceramic wastes incl\ude sanitary ware, floor tiles, wall tiles, roof tiles, and ceramics from refractory and vitrified clay tiles. Ceramic waste may come from two sources:

The first source is the ceramics industry, and this waste is classified as non-hazardous industrial waste (NHIW). According To Integrated National Plan on Waste 2008-2015, NHIW is all waste generated by industrial. The second source of ceramic waste is associated with construction and demolition activity.

Figure 5 crushed ceramic waste

3.1.5 Steel fiber:

Steel fibres continue to have a wide range of applications in civil engineering materials. There are some structural applications where they have been used in concrete without any conventional reinforcing bars. Steel fibre concrete has also been employed as slabs, bridge decks, airport pavements, parking areas, and cavitations or erosion environments, as well as worldwide for the production of highway slabs.

Figure 6: Steel fibre

3.1.6 Conplast sp430 superplasticizer

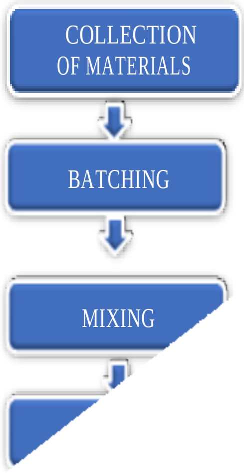
Conplast SP430 is a chloride free, super plasticising admixture based on selected sulphonated naphthalene polymers. It is supplied as a brown solution which instantlydisperses in water.Conplast SP430 disperses the fine particles in the concretemix, enabling the water content of the concrete to performmore effectively. The very high levels of water reductionpossible allow major increases in strength to be obtained.

Figure 7: Conplast sp430 superplasticizer

3.2 METHODOLOGY

Literature reviews related to the Ceramic waste were collected and based onthe literature survey preliminary works were performed. Works like collection of ceramic waste was performed. Materials required for concrete such as coarse aggregate, fineaggregate, cement were collected. Basic tests were conducted on fine aggregate, coarse aggregate, cement, ceramic waste, to check their suitability concrete making The properties of fine and coarse aggregates sieve analysis of fine and coarse aggregates, tests on cement are found out. The Study aims to investigate the strength related properties of concrete of M25 grade. The proportions of ingredients of the control concrete of grade M25 had determined by mix design as per IS code. Moulds were prepared to cast the specimen. Cube Mould of size 150mm*150mm*150mm and cylinder mould 150mm*300mm and prism mould 100*100*500 were cast with desired of partially replacement (0%, 5%, 10%, 15%) of coarse aggregate. Casted Samples were tested after 7days and 28 days of curing Compressive strength and split tensile strength test and flexural strength was performed using casted concrete. Results were obtained and conclusion was arrived.

3.2.1 Flow chart representing the Methodology



3.3 MIX DESIGN

(M25 GRADE CONCRETE)

3.3.1 Mix proportions

Coarse aggregate was partially replaced by ceramic waste as aggregate in the range of varying 5%, 10%, 15% and 2% of steel fiber. And the mix proportions have been recommended based on trial mixes. In the present study, M25 grade with design mix asper IS: 456-2000 was used. Concrete mix proportion by weight for one cubic meter andwater cement ratio of 0.48. Gives the mix used for study.

Table 1: Mix Proportions for conventional concrete

W/C Ratio	Cement	Fine Aggregate	Coarse Aggregate
0.48	387.5 kg/m^3	695.83 kg/m^3	1156.73 kg/m^3
	1	1.79	2.98

A) Design stipulations

1. Characteristic compressive strength required in the field at 28 days is 25N/mm^2
2. Maximum size of aggregate: 20mm (angular)
3. Degree of quality control: Good
4. Type of exposure: moderate

B) Test data for materials:

1. Cement used OPC satisfying the requirements of IS: 269-1967
2. Specific gravity of cement: 3.04
3. Specific gravity
   a) Coarse aggregate: 2.65
   b) Fine aggregate: 2.75
4. Coarse aggregate: Conforming to IS:2386 (part-2)
5. Fine aggregate: Conforming to Zone II of IS2386

(part-1) 6. Water: IS 456-2000

C) Target mean strength:

Target mean strength

$f'ck = fck + 1.6(\sigma)$ Where

f'_{ck}=Target mean compressive

strength f_{ck}= Characteristic

compressive strength

σ= Standard

deviation Target mean strength

=25+1.65*4

=31.6 Mpa

D) Selection for w/c ratio for target mean strength of 31.6Mpa is 0.45. This is lower than maximum of 0.5. Solution w/c ratio=0.45.

E) Selection of water and sand content for maximum 20mm size aggregate and confirmed is to grade zone II, water content per cubic meter of concrete is 186kg.and sand content as percentage of total aggregate by absolute volume=33%.

F) Determination of water

content W/c ratio =0.48

Water = 180 lit

Water content required= 186
The cement content is adequate for moderate exposure condition.

Mix Calculations for 1m^{3}of Concrete:

a). Volume of concrete =1 m^3

From Table 3, for the specified maximum size of aggregate of 20 mm, the amount of entrapped air in the wet concrete is 2 percent. 'Taking this into account

Volume of concrete = 1m3

b). Volume of cement =Mass of cement/ Specific gravity of cement X 1/1000

= 439.13/ (3.05x1000)

=0.123m^3

c). Volume of water = 0.186 m^3

d). Volume of all aggregate = a- (b + c)

= 1- (0.123+0.186)

= 0.691 m^3

e). Mass of coarse aggregate = d×0.63×specific gravity of CA ×1000

= 0.691×0.62×2.75×1000

=1156.734 kg

f). Mass of fine aggregate = d×0.37×specific gravity of FA ×1000

= 0.691×0.38×2.65×1000

= 695.837 kg

Hence, mix details per m^3

Therefore, mix proportions for concrete mix of M 25 Grade is

Cement: FA: CA: Water Cement ratio = 1 : 1.79 : 2.98 : 0.48

3.4 Experimental Procedure

In the present experimental investigation ceramic waste has been used as partial replacement of coarse aggregate in concrete mixes and addition of steel fibre. On replacing coarse aggregate with different percentage of ceramic waste aggregate of 0%, 5%, 10%, 15%. The compressive strength, split tensile strength and flexural strength is studied at different ages of concrete cured in normal water.

3.4.1 Batching

Measuring the quantities of constituents of concrete required for the preparation of concrete mix is called Batching. Weight batch method is used to measure the quantities. The quantities of fine aggregate, Natural coarse aggregate, crushed ceramic waste, steel fiber, cement, water and admixture for each batch were measured by a weighing balance according to the mix proportions obtained by the mix design.

The process of measuring ingredients or materials to prepare concrete mix is known as batching of concrete. Batching can be done by two methods, volumebatching and weight batching. Batching should be done properly to get qualityconcrete mix.

3.4.2 Mixing

The objective of mixing is to coat the surface of all aggregate particles with Cement paste and to blend all the ingredients of concrete into a uniform mass. Though mixing of the materials is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in color and consistency. At first dry mixing is necessary of the uniform distribution of the fiber. Then the required amount of water is added to the mix. Through mixing is necessary to get the consistent slurry of concrete. Admixture is added to the mix at the later stage and after few minutes of mixing, the concrete becomes ready for placing.

3.4.3 Casting :

The specimens are casted in the ratio of 0%, 5% 10%, 15%, the mix design is based on strength criteria and durability criteria for mild environmental exposure. The ratios by weight of cement, fine aggregates, coarse aggregate, broken ceramic waste and steel fibre are obtained and mixed thoroughly in dry condition. Then water required is added to the dry mix and mixed thoroughly till to obtain uniform mixture. Superplasticizer is added to the mix to maintain the workability of fresh concrete. The concrete is filled into the mould in 3 layers. Each layer is compacted with tamping rod, for 25 blows each time. After the top layer has been compacted the surface of the concrete is brought to the finished. After the casting process, the cubes, prisms, and cylinders were kept for 24 hours and de-moulded, and they were cured for 7 days and 28 days

Sl.no	Specimen	Sizes
1	Cube	150*150*150
2	Cylinder	300(height)*150(Dia)
3	Prism	500*100*100

Table 2: Details of specimens

Cube

Cylinder

Prism

Figure 8: Standard specimens

3.4.3.1 Procedure for Casting Cubes

Clean the cube mould properly with a cloth and apply a coat of firm oil on the inner surfaces of the mould. No excess oil should be visible on the inner surfaces. Fix the nuts & bolts tightly with base plate and side plates, no gaps should be seen within the parts of cube mould. It is necessary that the cube mould should be placed on a clean, level & firm surface for filling the concretein it.

Concrete for specimen should be collected from three or four random mixes according to the preferred mix design of M20 grade. Place the concrete mix intothe mould in each layer of maximum 50 mm thick. Level off the top with the steel float & clean any concrete from around the mould and leave the mould undisturbed for 24 hours. Give number & casting date of the specimens on the top surface after 30 minutes. Remove the cube from the mould after 24 hours. The specimen should be put straight into a tank of clean water. The specimen should be fully submerged under water. After 7 and 28 days, send the specimento the testing laboratory to determine the compressive strength of concrete.

3.4.3.2 Procedure for Casting Cylinders

Clean the Cylinder mould properly with a piece of cloth and apply a coat of firmoil on the inner surface of mould. No excess oil should be visible on inner surface. Fix the nuts & bolts tightly with base plate and no gaps should be withinthe parts of cylinder mould. It is necessary that the cylinder mould should be placed on a clean, level & firm surface.

Concrete for specimen should be collected from three or four random mixes. Place concrete into the mould in each layer of maximum 50 mm thick. Level off the top with the steel float & clean any concrete from around the mould andleave the mould undisturbed for 24 hours.Give number & casting date of the specimens on the top surface after 30 minutes. After 24 hours the

Figure 9: casting of cylinder

specimen should be taken out from the mould and put it straight into a tank of clean water. The specimen should be fully submerged under water. After 7 and 28 days, send the specimen to the testing laboratory to determine the tensile strength of concrete. Minimum three specimens are made at a time on site. The average test result is taken to determine the tensile strength of concrete

3.4.3.3 Procedure for Casting prism

Clean the prism mould properly with a cloth and apply a coat of firm oil on theinner surfaces of the mould. No excess oil should be visible on the inner surfaces. Fix the nuts & bolts tightly with base plate and side plates, no gaps should be seen within the parts of prism mould. It is necessary that the mould should be placed on a clean, level & firm surface for filling the concrete in it. Concrete for specimen should be collected from three or four random mixes according to the preferred mix design of M20 grade. Place the concrete mix intothe mould in three layers and then perform the compaction process by using mechanical vibrator. Level off the top with the steel float & clean any concretefrom around the mould and leave the mould undisturbed for 24 hours. Give number & casting date of the specimens on the top surface after 30 minutes. Remove the prism from the mould after 24 hours. The specimen shouldbe put straight into a tank of clean water. The specimen should be fullysubmerged under water. After 7 and 28 days, send the specimen to the testing laboratory to determine the flexural strength of concrete

Figure 10: casting of prisms

3.4.4 Curing

The specimens shall be removed from the moulds at the end of 24 hours and immersed in clean water till the 7 and 28-days age of testing. The specimens shall be tested in the saturated and surface dry condition. For the true representation of actual strength of concrete in the structure, extra specimens shall be cast, stored, and cured as per the identical conditions of that structure, and tested at required age.

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Figure 11: Curing of specimens

3.5 WORKABILITY TEST

3.5.1 SLUMP CONE TEST:

This test is used extensively in site all over the world. The slump test does not measure the workability of concrete, but the test is very useful in detecting variations in the uniformity of a mix of given nominal proportions.

The slump test is done as prescribed by IS: 516.

The apparatus for conducting the slump test essential consists of a metallic mould in the form of a cone having the internal dimensions as under

Bottom diameter: 200 mm

Topdiameter: 100 mm

The mould for slump is a frustum of a cone, 300 mm high. It is placed on a smooth surface with the smaller opening at the top, and filled with concrete in three layers. Each layer is tamped twenty five times with a standard 16 mm diameter steel rod, rounded at the end, and the top surface is stricken off by means of sawing and rolling motion of the tamping rod. The mould must be firmly fixed against its base during the entire operation; this is facilitated by handles or foot-rests brazed to the mould. Immediately after filling, the cone is slowly lifted vertically up, and the unsupported concrete will now slump – hence the name of the test. The difference in level between the height of the mould and that of highest point of subsided concrete is measured. This difference in height in mm is taken as slump of concrete. If instead of slumping evenly all rounds as in a true slump one half of the cone slides down an Inclined plane, a shear slump is said to have taken place and test should be replaced. If shear slump persists, as may be the case with harsh mixes, this is an inclination of lack of cohesion in the mix.

Mixes off stiff consistency have a zero slump, so that in the rather by range, no variation can be detected between mixes of different workability. Rich mixes behave satisfactorily, their slump being sensitive to variations in workability however, in a lean mix a with a tendency to harshness, a true slump can easily change to the shear type, or even to collapse and widely different values of slump can be obtained in different samples from the same mix.Despite these limitations, the slump test is very useful at the site to check on the batch or hour- to- hour variation in the materials being fed into mixer, as increase in slump may mean, for instance, that the moisture content of aggregate has unexpectedly increased; another cause would be a change in the grading of the aggregates, such as a defiance of sand .too low and too high slump gives immediate waning and enables the mixer operator to remedy the situation. This application of the slump test as well as its simplicity is responsible for its widespread use. A mini slump test was developed for the purpose of assessing the influence of various water- reducing admixtures and super plasticizers on neat cement paste. The test may be useful for the specific purpose, but it is important to remember that workability of concrete is affected also by factors other than the flow properties of the constituent cement paste.

Figure 12: Slump cone test

3.5.2 COMPACTION FACTOR TEST:

The compaction factor test is carried out to measure the degree of workability of fresh concrete with regard to the internal energy required for compacting concrete thoroughly. The compacting factor test is used to find out the low workability of concrete. it is a fact that the slump cone test of concrete is not given accurate results for the low workability of concrete when the slump is <50mm. This test is more precise than the slump test but it is less common. The size of the apparatus makes it difficult to conduct the test in the field. The compaction factor test was developed by Road Research Laboratory in the United Kingdom.

Procedure:

1. The sample of concrete to be tested shall be placed gently in the upper hopper, using the hand scoop.
2. The hopper shall be filled level with its brim and the trap-door shall be opened so that the concrete falls into the lower hopper.
3. Certain mixes have a tendency to stick in one or both of the hoppers. If this occurs, the concrete may be helped by pushing the rod gently into the concrete from the top.
4. Immediately after the concrete has come to rest, the cylinder shall be uncovered, the trap-door of the lower hopper opened, and the concrete allowed falling into the cylinder.
5. The excess of concrete remaining above the level of the top of the cylinder shall then be cut off by holding a trowel.
6. Weight the cylinder with concrete to the nearest 10 g. This weight is known as the weight of partially compacted concrete (**W1**).
7. Empty the cylinder and then refill it with the same concrete mix in layers approximately 5 cm deep, each layer being heavily rammed to obtain full compaction.
8. Level the top surface.
9. Weigh the cylinder with fully compacted. This weight is known as the weight of fully compacted concrete (**W2**).

Find the weight of the empty cylinder (**W**).

Compaction factor = Weight of Partially Compacted Concrete(Wp) / Weight of Fully Compacted Concrete(Wf)

3.6 MECHANICAL PROPERTY TEST

The cured specimens are taken from the curing tank and placed outside until it gets dried. Later, the entire specimens were tested in the laboratory for 7 days and 28 days. The tests conducted are;

- Compression test
- Split tensile test
- Flexural strength test

3.6.1 COMPRESSIVE STRENGTH:

Compressive strength of concrete is the Strength of hardened concrete measured by the compression test. The compression strength of concrete is a measure of the concrete's ability to resist loads which tend to compress it. It is measured by crushing concrete cube specimens in compression testing machine.

The compressive strength of concrete can be calculated by the failure load divided with the cross sectional area resisting the load and reported in mega pascals (MPa) in SI units. Concrete's compressive strength requirements can vary from 17 MPa for residential concrete to 28 MPa and higher in commercial structures. Higher strengths up to and exceeding 70 MPa are specified for certain applications.

For cube test two types of specimens either cubes of 150mm X 150mm X 150mm or 100mm X 100mm x 100mm depending upon the size of aggregate are used. For most of the works cubical moulds of size 150mm x 150mm x 150mm are commonly used.

This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing.These specimens are tested by compression testing machine after 7 days curing and 28 days curing. Load should be applied gradually till the Specimens fails. Load at thefailure divided by area of specimen gives the compressive strength of concrete.

$$\text{Compressive strength of concrete} = \frac{\text{Load at which cpecimen fails}}{\text{Cross section area of cube}}$$

Fig 13 compression test

Fig 14 Tested specimen

3.6.2 SPLIT TENSILE STRENGTH TEST:

The tensile strength of concrete is one of the basic and important properties which greatly affect the extent and size of cracking in structures.

Moreover, the concrete is very weak in tension due to its brittle nature. Hence it is not expected to resist the direct tension. So, concrete develops cracks when tensile forces exceed its tensile strength.

Therefore, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack. Furthermore, splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete.

The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of compression testing machine and the load is applied until failure of cylinder, along its longitudinal direction.

Split tensile strength=

$$\frac{2\times P}{\pi\times D\times L}$$

Where

P = compressive load on the cylinder

. L=length of the cylinder

D= diameter of cylinder

Fig 15: Split tensile test on cylinders

3.6.3 FLEXURE TEST

Flexure tests are generally used to determine the flexural modulus or flexural strength of a material. A flexure test is more affordable than a tensile test and test results are slightly different. The beam is laid horizontally over two points of contact (lower support span) and then a force is applied to the top of the material through one points of contact (upper loading span) till the sample failed. The force at failure is taken and tabulated.

Prepare the test specimen by filling the concrete into the mould in 3 layers of approximately equal thickness. Tamp each layer 35 times using the tamping bar asspecified above. Tamping should be distributed uniformly over the entire cross section of the beam mould and throughout the depth of each layer.

Clean the bearing surfaces of the supporting and loading rollers, and remove any loose sand or other material from the surfaces of the specimen where they are to contact the rollers

Circular rollers manufactured out of steel having cross section with diameter 38mm will be used for providing support and loading points to the specimens. Thelength of the rollers shall be at least 10 mm more than the width of the test specimen. A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes. The distance between the outer rollers(i.e., span) shall be 3d and the distance between the inner rollers shall be d. Theinner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic.

The specimen stored in water shall be tested immediately on removal from water; whilst they are still wet. The test specimen shall be placed in the machinecorrectly centred with the longitudinal axis of the specimen at right angles to the rollers. For moulded specimens, the mould filling direction shall be normalto the direction of loading.

The load shall be applied at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens.

CHAPTER-4

TEST ON MATERIALS

4.1 TESTS ON CEMENT

4.1.1 Fineness Of Cement

Aim: To determine the fineness of the given sample of cement by sieving.

Apparatus: IS-90 micron sieve conforming to IS:460-1965, standard balance, weights, brush.

Procedure

1. Weigh accurately 100 g of cement and place it on a standard 90 micron IS sieve.
2. Break down any air-set lumps in the cement sample with fingers.
3. Continuously sieve the sample giving circular motion for a period of 15minutes.
4. Weigh the residue left on the sieve. As per IS code

percentage residue should not exceed 10%.

Observations

1) Weight of cement taken on the sieve = 100gm
2) Weight of residue after sieving = 6 gm
3) Percentage of fineness $= \frac{\text{Weight of residue}}{\text{Weight of cement}} \times 100$

$$= \frac{6}{100} \times 100$$

$$= 6\ \%$$

Result: Fineness of given sample of cement is 6%

4.1.2 Normal Consistency Of Cement

Aim: To determine the quantity of water required to produce a cement paste of standard consistency.

Apparatus: Vicat's apparatus (conforming to IS: 5513 - 1976) with plunger (10 mm in diameter) balance, weights, gauging trowel.

Procedure:

- Prepare a paste of weighed quantity of cement (400 grams) with a weighed quantity of potable or distilled water, starting with 28% water of 400g of cement.
- Take care that the time of gauging is not less than 3 minutes, not more than 5 minutes and the gauging shall be completed before setting occurs.
- The gauging time shall be counted from the time of adding the water to the dry cement until commencing to fill the mould.
- Fill the vicat mould with this paste, the mould resting upon a non porous plate.
- After completely filling the mould, trim off the surface of the paste, making it in level with the top of the mould. The mould may slightly be shaken to expel the air.
- Place the test block with the mould, together with the non-porous resting plate, under the rod bearing the plunger (10mm diameter), lower the plunger gently to touch the surface of the test block and quickly release, allowing it to penetrate into the paste.
- This operation shall be carried out immediately after filling the mould.
- Prepare trial pastes with varying percentages of water and test as described above until the amount of water necessary for making the standard consistency as defined above is obtained.
- Express the amount of water as a percentage by weight of the dry cement.

Table 3: Observations for normal consistency of cement

Sl.No	Percentage of water added	Quantity of water added in ml	Vicat's plunger reading
1	28%	112	19
2	30%	120	6

Result: Normal consistency for the given sample of cement is 30%

4.1.3 Initial Setting Time

Aim: To determine the initial setting time of cement

Apparatus

Vicat apparatus conforming to IS:5513-1976

Balance, whose permissible variation at a load of 1000g should be +1.0g

Gauging trowel conforming to IS: 10086-1982

Procedure

Prepare a cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency.

Start a stop-watch, the moment water is added to the cement.

Fill the vicat mould completely with the cement paste. The mould is placed on non-porous plate and smooth off the surface of the paste making it level with the top of the mould. The cement block thus prepared in the mould is the test block.

Place the test block under the rod bearing the needle.

Lower the needle gently in order to make contact with the surface of paste and quickly released allowing it to penetrate the block

Repeat the procedure till the needle fails to penetrate to a point 5.0±0.5mm measured from the bottom of the mould. The time taken between adding of water and above mentioned point is the initial setting time.

Observations

Weight of cement taken =

400gms Water required for normal consistency =

30(120ml)

Weight of water taken for making specimen= 102ml

Initial setting time =

3minutes

Result : The initial setting time of given cement sample is 35 minutes.

4.4.1 Specific Gravity Of Cement

Aim: To determine the specific gravity of given sample of hydraulic cement.

Apparatus: Physical balance, specific gravity bottle of 50ml capacity, cleans kerosene.

Procedure:

Clean and dry the specific gravity bottle and weigh it with the stopper (W1).

Fill the specific gravity bottle with cement sample at least half of the bottle and weigh with stopper (W2).

Fill the specific gravity bottle containing the cement, with kerosene (free of water) placing the stopper and weigh it (W3).

While doing the above do not allow any air bubbles to remain in the specific gravity bottle.

After weighing the bottle, the bottle shall be cleaned and dried again.

Then fill it with fresh kerosene and weigh it with stopper (W4).

Remove the kerosene from the bottle and fill it with full of water

All the above weighing should be done at the room temperature of 27c + 10c.

Observations

Weight of empty specific gravity bottle (W1)= 26.5gm

Weight of specific gravity bottle and cement (W2)= 36gm

Weight of specific gravity bottle, cement and kerosene (W3)= 73.5gm

Weight of specific gravity bottle and kerosene (W4)= 68gm

Result: Specific gravity of cement =3.04

4.2 TESTS ON FINE AGGREGATES

4.2.1 Specific Gravity

Aim: To determine Specific gravity of sand using Pycnometer.

Apparatus: Pycnometer, Tray, Weighing

balance,stirrer. **Materials used:** Fine aggregate

or sand, distilled water. **Procedure:**

- Take a clean, dry pycnometer, and find its weight with its cap and washer (W1)
- Put about 500 g of sand in the pycnometer and find its weight (W2)
- Fill the pycnometer and filled in sand as in step2, with distilled water and measure its weight (W3)
- Empty the pycnometer, clean it thoroughly, and fill it with clean water only to the hole of the conical cap, and find its weight (W4)
- Repeat the same procedure at least for three different samples

Observations:

- Weight of empty pycnometer (W_1)= 500gm
- Weight of pycnometer and fine aggregate (W_2)= 880gm
- Weight of pycnometer, fine aggregate and water (W_3)= 1757gm
- Weight of pycnometer and water (W_4)= 1520gm

$$\text{Specific gravity} = \frac{W2-W1}{((W2-W1)-(W3-W4))} = \frac{880-500}{((880-500)-(1757-1520))}$$

=2.65

Result: Hence the Specific Gravity of sand is calculated as2.65

Figure 16: Specific gravity of fine aggregate

4.2.2 Sieve Analysis Of Sand

Aim: To determine fineness modulus of sand.

Apparatus: The apparatus consists of eight different types of sieves i.e. 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ and 75µ sieve for fine aggregate.

Materials used: 500 gram sample of sand.:

Procedure

The sample shall be brought to an air-dried condition before weighing and sieving.

Measure 3000 gram of the sand.

Arrange sieve in descending order of size from the top.

Put the sand in sieve 4.75mm, and shake for 10 minutes. Material shall not be forced through the sieve by hand pressure.

After 10 minutes stop the shaker and separate the sieve 4.75mm from the apparatus. Then with the help of balance measure the weight of retained particles, note this weight in the table.

Measure the weight of the particles retained in each sieve and notes them in the table.

calculate the percentage of weight retained on each sieve.

Find the percentage of the weight which has passed through each sieve.

Table 4: Observations of sieve analysis of sand

Sieve size (mm)	Weight retained (gm)	Percentage Weight retained (gm)	Cumulative Percentage of weight retained	Cumulative percentage of weight passed
4.75	22	0.6	0.6	99.4
2.36	32	0.76	1.32	98.68
1.18	144	3.6	4.92	95.08
600 µ	973	12.28	17.2	82.8
300 µ	2000	57.5	74.7	25.3
150 µ	1170	24.1	98.8	1.2
75 µ	480	1.2	99.99	0.01
Pan	5	0.033	100	0
Total			**275**	

•

Result: Hence the Fineness modulus of sand is calculated as 2.75

4.2.3 Bulking of sand

Aim: To determine the moisture content at which bulking of sand occurs

Apparatus: Measuring jar, weighing balance, mixing pan, trowel….etc

Principle: Percentage of bulking of sand= (h1-h2)/h1 X100

Where, h_1= level of dry

sand h_2= level of

wet sand

Procedure

Take a measuring jar and pour in the certain volume of sand, say up to the height h1.

Now pour the same volume of water into the jar and stir the mixture of sand and water.

Keep the jar on the plain surface. Leave it for about 30 minutes. It is observed that a first volume of sand decreases due to expulsion of entrapped air and later volume slightly increases due to bulking action.

Finally the final level of sand, say h2 is noted.

Observation

Level of dry sand, h1 =

200 ml Level of wet sand, h2

=

180 ml

Bulking percentage $= \frac{h1-h2}{h1} \times 100$

$= \frac{200-180}{180} \times 100$

=11.11%

Result: Hence the percentage of bulking of sand is 11

4.3 Testing on coarse Aggregate

4.3.1 Specific gravity

Aim: To determine Specific gravity of coarse aggregate using Pycnometer.

Apparatus: Pycnometer, Tray, Weighing balance, stirrer.

Materials used: Coarse aggregate, distilled water.

Procedure:

Take a clean, dry pycnometer, and find its weight with its cap and washer (W1)

Put about 500 g of coarse aggregate in the pycnometer and find its weight (W2)

Fill the pycnometer and filled in coarse aggregate as in step2, with distilled water and measure its weight (W3)

Empty the pycnometer, clean it thoroughly, and fill it with clean water only to the hole of the conical cap, and find its weight (W4)

Repeat the same procedure at least for three different samples

Weight of empty pycnometer (W_1)= 500gm

Weight of pycnometer and coarse aggregate (W_2)= 940gm

Weight of pycnometer, coarse aggregate and water (W_3)= 1800gm

Weight of pycnometer and water (W_4)= 1520gm

Result: Hence the Specific Gravity of sand is calculated as2.75

4.3.4 .Sieve Analysis Of Coarse Aggregate

Aim: To determine the fineness modulus of given coarse aggregates.

Apparatus: IS test sieves, square hole perforated plate 80mm, 40mm, 20mm, 12.5mm, and 4.75mm .Weighing balance (Sensitivity0.1 percent) sieve shaker, tray plates.

Procedure:

- Take 5Kgs of coarse aggregate (nominal size 20mm) from the sample by quartering.

- Carry out sieving by hand, shake each sieve in order 80mm, 40mm, 20mm, 12.5mm, and 4.75mm for about 5 minutes.
- The shaking is done with a varied motion backward and forward, left to right, circular, clockwise and anticlockwise and with frequent jarring.
- So that material is kept moving over the sieve surface in frequently changing directions.
- Find the weight retained on each sieve taken in order

observations

Table 5: Observations of sieve analysis of gravels

Sieve size (mm)	Weight retained (kg)	Cumulative Percentage of weight retained	Cumulative percentage of weight passed
80	0	0	100
40	0.99	19.8	80.2
20	1.9	57.8	42.2
12.5	1.43	86.4	13.6
4.75	0.68	100	0
Total		**864**	

$$\text{Fineness modulus} = \frac{\text{sum of cumulative \% of weight retained}}{100}$$

$$= \frac{864}{100}$$

$$= 8.64$$

Result: Hence the Fineness modulus of coarse aggregate is calculated as 8.64

4.3.5 Aggregate Elongation Index Value

Aim: For determination of elongation index of coarse aggregate, where the sizes of the coarse aggregate are larger than 6.3 mm..

Apparatus

Length gauge, Sieves (50mm,40mm,25mm,20mm,16mm,12.5mm,10mm)

Balance (0-10kg), Oven (300^0c)

Figure 17: Length gauge

Procedure:

- The sample is sieved through IS sieve specified in Table shown below.
- A minimum of 200 pieces of each fraction is taken and weighed.
- In order to separate elongated materials, each fraction is then gauged individually for length in the length gauge.
- The pieces of aggregate from each fraction tested which could not pass through the specified gauge length with its long sides elongated are collected separately to find the total weight of aggregate retained on the length gauge from each fraction.
- The total amount of elongated material retained by the length gauge is weighed to an accuracy of 0.1% of the weight of sample.

Total weight taken W = 2420gm

Table 6: Observations for elongation index value

Is sieve (mm)	Weight Retained (gm)	On length gauge	
		Weight retained (gm)	**Weight passing (gm)**
50	-	-	-
40	-	92	1058
25	1150	125.8	1144.2
20	1270	-	-
16	-	-	-
12.5	-	-	-
10	-	-	-

Calculation:

In order to calculate the elongation index of the entire sample of aggregates, first the weight of each fraction of aggregate passing and retained

on the specified set of sieves is noted (Y1, Y2, Y3, Y4…..etc). Each piece of these are tried to be passed through specified length of the gauge length with its longest side and those elongated pieces which do not pass the gauge are separated and weighed (W1, W2, W3, W4…etc). Then the elongated index is the total weight of the material retained on the various length gauges, expressed as a percentage of the total weight of the sample gauged.

$$\text{Elongation index} = \frac{(Y1+Y2+Y3+\cdots)}{(W1+W2+W3+\cdots)} \times 100$$

$$= \frac{92+125.8}{2420} \times 100$$

$$= 9\%$$

Result: The elongation index of given sample of aggregate is = 9%

4.3.6 Aggregate flakiness index

Aim: For determination of flakiness index of coarse aggregate, where the sizes of the coarse aggregate are larger than 6.3mm.

Apparatus: Thickness gauge, Sieves [63, 50, 40, 31.5, 25, 20, 16, 12.5, 10& 6.3mm], Balance [0-10 kg]

Procedure:

The sample is sieved through IS sieve specified in Table shown below. A minimum of 200 pieces of each fraction is taken and weighed. In order to separate flaky materials, each fraction is then gauged individually for thickness on a thickness gauge. The total amount of flaky material retained by the thickness gauge is weighed to an accuracy of 0.1% of the weight of sample.

Table 7: Observations for flakiness index value

Is sieve (mm)	Weight Retained (gm)	On length gauge	
		Weight retained (gm)	Weight passing (gm)
63	-	-	-
54	-	-	-
40	-	-	-
31.5	-	1055.6	94.4
25	1150	1195	75
20.0	1270	-	-
16	-	-	-
12.5	-	-	-
10	-	-	-

Calculation:

In order to calculate the flakiness index of the entire sample of aggregates, first the weight of each fraction of aggregate passing and retained on the specified set of sieves is noted (Y1, Y2, Y3, Y4…..etc). Each piece of these are tried to be passed through the slot of the specified thickness of the thickness gauge are found and weighed (W1, W2, W3, W4…etc). Then the flakiness index is the total weight of the material retained on the various thickness gauges, expressed as a percentage of the total weight of the sample gauged.

$$\text{Flakiness index} = \frac{(Y1+Y2+Y3+\cdots)}{(W1+W2+W3+\cdots)} \times 100$$

$$= \frac{94.4+75}{2420} \times 100$$

$$= 7\%$$

Result: The Flakiness index of given sample is = 7

4.4 TESTS ON CRAMIC WASTE:

Specific Gravity:

Weight of empty pycnometer(W_1)= 500gm

Weight of pycnometer and broken ceramic waste (W_2)= 838gm

Weight of pycnometer, broken ceramic waste and water (W_3)= 1656gm

Weight of pycnometer and water (W_4)= 1520gm

$$\text{Specific gravity} = \frac{\text{sum of cumulative \% of weight retained}}{100}$$

$$\frac{W2-W1}{((W2-W1)-(W3-W4))}$$

RESULT : Specific gravity = 1.67

Figure 18: Specific gravity of ceramic waste

CHAPTER 5
RESULT

5.1 WORKABILTY TEST:

The ideal concrete is the one which is workable in all conditions i.e., can prepared easily placed, compacted and molded. In this project ceramic waste and steel fiber is added in concrete mix and workability is tested by doing slump cone and compaction factor test. From the results obtained, the addition of ceramic waste and steel fiber does not affect the workability of concrete.

5.1.1 Slump cone test:

The test was conducted for fresh concrete prepared before the molding process. Workability Results obtained from slump cone test for M25 grade of concrete for replacement of coarse aggregate with various proportions of ceramic waste and addition of 2% of steel fiber are listed below.

Table 8: Observations for slump cone test

S. NO.	Specimen Designation	Slump Value In mm	Type Of Slump
1	CS_0	55	True
2	CS_5	58	True
3	CS_{10}	63	True
4	CS_{15}	69	True

5.1.2 Compaction factor test:

The compaction factor test for replacement of coarse aggregate with various proportions of ceramic waste and addition of steel fiber are listed below

.Table 9: Observation for compaction factor test

Sl. No.	Specimen Designation	Compaction factor
1	CS_0	0.91
2	CS_5	0.86
3	CS_{10}	0.89
4	CS_{15}	0.84

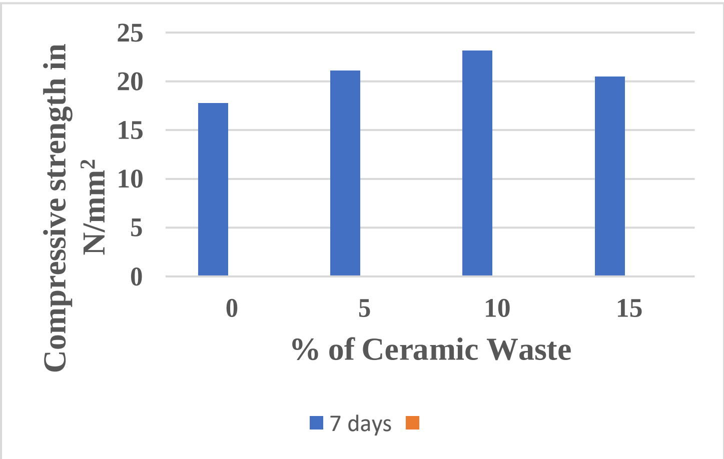
5.2 MECHANICAL PROPERTY TEST

5.2.1 Compression Strength

Size 150 x 150 x 150mm were casted and tested for 7 days and 28 days testing of the specimens for each percentage after conducting the workability tests. The results are tabulated below:

Table 10: Compressive strength on cubes for 7 days

Sl.No	Specimen Designation	Compressive Strength in N/mm^2
1	CS_0	17.78
2	CS_5	21.09
3	CS_{10}	23.04
4	CS_{15}	20.50



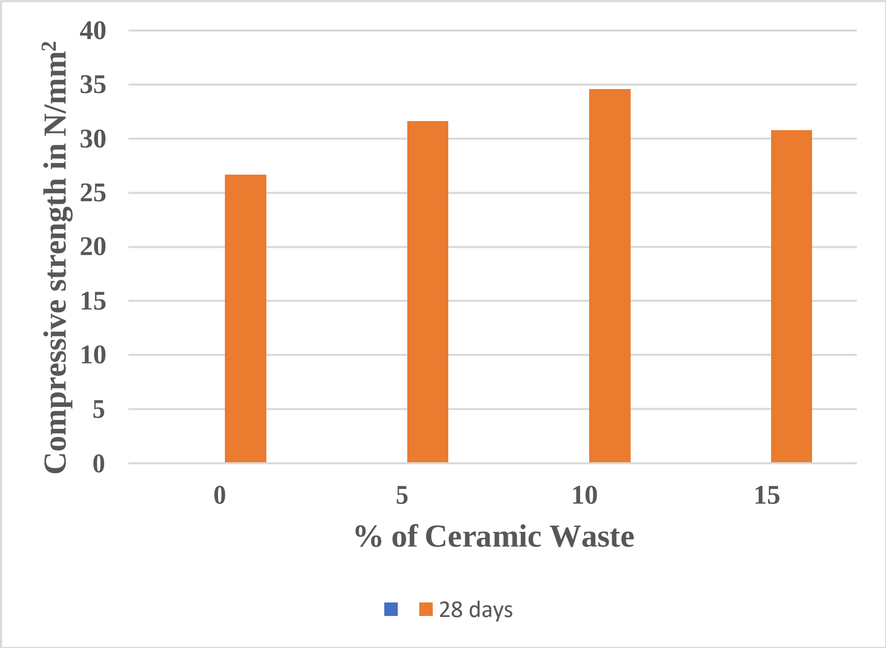
Graph 1: Compressive strength for 7 days

Discussion

The Compressive strength of concrete varies as 27.45%, 37.60% and 31.48% for CS5, CS10 and CS15 compared with the conventional concrete after 7days of curing.

Table 11: Compressive strength on cubes for 28 days

Sl.No	Specimen Designation	Compressive Strength in N/mm^2
1	CS_0	26.67
2	CS_5	31.635
3	CS_{10}	34.56
4	CS_{15}	30.75



Graph 2: Compressive strength for 28 days

Discussion:

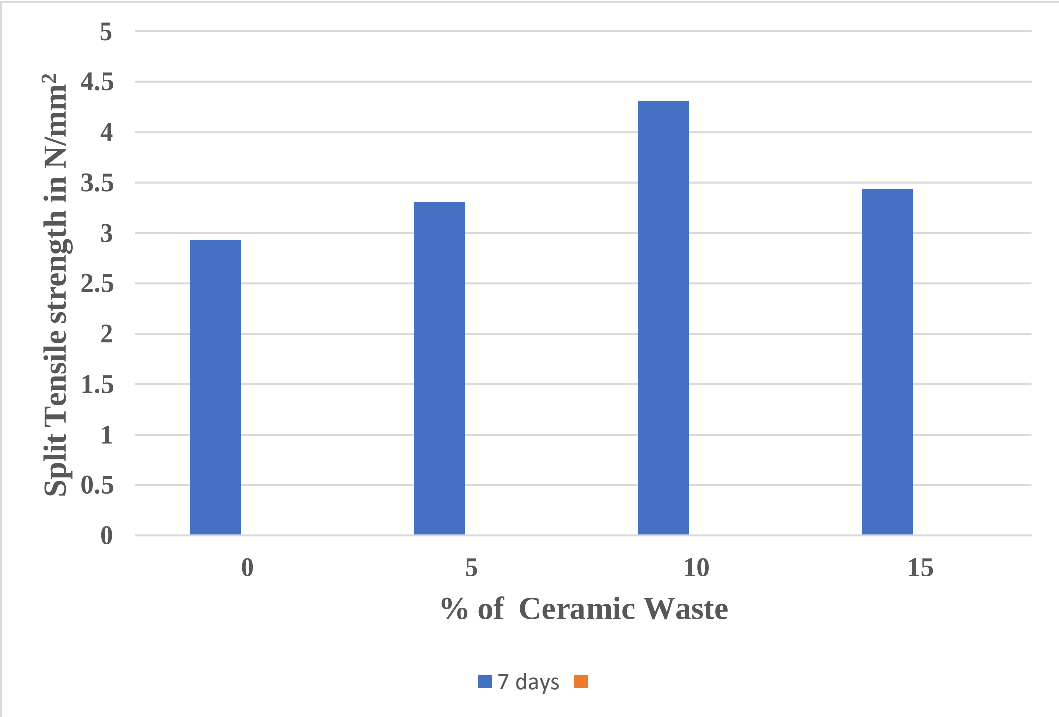
The Compressive strength of concrete varies as 31.56%, 41.23% and 38.42% for CS5, CS10 and CS15 compared with the conventional concrete after 28days of curing.

On comparing the strengths of all mixes, CS10 has the highest i.e., 10% replacement of coarse aggregate with ceramic waste. The addition of steel fibre has positive effect on strength.

5.2.2 Split Tensile Test:

Tables 12: Split tensile strength for 7 days

Sl.No	Specimen Designation	Split Tensile Strength in N/mm^2
1	CS_0	2.93
2	CS_5	3.31
3	CS_{10}	4.31
4	CS_{15}	3.44

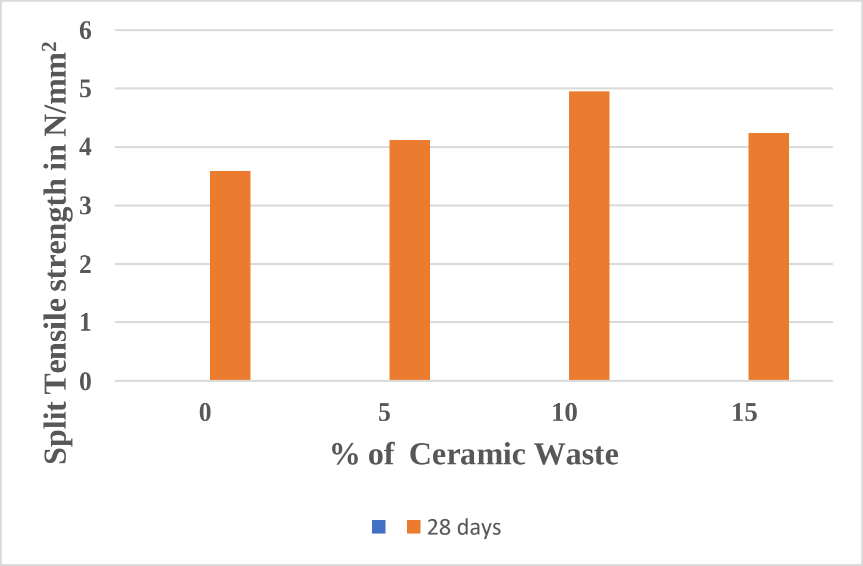


Graph 3: Split tensile strength for 7 days

The split tensile strength of concrete varies as 12.96%, 17.40 and 15.01% for CS_5, CS_{10} and CS_{15} compared with the conventional concrete after 7days of curing.

Table 13: Split Tensile strength for 28 days

Sl.No	Specimen Designation	Split Tensile Strength in N/mm^2
1	CS_0	3.59
2	CS_5	4.12
3	CS_{10}	4.95
4	CS_{15}	4.24



Graph 4: Split tensile strength for 28 days

Discussion

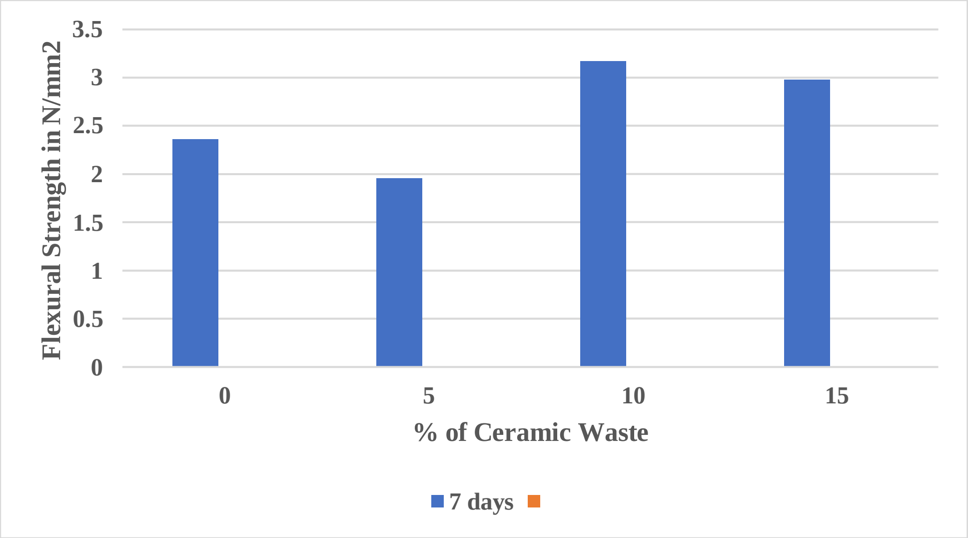
The split tensile strength of concrete varies as 14.76%, 18.94% and 17.56% for CS5, CS10 and CS15 compared with the conventional concrete after 28days of curing.

On comparing the strengths of all mixes, CS10 has the highest i.e., 10% replacement of coarse aggregate with ceramic waste. The addition of steel fibre has positive effect on strength.

5.2.3 Flexural Strength Test:

Table 14: Flexural strength for 7 days

Sl.No	Specimen Designation	Flexureal Strength in N/mm^2
1	CS_0	2.36
2	CS_5	1.96
3	CS_{10}	3.17
4	CS_{15}	2.98

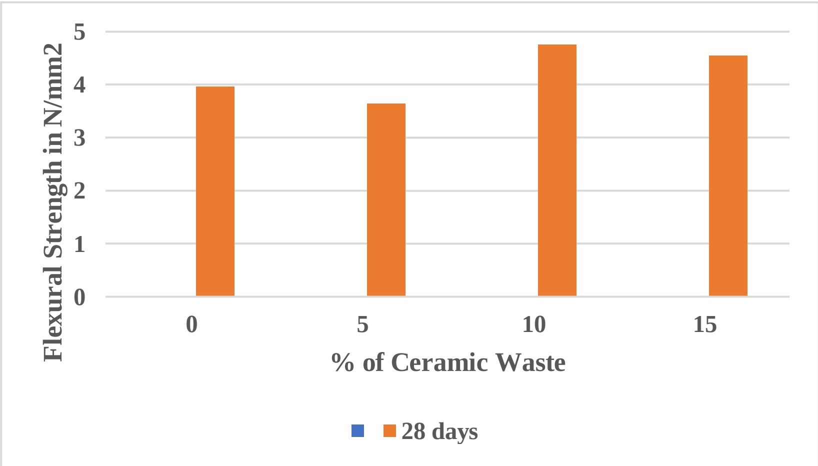


Graph 5: Flexural strength for 7 days

The flexural strength of concrete varies as 65.5%, 74.08% and 72.31% for CS_5, CS_{10} and CS_{15} compared with the conventional concrete after 7 days of curing.

Table 15: Flexural strength for 28 days

Sl.No	Specimen Designation	Flexural Strength in N/mm^2
1	CS_0	3.96
2	CS_5	3.64
3	CS_{10}	4.75
4	CS_{15}	4.55



Graph 6: Flexural strength for 28 days

Discussion:

The flexural strength of concrete varies as 47.35%, 62.25% and 57.73% for CS5, CS10 and CS15 compared with the conventional concrete after 28days of curing.

On comparing the strengths of all mixes, CS10 has the highest i.e., 10% replacement of coarse aggregate with ceramic waste. The addition of steel fiber has positive effect on strength.

6.CONCLUSION AND FUTURE ENHANCEMENT

6.1 CONCLUSION

The following conclusions are made based on the experimental investigations on compressive strength, split tensile strength and flexural strength considering the environmental aspects also:

- The workability of concrete increases with the increase in tile aggregate replacement.
- The properties of concrete increased linearly with the increase in ceramic aggregate up to 10% replacement later it is decreased linearly.
- CS10 mix of concrete produced a better concrete in terms of compressive strength, split tensile strength and flexural strength than the other mixes.
- The addition of steel fiber along with the ceramic coarse aggregate improves the mechanical properties of concrete since the steel fiber improves the tensile strength of concrete.
- Use of ceramic waste has no negative effect on the properties of concrete.
- The use of ceramic waste and steel fiber in concrete is an effective measure in reducing the cost of concrete, increasing its strength and keeping the environment clean by maintaining waste management and reducing the use of raw materials.

6.2 FUTURE ENHANCEMENT

1) Experiment can be done by different compositions and materials to get better workability.
2) More investigations and research can be done on the strength characteristics of ceramic waste.
3) Use of waste can sustain environment and eco-system the whole, therefore there is an active research on ceramic waste.

6.3 PUBLICAIONS

- A.Sravani, B.Kalpana, U.Vamshi Krishna, V. Rajeswari, M.Susheelkumar.,(2021**).** **"**Experimental Investigation On Partial Replacement Of Coarse Aggregate With Ceramic Waste And Steel Fiber As Reinforcing Agent In Concrete: An Concrete Technology Project", International Conference on Computing for Sustainable Development in Civil Engineering (ICCSDC 2021), St.Martin's Engineering College, Secunderabad, 24 & 25th June, 2021

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15. P.Rajalakshmi, Dr.D.Suji, M. Perarasan, E.Niranjani International Journal of Civil and Structural Engineering Research ISSN 2348-7607 (Online) Vol. 4, Issue 1, pp: (114-125), Month: April 2016 - September 2016. (Study of partial replacement of coarse aggregate by Mosaic tile chips)
16. Paul O. Awoyera , Julius M. Ndambuki , Joseph O. Akinmusuru , David O. Omole-4048 2016 Housing and Building National Research Center. Production and hosting by Elsevier B.V. 15 November 2016) (Characterization of ceramic waste aggregate concrete)
17. N.Naveen Prasad, P.Hanitha, N.C.Anil IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 13, Issue 6 Ver. V (Nov.Dec. 2016), PP 168-176.
18. Batriti Monhun R. Marwein, M. Sneha, I. *Bharathidasan International Journal of Scientific & Engineering Research, Volume 7, Issue 4, April-2016 ISSN 2229-5518. (A Review Paper On Utilisation Of Ceramic Waste In Concrete)

A project

On

EXPERIMENTAL ANALYSIS ON SELF COMPACTING CONCRETE USING NANO SILICA MATERIAL

Submitted by

Ms.Chellem Kavya	**(18K85A0123)**
Mr.Akhilesh pawar	**(17K81A0162)**
Mr.Rathod Rajkumar	**(18K85A0118)**
Mr.Balolu Laxman	**(17K81A0168)**

in partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under The Guidance of

Mr.V.RAJESH

ASSISTANT PROFESSOR

DEPARTMENT OF CIVIL ENGINEERING

ST.MARTIN'S ENGINEERING COLLEGE

(An Autonomous Institute)

Dhulapally, Secunderabad – 500 100

JUNE 2021

BONAFIDE CERTIFICATE

This is to certify that the project entitled **EXPERIMENTAL ANALYSIS ON SELF COMPACTING CONCRETE USING NANO SILICA MATERIAL**, is being submitted by **1) Ms.Chellem Kavya (18K85A0123) 2) Mr.Akhilesh pawar (17K81A0162) 3) Mr.Rathod Rajkumar (18K85A0118) 4) Mr.Balolu Laxman (17K81A0168)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN** civil engineering is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

Guided By	Head of the Department
Mr.V.RAJESH	Ms. SANDHYA KIRAN.J.K.
Department of civil engineering	Department of civil engineering

Internal Examiner External Examiner

Place:

Date :

DECLARATION

We, the student of Bachelor of Technology in Department of civil engneeringt, session: 2017 – 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled **EXPERIMENTAL ANALYSIS ON SELF COMPACTING CONCRETE USING NANO SILICA MATERIAL**, is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

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ABSTRACT

In this study, the mechanical properties of concrete composites containing Nano silica were investigated to produce more flexible and high strength concrete. For this purpose, the different content of Nano-silica powder was added to concrete. The mechanical properties and the morphology of the sample were investigated.

The mechanical properties such as flexural, tensile and compressive strength were significantly improved by incorporating the Nano-silica.Optimum composition containing 2.5 wt. % to 3.5 wt. % of nano silica was obtained, in which the tensile strength, compressive strength and flexural strength were expected increase for 0.25% to 1.28% respectively compared to the next concrete.

Scanning Electron Microscope images showed that introducing the nano-silica into concrete improved the interfacial transition zone in between the cement particles.When SCC compared with Nominal Concrete, there is significant increase in workability and compressive strength. And also Normal SCC (without NS) is compared with Different small dosages of SCC with NS powder, there will be a significant increase in strength.

INDEX TERMS – self compacting concerete, filling ability,passing abilty.

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Chapter - 1

Introduction

1.1 General

Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete.

The elimination of vibrating equipment improves the environment on and near construction and precast sites where concrete is being placed, reducing the exposure of workers to noise and vibration.

SCC is still not widely used in India in spite of its many advantages including reduction in labour and fast track construction etc. This is because of lack of sufficient data and information on SCC made of materials available in the different parts of the country and hence insufficient confidence of engineers in producing this material. India has abundant supply of fly ash, with its sources well distributed across the country. SCC generally possesses a high powder content which keeps the concrete cohesive with high flow ability. This high powder content is required to maintain a sufficient yield value of the fresh mix and cement cannot be the only powder material in SCC. For achieving economy, a substantial part of this powder could also contain fly ash. SCC can accommodate more than 200 kg/m3 of fly ash which is regarded as a high-volume addition. Hence it is considered worthwhile to investigate the influence of fly ash in SCC.

In 2002 EFNARC published their “Specification & Guidelines for Self-Compacting concrete” which, at that time, provided state of the art information for producers and users. Since then, much additional technical information on SCC has been published but European design, product and construction standards do not yet specifically refer to SCC and for site applications this has limited its wider acceptance, especially by specifiers and purchasers. In 1994 five European organisations BIBM, CEMBUREAU, ERMCO, EFCA and EFNARC, all dedicated to the promotion of advanced materials and systems for the supply and use of concrete, created a "European Project Group" to review current best practice and produce a new document covering all aspects of SCC.

1.2 Concrete and Sustainability

Concrete is probably unique in construction, it is the only material exclusive to the business and therefore is the beneficiary of a fair proportion of the research and development money from industry. Concrete is a composite construction material composed primarily of aggregate, cement and water, which is a nanostructured, complex, multi-phase material that ages overtime. It is basically an idea for concern for the wellbeing of planet Earth with continued growth and human development. The current construction practices are based on the consumption of enormous quantities of building materials and water, resulting in the scarcity of these resources after a long term.

The sustainable development of the cement concrete would save not only the natural resources and energy but also protect the environment with the reduction of waste material. The mortar properties in fresh state such as workability are governed by the particle size distribution and the properties in hardened state, such as strength and durability, are affected by the mix grading. Rheological properties of a fresh cement paste play an important role in determining the workability of concrete.

The water requirement for flow, hydration behavior and properties of the hardened state largely depends upon the degree of dispersion of cement in water. Factors such as water content, early hydration, water reducing admixtures and mineral admixtures like Nano-silica determine the degree of flocculation in a cement paste.

The development of Self Compacting Concrete is based on the following well known relationships of concrete technology. For high strength, water cement ratio should be low. The strength w/c ratio rule holds good for concrete strength. Low water cement ratio is also required for low permeability of concrete, which is vital for high durability. Impermeability is also aided by pore filling effects of fine pozzolanic additions.

The relationship between coefficient of permeability of cement paste and water cement ratio is such that the permeability increases asymptotically for water cement ratio above 0.45 or according to the mix design.

Thus, low water cement ratio ensures high strength and low permeability, or high durability. Low water cement ratio will require high cement content to ensure the amount of water and cement paste are adequate for the workability of concrete. However, too high a cement content will cause high heat of hydration and increase cracking tendency. The use of Ns when added in different percentages will give the difference between the compressive strength of the concretes.

1.3 Self-constricting concrete definition

The British Standard describes "SCC is the concrete that is capable to flow and compact under its own weight, fill the formwork with its reinforcement, ducts, box outs etc., whilst managing homogeneity".

1.4 Requirements for SCC

SCC exhibits following properties in its plastic state.

Filling Ability: It is the ability of SCC to flow into and fill completely all spaces in the formwork and encapsulate reinforcement while maintaining homogeneity.

Passing Ability: It is the ability of concrete mix to pass through obstacles like narrow sections in form work, closely spaced reinforcement bars without getting blocked by interlocking of aggregate particles.

Resistance to segregation: Segregation resistance of self-compacting concrete is its capability to retain homogeneity in the distribution of ingredient in fresh state during both static and moving condition i.e., during mixing, transportation and placing. It is dependent on viscosity of mix in fresh state

1.5 History and development of SCC

In the mid-1980s, exploration begun into underwater induction technology within the UK, North America and Japan led to the improvement of concrete mixes with a high degree of washout resistance. However, the creation of durable structures from such mixes enforced adequate compaction by skilled workers. At the same time in Japan, a gradual reduction in the number of skilled workers in the construction industry was leading to a reduction in the quality of construction work, with subsequent knock-on effects on concrete durability (Okamura et al., 1998). One quick fix to overcome the durability issues in concrete structures independently of the quality of construction work was to use self-compacting concrete (SCC) (Okamura and Ouchi, 2003).

Its use was early proposed by Okamura (1986) who also conducted a fundamental study on the workability of SCC. The first prototype SCC was concluded in 1988 at Tokyo University, adopting constituent materials promptly used in conventional vibrated concrete (Ozawa et al., 1989). The main reasons for the employment of SCC were to shorten the construction time, to avoid vibrating the confined zones which are a bit crucial to reach and to erase noise caused by vibration (Okamura and Ouchi, 2003).

In the far two decades, self-consolidating concrete has been advanced further, applying different materials such as pulverized-fuel ash (PFA), ground granulated blast furnace slag (GGBS) and condensed silica fume (CSF). SCC has achieved wide interest especially for structures with very complicated shapes, crucial casting process and congested reinforcement. In spite of this, the overall production is still almost small compared to conventional concrete, the global gap that has been ever present in the market for such a concrete argue that in the future there is possible to be an even greater demand for all samples of SCC.

1.6 Nano Technology in Concrete

Nanotechnology is rapidly becoming the Industrial Revolution of 21st century. It will affect almost every aspect of life. In comparison to other technologies, nanotechnology is much less well defined and well-structured. It is known that 'Nano' is a Greek word and means 'dwarf'. It is a common word for everything which is smaller than 1Micron or 1 Million of a millimeter (10^{-9}) 1 Micron is 1000 Nanometer. Nano Silica is mainly added to provide strength to the concrete. Until today, concrete has primarily been seen as a structural material. Nano technology is helping to make it smart functional material.

Nano Silica has been added in order to increase the strength, low permeability and reduces shrinkage. Nano-concrete is defined as a concrete made with Portland cement particles that are less than five hundred Nano-meters as the cementing agent. Currently cement particle sizes range from a few Nano-meters to a maximum of about one hundred micro meters. In the case of micro- cement the average particle size is reduced to 5 micro meters. An order of magnitude reduction is needed to produce Nano-cement. Certain unique properties of Portland cement such as: room temperature processing, low shrinkage, temperature resistance up to 600°C, compatibility with a number of fiber types including carbon fibers, reaction capability with currently available Nano-materials such as Nano-silica and nontoxic characteristics can be effectively used to create unique products. It can also be molded to complex shapes; heat cured and coated with other Nano-materials. Conventional analytical methods are unable to provide an accurate model for the rate of cement's reaction with water as a function of temperature, water/cement ratio, and grain size because the reactions occur in the Nano-scale pores of the cement.

1.7 Problem Statement

The majority of concrete cast required compaction to ensure that the development of adequate strength and durability. Generally, the purpose of compaction of concrete is to achieve the highest possible density of the concrete. Dense microstructure of concrete will results in low permeability, high strength, high resistance to chloride and sulfate attacks, low carbonation, and improved durability. Inclusion of voids will also influence the protection of the embedded steel reinforcement. Compaction of concrete is done manually by using vibrators in construction site. However, compaction will be difficult to be carried out at conditions as follows:

1.7.1 Large concrete casting areas.

1.7.2 Presence of congested reinforcement

1.7.3 Inaccessible areas and spaces, etc.

The concrete floor slabs in factories and commercial buildings are of large areas and often subjected to continuous static and dynamic loadings. Self-weight is considered as static loading, while vibrations and impact loadings can be categorized as dynamic loadings. The loadings are usually induced by storages, containers, machineries, and heavy vehicles that present in the factories and commercial buildings. Hence, the concrete slabs have to exhibit good fatigue and impact strength to prevent failure in fatigue.

SCC will be suitable in the construction of industrial concrete floor slabs due to its Advanced features. The elimination of compaction enables the casting of large area of concrete slab to be completed in shorter time with reduced cost and manpower required. Besides, when fibers reinforced with SCC will improve the tensile properties, flexural strength, impact strength, toughness, and post- cracking behaviour of concrete. Therefore, SCC is an ideal solution for the construction of concrete slabs to maintain the serviceability of slab throughout their service lifespan. Figure show the casting of a large area of concrete slab with congested reinforcement in commercial centre in Italy.

1.8 Objective

The objective of the present work is to find the influence of the application of Nano silica partially replacing cement. Nano silica is added in different dosages to study the variation in the compressive strength of the concrete. 2%, 2.5%, 3% of Nano silica are adopted as replacement by weight according to the mix design of M20 grade. Cube and cylinder moulds are casted for the purpose of testing. Specific objectives are:

- To find the workability aspects of M20 grade concrete using Nano silica.
- To know the influence of Nano silica on the strength characters of self-compacting concrete.
- To decrease the permeability and to reduce the shrinkage in self compacting concrete.

1.9 Scope

The scope of present work is to decrease the permeability, increase the density as well as increase the compressive strength of the self- compacting concrete by adding Nano silica. Alterations can be done to achieve more strength and durability. Effect of Nano silica on the compressive strength of the self-compacting concrete are studied and further modifications can be done. Mix design of M20 grade is chosen to increase its strength and reduce shrinkage. Compressive strength of ordinary self compacting concrete is compared with SCC of Nano silica and conclusions are made.

Chapter - 2

Literature Review

2.1 Self-Compacting Concrete

M.C. Nataraja, Anvit Gadkar and Giridhar Jogin (2018) Developed a simple procedure to produce self-compacting concrete based on the requirement of strength by slight modification to IS 10262:2009. Considered the limits prescribed by EFNARC and investigated on 25 mix proportions to obtain the relationship between compressive strength and water cementitious ratio of SCC. For this method, compressive strength ranges from 20MPa to 60MPa were considered by using poly corboxilic ether based high water reducing agent. It was observed that w/c from 0.47 to 0.37 was sufficient to obtain the strength values between 25 to 60MPa. Fresh properties and strength results occurred by this procedure were in good agreement.

Athiyamaan. V & G. Mohan Ganesh (2018) Studied about SCC mix design using nan-su method and trail mixes were carried out by using Design of Experiments method (DOE). In trail mixes central composite design was farmed with variables; cement, superplasticizer, w/c, Fine aggregate and coarse aggregate. 33 trail runs were investigated and M16 numbered mix gave optimum results. And also noted that by decreasing coarse aggregate from 750Kg/m3 to 710 kg/m3 increase the rheological properties but signs against the strength, increasing of fine aggregate will results of maximum packing factor.

M. Sri Rama Chand, P. Rathish Kumar, P.S.N.R. Giri, G. Rajesh Kumar (2018) investigated the durability, strength and microstructures of SCC by addition of self-curing chemicals. Self-curing compounds are used to overcome the improper curing and compacting issues. Hydrophilic, Super absorbent polymers and Hydrophobic chemicals can use as self-curing compounds. Hydrophilic and Hydrophobic efficiencies were tested on M70 and M50 grade concretes. Polyethylene Glycol 4000, Liquid paraffin wax (LPW) with 0%, 0.1%, 0.5% and 1.0% was used in this study, which includes water retention capacity, compressive strength, RCPT, SEM, XRD, Sorptivity and Porosity tests. Results shows that LPW at 1% doesn’t influence the strength of concrete and by using self-curing compounds the strength obtained is 90% of the water curing specimen. XRD shows they will not increase the effect of freeze thaw effect and SEM confirmed that microstructure is dense in self-curing self-compacting concrete.

M. Sri Rama Chand, P. Swamy Naga Ratna, K. L. Radhika, P. Rathish Kumar and C. Yedukondalu (2017) Investigated to optimize the proportions on particle packing model to obtain the requirements of self-compacting concrete. Three models firstly Modified Toufar method, secondly J.D. Dewar method and last one Compressible Packing Method (CPM) were studied on M20, M40 and M60 grade concretes. It was discovered that particle packing methods MTM, JDDM and CPM with IS 383 grading shows that the percentage passing value of CPM coincides with upper limits of IS grading. MTM and JDDM are coarser content and not suitable for SCC, whereas CPM based optimization is suitable for designing SCC mixes.

Shaik Khaja Sameer, B. Jagadish Chakravarti and V. Ramesh (2017) Designed mix proportion using compressible packing model for M20, M40 and M60 self-compacting concrete grades and suggested a modification zone gradations similar to IS 383 for SCC to achieve optimum mix. Sample mix design was presented to get an idea about the mix calculations for SCC. It was observed that compressive strength increases from 7 days to 28 days at a ratio of 0.71, 0.7 and 0.68 for M20, M40 and M60 grade concretes respectively. The relation between compressive strength and flexural strength, split tensile strength were developed.

B. Nagendra Kumar (2017) High strength self-compacting concrete was developed by replacing natural river sand with quartz sand at a range of 20%, 40%, 60%, 80% and 100%. Specimens were casted in standard sizes and tested at periods of 7 days, 28 days, 90 days and 180 days. For every percentage of replacement, mix satisfies the fresh properties but at 100% replacement mix attains compressive strength of 100MPa for 28 days. Result shows that not only compressive strength but also split tensile and flexural strength increased with increase of quartz sand percentage.

S. Girish (2017) Studied about the importance of volume of paste and powder on hardened properties and of self-compacting concrete(SCC) with perpetual water content, ranging from 175 lit/m3 to 210 lit/m3. Paste contents (0.38, 0.41 and 0.43) chosen to test with cement from 300 kg/m3 to 450 kg/m3. Results show that compressive strength of SCC increase with increase of volume paste for same water cement ratio and water content. 30% increase was observed at 190 lit/m3 and 35% at 175 lit/m3 and maximum compressive strength is noted at volume paste 0.14. By this, increase in strength as the paste is increased but beyond the particular amount strength values decreases due to decrease of coarse aggregate, load transfer within the body gets affected and strength may reduce.

T. H. Patel, J. M. Srihaila, Prahalada. V (2016) explored the durability properties of High Performance Self-Compacting Concrete by using sodium chloride (NaCl), Magnesium Sulphate ($MgSO_4$). Cement was substituted with Fly ash at 10%, 20%, 30% 40%, 50% and GGBS at 10%, 20%, 30%, 40%, 50% separately and experiments conducted and results were compared. Cubes casted at standard size and cured in water for 28 & 56 days but for durability study after 28 days water curing, cubes were cured in 10% concentration of NaCl & $MgSO_4$ solution for 28 and 56 days. Cement with 10% fly ash and cement with 20% GGBS gave maximum compressive strengths. It was observed that NaCl effects more on self-compacting concrete(SCC) without fly ash and also without GGBS, by adding fly ash or GGBS acid resistance could be increased but, sulphate resistance is higher than chloride resistance.

R. Vasusmitha and Dr. P. Srinivasa Rao (2013) developed M80 grade concrete by using micro silica, quartz powder in addition to the cement, chemical admixtures are used. Water cement ratio maintained at 0.215 and as part of hardened properties; split tensile strength, compressive strength, flexural strengths were calculated. For durability characteristics tests like rapid chloride penetration test (RCPT), acid resistance by using HCl, H_2SO_4, Na_2SO_4 were conducted on designed grade of concrete. Acid attack tests are carried out based on weight loss technique, from the results it was perceived that the specimens are more resistant to 5% Na_2SO_4 than 5% H_2SO_4 and 5% HCl. Chloride ion penetrability getting decreased by the increasing of age and obtained values are at a range of very low.

N. Venkat Rao, M. Rajasekhar, Mohd Mujeeuddiahmed (2013) studied about durability properties of high strength self-compacting concrete by maintaining water cement ratio at 0.24 and all fresh properties of SCC was examined as per the guidelines given by EFNARC. To study durability properties, acid attack and sulphate attack was considered, for this study 8% HCl, 8% H_2SO_4, 8% Na_2SO_4 were used and weight loss technique was used to determine the durability properties. It showed that the designed grade was more resistant against the sodium sulphate than hydrochloric acid and sulphuric acid. Acid attack resistance also determined by conducting compressive strength test after immersing specimens in 5% HCl, 5% H2SO4, 5% Na2SO4 in alternative days and it was observed that compressive strength decreased at 16.31%, 47.07% and 19.8% while using HCl, H2SO4 and Na2SO4 respectively

2.2 Workability test on SCC

Daniel C, Joel Shelton J, Vincent Sam Jebadurai S, Arun Raj E (2016) Studied on high strength self-compacting concrete by using copper slag in place of river sand at an interval of 10% from 0% to 100% with water cement ratio at 0.4 and super plasticizer was maintained at 0.6%. Wet concrete properties like passing ability, flow ability and filling ability was tested by using L-box, U-box, V-funnel, slump flow test. Mechanical properties like flexural strength, split tensile strength, compressive strength were also known at 7 days and 28 days. By the increase of copper slag, workability improves and at 40% replacement shows the optimum values in both fresh and hardened properties.

M. Fadee, R. Mirhosseini, R. Tabatabaei & M.J. Fadaee (2015) Investigated about usage of copper slag as cementitious material in self-compacting concrete(SCC); physical and chemical analyses were performed. Cement was replaced with copper slag at 20%, 25%, 30%, 35% and 40%, and tests were conducted to know the variation of fresh and mechanical properties with and without copper slag. V-funnel and J-Ring tests on wet concrete, compressive strength at 7, 14, 28 and 42 days age on hardened concrete were conducted. In the results, it shows that copper with 40% gives better passing ability and filling ability than without copper slag. Copper slag with 20% gives 85 percentage of compressive strength without slag, by this it was recommended to use at 20%.

Karthik, Dr. G. Baskar (2015) Mainly studied about durability of self-compaction concrete with copper slag used as fine aggregate at levels of 20%, 40%, 60% and 80%. By conducting fresh concrete tests like T50, V-funnel, slump flow, L-box, J-ring to examined the fresh properties. Durability properties were studied by using weight loss technique. To conduct durability tests like acid resistance, sulphate resistance and corrosion tests, various chemicals like sulphuric acid, ferrous sulphate and sodium chloride solutions were used. From the results it was concluded that at 60% copper slag in concrete as fine aggregate gave the more durable concrete

Iman Afshoon and Yasser Sharifi (2014) Investigated about influence of Ground Copper Slag as a binding material on the fresh properties of self-compacting concrete(SCC). In this investigation water – powder ratio was maintained at 0.51 and cement replaced at a levels of 0%, 5%, 10%, 15%, 20%, 25% and 30% with ground copper slag. Tests on wet concrete like slump flow, viscosity index, J – ring, V-funnel, L-box, air content and setting times were conducted. Due to usage of ground copper slag as cementing material slump flow increases, viscosity decreases, passing ability decreases, air content also decreased but setting increased.

2.3 Admixtures in SCC

C. Sashidhar, B. Radhamma, J. Gurujawahar, C. Yedukondalu (2018) Studied about self-compacting geopolymer concrete with 50:50 proportions using class F fly ash and GGBS with artificial sand as fine aggregate. EFNARC guidelines are considered for trail mixes to get optimum proportions and 8M, 10M, 12M NaoH issued in the experiment. Various fresh properties like segregation resistance, passing ability and filling ability were examined by using test methods; L-box, T500 slump flow, v-funnel and slump flow. It was observed that by increasing the NaOH morality the fresh properties are decreased and no adverse effect has been marked when self-compacting geopolymer concrete mixes prepared with artificial sand.

K Ganesh Babu and B Chandrasekhar (2018) worked on high performance self-compacting concrete with fly ash of 25%, 35%, 50% and 70% as a cementitious content. Various water powder ratios were used ranging from 0.25-0.72. It was observed that fly ash based SCC ranging from 25-110 Mpa could be produced by replacing 70-25% of cement, charge passing through the specimen is also decreased by increasing the fly ash content. Durability tests like acid attack, corrosion tests shows better results by increasing fly ash percentage.

H. Y. Leung, J. Kim, A. Nadeem, Jayaprakash J and M. P. Anwar (2016) Studied about water absorption of self-compacting concrete with silica fume and fly ash by conducting sorptivity test. For this test two separate mix series were casted namely F-series and FS-series. In F-series ordinary Portland cement was replaced with 0%, 12.9%, 20%, 30%, 40% and 50% but in FS-series Fly ash fixed at 25% and cement replaced at 0%, 5%, 10% and 15% with silica fume. Water to powder ratio maintained at 0.38 and water content at 235.6kg/m3. From the results it can conclude that OPC with silica fume and fly ash reduces sorptivity. Combination of flyash and silica fume decreases sorptivity than only using fly ash and also witnessed that there is no relation between strength and sorptivity. Behaviour of compressive strength and surface absorption depends on proportion of mineral admixture and other environmental factors.

Gritsada Suaiam, Natt Mukal (2015) Studied about self-consolidating concrete which prepared with recycled alumina and fly ash waste as mineral admixtures. Fly ash replaced at fixed 20% and recycled alumina waste replaced at 0%, 25%, 50%, 75% and 100%. Fresh and mechanical properties were examined by using, J-ring, V-funnel, slump flow, compression strength; quality of concrete by using ultra pulse velocity test. In the results it was observed that alumina waste up to 75% as optimum and satisfied all the conditions given by the EFNARC and best results shown than the conventional concrete, achieved compressive strength up to 56MPa at 28 days age.

T. Adhavanathan, V. Vinoth (2015) M30 grade concrete was used to investigate the consumption of copper slag as fine aggregate and cement replaced with fly ash moderately. In this study copper slag used at level of 0%, 10%, 20%, 30% up to 100%. Fresh concrete properties and hardened concrete properties are studied at 7,14,28 days and by results it was concluded that 30% of copper slag obtains the optimum results and concrete replaced by 40% of fly ash increases the compressive strength, the maximum split tensile strength obtained at 40% copper slag and maximum flexural strength at 60% copper slag.

K. S. Jhansirani and A. Jagannathan (2015) Durability was studied on self-compacting concrete by considering acid resistance, sulphate resistance, alkaline, sorptivity, chloride penetration. In this study fly ash and silica fume was used as cementitious material by replacing fly ash at 10%, 20%, 30% and silica fume at 5%, 10%, 15%, and 20%. Not only observed the results by using fly ash and silica fume separately but also by combining them at different levels. From the results it was identified that silica fume shows more resistance against the acid, alkaline, chlorine penetration then the fly ash and also when combine both. It also observed that by increasing of mineral admixtures in self compacting concrete both fresh and durability properties are increased.

2.4 Concrete with Nano-silica

G.Quercia et.al(2013) A new Nano-silica (Ns) can be produced in high quantities and for low prices that allows for a mass application in concrete. It may replace cement in the mix, which is the most costly and environmentally unfriendly component in concrete. The use of Ns makes concrete financially more attractive and reduces the CO2 footprint of the produced concrete products. The nS will also increase the product properties of the concrete: the workability and the properties in hardened state, enabling the development of high performance concretes for extreme constructions. That means that a concrete with better performance, lower costs and an improved ecological footprint can be designed.

Yuvaraj Shanmugasundaram et.al(2012) Nano concrete could control the carbon dioxide emission from the earth which is shown by using fly ash concrete products instead of cement concrete. Thus the Nano particles which is in the form of silica can easily react with cement particles which are normally in Nano scale initiate the CSH reaction and hence its tend to accelerate the compressive strength of concrete. Nano-silica consumes calcium hydroxide crystals, reduces the size of the crystals at the interface zone and transmute the calciumhydroxide feeble crystals to the C-S-H crystals, and improves the interface zone and cement paste structures.

M. Nili et.al(2010) The results show that increasing in Nano silica content 1.5% to 4.5% by weight, leads to an increase of compressive strength at all stages. The results also indicate thatthe specimens which contain both nano and micro silica, due to the high pozzolanic activity, have higher compressive strength than reference ones. However, large quantities of nano silica in the mixtures, due to agglomerate effect, don't lead to increase compressive strength. As it is shown the highest compressive strength at the age of 28 days is corresponding to SF6, NS1.5 mixture.

Loland (1981) Nano-silica is typically a highly effective pozzolanic material. It normally consists of very fine vitreous particles approximately 1000 times smaller than the average cement particles. It has proven to be an excellent admixture for cement to improve strength and durability and decrease permeability (Loland, 1981; Aitcin et al., 1981). NS reduces the setting time and increases the strength (compressive, tensile) of resulting cement in relation with other silica components that were tested (Roddy et al., 2008). Nano-silica is obtained by direct synthesis of silica sol or by crystallization of nano-sized crystals of quartz.

2.5 SEM analysis

Divya chopra, rafat siddique and kunal (2015) strength, permeability and microstructure of self-compacting concrete containing rice husk", biosystems engineering

Salim barbhuiya , pengloy chow and shazimmemon(2015) microstructure , hydration and nanomechanical properties of concrete containing metakaolin", construction and building materials.

Yogesh aggarwal and rafat siddique (2014) microstructure and properties of concrete using bottom ash and waste foundry sand as partial replacement of fine aggregates" construction and building materials.

Vitoldas vaitkevicius, evaldasšerelis and harald hilbig(2014) the effect of glass powder on the microstructure of ultra high performance concrete", construction and building materis

Mahmoud khashaa mohammed, andrew robert dawson and nicholas howard thom,(2014) production, microstructure and hydration of sustainable self-compacting concrete with different types of fillers", construction and building materials.

R. Roychand, s. De silva, d. Law, and s. Setung(2016) micro and nano engineered high volume ultrafine fly ash cement composite with and without additives" international journal of concrete structures and materials, vol.10, no.1, pp.113–124.

Jumate .elena and manea daniela lucia (2012)application of x ray diffraction (xrd) and scanning electron microscopy (sem) method to the portland cement hydration processes" journal of applied engineering science volume 2(15),issue 1

Hui li, hui-gang xiao, jie yuan and jimping ou(2004) microstructure of cement motar with nano-particles" 'composite part b.

P. Kumar mehta and paulo.j.m. Monterio(2006) concrete microstructure, properties and materials"3rd edition.

Chapter-3

Methodology

3.1 General

The present study deals with the process of preparing of self-constricting concrete and its working. Various tests are conducted on the workability of the self-constricting concrete. The grade of concrete used is M20 which was designed in accordance with IS: 10262-2009. We have chosen mix design of M20 grade, in order to find the properties and working of self-constricting concrete.

Over the last decade, extensive research has been devoted to achieve self-compactability. Three different types of mixes can be distinguished: "Powder- type" by increasing the powder content, "VMA-type" using viscosity modifying admixture (VMA) and "Combined- type" by increasing powder content and using a viscosity agent in consideration of structural conditions, constructional conditions, available material, restrictions in concrete production plant, etc.

a) Powder-Type SCC

Okamura and Ozawa proposed a simple mix proportioning system for SC mix. Their main ideas were to fix the coarse aggregate content at 50% of solid volume and the fine aggregate content at 40% of mortar volume. Depending on the properties of mortar, the water to powder ratio is in the range of 0.9-1. This ratio should be carefully selected due to the high sensitivity of SCC to it. The self-compactability is achieved by adjusting the super-plasticizer dosage and the final water to powder ratio. This independent consideration of gravel and sand, results in a relatively high content of paste. The Japanese method has been adopted and used in many European countries as a starting point for the development of SCC. Su and Miao (2003) then developed an alternative method, henceforth referred to as ‘the Chinese method’ which starts with packing all coarse and fine aggregates, and then filling of the aggregate voids with paste. This easier method can result in less paste and hence saving the most expensive constituents, namely cement and filler. With this method, concrete with normal strength is obtained, while in Japanese method a higher strength than actually required can be attained.

b) VMA-Type SCC

By adding a high dosage of VMA to the mix of SCC, plastic viscosity can be controlled and increased without adding extra powder. To achieve flow-ability using this method a higher amount of super-plasticizer or higher water-powder ratio is required compared with the powder-type method.

c) Combined-Type SCC

This charter of mix was advanced to improve the robustness of powder-type SCC by adding a slight amount of VMA. In such mixes, the VMA content is less than that in the VMA-type SCC and the powder content and water to powder ratio are less than those in the powder-type SCC. The viscosity is provided by the VMA along with the powder. This type of SCC was reported to have high filling ability, high segregation resistance and improved robustness.

3.2 Materials used

3.2.1 Cement

In the present investigation Birla Shakti, Ordinary Portland Cement (PPC) of 53 Grade confirming to IS: 12269:1999 was used. The physical properties of cement as per IS: 12269:1999 when tested at the concrete lab at St. Martin's Engineering College are shown below.

Cement starts to set when mixed with water which causes a series of hydration chemical reactions. The constituents slowly hydrate and the mineral hydrates solidify; the interlocking of the hydrates gives cement its strength. Contrary to popular perceptions, hydraulic cements do not set by drying out, proper curing requires maintaining the appropriate moisture content during the curing process. If hydraulic cements dry out during curing, the resulting product can be significantly weakened.

Portland cement is by far the most common type of cement in general use around the world. This cement is made by heating limestone (calcium carbonate) with other materials (such as clay) to 1450 °C in a kiln, in a process known as calcination, whereby a molecule of carbon dioxide is liberated from the calcium carbonate to form calcium oxide, or quicklime, which then chemically combines with the other materials that have been included in the mix to form calcium silicates and other cementitious compounds.

The resulting hard substance, called 'clinker', is then ground with a small amount of gypsum into a powder to make 'ordinary Portland cement', the most commonly used type of cement (often referred to as OPC). Portland cement is a basic ingredient of concrete, mortar and most non- specialty grout. The most common use for Portland cement is in the production of concrete. Concrete is a composite material consisting of aggregate (gravel and sand), cement, and water.

As a construction material, concrete can be cast in almost any shape desired, and once hardened, can become a structural (load bearing) element. Portland cement may be grey or white.

3.2.2 Fine Aggregate

Locally available river sand confirming to IS: 383:1970 was used as the fine aggregate in the concrete preparation.

Table:3.3.2.1 Properties of Fine Aggregates

S.no	Property	Result
1	Specific Gravity	2.61
2	Fineness Modulus	2.8
3	Bulk Density (loose)	15.75 kN/m^3
4	Grading of Sand	ZONE-II

Construction aggregate, is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. Aggregates are the most mined materials in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material. Due to the relatively high hydraulic conductivity value as compared to most soils, aggregates are widely used in drainage applications such asfoundation and French drains, septic drain fields, retaining wall drains, and road side edge drains. Aggregates are also used as base material under foundations, roads, and railroads. In other words, aggregates are usedas a stable foundation or road/rail base with predictable, uniform properties (e.g. to help prevent differential settling under the road or building), or as a low-cost extender that binds with more expensive cement or asphalt to form concrete.

Fine aggregate is natural sand which has been washed and sieved to remove particles larger than 5 mm and coarse aggregate is gravel which has been crushed, washed and sieved so that the particles vary from 5 up to 50 mm in size. The fine and coarse aggregate are delivered separately. Because they have to be sieved, a prepared mixture of fine and coarse aggregate is more expensive than natural all-in aggregate.

The reason for using a mixture of fine and coarse aggregate is that by combining them in the correct proportions, a concrete with very few voids or spaces in it can be made and this reduces the quantity of comparatively expensive cement required to produce a strong concrete**.**

Sieving can be done by holding the sieving in both hands and gentle wrist motion; this will be involving the no danger of spilling of sand. This shall be kept well spread out on the screen. More or less continuous rotation of sieve can be carried out throughout the sieving. Washers, shortsand slugs shall not be used on the sieve. The underside of sieve shall be lightly brushed with a 25 or 45 mm brittle brush after even five minutes of sieving. Mechanically sieving devices may be used but the sand cannot be rejected if it meets fineness requirement.

3.2.3 Coarse Aggregate

Coarse aggregate of nominal size 12 mm and 10 mm, obtained from the local quarry confirming to IS: 383:1970 was used. The properties of coarse aggregate are shown in Table 3.3.3. The coarse aggregate used for the preparation of concrete is a mixture of 12 mm and 10 mm size aggregates in ratio 1.5: 1.0.

Table 3.2.3.1 Properties of Coarse Aggregate

S.No	Property	Result
1	Specific Gravity	2.60
2	Bulk Density	14.15 kN/m^3

3	Water Absorption	0.5%
4	Fineness Modulus	7.2

The advent of modern blasting methods enabled the development of quarries, which are now used throughout the world, wherever competent bedrock deposits of aggregate quality exist. In many places, good limestone, granite, marble or other quality stone bedrock deposits do not exist.

In these areas, natural sand and gravel are mined for use as aggregate. Where neither stone, nor sand and gravel, are available, construction demand is usually satisfied by shipping in aggregate by rail, barge or truck. Additionally, demand for aggregates can be partially satisfied through the use of slag and recycled concrete. However, the available tonnages and lesser quality of these materials prevent them from being a viable replacement for mined aggregates on a large scale. Large stone quarry and sand and gravel operations exist near virtually all population centers. These are capital-intensive operations, utilizing large earth- moving equipment, belt conveyors, and machines specifically designed for crushing and separating various sizes of aggregate, to create distinct product stockpiles. Aggregates themselves can be recycled as aggregates. Unlike deposits of sand and gravel or stone suitable for crushing into aggregate, which can be anywhere and may require overburden removal and/or blasting, "deposits" of recyclable aggregate tend to be concentrated near urban areas, and production from them cannot be raised or lowered to meet demand for aggregates. Supply of recycled aggregate depends on physical decay of structures and their demolition. The recycling plant can be fixed or mobile; the smaller capacity mobile plant works best for asphalt-aggregate recycling. The material being recycled is usually highly variable in quality and properties. Many aggregate products of various types are often recycled for other industrial purposes.

3.2.4 Nano-Silica

Silicon dioxide nanoparticles, also known as silica nanoparticles or nano silica, are the basis for a great deal of biomedical research due to their stability, low toxicity and ability to be functionalized with a range of molecules and polymers. Nano-silica is a new pozzolanic material commercially available in the form of water emulsion of colloidal silica. It is potentially better than the other pozzolanic materials because of high content of amorphous silica (>99%) and the reduced size of its spherical particles of order 5-10nm.

Nano-technology (NT) has been a recent development and is getting applied to many varieties of fields. There have been many highly successful NT based applications which could have been almost impossible without utility of nano sized particles. This is due to extra-ordinary properties of materials when their particle sizes are in nano-scale. However, for civil engineering applications, nano-silica (NS) seems to have very high potential, since, Portland cement generates free lime which can be utilized with very high efficiency by nS, as there is always a chemical affinity between Ca(OH)2 and SiO2 to form secondary calcium-silicate hydrates (C-S-H) which are both pore filling and refining compounds in a cement matrix. This was found to occur in the high volume fly ash containing cement mortar.

Table 3.3.4 Properties of Nano-Silica

S.No	Property	Actual Analysis
1	Active nano silica content	35-40%
2	pH	9.3-9.6
3	Specific Gravity	1.08-1.11
4	Texture	Milky White Liquid
5	Dispersion	Water

Nano-silica incorporation into cement concrete is the direct application approach of nanomaterial's. Researchers have worked on the mechanical and durability properties and microstructure analysis of concrete with nano-silica as discussed below.

Reduced setting times were observed by various researchers on incorporation of nano-silica in concrete which is same as observed for pastes and mortar. Use of nano-silica to reduce setting time and increase early strength of concretes with high volumes of fly ash or slag.

Concrete strength is influenced by lots of factors like concrete ingredients, age, ratio of water to cement materials, etc. Nano-silica incorporation into concrete resulted in higher compressive strength than that of normal concrete to a considerable level.

The nano-silica (Ns), a product of modern Nano-technology (NT), was chosen to examine whether it can improve the degree of impermeability of a porous cement matrix containing mineral admixtures such as FA and SF. For this, a high water- binder ratio of 0.5 was chosen to produce a porous mortar matrix wherein 25% of cement was replaced by Class F fly ash and in another mix, 5% SF was utilised. It may be noted here that the value of 25% represents the average FA content of common Portland Pozzolana Cements (PPCs) available in the market today in India and the value of 5% represents the common SF content used in most of the concrete mixes. After curing the mortar specimens, they were oven dried and then impregnated with 'nano-silica solution' (Nss) by simple soaking. The (Nss) contained 30 %(Ns) solids. The permeability of (Nss) treated specimens were evaluated by determining the COA which required water absorption measurements on oven dried specimens.

3.2.5 Water

Water used for mixing the concrete ingredients, casting and curing the test specimens is free from impurities which when present can adversely influence the strength of concrete confirming to IS:3025:1964 (part 22 and 23) and IS:456:2000.

3.2.6 Super plasticizer

As the locally available PCE based super plasticizers proved to be very effective in SCC; this study is carried out using such type of super plasticizers. CONPLAST SP430 Commercially available poly- carboxylic ether based super plasticizer it is an admixture of a new generation based on modified polycarboxylic ether. CONPLAST SP430 is a super plasticizer manufactured by DOM CONSTRUCTIVE SOLUTIONS, was used in this experimentation. Its use enhances the workability of the mix and strength aspect, helps in producing a better compaction and finishing. It also permits reduction in water content

3.3 Conplast SP430

High performance superplasticising admixture

Description

Conplast SP430 is a chloride free, superplasticising admixture based on selected sulphurated naphthalene polymers. It is supplied as a brown solution which instantly disperses in water.

Conplast SP430 disperses the fine particles in the concrete mix, enabling the water content of the concrete to perform more effectively. The very high levels of water reduction possible allow major increases in strength to be obtained.

Properties of Conplast SP430

Table 3.3.1: Properties of Conplast SP430

S.No	Properties
Appearance	Brown liquid
Specific gravity	Typically, 1.20 at 20°C
Chloride content	Nil to BS 5075
Air entrainment	Typically, less than 2% additional air is entrained at normal dosages.
Alkali content	Typically, less than 72.0 g. Na_2O equivalent/liter of admixture.
Fire resistance	Conplast SP430 is water based and non- flammable.

Additional information

Conplast SP430 was previously known as Conplast 430.

Typical dosage

The optimum dosage of Conplast SP430 to meet specific requirements should always be determined by trials using the materials and conditions that will be experienced in use. This allows the optimization of admixture dosage and mix design and provides a complete assessment of the concrete mix. Starting points for such trials, based on the primary use of the product, are to use a dosage within the normal typical ranges.

For high strength, water reduced concrete the normal dosage range is from 0.70 to 2.00 liters/100 kg of cementitious material, including PFA, GGBFS and micro silica. For high workability concrete the normal dosage range is from 0.70 to 1.30 liters/100 kg of cementitious material.

Where a combination of performance is required, such as some increase in workability combined with reduced water content, then the whole range of dosages from 0.70 to2.00 liters/100 kg of cementitious material can be considered.

Use at other dosages

Dosages outside the typical ranges quoted above may be used if necessary and suitable to meet particular mix requirements, provided that adequate supervision is available. Compliance with requirements must be accessed through trial mixes. Contact the Fosroc Customer Service Department for advice in these cases.

Instructions for use

Mix design

Where the primary intention is to improve strengths, initial trials should be made with normal concrete mix designs. The addition of the admixture will allow the removal of water from the mix whilst maintaining the workability at the levels obtained before the use of the admixture. After initial trials, minor modifications to the overall mix design may be made to optimise performance.

Where the primary intention is to provide high workability concrete, the starting mix design should be one suitable for use as a pump mix. Advice on mix design for flowing concrete is available from the Fosroc Customer Service Department.

In correctly designed flowing concrete, the improved dispersion of the cement particles and the more efficient use of mixing water will improve mix cohesion. The slight air entrainment obtained with Conplast SP430 will also help to minimise bleed and segregation. After initial trials, minor modifications to the mix design may be made to optimise performance.

Compatibility

Conplast SP430 is compatible with other Fosroc admixtures used in the same concrete mix. All admixtures should be added to the concrete separately and must not be mixed together prior to addition. The resultant proper- ties of concrete containing more than one admixture should be assessed by the trial mix procedure recommended on this data sheet to ensure that effects such as unwanted retardation do not occur.

Conplast SP430 is suitable for use with all types of ordinary Portland cements and cement replacement materials such as PFA, GGBFS and silica fume.

Uses

- To provide excellent acceleration of strength gain at early ages and major increases in strength at all ages by significantly reducing water demand in a concrete mix.

- Particularly suitable for precast concrete and other high early strength requirements.

- To significantly improve the workability of site mixed and precast concrete without increasing water demand.

- To provide improved durability by increasing ultimate strengths and reducing concrete permeability.

- In screeds it reduces the water content required to give suitable workability for placing and compaction.

Advantages

- Major increases in strength at early ages without increased cement contents are of particular benefit in precast concrete, allowing earlier stripping times.

- Makes possible major reductions in water: cement ratio which allow the production of high strength concrete without excessive cement contents.

- Use in production of flowing concrete permits easier construction with quicker placing and compaction and reduced labour costs without increasing water content.

- Increased workability levels are maintained for longer than with ordinary sulphurated melamine admixtures.

- Improved cohesion and particle dispersion minimises segregation and bleeding and improves pumpability.

- Chloride free, safe for use in prestressed and rein- forced concrete.

- In screed material, the lower water content leads to quicker drying times

3.4 Mixture proportioning

Table 3.4.1: Mix proportions of SCC

Mixture ID	Cement (kg/m3)	Sand (kg/m3)	C.A (kg/m3)	Water	NS (kg/m3)	SP 3% (kg/m3)
SCC	550	910	590	252	0	16.5
SCC 2%NS	539	910	590	228	11	16.5
SCC 2.5%NS	537.25	910	590	233.3	13.75	16.5
SCC 3%NS	533.5	910	590	242	16.5	16.5

Where,

SCC = Self compacting concrete,

SCC2% = Compacting toward oneself Cement with 2% NS as concrete substitution.

SCC2.5% = Compacting toward oneself Cement with 2.5% NS as concrete substitution.

SCC3% = Compacting toward oneself Cement with 3% NS as concrete substitution.

NS = Nano silica.

CA = Coarse aggregate

SP = Super plasticizer

3.5 Fresh properties of self-constricting concrete

The fresh concrete is an assembly of solid particles which behaves like other granular materials. The paste is then added in quantities, which are adequate to fill the voids between the aggregate particles.

The assumption is made that fresh concrete is a homogeneous material of uniform composition. The three key properties of SCC of its fresh state are to be achieved are

1. Filling ability

2. Passing ability

3. Segregation resistance.

These properties are tested in the laboratory

1. Filling ability:

It is the potential of concrete to flow under its own weight both vertically downwards and horizontally, without honeycombing around any shape.

Filling ability refers to the ability of SCC mix to deform and undergo changes in shape with completely filling all areas and corners of the formwork horizontally and vertically while maintaining its homogeneity. The deformability of SCC is characterized by the concrete's fluidity and cohesion, and mainly assessed using the slump flow test.

2. Passing ability:

This is the potential of the concrete to flow freely without getting blocked through dense reinforcement.

Passing ability refers to the ability of SCC mix to pass through congested reinforcement without blocking, whilst maintaining good suspension of coarse particles in the matrix, thus avoiding arching near obstacles and blockage during flow. The J-ring and L-box tests are the most common methods used to assess this property. The probability of blocking

increases when the volume fraction of large aggregates and/or fibres increases. The size of aggregates, their shapes and their volume fraction influence the passing ability of SCC, moreover, the presence of fibres especially long and hooked or crimped ends make self-compacting fibre reinforced concrete (SCFRC)more difficult to pass through reinforcement.

3. Resistance to segregation: This is the potential of SCC to resist separation of aggregate from the paste to maintain a homogenous mix during and after placement.

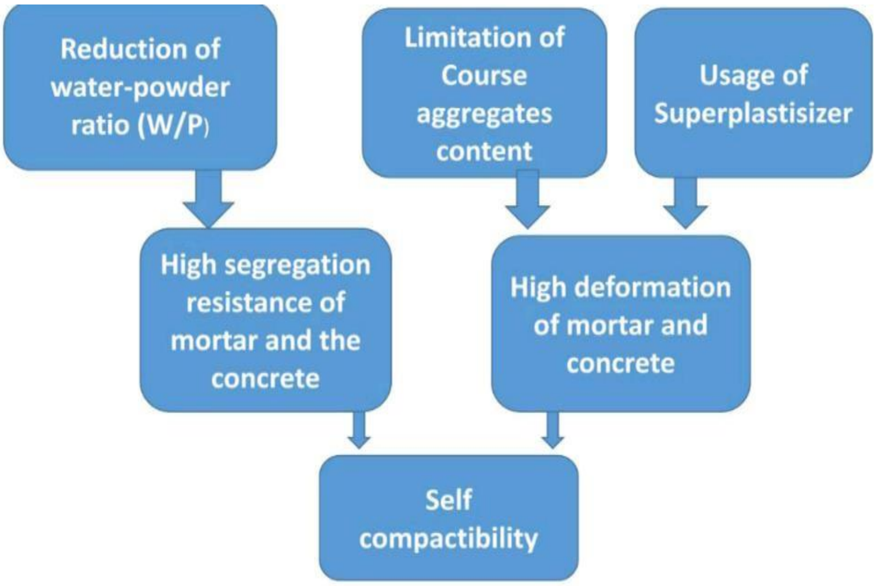
Segregation Resistance (Homogeneity/Cohesiveness) Segregation resistance refers to the ability to retain the coarse components of the mix and the fibres in suspension in order to maintain a homogeneous material. Stability is largely dependent on the cohesiveness and the viscosity of the concrete mixture which can be increased by reducing the free water content and increasing the amount of fines.

“Since coarse aggregate is smaller a finer than that of NCC”, SCC obtains strength due to densification”, table 3.4 gives the methods of evaluating the properties of SCC.

Table 3.5.1 List of Test Methods for Workability Properties of SCC

S. No	Test	Property
1	Slump cone	Filling ability
2	Flow table	Filling ability
3	J-ring	Passing ability
4	V-funnel	Filling ability
5	L-box	Passing ability
6	U-box	Passing ability

Fig.1 Methodology to achieve self compactability in concrete



3.6 Flow chart showing methodology to achieve self compactability in concrete

Chapter-4

Results and Discussions

4.1 Tests on Cement

Cement is an important constituent in concrete. The process of manufacture of cement consist of grinding the raw materials mixing them intimately in certain proportions and burning them in kiln at a temperature 13000C to 15000C. To determine the various properties of cement different tests are done. The tests done are:

1. Standard Consistency

2. Initial & Final Setting Time

3. Fineness of Cement

4. Specific gravity of Cement

5. Soundness of Cement

6. Marsh cone test

7. Compression strength of Cement

Standard procedure of the above test are given in detail with results in next part of document

4.1.1 Standard Consistency

The basic aim is to find out the water content required to produce a cement paste of standard consistency as specified by the IS: 4031 (Part 4) – 1988. The principle is that standard consistency of cement is that consistency at which the Vicat plunger penetrates to a point 5-7mm from the bottom of Vicat moulds. Vicat apparatus conforming to IS: 5513 – 1976.

Procedure to determine consistency of cement

- Weigh approximately 400g of cement and mix it with a weighed quantity of water. The time of gauging should be between 3 to 5 minutes.
- Fill the Vicat mould with paste and level it with a trowel.
- Lower the plunger gently till it touches the cement surface.
- Release the plunger allowing it to sink into the paste. Note the reading on the gauge.
- Repeat the above procedure taking fresh samples of cement and different quantities of water until the reading on the gauge is 5 to 7mm.

Observation and calculations

Table 4.1.1: Standard Consistency observations

Cement	% of Water added	Penetration
250gms	27*(250/100)	38
	28*(250/100)	20
	29*(250/100)	9
	30*(250/100)	7
	31*(250/100)	4

Result

The percentage of water for normal consistency for the given sample of cement is 36%

4.1.2 Initial Setting Time

Initial setting time is the time elapsed between the moment the water is added to the cement to the time that the paste starts losing its plasticity is called initial setting time.

Procedure to determine Initial setting time

- Prepare a cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency.
- Start a stop-watch, the moment water is added to the cement.

- Fill the Vicat mould completely with the cement paste gauged as above, the mould resting on a non-porous plate and smooth off the surface of the paste making it level with the top of the mould.
- The cement block thus prepared in the mould is the test block.

Observation and calculations

Table 4.1.2: Initial Setting Time observations

Cement	% of Water added	Time (sec)	Penetration (mm)
250gms	0.85*31% of weight of cement 0.85/100*(31)*(250)=66.935	5	0
		10	0
		15	0
		20	0
		25	3
		30	3
		35	4
		40	5

Results

Initial setting time of given cement sample is found to be 40 min & Final setting time as 10 hrs

4.1.3 Fineness of Cement

To determine the fineness of cement by dry sieving as per IS: 4031 (Part1) – 1996.The principle of this is that we determine the proportion of cement whose grain size is larger than 90µm IS Sieve size.

Procedure to determine fineness of cement

- Break down any air set lumps in the cement sample with fingers.
- Weigh accurately 100 g of cement and place it on standard 90 micron IS sieve
- Continuously sieve the sample giving circular and vertical motion for a period of 15 minutes.
- Weigh the residue left on the sieve. As per IS code the percentage residue should not exceed 10%.

Observation and calculations

Table 4.1.3: Fineness of Cement observations

S.No	Weight of cement (gms)	Weight of residue formed (gms)	Fineness of cement (%)
1	300	18g	6%

Result

The fineness of cement is found to be 6%, Which is less than 10%

4.1.4 Specific Gravity of Cement

Specific Gravity is just a comparison between the weight of a volume of a particular material to the weight of the same volume of water at a specified temperature.

Procedure to determine the Specific gravity of cement

- The Flask should be free from the liquid that means it should be fully dry. Weigh the empty flask (W1).
- Fill the cement on the bottle up to half of the flask (about 50gm) and weigh with its stopper (W2).
- Add Kerosene to the cement up to the top of the bottle. Mix well to remove the air bubbles in it. Weigh the flask with cement and kerosene (W3).
- Empty the flask. Fill the bottle with kerosene up to the top and weigh the flask (W4).
- Specific Gravity

Observation and calculations

Table 4.1.4: Specific Gravity of Cement observations

Description of items	Weights
Weight of empty bottle W_1g	26g
Weight of bottle + Cement W_2g	31g
Weight of bottle + Cement + Kerosene W_3g	70g
Weight of bottle + Kerosene W_4g	66g
Weight of bottle with full water W_5g	77g

Sp.gravity of kerosene $S_K = \frac{W4-W1}{W5-W1}$

$S_K = \frac{66-26}{77-26} = 0.784$

Sp.gravity of cement Sc $= \frac{W2-W1}{(W4-W1)-(W3-W2)Sk}$

$Sc = \frac{(31-26)}{(66-26)-(70-31)*0.784} = 3.92$

Result

The specific gravity of the given cement sample is 3.92

4.1.5 Soundness of Cement

The testing of soundness of cement is to ensure that the cement does not show any applicable subsequent expansion. Unsoundness in cement is due to excess of lime, magnesia or excessive proportion of sulphates. Experiment is done by Le Chatelier apparatus.

Procedure to determine soundness of cement

- Place the mould on a glass sheet and fill it with the cement paste formed by gauging cement with 0.78 times the water required to give a paste of standard consistency.
- Cover the mould with another piece of glass sheet, place a small weight on this covering glass sheet and immediately submerge the whole assembly in water at a temperature of 27 ± 2oC and keep it there for 24hrs.
- Measure the distance separating the indicator points to the nearest 0.5mm (say d1).
- Submerge the mould again in water at the temperature prescribed above. Bring the water to boiling point in 25 to 30 minutes and keep it boiling for 3hrs.
- Remove the mould from the water, allow it to cool and measure the distance between the indicator points (say d2).
- (d2 – d1) represents the expansion of cement.

Observation and calculations

Table 4.1.5 Soundness of Cement observations

Distance separating the indicator submerged in normal KMP water from 24hrs	Distance separating the indicator submerged in boiling water for 3hrs	Difference between two measurements
7mm	8mm	1mm
9mm	10mm	1mm

Result

The given cement is found to be SOUND

4.1.6 Marsh cone test

The Marsh cone test is a workability test used for specification and quality control of cement pastes. Marsh cone test standard varies from one country to another, but its principle is usually the same. The time needed for a certain amount of material to flow out of the cone is recorded. This measured flow time is linked with the fluidity of the tested material. The longer the flow time, the lower is the fluidity.

The Marsh cone test is a simple approach to get some data about cement pastes behaviour. It is used in cement based materials mix design in order to define the saturation point, i.e. the dosage beyond which the flow time does not decrease appreciably. The cone is filled with the fluid material while the nozzle is kept closed. When the cone is filled with measured quantity of fluid, the nozzle is opened and the fluid is allowed to flow freely. The time needed for measured quantity of material to flow out is recorded as Marsh cone time.

The saturation point is defined as the chemical admixture dosage beyond which the flow time dose not decrease appreciably. The dose at which the Marsh cone time is lowest is called the saturation point. The dose is the optimum dose for that brand of cement and admixture (plasticizer or superplasticizer) for that w/c ratio.

Procedure to determine the flowability of cement by Marsh cone test

- Observations for 0 minutes, 15 minutes and 60 minutes retention period are taken.
- For first test, water cement ratio is kept as 0.55 and Conplast SP430 admixture dose of 0.2% is administered. Temperature is noted down.
- Mix the measured quantity of Jaypee Cement, water and Conplast SP430 admixture thoroughly in a mechanical mixer for two minutes.
- While mixing, first put the water in mixing bowl and then add 2 Kg of cement to this water. Stirrer for 1 minute and then add Conplast SP430 admixture dose and stirring operation is continued for next one minutes. Thus slurry is formed.
- Pour one-liter slurry into marsh cone duly closing the aperture with a finger.
- Start the stop watch and simultaneously remove the finger. Note the time taken for emptying the Marsh Cone. This time is called the "Marsh Cone Time".
- Repeat the test for 15 minutes and 60 minutes retention period for same mix and duly noting Marsh Cone time. The mixture of cement and admixture should be kept stirred throughout the test.
- Repeat the test for different plasticizer dosage i.e. 0.2% to 2.0% (AS per IS 456: 2000).

- A typical graph of Marsh Cone Time in Seconds Vs Admixture/Cement dosage in percentage is drawn and optimum dose is ascertained. This point is known as "Saturation Point"
- For Jaypee Cement and Conplast SP430 admixture, different w/c ratio i.e. 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.55 the whole procedure is repeated and for each combination of cement, water and plasticizer, saturation point is obtained.
- Repeat step 2 to 9 for the Jaypee Cement and Conplast SP430 admixture.

Observation and calculations

Table 4.1.6 Flowability by Marsh cone test observations

S.No	Chemical dosage	Passing in sec
1	50ml	126sec
2	100ml	87sec
3	150ml	54sec
4	200ml	36sec
5	250ml	20sec
6	300ml	7sec

Result

Max passing value is found at the chemical dosage of 300ml as 7sec

4.2 Tests on Fine Aggregate

4.2.1 Sieve Analysis

The properties of fine aggregate are shown in Tables below. Weight of sand = 1000gms

Weight of pan = 814gms

Weight of pan +sand = 1814gms

Table 4.2.1.1 Sieve Analysis Results

S.No	Sieve Size(mm)	Percent Retained	Cumulative % Retained	Percentage Passing
1	4.75	4.91	4.91	95.09
2	2.36	3.24	8.15	91.85
3	1.18	8.47	16.62	83.38
4	600 microns	26.00	42.60	57.38
5	300 microns	32.50	75.10	24.90
6	150 microns	21.20	96.30	3.70

Fine aggregate is allowed to pass through the 4.75mm sieve and retain on 150microns sieve.

4.2.2 Bulking of Fine Aggregate

Put sufficient quantity of sand loosely into a container until it is 2/3 rd. full. Level the top surface of the sand.

Push the steel rule vertically down through the sand at the middle to bottom and measure the height 'h'. Empty the container and to a clean metal tray without any loss of sand. Add 2% water by weight of sand and mix thoroughly with hand.

Put back the loose sand into container without tamping it. Repeat above the procedure by increasing the moisture content in the sample till the bulking is maximum starts dropping ultimately zero.

Prepare bulking chart by plotting increase volume verses percentage increase in moisture content.

Calculation:

Initial reading h=17.9cm

Table 4.2.2.1 Bulking of Fine Aggregate

S.No	% of water added to the weight of sand	Height of moist sand in cm (h^i)	Percentage of bulking of sand ($(h^i-h)/h*100$
1	2	20.5	12.02
2	4	22.5	22.9
3	6	23	25.6
4	8	22	22.02
5	10	21	14.75
6	12	19.7	7.65

Result:

Bulking of fine aggregate is 25.6%.

4.3 Workability test on SCC

4.3.1 Slump flow test

Introduction

The slump flow is used to assess the horizontal free flow of SCC in the absence of obstructions. It was first developed in Japan (1) for use in assessment of underwater concrete. The test method is based on the test method for determining the slump. The diameter of the concrete circle is a measure for the filling ability of the concrete.

Assessment of test

This is a simple, rapid test procedure, though two people are needed if the T50 time is to be measured. It can be used on site, though the size of the base plate is somewhat unwieldy and level ground is essential. It is the most commonly used test, and gives a good assessment of filling ability. It gives no indication of the ability of the concrete to pass between reinforcement without blocking, but may give some indication of resistance to segregation. It can be argued that the completely free flow, unrestrained by any boundaries, is not representative of what happens in practice in concrete construction, but the test can be profitably be used to assess the consistency of supply of ready-mixed concrete to a site from load to load.

Equipment

A mould in the shape of a truncated cone with the internal dimensions 200 mm diameter at the base, 100 mm diameter at the top and a height of 300 mm, conforming to EN 12350-2

base plate of a stiff none absorbing material, at least 700mm square, marked with a circle marking the central location for the slump cone, and a further concentric circle of 500mm diameter

- trowel
- scoop
- ruler
- stopwatch (optional)

Procedure

About 6 litres of concrete is needed to perform the test, sampled normally. Moisten the base plate and inside of slump cone, Place base plate on level stable ground and the slump cone centrally on the base plate and hold down firmly. Fill the cone with the scoop. Do not tamp, simply strike off the concrete level with the top of the cone with the trowel. Remove any surplus concrete from around the base of the cone. Raise the cone vertically and allow the concrete to flow out freely.

Simultaneously, start the stopwatch and record the time taken for the concrete to reach the 500mm spread circle. (This is the T50 time). Measure the final diameter of the concrete in two perpendicular directions. Calculate the average of the two measured diameters. (This is the slump flow in mm).

Table 4.3.1.1 Properties and Acceptance criteria for Slump flow

S No	Method	Properties evaluated by the test	Acceptance criteria		
			unit	Min	max
1	Slump flow	Filling ability,flowability,segregation and bleeding	mm	650	800

Observation and calculations

Table 4.3.1.2 Slump flow test observations

Water cement ratio	Slump in cm
0.4	22cm
0.5	17cm
0.6	15cm

Result

Slump value for the given SCC sample is found to be 22cm for W/C ratio of 0.4, 17cm for W/C ratio of 0.5 & 15cm for W/C ratio of 0.6

4.3.2 J Ring test

Introduction

The principle of the J-Ring test may be Japanese, but no references are known. The J-Ring test itself has been developed at the University of Paisley. The test is used to determine the passing ability of the concrete. The equipment consists of a rectangular section (30mm x 25mm) open steel ring, drilled vertically with holes to accept threaded sections of reinforcement bar. These sections of bar can be of different diameters and spaced at different intervals: in accordance with normal reinforcement considerations, 3x the maximum aggregate size might be appropriate. The diameter of the ring of vertical bars is 300mm, and the height 100 mm. The J-Ring can be used in conjunction with the Slump flow, the Orimet test, or eventually even the V- funnel. These combinations test the flowing ability and (the contribution of the J-Ring) the passing ability of the concrete. The Orimet time and/or slump flow spread are measured as usual to assess flow Characteristics. The J-

Ring bars can principally be set at any spacing to impose a more or less severe test of the passing ability of the concrete. After the test, the difference in height between the concrete inside and that just outside the J-Ring is measured. This is an indication of passing ability, or the degree to which the passage of concrete through the bars is restricted.

Assessment of test

These combinations of tests are considered to have great potential, though there is no general view on exactly how results should be interpreted. There are a number of options for instance it may be instructive to compare the slump-flow/J-Ring spread with the unrestricted slump-flow: to what extent is it reduced? Like the slump-flow test,

these combinations have the disadvantage of being unconfined, and therefore do not reflect the way concrete is placed and moves in practice. The Orimet option has the advantage of being a dynamic test, also reflecting placement in practice, though it suffers from requiring two operators.

Equipment

Mould, WITHOUT foot pieces, in the shape of a truncated cone with the internal dimensions 200 mm diameter at the base, 100 mm diameter at the top and a height of 300 mm.

Base plate of a stiff non absorbing material, at least 700mm square, marked with a circle showing the central location for the slump cone, and a further concentric circle of 500mm diameter

- Trowel
- Scoop
- Ruler

J-Ring a rectangular section (30mm x 25mm) open steel ring, drilled vertically with holes. In the holes can be screwed threaded sections of reinforcement bar (length 100mm, diameter 10mm, and spacing 48 +/- 2mm)

Procedure

About 6 litres of concrete is needed to perform the test, sampled normally. Moisten the base plate and inside of slump cone, Place base-plate on level stable ground. Place the J-Ring centrally on the base-plate and the slump-cone centrally inside it and hold down firmly.

Fill the cone with the scoop. Do not tamp, simply strike off the concrete level with the top of the cone with the trowel. Remove any surplus concrete from around the base of the cone.

Raise the cone vertically and allow the concrete to flow out freely. Measure the final diameter of the concrete in two perpendicular directions. Calculate the average of the two measured diameters. (in mm). Measure the difference in height between the concrete just inside the bars and that just outside the bars. Calculate the average of the difference in height at four locations (in mm). Note any border of mortar or cement paste without coarse aggregate at the edge of the pool of concrete.

Table 4.3.2.1 Properties and Acceptance criteria for J-ring

S No	Method	Properties evaluated by the test	Acceptance criteria		
			Unit	Min	Max
1	J-ring	Passing ability, flowing ability	Mm	0	10

Observation and calculations

Table 4.3.2.2 J-ring test observations

Water cement ratio	Flowing of concrete in mm
0.4	7mm
0.5	6mm
0.6	4mm

Result

J-ring value for the given SCC sample is found to be 7mm for W/C ratio of 0.4, 6mm for W/C ratio of 0.5 & 4mm for W/C ratio of 0.6

4.3.3 V funnel test

Introduction

The test was developed in Japan and used by Ozawa et al (5). The equipment consists of a V-shaped funnel, shown in Fig. An alternative type of V-funnel, the O funnel, with a circular section is also used in Japan. The described

V-funnel test is used to determine the filling ability (flow ability) of the concrete with a maximum aggregate size of 20mm. The funnel is filled with about 12 litres of concrete and the time taken for it to flow through the apparatus measured. After this the funnel can be refilled concrete and left for 5 minutes to settle. If the concrete shows Segregation, then the flow time will increase significantly.

Assessment of test

Though the test is designed to measure flow ability, the result is affected by concrete properties other than flow. The inverted cone shape will cause any liability of the concrete to block to be reflected in the result – if, for example there is too much coarse aggregate. High flow time can also be associated with low deformability due to a high paste viscosity, and with high inter-particle friction. While the apparatus is simple, the effect of the angle of the funnel and the wall effect on the flow of concrete are not clear.

Equipment

- V-funnel
- bucket (±12 litres)
- trowel
- scoop
- stopwatch

Procedure flow time

About 12 litres of concrete is needed to perform the test, sampled normally. Set the V-funnel on firm ground. Moisten the inside surfaces of the funnel. Keep the trap door open to allow any surplus water to drain. Close the trap door and place a bucket underneath. Fill the apparatus completely with concrete without compacting or tamping; simply strike off the concrete level with the top with the trowel. Open within 10 sec after filling the trap door and allow the concrete to flow out under gravity. Start the stopwatch when the trap door is opened, and record the time for the discharge to complete (the flow time). This is taken to be when light is seen from above through the funnel. The whole test has to be performed within 5 minutes.

Table 4.3.3.1 Properties and Acceptance criteria for V- funnel test

S No	Method	Properties evaluated by the test	Acceptance criteria		
			Unit	min	max
1	V-Funnel	Filling ability,viscosity,segregation	Sec	6	12

Results

The time of the flow in V-funnel for SCC is found to be 8sec

4.3.4 L-box test

Introduction

This test, based on a Japanese design for underwater concrete, has been described by Peterson. The test assesses the flow of the concrete, and also the extent to which it is subject to blocking by reinforcement. The apparatus is shown in figure. The apparatus consists of a rectangular-section box in the shape of an ‘L’, with a vertical and horizontal section, separated by a moveable gate, in front of which vertical lengths of reinforcement bar are fitted. The vertical section is filled with concrete, and then the gate lifted to let the concrete flow into the horizontal section. When the flow has stopped, the height of the concrete at the end of the horizontal section is expressed as a proportion of that remaining in the vertical section (H2/H1in the diagram). It indicates the slope of the concrete when at rest. This is an indication passing ability, or the degree to which the passage of concrete through the bars is restricted. The horizontal section of the box can be marked at 200mm and 400mm from the gate and the times taken to reach these points measured. These are known as the T20 and T40 times and are an indication for the filling ability. The sections of bar can be of different diameters and spaced at different intervals: in accordance with normal reinforcement considerations, 3x the maximum aggregate size might be appropriate. The bars can principally be set at any spacing to impose a more or less severe test of the passing ability of the concrete.

Assessment of test

This is a widely used test, suitable for laboratory, and perhaps site use. It assesses filling and passing ability of SCC, and serious lack of stability (segregation) can be detected visually. Segregation may also be detected by subsequently sawing and inspecting sections of the concrete in the horizontal section. Unfortunately, there is no agreement on materials, dimensions, or reinforcing bar arrangement, so it is difficult to compare test results. There is no evidence of what effect the wall of the apparatus and the consequent 'wall effect' might have on the concrete flow, but this arrangement does, to some extent, replicate what happens to concrete on site when it is confined within formwork. Two operators are required if times are measured, and a degree of operator error is inevitable.

Equipment

- L box of a stiff non absorbing material see figure.
- trowel
- scoop
- stopwatch

Procedure

About 14 litres of concrete is needed to perform the test, sampled normally. Set the apparatus level on firm ground, ensure that the sliding gate can open freely and then close it. Moisten the inside surfaces of the apparatus, remove any surplus water Fill the vertical section of the apparatus with the concrete sample. Leave it to stand for 1 minute. Lift the sliding gate and allow the concrete to flow out into the horizontal section. Simultaneously, start the stopwatch and record the times taken for the concrete to reach the 200 and 400 mm marks. When the concrete stops flowing, the distances “H1” and “H2” are measured. Calculate H2/H1, the blocking ratio. The whole test has to be performed within 5 minutes.

Table 4.3.4.1 Properties and Acceptance criteria for L-box test

S No	**Method**	**Properties evaluated by the test**	**Acceptance criteria**		
			Unit	**mm**	**Max**
1	L-box	Passing ability,flowability,blocking effects	(h2-h1)	0.8	1.00

Result

The time of flow of SCC in L-box is 1.7min

4.3.5 U-box test

Introduction

The test was developed by the Technology Research Centre of the Taisei Corporation in Japan. Sometimes the apparatus is called a “box-shaped” test. The test is used to measure the filling ability of self-compacting concrete. The apparatus consists of a vessel that is divided by a middle wall into two compartments, shown by R1 and R2 in fig. An opening with a sliding gate is fitted between the two sections. Reinforcing bars with nominal diameters of 13 mm are installed at the gate with centre-to-centre spacing of 50 mm. This creates a clear spacing of 35 mm between the bars. The left hand section is filled with about 20 litres of concrete then the gate lifted and concrete flows upwards into the other section. The height of the concrete in both sections is measured.

Note: An alternative design of box to this, but built on the same principle is recommended by the Japan Society of Civil Engineers.

Assessment of test

This is a simple test to conduct, but the equipment may be difficult to construct. It provides a good direct assessment of filling ability – this is literally what the concrete has to do – modify by an unmeasured requirement for passing ability. The 35mm gap between the sections of reinforcement may be considered too close. The question remains open of what filling height less than 30 cm. is still acceptable.

Equipment

- U box of a stiff non absorbing material see figure
- trowel
- scoop
- stopwatch

Procedure

About 20 litre of concrete is needed to perform the test, sampled normally. Set the apparatus level on firm ground, ensure that the sliding gate can open freely and then close it. Moisten the inside surfaces of the apparatus, remove any surplus water Fill the one compartment of the apparatus with the concrete sample. Leave it to stand for 1 minute. Lift the sliding gate and allow the concrete to flow out into the other compartment. After the concrete has come to rest, measure the height of the concrete in the compartment that has been filled, in two places and calculate the mean (H1). Measure also the height in the other compartment (H2) Calculate H1 - H2, the filling height. The whole test has to be performed within 5 minutes.

Table 4.3.5.1 Properties and Acceptance criteria for U-box test

S No	Method	Properties evaluated by the test	Acceptance criteria		
			Unit	min	Max
1	U-box	Passing ability, filling ability, blocking effects	(h2-h1)	0	30

Result

The passing value of SCC in U-box test is found to be 26cm.

4.3.6 FLOW TABLE TEST

Introduction

This test is performed to determine the consistency of concrete where the nominal maximum size of aggregate does not exceed 38 mm using flow table apparatus.

Apparatus

- Flow table
- Trowel
- Scale

PROCEDURE

- Before commencing test, the table top and inside of the mould is to be wetted and cleaned of all gritty material and the excess water is to be removed with a rubber squeezer.
- The mould is to be firmly held on the centre of the table and filled with concrete in two layers, each approximately one-half the volume of the mould and rodded with 25 strokes with a tamping rod, in a uniform manner over the cross section of the mould.
- After the top layer has been rodded, the surface of the concrete is to be struck off with a trowel so that the mould is exactly filled.
- The mould is then removed from the concrete by a steady upward pull.
- The table is then raised and dropped from a height of 12.5 mm, 15 times in about 15 seconds.
- The diameter of the spread concrete is the average of six symmetrically distributed calliper measurements read to the nearest 5 mm.

Table 4.3.6.1 Properties and Acceptance criteria for Flow table test

S.No	Method	Properties evaluated by the test	Acceptance criteria		
			Units	Min	Max
1	Flow table	Flowability, consistency & segregation	%	0	150

Observation and calculations

Table 4.3.6.2 Flow table test observations

Chemical dosage	% flowability
100ml	52%
200ml	86%
300ml	102%

Result

The flow table value of SCC is found to be max at 300ml chemical dosage as 102%

4.4 Casting

The cube mould plates should be removed properly, cleaned, assembled and all the bolts should be fully tight. A thin layer of oil then shall be applied on all the faces of the mould. It is important that cube side faces must be parallel. After taking concrete samples and mixing them, the cubes shall be cast as soon as possible. The concrete sample shall be filled into the cube moulds in layers approximately 5 cm deep. In placing each scoopful of concrete, the scoop shall be moved around the top edge of the mould as the concrete slides from it, in order to ensure a symmetrical distribution of the concrete with in the mould. Number of specimens casted are shown below.

Table 4.4.1. Number of specimens casted

S.No	Mix Designation	No. of cubes		No. of Cylinders
1	NOMINALCONCRETE	3	3	3
2	SCC(without nano silica)	3	3	3
3	SCC 2%	3	3	3
4	SCC 2.5%	3	3	3
5	SCC 3%	3	3	3
Total Specimens		15	15	15

4.4.1 Procedure for Casting Concrete Cubes

Clean the cube mould properly with a cloth and apply a coat of form oil on the inner surfaces of the mould. No excess oil should be visible on the inner surfaces. Fix the nuts & bolts tightly with base plate and side plates, no gaps should be seen within the parts of cube mould. It is necessary that the cube mould should be placed on a clean, level & firm surface for filling the concrete in it.

Concrete for specimen should be collected from three or four random mixes according to the preferred mix design of M20 grade. Place the concrete mix into the mould in each layer ofmaximum 50 mm thick. Level off the top with the steel float & clean any concrete from around the mould and leave the mould undisturbed for 24 hours.

Give number & casting date of the specimens on the top surface after 90 minutes. Remove the cube from the mould after 24 hours. The specimen should be put straight into a tank of clean water. The specimen should be fully submerged under water. After 7 and 28 days, send the specimen to the testing laboratory todetermine the compressive strength of concrete.

4.4.2 Procedure for casting concrete cylinder

Clean the Cylinder mould properly with a piece of cloth and apply a coat of form oil on the inner surface of mould.No excess oil should be visible on inner surface. Fix the nuts & bolts tightly with base plate and no gaps should be within the parts of cylinder mould. It is necessary that the cylinder mould should be placed on a clean, level & firm surface. Concrete for specimen should be collected from three or four random mixes. Place concrete into the mould in each layer of maximum 50 mm thick. Level off the top with the steel float & clean any concrete from around the mould and leave the mould undisturbed for 24 hours.

Give number & casting date of the specimens on the top surface after 90 minutes. After 24 hours the specimen should be taken out from the mould and put it straight into a tank of clean water. The specimen should be fully submerged under water. After 7 and 28 days, send the specimen to the testing laboratory to determine the tensile strength of concrete. Minimum three specimens are made at a time on site. The average test result is taken to determine the tensile strength of concrete.

4.4.3 Curing

The cube shall be removed from the moulds at the end of 24 hours and immersed in clean water till the 7 or 28-days age of testing. The cubes shall be tested in the saturated and surface dry condition. For the true representation of actual strength of concrete in the structure, extra cubes shall be cast, stored and curded as per the identical conditions of that structure, and tested at required age.

4.4.4 Compressive Strength Test

The dimensions of the specimens to the nearest 0.2 mm and their weight shall be noted before testing. The bearing surfaces of the testing machine shall be wiped clean and any loose sand or other materials removed from the surface of the specimen which are to be in contact with the compression platens. The cube shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast that is not to the top and bottom.

The axis of the specimen shall be carefully aligned with the center of the thrust of the spherically seated platen. No packing shall be used between the faces of the test specimen and the steel platen of the testing machine. As the spherically seated block is brought to bear on the specimen, the movable portion shall be rotated gently by hand so that uniform seating may be obtained.

The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted. The compressive strength of concrete shall be calculated from:

$$Compressive\ strengt\boldsymbol{h} = \mathbf{(}Maximumload\mathbf{)/(}Cross{-}sectional\ area\mathbf{)}$$

The compressive strengths of the casted specimens were determined by the compressive test machine and are tabulated as follows:

Table 4.4.4.1 Compressive Strength Values

S.No	Mix Designation	Characteristic Compressive Strength(N/mm^2)	
		7 Days	28 Days
1	Nominal Concrete	17.52	20.8
2	SCC	19.81	22.32
3	SCC 2% NS	21.30	23.12
4	SCC 2.5% NS	22.20	24.90
5	SCC 3% NS	21.40	24.50

Graphs are plotted for the obtained results and increase in the characteristic compressive strengths can be clearly read out. It was observed that the percentage increase in compressive strength was greater for 7 days compared to 28 days. Hence from the experimental investigation results it can be inferred that Nano-silica improves early strength also.

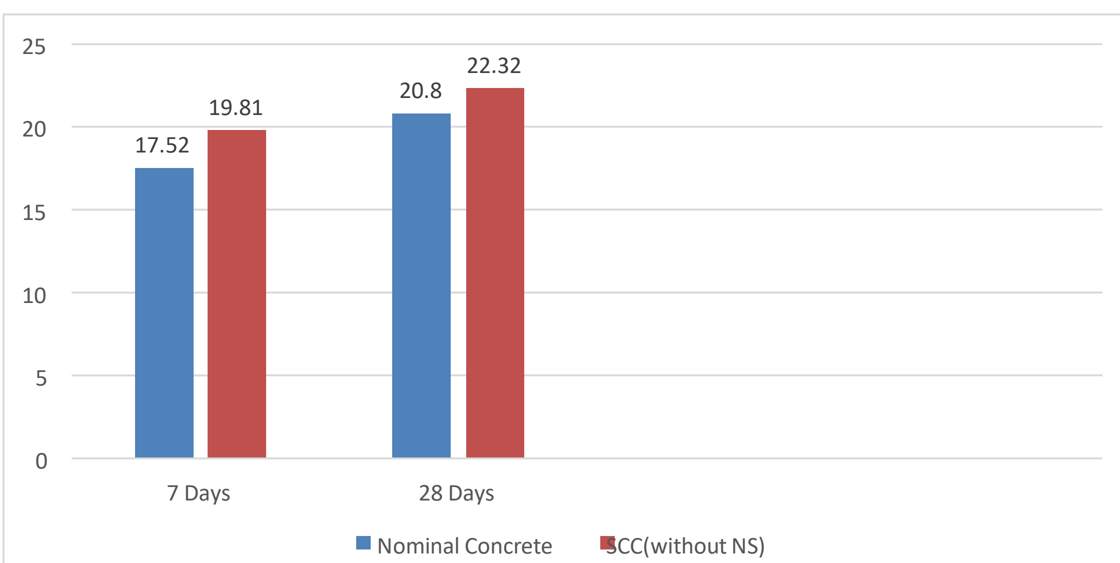


Fig 4.4.1 Compressive Strength of Nominal concrete and SCC (without NS)

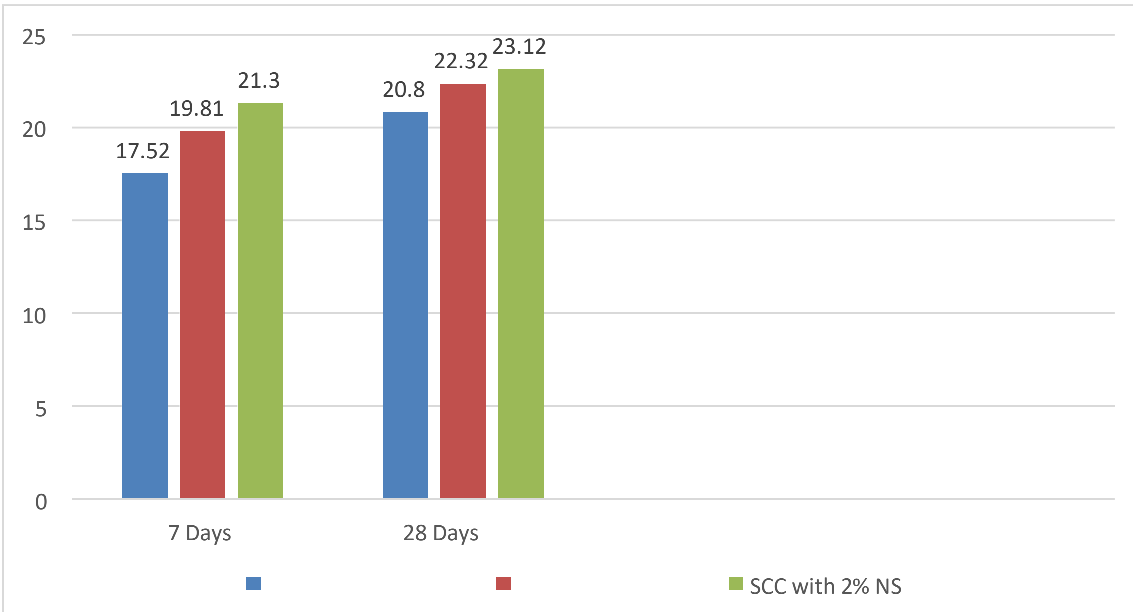


Fig 4.4.2 Compressive Strength of Nominal Concrete, SCC and SCC with 2% NS

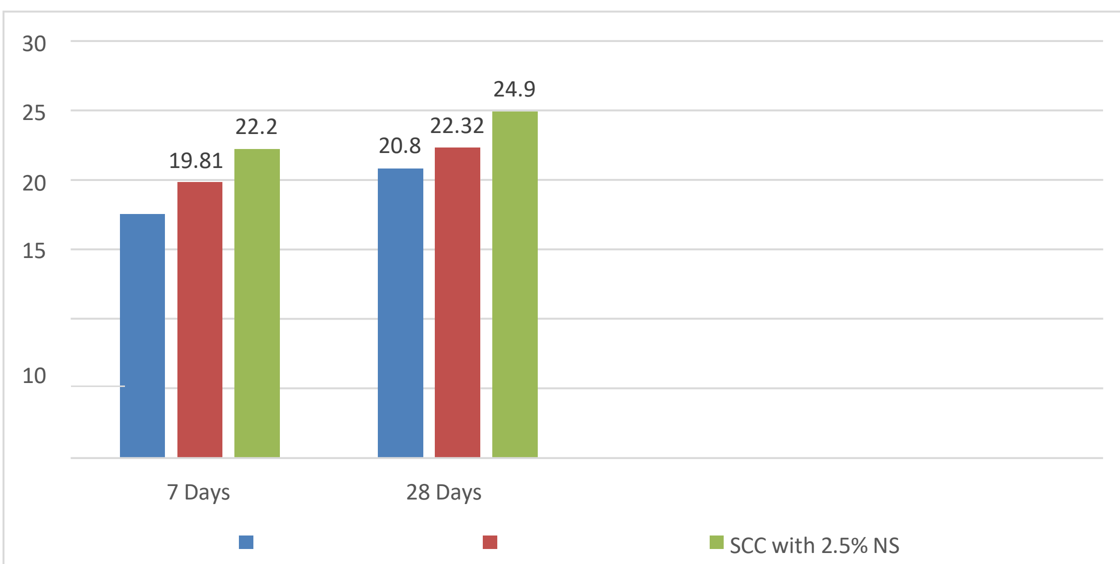


Fig 4.4.3 Compressive Strength of Nominal Concrete, SCC and SCC with NS 2.5%

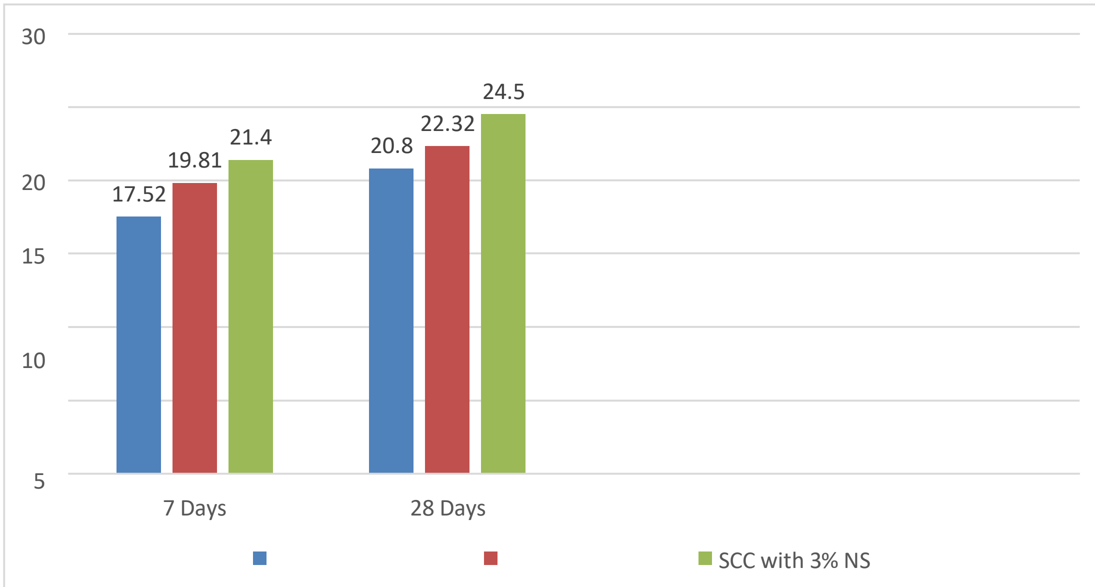


Fig 4.4.4 Compressive Strength of Nominal Concrete, SCC and SCC with NS 3%

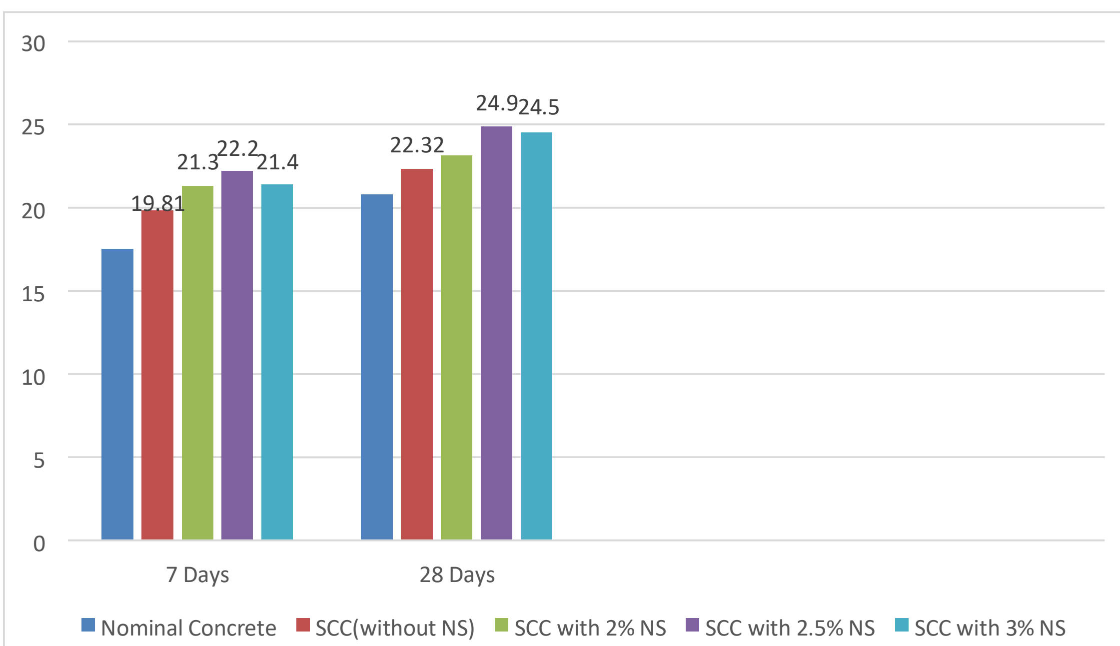


Fig 4.4.5 Compressive Strength of Nominal Concrete, SCC without NS, SCC with 2% NS, SCC with 2.5% NS and SCC with 3% NS

Nano silica reacts with calcium hydroxide ($Ca(OH)_2$) to develop more of the strength carrying structure of cement: calcium silica hydrate (C-S-H). Hence there is an increase in the compressive strength in specimens in which cement is replaced by Nano-silica.

Table 4.4.4.2 Percentage increase in Compressive Strength

S.No	Dosage of Nano –Silica (% by weight)	Percentage increase in Characteristic Compressive Strength	
		7 Days	28 Days
1	2%	0.25	1.28
2	2.5%	2.26	1.38
3	3%	1.25	2.9

4.4.5 Split-Cylinder Test (Tensile Strength)

It is the standard test, to determine the tensile strength of concrete in an indirect way. This test could be performed in accordance with IS: 5816-1970.

A standard test cylinder of concrete specimen (300mm x 150mm diameter) is placed horizontally between the loading surfaces of Compression Testing Machine. The compression load is applied diametrically uniformly along the vertical diameter. Concrete cylinders split into two halves along this vertical plane due to indirect tensile stress generated by poisson's effect.

Due to this compressive loading, an element lying along the vertical diameter of the cylinder is subjected to a vertical compressive stress and a horizontal stress. The loading condition produces a high compressive stress immediately below the loading points. But the larger portion of cylinder, corresponding to its depth is subjected to uniform tensile stress acting horizontally. It is estimated that the compressive stress is acting for about 1/6 depth and the remaining 5/6 depth is subjected to tension due to poission's effect.

Assuming concrete specimen behaves as an elastic body, a uniform lateral tensile stress of

ft acting along the vertical plane causes the failure of specimen, which can be calculated from the formula as, **ft =** $\boldsymbol{2P/\pi DL}$

P= Compressive load at failure L= Length of cylinder

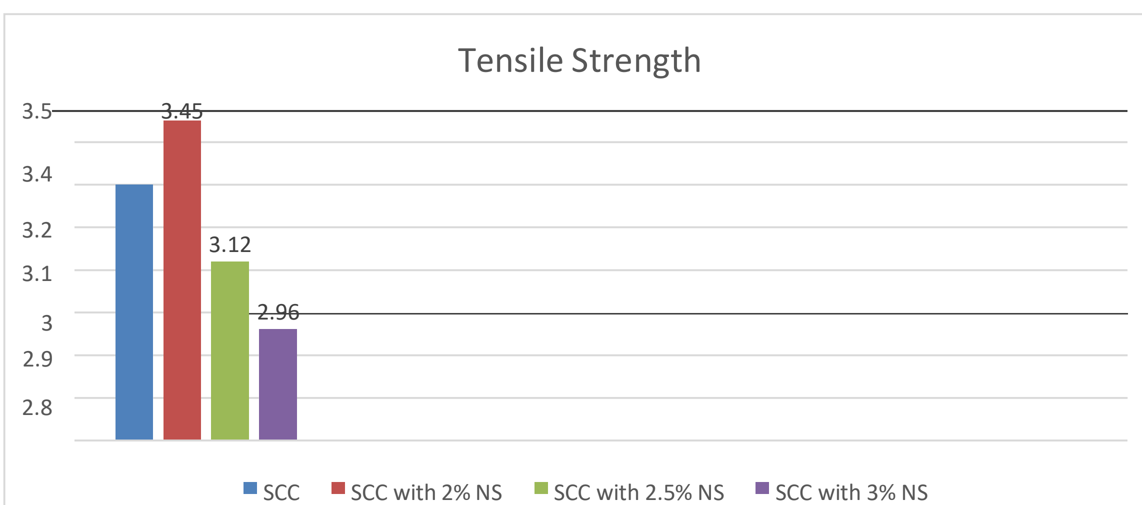
D= Diameter of cylinder

It can be observed that as the percentage of Nano-silica is increased, split tensile strength of concrete is also decreased. The split tensile strength of M20 grade controlled concrete is 3.306N/mm^2.

Table 4.4.5.1 Tensile strength of concrete

S.No	Mix Designation	Tensile Strength(N/mm^2)
1	SCC	3.30
2	SCC with NS 2%	3.45
3	SCC with NS 2.5%	3.12
4	SCC with NS 3%	2.96

Fig 4.5.1 Tensile Strength of SCC and SCC with NS dosages



4.6. *SEM Analysis (scanning electron microscopy)*

A **scanning electron microscope** (**SEM**) is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the surface topography and composition of the sample. The electron beam is scanned in a raster scan pattern, and the position of the beam is combined with the intensity of the detected signal to produce an image. In the most common SEM mode, secondary electrons emitted by atoms excited by the electron beam are detected using a secondary electron detector. The number of secondary electrons that can be detected, and thus the signal intensity, depends, among other things, on specimen topography. SEM can achieve resolution better than 1 nanometer.

Specimens are observed in high vacuum in conventional SEM, or in low vacuum or wet conditions in variable pressure or environmental SEM, and at a wide range of cryogenic or elevated temperatures with specialized instruments

In this current study, the hydrated cement pastes obtained from the samples are subjected to SEM analysis. The range of scale used in SEM analysis was 5 µm with the resolution of x30000. The detailed process of sample preparations for SEM analysis is described below.

After Compressive testing was finished, the cube samples are crushed and the hydrated cement was collected from the innermost core of the concrete cube sample. The collected samples are sieved through 300µ sieve.

The sample preparation was done by cone and quartering method for reducing the sample size. The sample was dispensed on flat surface so that it takes on a conical shape. The top of the conical shape was flattened. The cone is divided into quarters .Two opposite quarters was discarded; the other two are combined. The process was repeated until the suitable sample size was reached the sample preparation process for micro structural analysis is pictured below.

We went to SEM lab in OUCT (Osmania University College of Technology) at Osmania University, Hyderabad, Telangana.

3 samples of specimen was tested. This sample contain of

- Cement
- Nano silica
- Cement + nano silica gel.

Where cement + nano silica gel is made up by taking 300 grams of cement and 50 grams (0.3%) of nano silica and 0.55 water cement ratio. The sample is placed for 24 hours and allowed for harden the sample. After 24 hours sample is crushed and 10gm of powder is cared on to test.

Sample 1: Cement

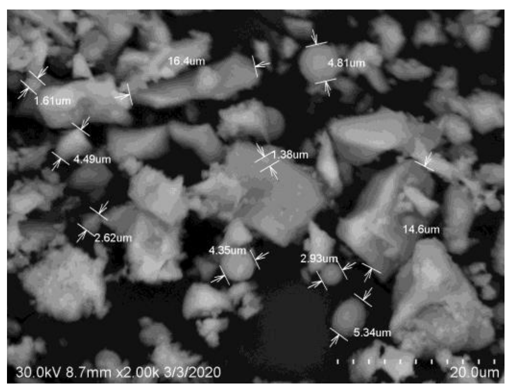


Figure 4.6.1:Cement

Specifications

- Pixel Size=49.60938
- Accelerating Voltage=30000 Volt
- Magnification=2000
- Working Distance=8700 um
- Emission Current=112000 nA
- Vacuum=60

- Micron Marker=20000
- Color Mode=Grayscale
- Condition=Vacc=30kV
- Mag=x2.00k
- WD=8.7mm
- Particles size of cement is in a range from 1.38 to 16.4 um.
- particles are in circular and irregular in shapes.
- Cement particles contain void spaces in between them.

Sample 2: Nano silica gel

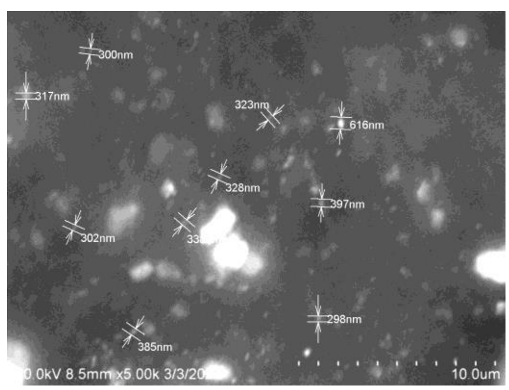


Figure 4.6.2: Nano silica gel

Specifications

- Pixel Size=19.84375
- Accelerating Voltage=30000 Volt
- Magnification=5000
- Working Distance=8500 um
- Emission Current=103000 nA
- Vacuum=60

- Micron Marker=10000
- Color Mode=Grayscale
- Condition=Vacc=30kV
- Mag=x5.00k
- WD=8.5mm
- Particles size of cement is in a range from 298 to 616 nm.
- particles are in circular and irregular in shapes.
- Surface tension between nano silica particles can be seen
- Particles of nano silica are closely packed and no space between particles is seen.

Sample 3: Nano silica gel + Cement

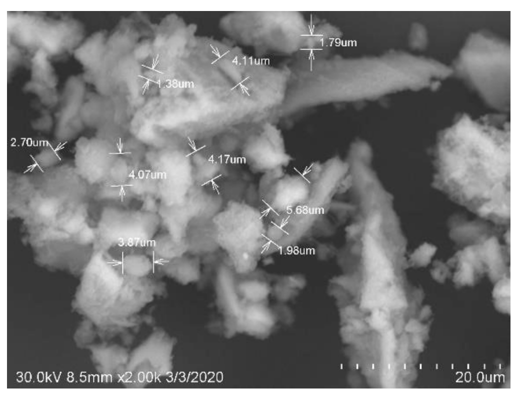


Figure 4.6.3: Nano silica gel + Cement

Specifications

- Pixel Size=49.60938
- Accelerating Voltage=30000 Volt
- Magnification=2000
- Working Distance=8500 um

- Emission Current=106000 nA
- Vacuum=60
- Micron Marker=20000
- Color Mode=Grayscale
- Condition=Vacc=30kV
- Mag=x2.00k
- WD=8.5mm
- Particles size of nano silica gel + cement is in a range from 1.38 to 5.68 um.
- particles are in angular, circular and irregular in shapes.
- Nano silica gel + cement particles are also closely packed they contain small amount void spaces in between them.

Chapter-5

CONCLUSION

From the above experimental study, it can be concluded that the optimum replacement of Nano Silica is 2.5% for M20 concrete. The compressive strength of cement concrete can be increased considerably by the addition of Nano-silica. Based on the experimental results, use of Nano- Silica as partial replacement of cement in small quantities is advantageous on the performance of concrete. Nano-Silica added in small quantities can improve the compressive strength. The increase in various strength characteristics of concrete containing nano-silica content can be due to the availability of additional binder in the presence of nano-silica. Nano silica has high amorphous silicon dioxide content. The Portland cement in concrete releases calcium hydroxide during the hydration process. The nano silica reacts with the calcium hydroxide to form additional binder material. The availability of additional binder leads to increase in the paste- aggregate bond, results improved strength properties of the concrete prepared with nano-silica combination.

From overall study, it is clear that the micro structural behaviour of concrete influences the strength characteristics of the mix. The addition of Nano materials changed the behaviour of microstructure of concrete and also influences the compressive strength of concrete mixes. From the test results of compressive strength, it was observed that replacement of concrete ingredients fairly improves on the strength of concrete mixes.

In SEM Observations, the existence of mineral elements and their reactions with the supplementary materials are studied which gives an initiative to understand the microstructure of the concrete mixes. Based on the comparison of the microstructure of concrete mixes, it is clear that the hydration process in the mixes with supplementary materials was different from conventional concrete mix.

Compressive strength with NS dosage of 2% has increased by 0.25 and 1.28 percentage for 7 and 28 days respectively compared to normal.

The percentage increase in compressive strength with NS dosage of 2.5% is 2.26 for 7 days and 1.38 for 28 days over normal concrete.

Similarly, a percentage increase of 1.25 for 7 days and 2.9 for 28 days has been observed when compared to that of concrete with 3% NS dosage.

The workability of the concrete along with Nano-silica has decreased.

The presence of nano silica is determined using sem Analysis in 4.3. There is increase in strength due to the density increase in Nano Silica.

PUBLICATIONS

- Published paper in **International conference on computing for sustainable development in civil engineering (ICCSDC-2021)**
- PAPER ID: ICCSDC-21-1059 (EXPERIMENTAL ANALYSIS ON SELF COMPACTING CONCRETE USING NANO SILICA MATERIAL)
- Published in june 2021

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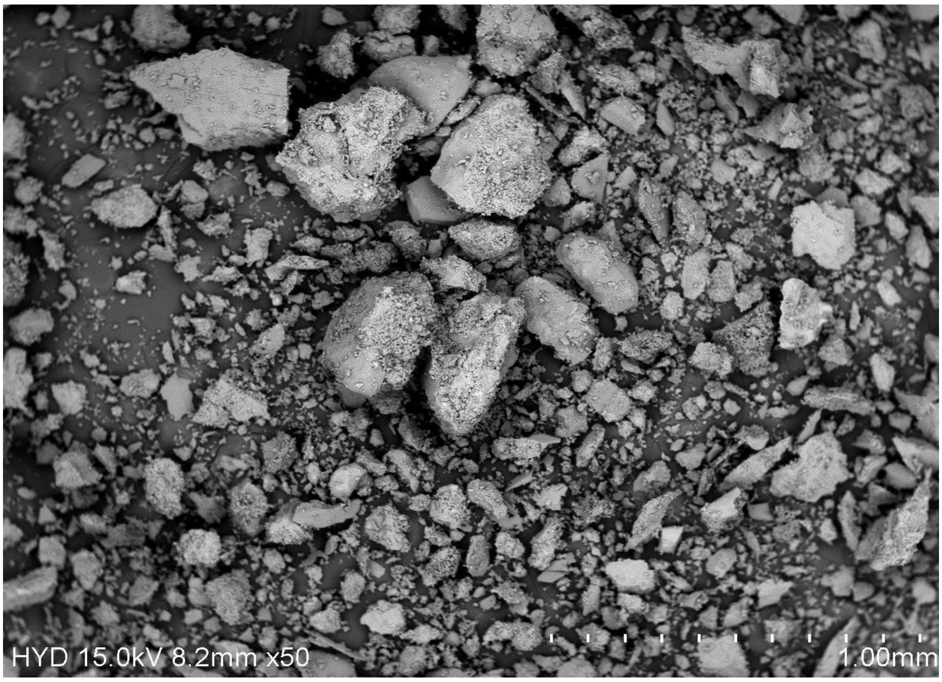

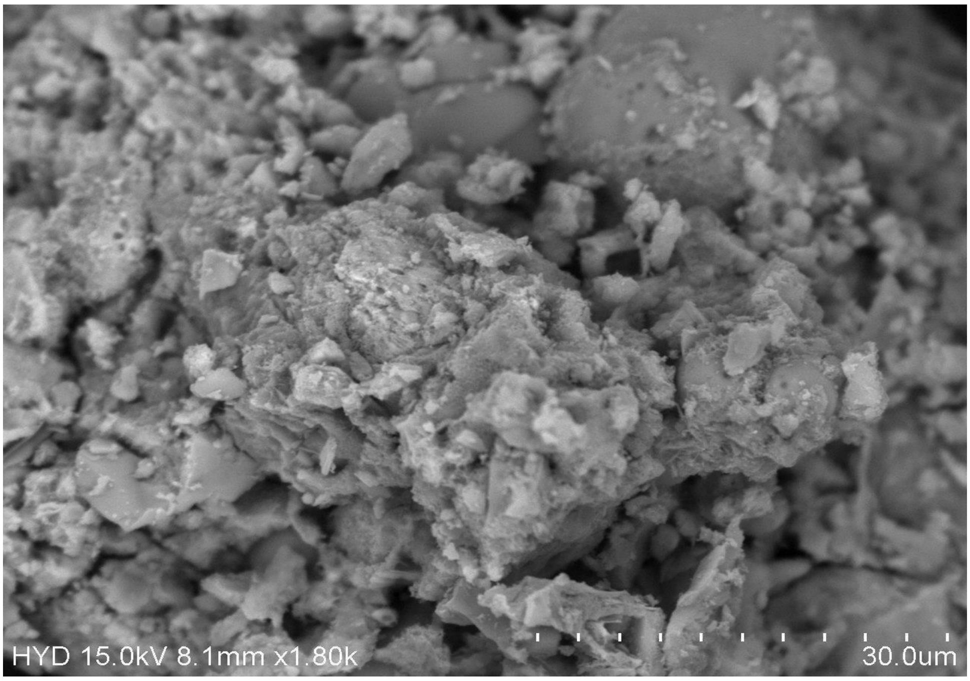

Fig 13.SCC WITH DOSAGE OF 2%
NANO-SILICA

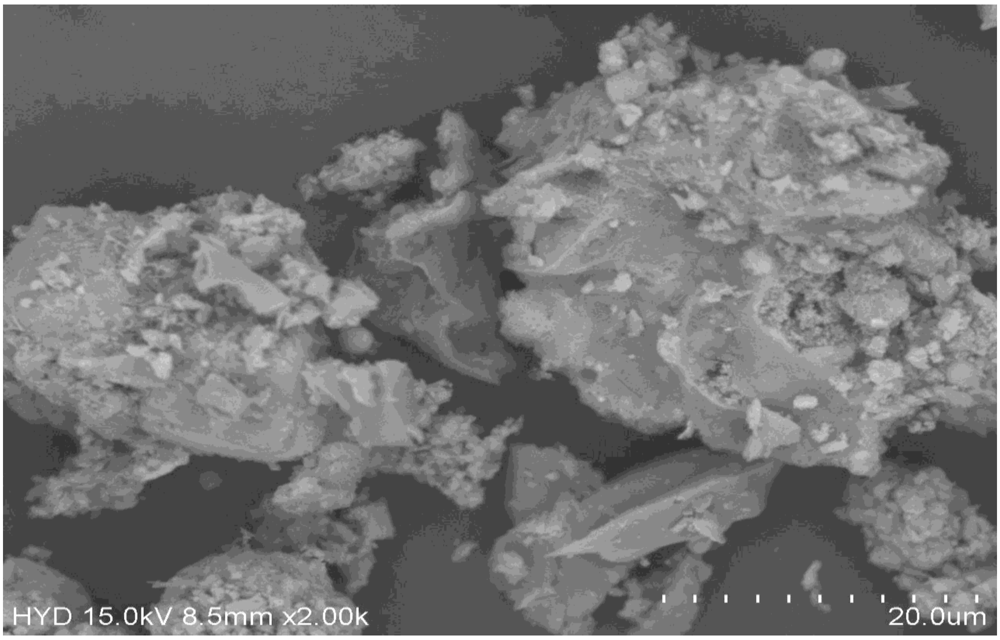

Fig 14.SCC WITH DOSAGE OF 2.5%
NANO SILICA

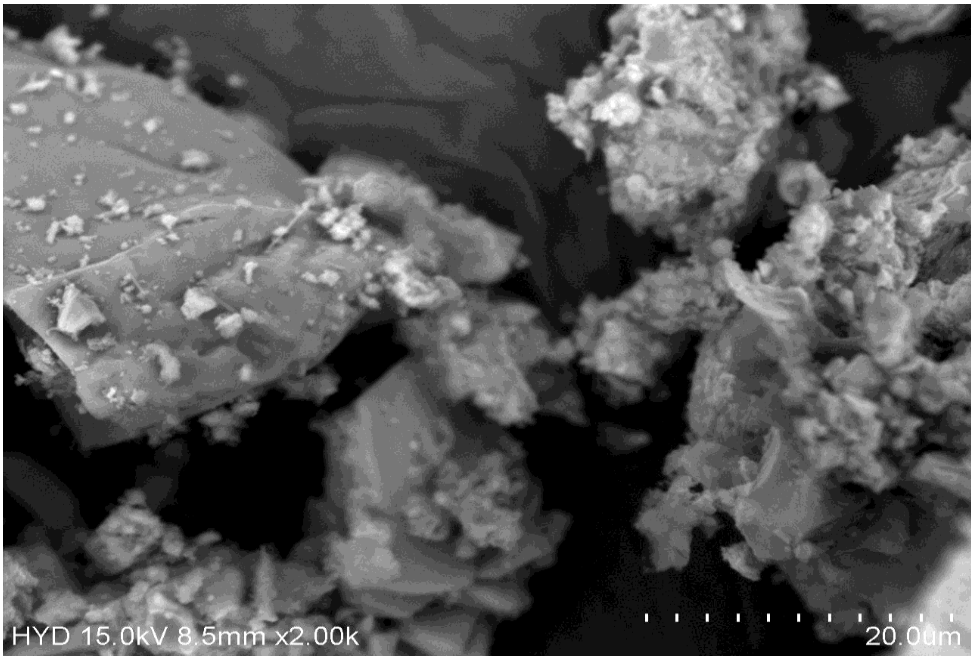

Fig 15.SCC WITH DOSAGE OF 3% NANO SILICA

Fig 16. SEM Analysis

A Major Project Report
On

EFFECT OF METKAOLINN AND PRE-TREATED OILPALM SHELL IN LIGHT WEIGHT CONCRETE

SUBMITTED TO

JawaharlalNehruTechnologicalUniversityHyderabad

In partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

by

E. RAM REDDY	**-**	**(17K81A0179)**
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Dhulapally, Secunderabad – 500 100

JUNE 2021

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BONAFIDE CERTIFICATE

This is to certify that the project entitled **EFFECT OF METKAOLIN AND PRE- TREATED OIL PLAM SHELL IN LIGHT WEIGHT CONCRETE**, is being submitted by **E.Ram reddy (17K81A0179), R.Sandeep reddy (17K81A0199), A.Sandeep reddy (17K81A01B1), P.Vivek (17K810195)** in partial fulfillment of the requirement for the award of the degree of **BACHELOR OFTECHNOLOGY IN CIVIL ENGINEERING** is recorded of bonafide work carried out by them. The result embodied in this report has been verified and found satisfactory.

Signature of Guide

Mr. M. RAJASHEKAR
Assistant Professor,
Department of Civil Engineering

Signature of HOD

Ms. Sandhya Kiran. J.K
Professor& Head of the Department
Department of Civil Engineering

Internal Examiner

External Examiner

Place:

Date:

DECLARATION

We, the students of **Bachelor of Technology** in **Department of Civil Engineering**, of the Academic Year:2017 - 2021, St. Martin’s Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project entitled **Effect of Metkaolin and Pre-treated Oil Palm shell in Light Weight Concrete** is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been carried by taking care of Engineering Ethics. The result embodied in this project report has not been submitted in any university for award of any degree.

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R. SANDEEP REDDY	(17K81A0199)
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ABSTRACT

Oil palm shell (OPS) is a bio solid waste in palm oil industry in the tropical countries which Could be used as aggregate in concrete mixture. Since 1984, OPS has been experimented as Natural lightweight aggregate in research studies to producelightweight concrete (LWC). Oil plam shell treated with cement to improve its engineering properties. Metakolin is replaced with cement as binding particle.Project study with the special concrete such as light weight concrete by using oil palm shell Asa replacer to the coarse aggregate light weight concrete having low density, reduction ofDead load. The reduction in density produced by using oil palm shell as a partial replacement Of coarse aggregate in concrete. In this investigation M20 grade has used and coarse Aggregate was replaced by various percentage of OPS i.e.0%,,20%,40%,50%. Then Determine the compression, tensile, flexural strength of concrete to check the favourable Replacement of OPS concrete. Finally, the results are compared with the nominal concrete. Light weight concrete is used for pavement filling and wall panels etc. From the test results, it Could be summarized that OPS content should not exceed 50% of total volume of coarse Aggregate.

Keywords: oil palm shell, light weight concrete, palm kernel shell.

CHAPTER – I

INTRODUCTION

1.1 General

There were many experimental works conducted to improve the property of the concrete by putting new materials, whether it is natural material or recycled materials or synthetic materials in the concrete mix. A large number of agricultural wastes were disposed in most oftropical countries especially in Asia for countries like Thailand, Philippines and Malaysia. If the waste cannot be disposed properly it will lead to social and environmental problems. The high cost of conventional building material is a major factor affecting housing delivery in Malaysia. This has necessitated research into alternative materials of construction. The present investigation deals with the various characteristics of the basic ingredients of concrete
e.g. cement, oil palm shell (OPS, fine aggregate and coarse aggregate.

Lightweight concrete, similar to normal weight concrete, is a mixture of water, Portland cement or Ordinary Portland Cement (OPC), and aggregate. Light-weight aggregate concrete uses a variety of aggregates with lower density than normal weight concrete. LWA can be divided into two categories.

- Those occurring naturally and are ready to use only with mechanical treatment, i.e., crushing and sieving.
- Those produced by thermal treatment from either naturally occurring materials or from industrial by-products, waste materials, etc

In this study, oil palm shell is used as light weight aggregate Production of lightweight concrete is a technology aimed at reducing dead load on structures and to reduce the overall cost of the structure. Nearly all LWACs are fire resistant. In addition, depending up-on the densities and strength, the concrete can be easily cut, nailed, drilled, and chiselled with ordinary wood working tools. The use of agricultural waste as aggregates can provide an alternative to conventional methods for production of lightweight aggregates. Structuralconcrete with densities from 1000 to 2000 kg/m3 can be prepared. Compressive strength upto 80MPa can be achieved. Structural lightweight concrete is an important and versatile material in modern construction. It has many advantages of dead load reduction, high thermal insulation. If floors and wallsare made up of light weight concrete, it leads to economy of structure. It also lowers power consumption for extreme climatic condition due to possessing property of low thermalconductivity. The use of lightweight concrete is gaining wide acceptance in building construction, obviously due to the considerable reduction in mass. Reduction in weight by theuse of light weight aggregate is preferred especially for structures built in seismic zones. Reduced dead load by using lightweight aggregate results in reduction of earthquake damages to structures. The cement content is a prominent factor in the physical/mechanical and durability properties of lightweight aggregate concretes.

Nowadays lightweight concrete is commonly used in precast and prestressed components. Lightweight concrete offers design flexibility and substantial cost savings by providing less dead load, improves seismic structural response, better fire rating, decreased storey height, smaller size structural members, lower foundation cost, and less reinforcing steel. The highly porous microstructure of lightweight aggregate gives it low density and better insulation and make that the concrete made with lightweight concrete exhibit lower thermal conductivity than that of normal weight concrete. Therefore, lightweight concrete provides more efficient fire protection than dense aggregate as it is less liable to spalling and has a higher thermal insulation.

Lightweight concrete plays an important role in structural engineering and its use issteadily increasing. It is defined as a type of concrete which includes an expanding agent in that it increases the volume of mixture. And mainly it is lighter than conventional concrete with dry density of 300kg/m^3 up to 1840kg/m^3. The reduction in weight by use of lightweightconcrete will be advantageous, especially for building structures.

Structural lightweight concrete has an in-place density (unit weight) on the order of 1440 to 1840 kg/m^3 compared to normal weight concrete with a density in the range of 2240 to 2400 kg/m^3. For structural applications the concrete strength should be greater than 17 Mpa. The concrete mixture is made with a lightweight coarse aggregate. In some cases, a portion or the entire fine aggregate may be a lightweight product. There are other classes of non-structural lightweight concretes with lower density made with other aggregate materials and higher air voids in the cement paste matrix, such as in cellular concrete. These are typically used for their insulation properties. The above properties focus on structural lightweight concrete.

Lightweight concrete is defined as a concrete that has a density, after oven drying, that isn’tlarger than 2000 kg/m3, total or partially produced with porous structure aggregate. Nowadays, the use of lightweight concrete is increasing, not only for structural applications, but also for other purposes, such as rehabilitation or pavement filling. The application of lightweight concrete on pavements is increasing, mainly due to the lower self-weight compared to the ordinary concrete, making possible the decrease of loading in the structure. However, one of the major problems that concrete has is the time that it takes to dry out, meaning, the time that the water takes to come out of the concrete, delaying the coating and causing anomalies on this one. Since, the drying process is slow, it is necessary to know the water content that is acceptable in the concrete so there isn’t any problem when a coating,that is sensitive to humidity, is applied. This dissertation has the aim of knowing the water content of concrete, throughout time, in order to estimate how long it does take to dry depending on the lightweight aggregate used.

ROLE OF METAKOLLIN

The raw material that is used in the manufacture of metakaolin is kaolin clay. Kaolin is a fine,white clay that is using from ancient times in the manufacture of porcelain. The prefix meta that is used to express change. Compared to other pozzolans raw metakaolin is highly reactive. Metakaolin is a useful admixture, cement and concrete applications. Partial replacement of metakaolin in mixture gives engineering properties likecompressive and tensile strength. It is the finest substance and has size of particle as 3 micrometers. It is obtained by calcination of kaolinitic clay at a temperature between 500°c and 800°c. Between 100 and 200°c, clay minerals lose most of their adsorbed water. Between 500 and 800°c kaolinite becomes calcined by losing water throughdihydroxylation. The raw material input in the manufacture of metakaolin ($Al_2Si_2O_7$) is kaolin clay. Metakaolin combines with the calcium hydroxide to produce additional cementing compounds, the material responsible for holding concrete together. Stronger concrete is formed with less calcium hydroxide and more cementing compounds. Metakaolin, because it is very fine and highly reactive, gives fresh concrete a creamy, non-sticky texture that makes finishing easier. Metakaolin is a Dehydroxylated form of the clay mineral kaolinite. Stone that are rich in kaolinite are known as China clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of metakaolin is smaller than the cement particles. Considering to having twice the reactivity of most other pozzolanas, Metakaolin is a valuable admixture for concrete/cement applications. Replacing of Portland cement with 8 to 20% by its weight, Metakaolin powder producesa concrete mix, which exhibits engineering properties, including the filler effect, the acceleration of OPC hydration, and the pozzolanic reaction. The filler effect is immediate, while the effect of Pozzolanic reaction occurs between 3 to 14 days.

Partial replacement of cement by metakaolin as SCMs in concrete causes chemical combination of the pozzolanic components of metakaolin with calcium hydroxide $Ca\ (OH)_2$ one of the by- products of the hydration reaction of cement in the presence of a high-water demand. This reaction produces stable calcium silicates hydrate (CSH) gel, which has cementitious propertiesand results in enhanced concrete strength and durabilityproperties. Moreover, in an experimental study observed that the metakaolin material is highly pozzolanic and can be used as a supplementary cementing material to produce high-performance concrete. However, incorporation of metakaolin in concrete demand more water and reduce the workability. Therefore, to achieve adequate workability, as well as high strength, the use of a water reducer, such as Metakaolin is required to improve the flow and workability of the modified concrete mix. The current research is designed to provide further understanding of the effect of the partial replacement of cement using metakaolin as the supplementary cementing materials and addition of polymers on the mechanical, durability and microstructure features of concrete, aiming to preserve the environment by reducing CO2 emissions in addition to the improvement of the concrete properties. It also investigates the effect of additional recycled plastic and glass fiberas reinforcements used in the modified concrete.

ROLE OF CEMENT WASH

Cement wash is done to increase the specific gravity and to decrease the water absorption of the oil palm shell aggregate.For every 300gms of OPS, 100gms of cement with sufficient water is used .The mixture is then naturally dried for 24 hrs and the tests are conducted after 24 hrs. The specific gravity is increased from 1.2-1.6 and water absorption value is decreased by 20%.

1.2 Objectives

- To develop light weight concrete.
- To determine whether Pre-treated oil palm shell concrete and metakaolin can be used as astructural concrete.
- To study the properties of the pre-treated oil palm shell and Metakaolin concrete tocompare it with the properties of the normal weight concrete of similar grade (M20).
- To know whether cement treatment of Oil palm shell can improve its properties or not.

• To determine the optimum content of pre-treated oil palm shell as substitute for coarseaggregate in concrete.

• To determine the compressive strength and flexural strength of light weight concretehaving density below 1800kg/m3

• To study the effect of various types replacements (0%,20%,40%,50%) of natural aggregate by light weight aggregate (OPS) and conventional concrete on 7,21 and 28days compressive strength in order to decrease the self-weight of structure.

1.3 Background of The Study

In many developed countries, due to the increasing cost of raw materials and the continuous reduction of natural resources, the use of waste materials is a potential alternative in the construction industry. This will have the double advantage of reduction in the cost of construction material and also as a means of disposal of waste. It can be used as building materials of high quality and can be used in construction in the near future.

Recycling or use of solid waste generated from most agricultural and manufacturing industries is very profitable. The anxiety about enormous waste production, resource preservation, and material cost has focused attention for the reuse of solid waste. Material recovery from the conversion of agricultural wastes and industrial wastes into useful materials has not only environmental gains, but may also preserve natural resources. It is desirable that a study on the use of various types of solid waste effective has received greater attention in the last few decades.

The palm oil industry in Malaysia accounts for more than half of the total world productionof palm oil and is expected to rise again as a result of the increase in global demand for vegetable oil. However, it is also a main contributor to the pollution problems in the country, covering 2.6 million tons of annual production of solid waste in the form of oil palm shell (OPS) (M.N. Amiruddin, 1998). contributing to the many 2 environmental problems associated with diverse ecosystem (Tomas U. Ganiron Jr, 2013).

OPS are hard endocarp surrounding the palm kernel. Wide availability of resources is still notused commercially. The practice of burning waste disposal in the industry is usually done in away that is not under control and many contribute to environmental pollution. OPS are light and naturally-sized, they are best suited to replace the aggregate in concrete construction. Become hard and organic origin, they will not contaminate or leach to produce toxic substances when they are bound in a matrix of concrete. OPS concrete can be potentially used in concrete applications that require low medium strength such as path and infill panel for floorings and walls. The use of oil palm shell will cause lighter concrete because of the low density (Mannan, M. A and Ganaphaty, C, 2002). One of the suggestions in the forefront has been the sourcing, development and use of alternative, non-conventional local construction materials including the possibility of using some agricultural wastes and residues as construction materials. As the natural fibres are agriculture waste, manufacturing natural product is, therefore, an economic and interesting option. Palm oil shows diversity in size, weight, shape and colour, depending on genetic diversity and maturity of the nut at harvest (Ohler, 1999).

1.4 Problem Statement

The development of the industry intensified today has brought a lot of revenue and the rest ofthe industry such as oil palm shells. The rest of the industry should be dealt with a perfect or original use the rest of the waste material this by generating a new product.

Additionally, this natural raw material resources increasingly limited means of disposal is the need to have other alternatives to make natural material waste to useful materials. One way isby using the Palm shells to replace the coarse aggregate in concrete. However, the test needs to be done in advance against the concrete to make sure it went through the concretespecifications has been defined in terms of strength and long-term durability. Example, desertsand generally not suitable to use for construction because the wind erosion of sand in the desert results in smooth and desert the next problem is noise pollution from the quarry of sound emitted as a result of fragmentation of rocks to produce aggregate. With the availability of replacement of natural ingredients such as palm oil shell, then the use of the aggregate can be reduced and can reduce breakage of rocks on a hill and necessarily will reduce noise noisy as a result of bombs breaking and machinery used.

1.5 Scope of Study

Scope of this study focus on the influence of using oil palm shells as partial replacement of coarse aggregate and metakolin asa replacement of cement in concrete production. This study

is also focusing on the characteristics of concrete grade M20 using Oil Palm shells as coarse aggregate in concrete material spare parts to replace the granite at a different percentage replacement 0%,20%,40% and 50% of the coarse aggregate volume. Studies using the cube size

150mm x 150mm x 150mm and prism size 100mm x 100mm x 500mm and cylinder size300mm length, 150mm dia. The study carried out for comparison with normal concrete madein terms of strength, workability, and mode of failure M20. The concrete mix was using Composite Portland cement. The cube test and tensile test and flexural test for concrete were tested within the range of 7, and 28 days according to the curing period.

1.6 Types of Lightweight Concrete Based on Density and Strength

- Low density concrete
- Moderate strength concrete
- Structural concrete

1.6.1 Low Density Concrete

These are employing chiefly for insulation purposes. With low unit weight, seldom exceeding 800 kg/m³, heat insulation value is high. Compressive strength is low, regarding from about 0.69 to 6.89 N/mm².

1.6.2 Moderate Density Concrete

The use of these concrete requires a fair degree of compressive strength, and thus theyfall about midway between the structural and low density concrete.
These are sometimes designed as ‘fill’ concrete. Compressive strength is approximately 6.89 to 17.24 N/mm² and insulation values are intermediate.

1.6.3 Structural Concrete

Concrete with full structural efficiency contain aggregates which fall on the other end of the scale and which are generally made with expanded shale, clay, slates, slag, and fly-ash. Minimum compressive strength is 17.24 N/mm².Most structural LWC are capable of producing concrete with compressive strength in excess of 34.47 N/mm².Since the unit weight of structural LWC are considerably greater than those oflow density concrete, insulation efficiency is lower. However, thermal insulationvalues for structural LWC are substantially better than Normal weight concrete.

1.7 Uses of Lightweight Concrete.

- Screeds and thickening for general purposes especially when such screeds orthickening and weight to floors roofs and other structural members.
- Screeds and walls where timber has to be attached by nailing.
- Casting structural steel to protect it’s against fire and corrosion or as a covering for architectural purposes.

- Heat insulation on roofs.
- Insulating water pipes.
- Construction of partition walls and panel walls in frame structures.
- Fixing bricks to receive nails from joinery, principally in domestic or domestic type construction.
- General insulation of walls.
- Surface rendered for external walls of small houses.
- It is also being used for reinforced concrete.

1.8 Advantages of Lightweight Concrete

1.8.1 Reduced dead load of wet concrete allows longer span to be poured un-propped. This save both labour and circle time for each floor.

1.8.2 Reduction of dead load, faster building rates and lower haulage and handling costs. The eight of the building in term of the loads transmitted by the foundations is an important factor in design, particular for the case of tall buildings.

1.8.3 The use of LWC has sometimes made it possible to proceed with the design which otherwise would have been abandoned because of excessive weight. In frame structures, considerable savings in cost can be brought about by using LWC for the construction floors, partition and external cladding.

1.8.4 Most building materials such as clay bricks the haulage load is limited not by volume but by weight. With suitable design containers much larger volumes of LWC can hauleconomically.

1.8.5 A less obvious but nonetheless important characteristics of LWC is its relatively low thermal conductivity, a property which improves with decreasing density in recent years, with the increasing cost and scarcity of energy sources, more attention has beengiven the formerly to the need for reducing fuel consumption while maintaining, and indeed improving, comfort conditions buildings. The point is illustrated by fact that a 125 mm thick solid wall of aerated concrete will give thermal insulation about four times greater than that of a 230 mm clay brick wall.

1.8.6 Screeds and thickening for general purposes especially when such screeds orthickening and weight to floors roofs and other structural members.

1.8.7 Screeds and walls where timber has to be attached by nailing.

1.8.8 Casting structural steel to protect it's against fire and corrosion or as a covering for architectural purposes.

1.8.9 Heat insulation on roofs.

1.8.10 Insulating water pipes.

1.8.11 Construction of partition walls and panel walls in frame structures.

1.8.12 Fixing bricks to receive nails from joinery, principally in domestic or domestic type construction.

1.8.13 General insulation of walls.

1.8.14 Surface rendered for external walls of small houses.

1.8.15 It is also being used for reinforced concrete.

1.9 Advantages of Lightweight Concrete

The primary use of light weight concrete is to reduce the dead load of the concrete structure, which then allows the structural designer to reduce the size of the column, footing and other load bearing elements. Structural lightweight concrete mixture can be designed to achieve similar strength as normal weight concrete. The same is true for the other mechanical and durability performance requirements. Structural lightweight concrete provides a more efficient strength to weight ratio in structural elements. Lightweight Concrete is used when structural concerns require. Lightweight Concrete is ideal for roof deck repairs, stair pan fill, elevated floor slabs or overlays on existing floor decks. It can also be used for appliance platforms, curbs, down spout gutters, balconies, floors, fish ponds, walls, setting posts, castings, steps, or virtually any job that would normally be done with standard weightconcrete. Use it where ease in lifting and carrying is important. Lightweight Concrete also offers slower temperature transfer rates than standard weight concrete, resulting in improved insulation factors.

Nowadays with the advancement of technology, lightweight concrete expands its uses, for example, in the form of perlite with its outstanding insulating characteristics. It is widelyused as loose-fill insulation in masonry construction where it enhances fire ratings, reduces noise transmission, does not rot and termite resistant. It is also used for vessels, roof decksand other applications.

The use of high strength, high performance lightweight concrete (HSLWC) can result in longer span lengths and lighter weight girders. Previous research at the Georgia Institute of Technology (Georgia Tech) showed that HSLWC bridge girders can be constructed with 10,000 psi (69 MPa) compressive strength concrete with a very low permeability, while achieving up to a 20% decrease in shipping weight

CHAPTER - II

LITERATURE REVIEW

Freedy L. Roberts. et. al., (1996). The aggregates that used in mixtures should accordingly to its specifications for durability, soundness, hardness and others. The form of the aggregates must be crushed and contains some allowable percentage of sand composition

Yang H.Huang, (2004). The aggregates used should meet these five requirements such as it must be strong and tough, it must be durable, easy to crush without many flaky particles, lowin porosity, low in permeability and the particle size and the gradation is suitable for the pavement type

Asean Sources.Com, (2004). According to Asean Sources. Com. Malaysia for many decadeshas been known as the main manufacturers of palm oil. The waste that been produced in palm oil mill known as clinker

Omar.w. et.al. (2001). As the aggregates were decreasing rapidly, clinker was explored as a suitable material to replace aggregate in Hot Mix Asphalt. Palm oil clinker can be found easily in our country as Malaysia is the largest manufacturer of palm oil products. Malaysia isholding the main production for world palm oil production as 51%, 62% for the world exports and 30% for the oils and fats exportation. Combustions of shell and fibre from the palm oil create clinkers as waste material which will be thrown away from mill .The significant usage of clinker as the artificial lightweight aggregate in HMA in road pavement will benefit us from the aspect of waste management from palm oil mill and minimize the demand on natural aggregate in the road construction industry.

Neville A.M, et al (1995) Usage of clinkers also will minimize the cost of the road construction due to the rate of palm oil clinker is cheaper than the natural aggregate.

Atkins, (2003) According to Atkins, Surface texture refers to the surface patterns and the smoothness of the aggregate. Particle shape and surface plays a major role in creating bond between aggregate and material for cementing. For example, rough surface texture provides something to grip, create a good bond and produced stronger hot mix asphalt concrete. It alsocreates higher friction strength if there is a force to slide over a particle over a particle. Some aggregates with good surface texture but the smoothness of texture might decay under the heavy traffic loading.

Yang H. Huang, (2004) Crushed gravel or crushed stone normally used for this asphalt pavements. These crushed aggregates have various section of shape for instant irregular and angular particles that will tend to interlock when compacted or consolidated. Mixes that contain both round and angular particles tend to result in high workability. Normally, coarse aggregate particles are made of crushed stone or crushed gravel.

Freedy L. Roberts. et. al., (1996) density is measuring of the weight per unit of volume of a substance. In another hand, Specific gravity is the ratio between the densities of the substance to the water

Yang H. Huang, (2004), Specific gravity will help us in determining the amount of asphalt needed in the hot mix asphalt. Highly absorptive aggregate will absorb asphalt at the starting of the mixture until the mix cools down. Then the aggregate will undergo the bonding process whereby the porous aggregate needs more asphalt compared to less porous asphalt

T. **Ashworth et al., (1992)** reported that Thermal conductivity of concrete increases with increasing moisture content. Since water has conductivity about 25 times that of air, it is clearthat when the air in the pores has been partially displaced by water or moisture, the concrete must have greater conductivity.

K. Guru Kesav Kumar, et al (2016) M20, M25 and M30 grade of concrete used with replacement percentage 10% and 20% can be effectively used for structural purpose. Replacement of 30% can only be used for non-structural purpose and optimum strength of replacement for 20% is effective.

Swamy R.H & Lambert G.H (1984) studied above the light weight aggregate and proved that the thermal efficiency is very more to the light weight concrete and the load carrying capacity of the light weight concrete is same as the normal concrete by using some mineral and chemical admixtures.

Alengaram et al., (2010) examine the effect of aggregate size and proportion on strength properties of palm kernel shell concrete. The research presents information on the physical and mechanical properties of different sizes of palm kernel shells (PKS) used as lightweight aggregates (LWA) and their influence on mechanical properties of palm kernel shell concrete (PKSC).

Daneshmand and Saadatian (2011), investigated the influence of oil palm shell on workability and compressive strength of high strength concrete. In the experiment, concrete was produced by different percentage of OPS i.e. 10%, 20%, 30%, 40% and 50% by weight of coarse aggregate. The results demonstrated that the workability for OPS samples shows a relatively medium to high workability with slump values ranging from 28 to 50mm and compaction factor from 0.93 to 0.95. It was concluded that the study can be a valuable contribution to the production of high strength concrete as well as lightweight concrete particularly in construction of high rise buildings.

Shafigureh et al., (2010) carried out a study on mix design and mechanical properties of oil palm shell lightweight aggregate concrete. It was reported that research over the last two decades shows that OPS can be used as a lightweight aggregate for producing structural lightweight aggregate concrete. However, the study concluded that significant achievements can be attained in OPS concrete and comparing it with other lightweight aggregate concrete.

P.C.Taylor: presently a professor at Wuhan University of Technology has said that mineral admixtures affect the physical and mechanical properties of High Strength Structural Light Concrete. Addition of Fly Ash enhances the compressive strength and splitting tensile strength of HSSLC when FA was more than 20% in cementitious materials, its 28 days compressive strength and splitting tensile strengths are less than those of the concrete withoutFA. Addition of silica fume enhances the compressive strength about 25% and splitting tensile strength also. Incorporating.

CHAPTER - III

MATERIALS & METHODOLOGY

3.1 Materials

3.1.1 Cement

Cement is the most common binder which allows to make structures, and used in construction that sets, hardens and adheres to other materials, binding them together. Cement starts to set when mixed with water which causes a series of hydration chemical reactions. The constituents slowly hydrate and the mineral hydrates solidify;the interlocking of the hydrates gives cement its strength. Contrary to popular perceptions, hydraulic cements do not set by drying out, proper curing requires maintaining the appropriate moisture content during the curing process. If hydraulic cements dry out during curing, the resulting product can be significantly weakened.

Cement is seldom used solely, but is used to bind sand (fine aggregate) and gravel (coarse aggregate) together. Cement is used with fine aggregate to produce mortar for masonry, or with sand and gravel aggregates to produce concrete. Portland cement is by far the most common type of cement in general use around the world. This cement is made by heating limestone (calcium carbonate) with other materials to 1450 °C in akiln, in a process known as calcination, whereby a molecule of carbon dioxide is liberated from the calcium carbonate to form calcium oxide, or quicklime, which then chemically combines with the other materials that have been included in the mix to form calcium silicates and other cementitious compounds. The resulting hard substance, called 'clinker', is then ground with a small amount of gypsum into a powder to make 'Ordinary Portland Cement'(OPC), the most commonly used type of cement (often referred to as OPC). Portland cement is a basic ingredient of concrete, mortar and most no specialty grout. The most common use for Portland cement is in the production of concrete. The cement used is Ordinary Portland Cement (OPC) of53 grade without any lumps. The physical properties of cement are tested in the laboratory as per IS: 12269-1999 code and the results are tabulated in the Table3.4.

Figure - 3.1: Cement

3.1.2 Fine Aggregate

Locally available river sand confirming to IS: 383-1970 was used as the fine aggregate in the concrete preparation. Aggregate is the granular material used to produce concrete or mortar and when the particles of the granular material are so fine that they pass through a 4.75mm sieve, it is called fine aggregate. It is widely used in the construction industry to increase the volume of concrete, thus it is a cost saving material and you should know everything about the fine aggregate size, its densityand grading zone to find the best material.

Fine aggregate is the essential ingredient in concrete that consists of natural sand or crushed stone. The quality and fine aggregate density strongly influence the hardened properties of the concrete. The concrete or mortar mixture can be made more durable, stronger and cheaper if you made the selection of fine aggregate on basis of grading zone, particle shape and surface texture, abrasion and skid resistance and absorption and surface moisture. Fine aggregates are the structural filler that occupies most of the volume of the concrete mix formulas. Depending on composition, shape, size and other properties of fine aggregate can have a significant impact on the output.

Figure - 3.2: Fine Aggregate

3.1.3 Coarse Aggregate

Coarse aggregate of nominal size 12 mm, obtained from the local quarry confirmingto IS: 383:1970 was used. The properties of coarse aggregate are shown in Table-3.5.

Basically, aggregates are used as an economical option to lower down the cost of concrete usage. In simpler words, we can say that these are the fillers used in concretemix. The majority of construction applications use different coarse aggregate size, butit is essential to keep the characteristics in mind to get uniform and strong output. Theproper definition of coarse aggregate depicts that it is the important constituent of concrete and used to give body to the concrete mix while reducing the shrinkage. Around 70% to 80% of the total volume of the concrete is made up from coarse aggregates. In lots of construction applications, you can see coarse aggregates are performing an integral role, for instance, as a granular base under a slab and as a component in a mixture, such as asphalt or concrete mixtures. Coarse aggregates are generally categorized as per their shape and size. Depending on the shape they can be round, irregular, angular, flaky, and elongated. Apart from that, depending on the coarse aggregate size you can have gravels, cobble, and boulders in the category.From normal strength to high strength concrete, coarse aggregates can be used between the sizes 5 mm to 256 mm.

Figure - 3.3: Coarse Aggregate

3.1.4 Oil Palm Shell Aggregate

Oil Palm shell (OPS) is available in various shapes, such as curved, flaky, elongated, roughly parabolic, and other irregular shapes as shown in Figure 3.4. Before the OPS was used as aggregate, it was sieved and only aggregate passing through the 12.5 mm sieve and retained on the 4.75 mm sieve was used.

Oil Palm Shell (OPS) is one of the waste materials obtained during the crushing of palm nuts in the palm oil mills for palm oil extraction. These are agricultural waste products and are available in large quantities in the tropical regions of the world. Oil palm shells are mostly used as a source of fuel for domestic cooking in most areas where they occur.

Normally, the Oil Palm shell is obtained by breaking the palm nut. Shells are lightweight in nature, but hard and come in different shapes and sizes. Further, the shells are often dumped as waste products of the oil palm industry. In South EastAsia, Oil Palm Shell (OPS) is one of the most quantitative waste materials produced every year. Among different countries Malaysia produces approximately 4 million tons of oil palm shells annually. Hence, utilizing Oil Palm Shell would impose lower construction costs compared to other waste materials like rubber crump, plastic waste etc.

Every year, palm oil industries produce large volume of Oil Palm shell as waste material after the production of palm oil. This will increase the production of both palm oil and its wastes such ass Oil Palm shells. Oil Palm shells are not fully utilized and it has contributed to environmental pollution. This kind of waste material can be utilized to substitute the conventional coarse aggregate to produce concrete.

Figure– 3.4: Oil Palm Shell Aggregate

3.1.5 Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Clean potable water conforming to IS: 456 – 2000 was used for the preparation of concrete mixture. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. In practice, very often great control on properties of cement and aggregate is exercised, but the control on the quality of water is often neglected. Since quality of water affects the strength, it is necessary for us to go into the purity and quality of water. If water is fit for drinking it is fit for making concrete. This does not appear to be a true statement for all conditions. Some waters containing a small amount of sugar would be suitable for drinking but not for mixing concrete and conversely water suitable for making concrete may not necessarily be fit for drinking. Some specifications require that if the water is not obtained from source that has proved satisfactory, the strength of concrete or mortar made with questionable water should be compared with similar concrete made with pure water. Some specifications also made accept water formaking concrete if the pH of water lies between 6 and 8 and the water is free from organic matter.

• To develop light weight concrete.

3.1.6 Metakaolin:

The metakaolin used in this project was supplied by ASTRRA CHEMICALS, CHENNAI. under the trade name of Meta Star 501. It is a premium metakaolin produced by carefully controlled calcinations. It is a high quality pozzolanic material which is blended with Portland cement in order to improve the properties of concrete and mortars. Table shows the propertiesof the metakaolin used in this study.

Figure 3.5: metakaolin powder form

3.2 Tests on Cement

The following tests are performed in the concrete technology laboratory to determinethe properties of cement and the results are shown in the Table 3.1

- Normal consistency test
- Fineness of cement
- Specific gravity of cement
- Initial and final setting time
- Soundness of cement

3.2.1. Normal consistency test:

Take 250gm of cement and weight carefully and add 20% water in it. Care should be taken that mixing time is not less than 3min and gauging shall be counted from the time of adding water. Fill the paste in the mould. The excess paste to trim off and vibrationare given to remove air bubbles. Fix the 10mm dia. plunger in the moving rod and bring down in touch with the paste. Release the plunger. Repeat the procedure till it penetrate 33-34mm from the top & note down the water percentage.

Observations and Calculations:

Cement	**% Of water added**	**Penetration**
250 grams	27 X (250/100)	33
250 grams	28 X (250/100)	25
250 grams	29 X (250/100)	15
250 grams	30 X (250/100)	10
250 grams	31 X (250/100)	7

Table - 3.1 Normal Consistency

Result: The percentage of water for normal consistency for the given sample of Cementis 31.67%.

3.2.2 Fineness of Cement:

Weigh approximately 300g of cement to the nearest 0.01g and place it on the sieve. Agitate the sieve by swirling, planetary and linear movements, until no more fine material passes through it. Weigh the residue and express its mass as a percentage w1,of the quantity first placed on the sieve to the nearest 0.3 percent. Gently brush all the fine material off the base of the sieve. Repeat the whole procedure using a fresh 300g sample to obtain w2. Then calculate R as the mean of w1 and w2 as a percentage, expressed to the nearest 0.1 percent. When the results differ by more than 1 percent absolute, carry out a third sieving and calculate the mean of the three values.

Observation and Calculations:

Fineness of cement = W1+W2+W3/ avg x10= weight retain on sieve/total weight

Table - 3.2 Fineness of Cement

S. No	Weight ofcement (grams)	Weight of residue formed (grams)	Fineness of cement(%)
1	300	20	6.67
2	300	30	5.29
3	300	30	7.0

Result: Thefinesse of cement is 6.32%, which is less than 10%.

3.2.2. Specific gravity of cement:

Result: The Specific Gravity of cement is **3.14**

3.2.3. Initial and final setting time:

Take about 500gms of cement. Add water of standard consistency. To make cement paste. To make the surface of the cement paste is till smooth and Level. The whole assembly kept in vicat's apparatus.

Bring the needle in the rod gently near the surface of the test block and release it quickly allowing it to penetrate into the block and note the time. Repeat the proceduretill the needle fails to penetrate into the test block by 5mm to 7mm from the bottom ofthe mould. Generally, the initial setting time of cement is not less than 30min.

Observation:

- Quantity of cement = 250 grams.
- Water for standard Consistency = 31.67%

Observation Table:

Table - 3.3 Initial and Final Setting Time

Cement	% of water added	Time (sec)	Penetration (mm)
250 grams	0.85x 315 of weight of cement	5	0
250 grams	0.85x 315 of weight of cement	10	0
250 grams	0.85x 315 of weight of cement	15	0
250 grams	0.85x 315 of weight of cement	20	0
250 grams	0.85x 315 of weight of cement	25	3
250 grams	0.85x 315 of weight of cement	30	5
250 grams	0.85x 315 of weight of cement	35	6
250 grams	0.85x 315 of weight of cement	40	10

Result:

(a) The initial setting time of the cement sample is found to be 44 minutes (b) Thefinal setting time of the cement sample is found to be 600 Minute

S. No.	Parameter	Result
1	Normal consistency test	31%
2	Fineness of cement	6.32%
3	Specific gravity of cement	3.14
4	Initial setting time	44 min
5	Final setting time	600 min
6	Soundness of cement	6 mm

Table –3.4: Test results of cement

Table 3.5: chemical composition of cement

Component	Values %	Standard
AL_2O_3	4.19	3 – 5%
FE_2O_3	2.75	2 – 3.5%
Ca O	65.00	60 – 70%
SO_3	3.19	Less than3.5%
MgO	0.86	0.5 – 1.5%
Na_2O	0.14	Less than0.75%
K_2O	0.51	-
SiO_2	16.19	15 – 25%

Table 3.6: Chemical composition of Metakaolin.

Chemicals	**Percentage (%)**
Sio2	52.86
Al2o3	44.10
Fe2o3	0.45
MgO	0.20
Cao	0.28
Na2o	0.25
K2o	0.03
Tio2	0.36
Li2o	2

3.3 Tests on Aggregates

The following tests are performed in the concrete technology laboratory to determine the properties of fine aggregate, coarse aggregate, oil palm shell aggregate and the results are shown in Table-3.5.

- Specific gravity of fine aggregate
- Specific gravity of coarse aggregate
- Specific gravity of oil palm shell aggregate
- Water absorption test for oil palm shell
- Bulk unit weight of oil palm shell
- Fineness modulus of oil palm shell
- Los Angeles abrasion test (oil palm shell)
- Aggregate impact test (oil palm shell)
- Aggregate crushing strength test (oil palm shell)

Table - 3.7: Test results of aggregates

S. No.	Parameter	Result
1	Specific gravity of fine aggregate	2.64
2	Specific gravity of coarse aggregate	2.66
3	Specific gravity of oil palm shell aggregate	1.6
4	Water absorption of oil palm shell	28%
5	Bulk unit weight of oil palm shell	672.56 kg/m^3
6	Fineness modulus of oil palm shell	6.08
7	Los Angeles abrasion value (oil palm shell)	4.90%
8	Aggregate impact value (oil palm shell)	7.51%
9	Aggregate crushing value (oil palm shell)	8.00%

3.4 Methodology

Literature reviews related to the Oil palm shell (OPS) were collected and based on the literature survey preliminary works were performed. Works like collection of OPS was performed. Materials required for concrete such as coarse aggregate, fine aggregate,cement were collected. Basic tests were conducted on fine aggregate, coarse aggregate, cement, Oil palm shell, to check their suitability concrete making.

The properties of fine and coarse aggregates sieve analysis of fine and coarse aggregates, tests on cement are found out. The Study aims to investigate the strength related properties of concrete of M20 grade. The proportions of ingredients of the control concrete of grade M20 had determined by mix design as per IS code. Moulds were prepared to cast he specimen. Mould of size 150mm*150mm*150mm and cylinder mould150mm*300mm and prism mould 100*100*500 were cast with desired of partially replacement (0%, 20%, 40%, and 50%) of coarse aggregate. Casted Samples were tested after 7days and 28 days of curing Compressive strength and split tensile strength test and flexural strength was performed using casted concrete. Results were obtained and conclusion was arrived.

3.4.1 Flow chart representing the methodology

3.5 Mix Design

The mix design procedure adopted to obtain M20 grade concrete is in accordance with IS: 10262 - 2009.Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. The mix proportion obtained for normal M20 grade concrete is 1: 1.72: 2.83 with a water-cement ratio of 0.50.

3.5.1 Mix proportions

Coarse aggregate was partially replaced by oil palm shell aggregate in the range of varying 10%, 20%, 30%, 40%, and 50%. And the mix proportions have been recommended based on trial mixes. In the present study, M20 grade with design mix as per IS: 456-2000 was used. Concrete mix proportion by weight for one cubic meter and water cement ratio of 0.5. Gives the mix used for study.

Table - 3.8: Mix Proportions for conventional concrete

w/c Ratio	Cement	Fine Aggregate	Coarse Aggregate
0.50	394.32 kg/m^3	680.16 kg/m^3	1118.15 kg/m^3
0.50	1	1.72	2.83

Table - 3.9: Mix proportion of different % of oil palm shell aggregate.

Mix Designation	OPS %	Cement in kg/m^3	Metakaolin kg/ m^3 (40% of cement)	Fine Aggregate in kg/m^3	Coarse Aggregate (kg/m^3)	OPS in kg/m^3
M0	0%	236.6	157.72	680.16	1118.15	0
M2	20%	236.6	157.72	680.16	894.52	134.51
M4	40%	236.6	157.72	680.16	670.89	269.02
M5	50%	236.6	157.72	680.16	559.07	336.28

Table - 3.10: Mix proportions for light weight concrete.

Mix Designation	Description	Proportion [C: FA: CA: PA]
M_0	Control concrete of M20 grade	1 : 1.72 : 2.83 : 0
M_2	20% OPS aggregate + 80% coarse aggregate	1 : 1.72 : 2.26 : 0.34
M_4	40% OPS aggregate + 60% coarse aggregate	1 : 1.72 : 1.70 : 0.68
M_5	50% OPS aggregate + 50% coarse aggregate	1 : 1.72 : 1.41 : 0.85

3.6 Experimental Procedure

In the present experimental investigation pre treated oil palm shell (OPS) aggregate has been used as partial replacement of coarse aggregate in concrete mixes. Onreplacing coarse aggregate with different percentage of oil palm shell (OPS)

aggregate of 0%, 20%, 40% & 50%. The compressive strength, split tensile strength and flexural strength is studied at different ages of concrete cured in normal water.

3.7 Batching

Batching is the process in which the quantity or proportion of materials like cement aggregates and water, etc. are measured on the basis of either weigh or volume to prepare the concrete mix. Proper Batching improves the workability of concrete by reducing the segregation or bleeding in concrete. In this study the process of weigh batching is adopted.

The process of measuring ingredients or materials to prepare concrete mix is knownas batching of concrete. Batching can be done by two methods, volume batching and weight batching. Batching should be done properly to get quality concrete mix.

3.7.1 Methods of Batching Concrete

i. Volume Batching

- In volume batching, materials are measured on the basis of volume. It is less precisemethod of batching
- Measurement boxes or gauge boxes of known volume are used to measure materials.
- Cement is taken in the form of bags, where volume of one bag of cement (50 kg) istaken as 35 litres.
- Volume of Gauge box used is made equal to the volume of one bag of cement whichis 35 litres.
- Gauge boxes are generally deeper and contains narrow top surface and they are madeof timber or steel or iron.
- Volumes of different sized fine aggregate and coarse aggregate are measuredindividually by these gauge boxes.
- Water is measured using water meter or water cans of known volume are used.

Weigh Batching

- In this method, Materials are measured on the basis of weight. It is accurate method ofbatching.
- Weigh batchers or other types of weighing equipment are used to measure weight of materials.

- Cement,metakaolin, fine aggregate, coarse aggregate and water are taken by weighing.
- Weigh batchers used are available in two types namely mechanical weigh batcher and electronic weigh batchers.
- In mechanical weigh batchers, weights are measured using spring and dial gauge arrangement and it is widely used equipment in weigh batching.
- In electronic weigh batchers, electronic scales and load cells supported by hoppers areused to measure the weight of ingredients of concrete.
- Weigh batchers available are may be Manual or semi-automatic or fully automatic. Manual type is used for small concrete production job while other two types are used for large concrete production.
- In case of semi-automatic weigh batching, aggregate container gates are lifted manually and it is automatically closed after reaching required quantity in the weighing machine.
- In fully automatic weigh batcher, all the process will be done automatically. The benefit of this type equipment is, it also measures the moisture content present in the aggregate and corrects the required quantity of water-cement with respect to moisture content of aggregates.

3.8 Mixing

Mixing is done according to the mix design of M20 grade. Calculated amount of cement, fine aggregate, coarse aggregate, oil palm shell, are first mixed in a tray witha trowel. The object of mixing is to coat the surface of all aggregate particles with Cement paste and to blend all the ingredients of concrete into a uniform mass. Thoughmixing of the materials is essential for the production of uniform concrete. Themixing should ensure that the mass becomes homogeneous, uniform in colour and consistency. In this study the process of hand mixing was adopted.

Fig 3.6 : Mixing of all ingredients

3.9 Casting

• The specimens are casted in the ratio of 0%, 20%, 40%, 50%, replacement of oil palm shell aggregate respectively with each ratio comprising of 6 cubes and 6 cylinders and6 prisms. A total of 36 cubes and 36 cylinders and 36 prisms were casted. After the casting process, the cubes, prisms and cylinders were kept for 24 hours and de- moulded, and they were cured for 7 days and 28 days.

Figure-3.7 casting of specimen

Table - 3.11: Details of specimens

S. No.	Properties Studied	Specimen	Specimen Size(mm)
1	Compressive strength	cube	150 X 150 X 150
2	Split tensile strength	cylinder	300 height & 150diameter
3	Flexural strength	prism	500 X 100 X 100

Cube **cylinder** **prism**

Figure - 3.8: Standard specimens

3.9.1 Procedure for Casting Cubes

Clean the cube mould properly with a cloth and apply a coat of firm oil on the inner surfaces of the mould. No excess oil should be visible on the inner surfaces. Fix the nuts & bolts tightly with base plate and side plates, no gaps should be seen within the parts of cube mould. It is necessary that the cube mould should be placed on a clean, level & firm surface for filling the concrete in it.

Concrete for specimen should be collected from three or four random mixes according to the preferred mix design of M20 grade. Place the concrete mix into the mould in each layer of maximum 50 mm thick. Level off the top with the steel float &clean any concrete from around the mould and leave the mould undisturbed for 24 hours. Give number & casting date of the specimens on the top surface after 30 minutes. Remove the cube from the mould after 24 hours. The specimen should be put straight into a tank of clean water. The specimen should be fully submerged underwater. After 7 and 28 days, send the specimen to the testing laboratory to determine the compressive strength of concrete.

3.9.2 Procedure for Casting Cylinders

Clean the Cylinder mould properly with a piece of cloth and apply a coat of firm oilon the inner surface of mould. No excess oil should be visible on inner surface. Fix the nuts & bolts tightly with base plate and no gaps should be within the parts of cylinder mould. It is necessary that the cylinder mould should be placed on a clean, level & firm surface.

Concrete for specimen should be collected from three or four random mixes. Place concrete into the mould in each layer of maximum 50 mm thick. Level off the topwith the steel float & clean any concrete from around the mould and leave the mould undisturbed for 24 hours.

Give number & casting date of the specimens on the top surface after 30 minutes. After 24 hours the specimen should be taken out from the mould and put it straight into a tank of clean water. The specimen should be fully submerged under water.After 7 and 28 days, send the specimen to the testing laboratory to determine the tensile strength of concrete. Minimum three specimens are made at a time on site. The average test result is taken to determine the tensile strength of concrete.

Figure-3.9: casting of cylinder

3.9.3 Procedure for Casting prism

Clean the prism mould properly with a cloth and apply a coat of firm oil on the inner surfaces of the mould. No excess oil should be visible on the inner surfaces. Fix the nuts & bolts tightly with base plate and side plates, no gaps should be seen within the parts of prism mould. It is necessary that the mould should be placed on a clean, level & firm surface for filling the concrete in it. Concrete for specimen should be collectedfrom three or four random mixes according to the preferred mix design of M20 grade.Place the concrete mix into the mould in three layers and then perform the compaction process by using mechanical vibrator. Level off the top with the steel float & clean any concrete from around the mould and leave the mould undisturbed for 24 hours.

Give number & casting date of the specimens on the top surface after 30 minutes. Remove the prism from the mould after 24 hours. The specimen should be putstraight into a tank of clean water. The specimen should be fully submerged under water. After 7 and 28 days, send the specimen to the testing laboratory to determine the flexural strength of concrete.

Figure-3.10: casting of prisms

Table - 3.12: Number of specimens casted

S.NO	Mix Designation	No. of. cubes		No. of. Cylinders		No. of. prisms	
		7 days	28 days	7 days	28 days	7 days	28 days
1	Nominal Concrete	3	3	3	3	3	3
2	20%Replacement with OPS	3	3	3	3	3	3
3	40%Replacement with OPS	3	3	3	3	3	3
4	50%Replacement with OPS	3	3	3	3	3	3
Total specimens		12	12	12	12	12	12

3.10 Curing

The specimens shall be removed from the moulds at the end of 24 hours and immersed in clean water till the 7 and 28-days age of testing. The specimens shall be tested in the saturated and surface dry condition. For the true representation of actual strength of concrete in the structure, extra specimens shall be cast, stored and cured asper the identical conditions of that structure, and tested at required age.

Figure - 3.11: Curing of Specimen.

3.11 workability

Workability is a property of raw or fresh concrete mixture. In simple words, workability means the ease of placement and workable concrete means the concrete which can be placed and can be compacted easily without any segregation. Workability is a vital property of concrete and related with compaction as well as strength. The desired workability is not same for all types of concrete. More workability is required for a thin inaccessible section or heavily reinforced section rather than a mass concrete body. Hence, we can’t set a standard workability for all casting works. Aggregates influence the workability of the concrete by the amount of aggregate, the relative proportions of fine and coarse aggregate, and the different aggregate properties. Generally, workability is determined by different methods, but mainly the slump cone test is used in site.

3.11.1Slump cone test

Slump Test is used to determine the consistency of concrete mix of given proportions.Scope and significance unsupported fresh concrete flows to the sides and a sinking in height takes place. This vertical settlement is known as slump. In this test fresh concrete is filled into a mould of specified shape and dimensions, and the settlementor slump is measured when supporting mould is removed. Slump increases as water- content is increased. The slump cone test is done for each mix and results are taken.

Figure - 3.12: slump testing

3.12 Testing of specimens

The cured specimens are taken from the curing tank and placed outside until it gets dried. Later, the entire specimens which include 24 cubes and 24 cylinders were tested in the compression testing machine for 7 days and 28 days. The tests conductedare;

- Compression test
- Split tensile test
- Flexural strength test

3.12.1 Compression test:

The cubes of standard size 150x150x150 mm are used to find the compressive strength of concrete. The load at the failure is noted down and compressive strength was calculated. Load at the failure divided by area of specimen gives the compressivestrength of the concrete. Compressive strength is the maximum stress a material can sustain under pushing, crushing force. It is determined by the shattering fracture of the material under these forces. The compressive strength is the ratio of the maximumload to the surface area of the concrete cube. Three cubes were tested for each mix ratio and the average of three specimens is taken as the compressive strength it was tested by compression testing machine of capacity 2000 KN. The light weight concrete was tested for compressive strength at the age of 7 day and 28 day. The specimens were subjected to a compressive force at the rate of 140KN per minute. Figure shows the concrete cube under test and the concrete cube specimens, respectively. The maximum load at failure was taken. The average compressivestrength of concrete specimens was calculated by using the following equation.

Compressive strength = $\frac{\text{Ultimate compressive strength}}{\text{Unit area of cross section}}$

Figure - 3.13: Compression testing machine

Figure – 3.14: Testing of cube

3.12.2 Split tensile test:

Concrete cylinders of size 150 mm diameter and 300mm length were cast with oil palm shell aggregate as partial replacement of coarse aggregate. During casting, the cylinders were mechanically vibrated using a table vibrator. After 24 hours, thespecimens were de-moulded and subjected to curing for 7 days, &28 days in portable water. After curing, the cylindrical specimens were tested for split tensile strength using compression testing machine of 2000kN capacity. The ultimate load was taken and the average split tensile strength was calculated using the equation.

- Split tensile strength = $2P/\pi DL$ (Mpa)
- Where:P = Failure load
- D = Diameter of the cylinder

- L = Length of the cylinder

The split tensile strength test was carried out as per IS 5819: 1999. Cylindricalconcrete specimens 150 mm in diameter and 300 mm in height were cast. Thespecimens were tested for split tensile strength using universal testing machine at the age of 7 and 28 days.

Figure - 3.15: Testing of cylinder specimen.

3.12.3Flexure Test:

Flexure tests are generally used to determine the flexural modulus or flexural strength of a material. A flexure test is more affordable than a tensile test and test results are slightly different. The beam is laid horizontally over two points of contact (lower support span) and then a force is applied to the top of the material through one points of contact (upper loading span) till the sample failed. The force at failure is taken and tabulated.

PROCEDURE

Prepare the test specimen by filling the concrete into the mould in 3 layers of approximately equal thickness. Tamp each layer 35 times using the tamping bar as specified above. Tampingshould be distributed uniformly over the entire cross section of the beam mould and throughout the depth of each layer.

- Clean the bearing surfaces of the supporting and loading rollers, and remove anyloose sand or other material from the surfaces of the specimen where they are to makecontact with the rollers.
- Circular rollers manufactured out of steel having cross section with diameter 38 mm will be used for providing support and loading points to the specimens. The length of the rollers shall be at least 10 mm more than the width of the test specimen. A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes. The distance between the outer rollers (i.e. span) shall be 3d and the distance between the inner rollers shall be d. The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic.

- The specimen stored in water shall be tested immediately on removal from water; whilst they are still wet. The test specimen shall be placed in the machine correctly
- centred with the longitudinal axis of the specimen at right angles to the rollers. For moulded specimens, the mould filling direction shall be normal to the direction of loading.
- The load shall be applied at a rate of loading of 400 kg/min for the 15.0 cm specimensand at a rate of 180 kg/min for the 10.0 cm specimens.

Figure-3.16: testing of flexural strength

CHAPTER-IV

RESULTS AND DISCUSSIONS

In this chapter, compressive strength, split tensile strength, Flexural strength and density of concrete at various concrete mixes is discussed. And results were compared, checked for compressive strength and split tensile strength.

4.1 Workability test results

4.1.1 Slump results

For each mix we have conducted the slump test and results are shown in Table No- 4.1. the slump value directly proportional to workability, as slump value increasesthen the workability also increased. Generally, slumps are classified in to three types they are,

- **Collapse slump**: In this slump the concrete collapses completely.
- **Shear slump**: In this slump the top portion of the concrete shears off and slips sideways.
- **True slump**: In this slump the concrete simply subsides, keeping more or less to shape.

Table - 4.1: slump cone results

Mix (percentage of replacement with oil palm shell)	Slump value(mm)
0%	101
20%	90
40%	95
50%	84

Slump Range	Workability
10-50mm	Low workability
50-100mm	Medium workability
Above 100mm	High workability

Table – 4.2: slump ranges

4.2 Compressive strength results

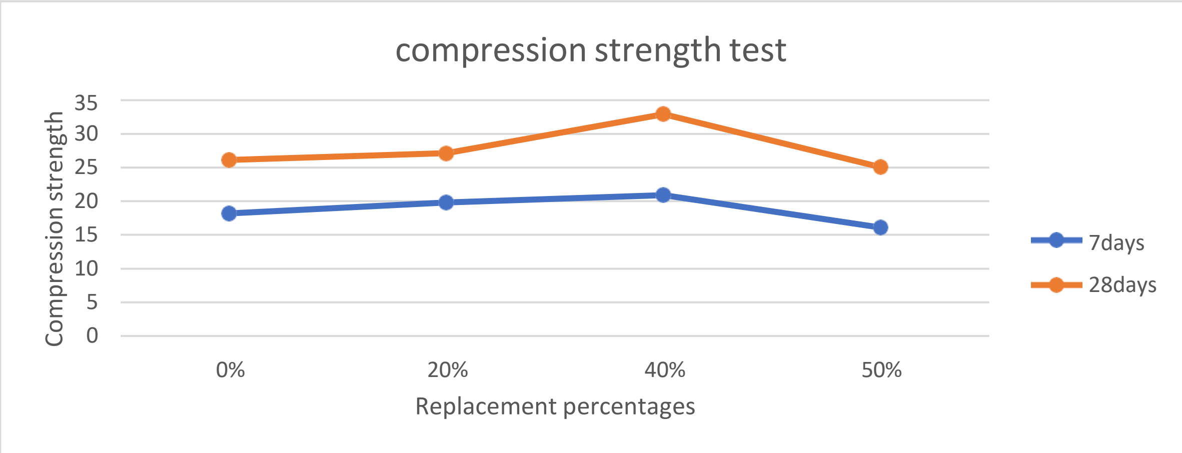
The compressive strengths of the casted specimens were determined by thecompressive test machine and are tabulated as follows:

Table -4.3: compressive strength results for 7 days

S. NO.	Percentage of Replacement	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1	0% (conventional concrete)	18.06	18.18
		19.08	
		17.40	
2	20%	19.60	19.81
		20.01	
		19.83	
3	40%	16.84	20.90
		16.95	
		16.92	
4	50%	16.01	16.09
		15.57	
		16.69	

Table - 4.4: compressive strength results for 28 days.

S. NO.	Percentage of Replacement	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1	0% (conventional concrete)	26.24	26.14
		25.95	
		26.23	
2	20%	27.74	27.14
		26.95	
		26.73	
3	40%	24.94	32.92
		26.85	
		25.95	
4	50%	23.64	25.07
		25.75	
		25.83	



Graph – 4.3.1 showing comparison of compressive strength result for 7 & 28 days

4.3 tensile strength results

The split tensile strength of the casted specimens was determined. And resultsare tabulated as follows:

Table – 4.5: Tensile strength results for 7 days

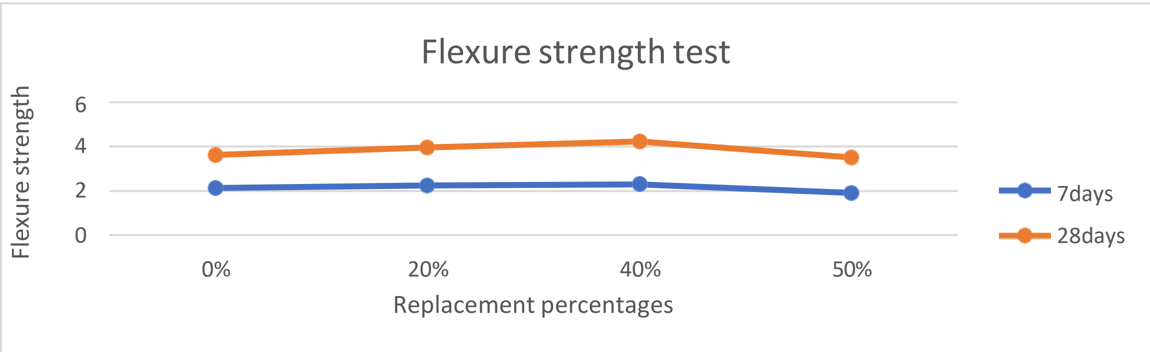
S. NO.	Percentage of Replacement	Split Tensile Strength (N/mm^2)	Average Split Tensile Strength(N/mm^2)
1	0% (conventionalconcrete)	2.89	2.67
		2.62	
		2.50	
2	20%	2.23	2.17
		2.50	
		1.79	
3	40%	1.72	2.97
		2.24	
		1.95	
4	50%	2.12	2.31
		2.61	
		2.20	

Table – 4.6: Tensile strength result for 28 days

S. NO.	Percentage of Replacement	Split Tensile Strength (N/mm^2)	Average Split Tensile Strength (N/mm^2)
1	0% (conventional concrete)	4.42	4.22
		3.62	
		4.64	
2	20%	4.20	4.61
		4.93	

		4.70	
3	40%	4.16	3.92
		3.78	
		3.82	
4	50%	3.30	3.02
		2.70	
		3.08	

Graph – 4.3.2 showing comparison of Tensile strength result for 7 & 28 days



4.1 flexural strength results

The flexural strength of the casted specimens was determined. And results aretabulated as follows:

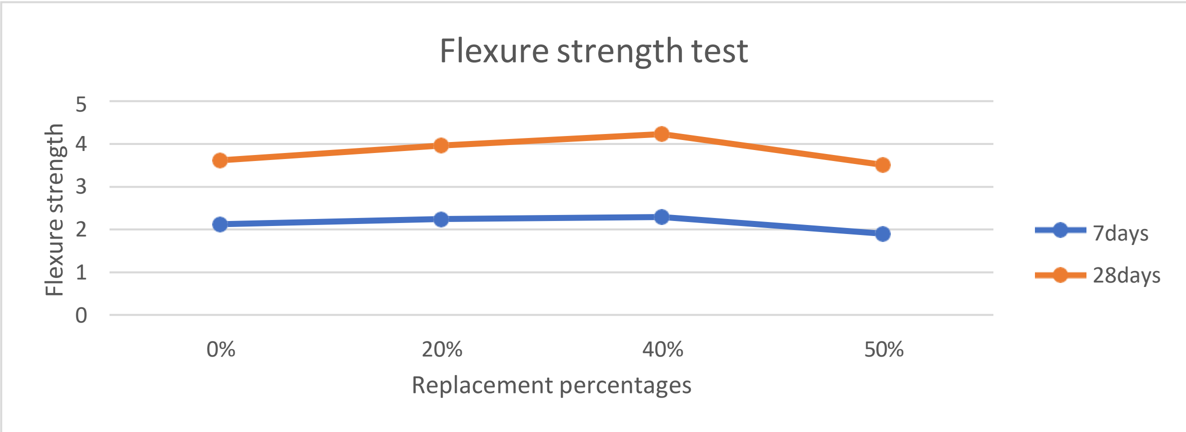
Table – 4.7: flexural strength results for 7 days

S. NO.	**Percentage of Replacement**	**flexural Strength (N/mm^2)**	**Average flexural Strength (N/mm^2)**
1	0% (conventional concrete)	1.96	2.12
		2.25	
		2.16	
2	20%	1.88	2.24
		2.50	
		2.35	
3	40%	2.18	2.29
		2.46	
		2.25	
4	50%	1.92	1.90
		1.65	
		2.15	

Table – 4.8: flexural strength results for 28 days

S. NO.	Percentage of Replacement	flexural Strength (N/mm^2)	Average flexural Strength (N/mm^2)
1	0% (conventional concrete)	3.45	3.62
		3.92	
		3.50	
2	20%	3.81	3.96
		4.28	
		3.80	
3	40%	4.42	4.23
		3.91	
		4.38	
4	50%	3.32	3.51
		3.50	
		3.71	

Graph – 4.3.3 showing comparison of flexural strength result for 7 & 28 days

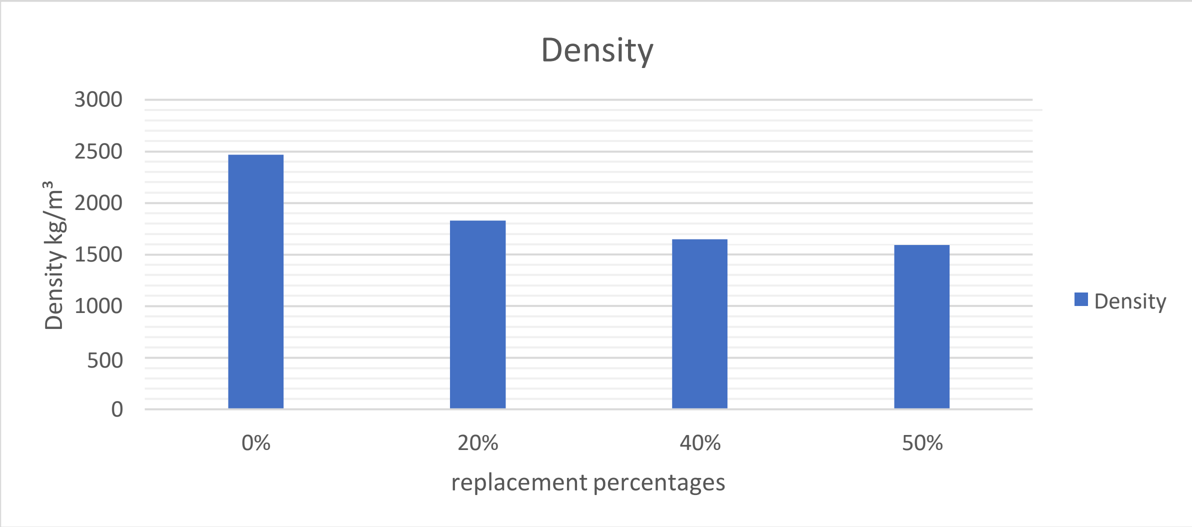


4.2 Density of Concrete

Table – 4.9: density of concrete at various mix designations

S. No.	Mix Designation	Density of Concrete (Kg/m^3)
1	M_0 (0% REPLACEMENT)	2466.7
2	M_2 (20% REPLACEMENT)	1828.0
3	M_4 (40% REPLACEMENT)	1648.2
4	M_4 (50% REPLACEMENT)	1592.2

Graph – 4.3.4: showing the comparison of density for each mix



CHAPTER - V

CONCLUSION

The concluding remarks are obtained from the comparative study of strength using different percentage of replacements with OPS. Based on the above results the following conclusions may be drawn.

- The concluding remarks are obtained from the comparative study of strength using different percentage of replacements with OPS.Based on the above results the following conclusions may be drawn.

- Generally, OPS aggregate was founded to be a good replacer of coarse aggregate and Metakolin as replacer of cement in concrete production from strength and workability.

- The Oil plam shell are pre-treated with cement to increase its specific gravity and decrease it's water obsportion.

- The strength of 0%,20%,40% and 50% OPS concrete samples produced lightweightconcrete with compressive strength reaching up to maximum of 36.13N/mm2 and least of 23.48N/mm2 for 28 days which satisfies the requirement for structural light weight concrete.

- Concrete with the 40% replacement gives highest at all tests such as compression test and flexural test.

- 50% replacement gives least compressive strength and flexural strength with more reduction in weight of concrete.• However, the strength of the concrete is depending on the two variables i.e. amount of OPSand curing period

- Finally, from the results we can conclude that 20% replacement sample is considered as partial lightweight concrete, because its density more than 2000kg/m3

- 40% samples is the ideal percentages of OPS concrete, it gives density below 2000kg/m3 and compressive strength results also promising. So, these two samples are considered as structural lightweight concrete.

- 50% samples also consider full light weight concrete but the results are not satisfying so it will consider as non-structural light weight concre

CHAPTER - VI

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A

PROJECT REPPORT
On

INCREASING COMPRESSIVE STRENGTH OF CONCRETE USING FIBERS

Submitted by

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In partial fulfilment for the award of the degree

Of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under The Guidance of

Mr. V. Madhu Krishna (M.Tech)

DEPARTMENT OF CIVIL ENGINEERING

ST.MARTIN'S ENGINEERING COLLEGE
(An Autonomous Institute)

Dhulapally, Secunderabad – 500 100

JUNE 2021

BONAFIDE CERTIFICATE

This is to certify that the project entitled “INCREASING COMPRESSIVE STRENGTH OF CONCRETE USING FIBERS, is being submitted by S. SAI KARTHIK REDDY, A. VISHNU VARDHAN, M. NAVEENA, P.S. ANAND KUMAR GOUD,in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY IN CIVIL ENGINEERING DEPARTMENT** is recorded of bonafide work carried out by them. The result embodied in this report have been verified and found satisfactory.

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Place:

Date:

DECLARATION

We, the student of Bachelor of Technology in Department of <CIVIL ENGINEERING DEPARTMENT', session: 2017 – 2021, St. Martin's Engineering College, Dhulapally, Kompally, Secunderabad, hereby declare that work presented in this Project Work entitled **"INCREASING COMPRESSIVE STRENGTH OF CONCRETE USING FIBERS"** is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics. This result embodied in this project report has not been submitted in any university for award of any degree.

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ABSTRACT

The usefulness of fiber reinforced concrete (FRC) in various civil engineering applications is indisputable. Fiber reinforced concrete has so far been successfully used in slabs on grade, architectural panels, precast products, offshore structures, structures in seismic regions, thin and thick repairs, crash barriers, footings, hydraulic structures and many other applications. Fiber Reinforced Concrete (FRC) is gaining attention as an effective way to improve the performance of concrete. Fibers are currently being specified in tunneling, bridge decks, pavements, loading docks, thin unbonded overlays, concrete pads, and concretes slabs. These applications of fiber reinforced concrete are becoming increasingly popular and are exhibiting excellent performance.

Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers , synthetic fibers and natural fibers

In conventional concrete, micro-cracks develop before structure is loaded because of drying shrinkage and other causes of volume change. When the structure is loaded, the micro cracks open up and propagate because of development of such micro cracks, results in inelastic deformation in concrete.

In the FRC, a number of small fibres are dispersed and distributed randomly in the concrete at the time of mixing, and thus improve concrete properties in all directions. The fibres help to transfer load to the internal micro cracks.

It is an effective way to increase toughness, shock resistance and resistance to plastic shrinkage cracking of the mortar.

These fibres have many benefits.

This study presents understanding strength of fiber reinforced concrete. Mechanical properties and durability of fiber reinforced concrete.

KEYWORDS: Steel Fibers, Glass Fibers, Fiber Reinforced Concrete

CHAPTER-I

INTRODUCTION

1.1 GENERAL

Compared to other building materials such as metals and polymers, concrete is significantly more brittle and exhibits a poor tensile strength. Based on fracture toughness values, steel is at least 100 times more resistant to crack growth than concrete. Concrete in service thus cracks easily and this cracking creates easy access routes for deleterious agents resulting in early saturation, freeze-thaw damage, scaling, discoloration and steel corrosion.

The concerns with the inferior fracture toughness of concrete are alleviated to a large extent by reinforcing it with fibers of various materials. The resulting material with a random distribution of short, discontinuous fibers is termed fiber reinforced concrete (FRC) and is slowly becoming a well-accepted mainstream construction material. Significant progress has been made in the last thirty years towards understanding the short and long-term performances of fiber reinforced cementitious materials, and this has resulted in a number of novel and innovative applications.

Concrete is one of the most versatile building materials. It can be cast to fit any structural shape from a cylindrical water storage tank to a rectangular beam or column in a high-rise building. The advantages of using concrete include high compressive strength, good fire resistance, high water resistance, low maintenance, and long service life.

The disadvantages of using concrete include poor tensile strength, low strain of fracture and formwork requirement. The major disadvantage is that concrete develops micro cracks during curing. It is the rapid propagation of these micro cracks under applied stress that is responsible for the low tensile strength of the material. Hence fibers are added to concrete to overcome these disadvantages.

The addition of fibers in the matrix has many important effects. Most notable among the improved mechanical characteristics of Fiber Reinforced Concrete (FRC) are its superior fracture strength, toughness, impact resistance, flexural strength resistance to fatigue, improving fatigue performance is one of the primary reasons for the extensive use of Steel Fiber Reinforced Concrete (SFRC)in pavements, bridge decks, offshore structures and machine foundation, where the composite is subjected to cyclically varying load during its lifetime.

The main reasons for adding steel fibers to concrete matrix is to improve the post cracking response of the concrete, i.e., to improve its energy absorption capacity and apparent ductility and to provide crack resistance and crack control. Also, it helps to maintain structural integrity and cohesiveness in the material. The initial researches combined with the large volume of follow up research have led to the development of a wide variety of material formulations that fit the definition of Fiber Reinforced Concrete.

Steel fiber's tensile strength, modulus of elasticity, stiffness modulus and mechanical deformations provide an excellent means of internal mechanical interlock. This provides a user-friendly product with increased ductility that can be used in applications of high impact and fatigue loading without the fear of brittle concrete failure. Thus, SFRC exhibits better performance not only under static and quasi-statically applied loads but also under fatigue, impact, and impulsive loading.

1.2 HISTORY OF REINFORCED CONCRETE:

A French gardener by name Joseph Monnier first invented the reinforced concrete in the year 1849. If not for this reinforced concrete most of the modern buildings would not have been standing today. Reinforced concrete can be used to produce frames, columns, foundation, beams etc. Reinforcement material used should have excellent bonding characteristic, high tensile strength and good thermal compatibility. Reinforcement requires that there shall be smooth transmission of load from the concrete to the interface between concrete and reinforcement material and then on to reinforcement material. Thus, the concrete and the material reinforced shall have the same strain.

1.3 FIBERS

1.3.1 STEEL FIBER REINFORCED CONCRETE

Steel fiber-reinforced concrete is basically a cheaper and easier to use form of rebar reinforced concrete. Rebar reinforced concrete uses steel bars that are laid within the liquid cement, which requires a great deal of prep work but make for a much stronger concrete. Steel fiber-reinforced concrete uses thin steel wires mixed in with the cement. This imparts the concrete with greater structural strength, reduces cracking and helps protect against extreme cold. Steel fiber is often used in conjunction with rebar or one of the other fiber types.

Fig :1.3.1 HOOKED STEEL FIBERS

1.3.2 GLASS REINFORCED CONCRETE

Glass fiber-reinforced concrete uses fiberglass, much like you would find in fiberglass insulation, to reinforce the concrete. The glass fiber helps insulate the concrete in addition to making it stronger. Glass fiber also helps prevent the concrete from cracking over time due to mechanical or thermal stress. In addition, the glass fiber does not interfere with radio signals like the steel fiber reinforcement does.

Fig :1.3.2 GLASS FIBERS

1.3.3 SYNTHETIC REINFORCED CONCRETE

Synthetic fiber-reinforced concrete uses plastic and nylon fibers to improve the concrete's strength. In addition, the synthetic fibers have a number of benefits over the other fibers. While they are not as strong as steel, they do help improve the cement pumpability by keeping it from sticking in the pipes. The synthetic fibers do not expand in heat or contract in the cold which helps prevent cracking. Finally synthetic fibers help keep the concrete from spalling during impacts or fires

Fig :1.3.3 SYNTHETIC FIBERS

1.3.4 NATURAL FIBRE REINFORCED CONCRETE

Historically, fiber-reinforced concrete has used natural fibers, such as hay or hair. While these fibers help the concrete's strength, they can also make it weaker if too much is used. In addition, if the natural fibers are rotting when they are mixed in then the rot can continue while in the concrete. This eventually leads to the concrete crumbling from the inside, which is why natural fibers are no longer used in construction.

Fig :1.3.4 NATURAL FIBERS

1.3.5 CARBON FIBER REINFORCED CONCRETE

carbon fibers (alternatively CF, graphite fiber or graphite fiber) are fibers about 5 to 10 micrometers (0.00020–0.00039 in) in diameter and composed mostly of carbon atoms. Carbon fibers have several advantages including high stiffness, high tensile strength, low weight to strength ratio, high chemical resistance, high temperature tolerance and low thermal expansion citation needed] These properties have made carbon fiber very popular in aerospace, civil engineering, military, and motorsports, along with other competition sports. However, they are relatively expensive when compared with similar fibers, such as glass fiber, basalt fibers, or plastic fibers.

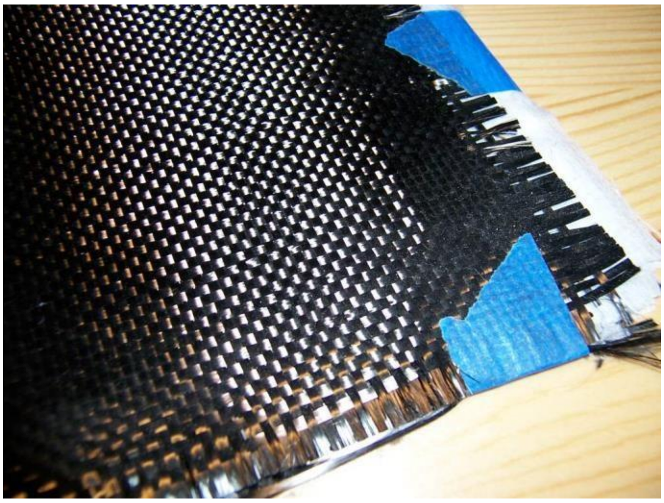


Fig :1.3.5 CARBON FIBERS

1.4 NECESSITY

The use of concrete as a structural material is limited to certain extent by deficiencies like brittleness, poor tensile strength and poor resistance to impact strength, fatigue, low ductility and low durability. It is also very much limited to receive dynamic stresses caused due to explosions. The brittleness is compensated in structural member by the introduction of reinforcement (or) pre-stressing steel in the tensile zone. However, it does not improve the basic property of concrete. It is merely a method of using two materials for the required performance. The main problem of low tensile strength and the requirements of high strength still remain and it is to be improved by different types of reinforcing materials. Further concrete is also deficient in ductility, resistance to fatigue and impact. The importance of rendering requisite quantities in concrete is increasing with its varied and challenging applications in pre-cast and pre-fabricated building elements. The development in the requisite characteristics of concrete will solve the testing problems of structural engineers by the addition of fibers and admixtures. The role of fibers is essentially to arrest any advancing cracks by applying punching forces at the rack tips, thus delaying their propagation across the matrix. The ultimate cracking strain of the composite is thus increased to many times greater than that of unreinforced matrix. Admixtures like fly ash, silica fume, granulated blast furnace slag and metakaolin can be used for such purposes. However, addition of fibers and mineral admixtures possess certain problems regarding mixing, as fibers tends to form balls and workability tends to decrease during mixing.

1.5 STATEMENT OF PROBLEM

The properties of the concrete in brittle material which is low in tensile strength and low in strain capacity. Low tensile strength and low strain at fracture were major deficiencies in plain concrete. The low tensile strength was attributed to numerous micro cracks in plain concrete. The rapid propagation at these cracks under applied stress was responsible for low tensile strength and brittle failure of material.

In structural application, the concrete will provide the reinforcing bars to carry the tensile force once the concrete has cracked, so that it remains largely in compression under load. As mentioned earlier, tensile failure strain of the reinforced concrete is significantly lower than the yield strain of the steel reinforced and the concrete crack before any significant load to transfer to the steel. In industry application, the steel reinforced needed to carry the tension forces in the concrete. According to the problem of steel reinforced concrete in structural application and needed in industry application, a new application of reinforced concrete need to develop. So, fiber is one of the methods to improve the mechanical properties of the structural concrete.

Fibres are typically used in concrete to control cracking due to plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibres usually produce greater impact, abrasion and Shatter – resistance in concrete. So, fiber is one of the methods to improve the mechanical properties of the structural concrete.

1.6 OBJECTIVE

- To study the behavior of the reinforced concrete strengthened with fibers.
- To study the effect of fibers strengthening of reinforced concrete on mechanical properties such as compressive strength and flexural strength.
- To improve durability of concrete and reduce crack growth by adding fibers to the concrete.
- To improve impact strength and resistance against freezing and thawing with the addition of fibers to the concrete.

CHAPTER-II

LITERATURE REVIEW

1 **Vasudev R, Dr. B G Vishnu ram (2013) et al** this paper aims to have a comparative study between ordinary reinforced concrete and steel fiber reinforced concrete. The fibers which were used in the study were the turn fibers. They were the scraps from the lathe shops. Experimental investigations and analysis of results were conducted to study the compressive & tensile behavior of composite concrete with varying percentage of such fibers added to it. The concrete mix adopted were M20 and M30 with varying percentage of fibers ranging from 0, 0.25, 0.5, 0.75 & 1%. On the analysis of test results the concrete with turn steel fibers had improved performance as compared to the concrete with conventional steel fibers which were readily available in market. These sustainable improvements or modifications could be easily adopted by the common man in their regular constructions.

2 **Pramod Kawde (2017) et al**, in this research it is shown that ordinary cement concrete possesses very low tensile strength, limited ductility and less resistance to cracking. The concrete shows the brittle behavior and fails to handle tensile loading hence leads to internal micro cracks which are mainly responsible for brittle failure of concrete. In this era, RCC constructions have their own structural and durability requirements, every structure has its own intended purpose and hence to meet this purpose, modification in traditional cement concrete has become mandatory. It has been proved that different type of fibers added in specific percentage to concrete improves the mechanical properties, durability and serviceability of the structure. As compared to other fibers it is now established that one of the important properties of Steel Fiber Reinforced Concrete (SFRC) is its superior resistance to cracking and crack propagation. In this paper Past studies based on the Steel fiber concrete is studied in detail.

3 **G. Jyothi Kumari, et al** studied behavior of concrete beams reinforced with glass fiber reinforced polymer flats and observed that beams with silica coated Glass fiber reinforced polymer (GFRP) flats shear reinforcement have shown failure at higher loads. Further they observed that GFRP flats as shear reinforcement exhibit fairly good ductility. The strength of the composites, flats or bars depends upon the fiber orientation and fiber to matrix ratio while higher the fiber content higher the higher the tensile strength.

4 **Yogesh Murthy, et al** studied the performance of Glass Fiber Reinforced Concrete. The study revealed that the use of glass fiber in concrete not only improves the properties of concrete and a small cost cutting but also provide easy outlet to dispose the glass as environmental waste from the industry. From the study it could be revealed that the flexural strength of the beam with 1.5% glass fiber shows almost 30% increase in the strength. The reduction in slump observed with the increase in glass fiber content.

5 **Lin Show may Hsu. et al (1994),** Studied Stress-Strain Behavior of Steel-fiber High- Strength Concrete under Compression. They were conducted a series of compression tests on 3 x 6-in. cylindrical specimens using a modified test method that gave the complete stress-strain behavior for high-strength steel-fiber concrete with or without tie confinements. The volume fractions of steel fiber in the concrete were 0, 0.5, 0.75, and 1 percent, respectively. Empirical equations are proposed herein to represent the complete stress-strain relationships of high-strength steel-fiber concrete with compressive strength exceeding 10,000 psi. Various parameters were studied, and their relationships were experimentally

determined. The proposed empirical stress-strain equations have been compared to actual cylinder tests under axial compression and were found to be in good agreement.

6 **Allogamy et al. (1995)** witnessed an increase in flexural toughness in their research by performing flexural strength tests on concrete specimens reinforced with polypropylene fibers. They found that for volume fractions of 0.1%, 0.2% and 0.3% of fibers the flexural toughness increased by 44%, 271% and 386% respectively over that of plain unreinforced concrete for the same mix compositions.

7 **Gopalakrishnan. et al (2003)** Structural Engineering Research Centre (SERC), Chennai have studied 'The properties of steel fiber reinforced concrete' namely the toughness, flexural strength, impact resistance, shear strength ductility factor and fatigue endurance limits. It is seen from the study that the thickness of the Steel Fiber Reinforced Concrete (SFRS) panels can be considerably reduced when compared with weld mesh concrete. The improvements in the energy absorption capacity of SFRS panels with increasing proportions of steel fibers are clearly shown by the results of static load testing of panels. This investigation has clearly shown that straight steel fibers of aspect ratio 65 can be successfully used in field application.

8 **Song P.S. et al (2004)** studied Mechanical properties of high-strength steel fiber-reinforced concrete. They have observed brittleness with low tensile strength and strain capacities of high strength concrete can be overcome by addition of steel fibers. The steel was added at the volume of 0.5%, 1.0%, 1.5% and 2.0%. The compressive strength of fiber concrete reached a maximum at 1.5%volume fraction and resulted in 15.3% improvement over the HSC. The split tensile and Flexural Strength improved 98.3% and 126.6% at 2.0% volume fraction. Strength models were developed to predict the compressive strength with split and flexural Strength of the fiber reinforced concrete.

9 **Nataraja. C. et al (1998 & 1999).** Studied Steel fiber reinforced concrete under compression and Stress-strain curve for steel fiber reinforced concrete in compression. They have proposed an equation to quantify the effect of fiber on compressive strength of concrete in terms of fiber reinforcing parameter. In their model the compressive strength ranging from 30 to 50 MPa, with fiber volume fraction of 0%, 0.5%, 0.75% and 1% and aspect ratio of 55 and 82 were used. In all the models only a particular w/c ratio with varying fiber content was used. The absolute strength values have been dealt with in all the models and thus are valid for a particular w/c ratio and specimen parameter.

10 **Balachandran S.A. et al (2007).** Studied Performance of high strength steel fiber reinforced concrete. They present work deals with the results of experimental investigations on high strength fiber reinforced concrete. Variable ingredients are silica fume and superplasticizer (by % weight of cement). Fiber content varied from 0 to 5% at interval of 0.5% by weight of cement in high grade mix compressive strength, flexural strength at 28 days. The maximum increase in compressive strength is up to 4.73 % at 4.5 % of fiber content. It is observed that the flexural strength increases with increase in the fiber content up to 2%. The maximum increase in this strength, i.e., 23.34 at 2.0 %. fiber content over that of normal concrete.

11 **J.D. Chaitanya Kumar et al. (2016)** study was carried out using an M20 grade of concrete and glass fiber is added as 0.5%, 1%, 2%, 3%. And the specimens are cast for a compressive and tensile test of the concrete. In this experiment, concrete attains strength when 2% of the fiber is added to the concrete and when 3% fiber is added to the concrete the strength of concrete declines. When the fiber is added 2% the strength of the concrete attains 26.98Mpa of compressive strength, 2.94Mpa of Flexural

Strength and 3.57Mpa of the Tensile strength of the concrete after 28 days of curing. In this experiment, the author mentioned that the workability of the concrete is increased and thus the glass fiber reduces the crack under different loading.

12 **Perumelsamy N. Bal guru and Surendra P. Shah (1992)** examined that the tests conducted on GFRC in laboratory have shown good resistance for fire, since the major use of GFRCs is for architectural building panels. In these buildings, fire resistance becomes an important factor in design.

CHAPTER -III

METHODOLOGY

Literature reviews related to the Fiber reinforced concrete were collected and based on the literature survey preliminary works were performed. Works like collection of fiber was performed. Materials required for concrete such as coarse aggregate, fine aggregate, cement were collected. Basic tests were conducted on fine aggregate, coarse aggregate, cement, fibers, to check the suitability concrete making The properties of fine and coarse aggregate sieve analysis of fine and coarse aggregates, tests on cement are found out. The Study aims to investigate the strength related properties of concrete of M20 grade. The proportions of ingredients of thecontrolconcreteofgradeM20 had determined by mix design as per IS code. Moulds were prepared to cast the specimen. Cube Mould of size 150mm*150mm*150mm and prism mould700*150*700 were cast with desired of partially replacement (0%, 5%, 10%, 15%) of coarse aggregate. Casted Samples were tested after 7days and 28days of curing Compressive strength and split tensile strength test and flexural strength was performed using casted concrete. Results were obtained and conclusion was arrived.

FLOW CHART


COLLECTION OF MATERIALS
BATCHING
MIXING
MOULDING
CURING
TESTING
Results

CHAPTER -IV

MATERIALS

FIBERS

4.1 STEEL FIBRES:

Steel fibres are of three types. They are Straight, Hooked-end and Corrugated fibre, and a type of monofilament polypropylene fibre are considered. The steel fibre used in this project is Hooked end steel fibres.

Cold-drawn hooked end steel fibre is manufactured by quality base steel bar, which has excellent mechanical properties including high tensile strength. Hence, the average tensile strength of the reinforced fibre surpasses 1100MPa. Owing to high strength and uniform distribution of fibres, stresses can be fully dispersed and cracking propagation be effectively controlled.

Unlike conventional reinforced fibre, steel fibres focus on three-dimensional reinforcement and make it impossible for plain crack to follow.

Description:

Diameter: 0. 5 to 1. 0mm;

Length: 25 to 60mm: Aspect Radio: 250;

Tensile strength: ≥1000Mpa:

Material: Low carbon steel bar; Coating: Non, Bright.

Advantages:

Substantially enhance initial crack strength: Continuously provide post-crack strength: Increase speed of construction: Stronger joints lower the possibility of maintenance. Save money and time.

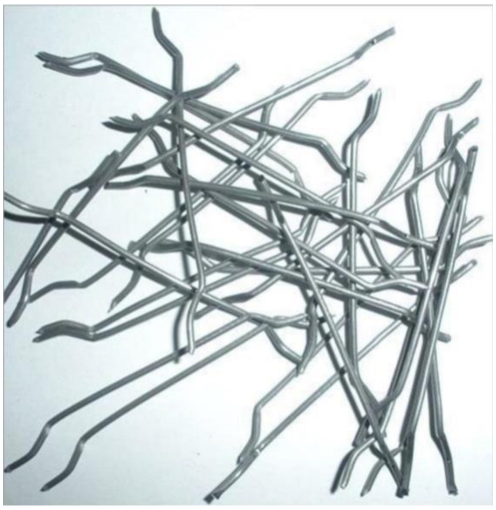


Fig :4.1 HOOKED STEEL FIBERS

4.2 GLASS FIBERS:

Glassmakers throughout history have experimented with glass fibres, but mass manufacture of glass fibre was only made possible with the invention of finer machine tooling.

Glass fibre has roughly comparable mechanical properties to other fibres such as polymers and carbon fibre. Although not as rigid as carbon fibre, it is much cheaper and significantly less brittle when used in composites. Glass fibres are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fibre-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "fiberglass".

Description:

Diameter: 3.8 and 20 mm;

Length: 12mm;

Material: Silica-based glass fibres.

ADVANTAGES

Uses for regular glass fibre include mats and fabrics for thermal insulation, electrical insulation, sound insulation, high-strength fabrics or heat and corrosion-resistant fabrics.

Fig :4.2 Glass fibers

4.3 CEMENT:

Ordinary Portland cement, 53 grade shall be manufactured by intimately mixing together calcareous and argillaceous and/or other silica, alumina or iron oxide bearing materials, burning them at a clinkering temperature and grinding the resultant clinker so as to produce a cement capable of complying with this standard. No material shall be added after burning, other than gypsum (natural mineral or chemical), water, performance improver(s), and not more than a total of 1.0 percent of air-entraining agents or other agents including colouring agents, which have proved not to be harmful.

Grade: 53;

Company: Deccan cement

Fig :4.3 cement

AGGREGATES:

'Aggregate' is a term for any particulate material. It includes gravel, crushed stone, sand, slag, recycled concrete and geosynthetic aggregates. Aggregate may be natural, manufactured or recycled. Aggregates make up some 60 -80% of the concrete mix. They provide compressive strength and bulk to concrete.

4.4 COARSE AGGREGATES:

Coarse aggregates are particulates that are greater than 4.75mm. The usual range employed is between 9.5mm and 37.5mm in diameter.

Stone: Crushed stone

Size: 15mm, 20mm and 25mm

Specific gravity: 2.76

Density: 1100-1750kg/m³

Code:IS-393-1970

Fig:.4.4 coarse aggregates

4.5 FINE AGGREGATES:

Sand occurs naturally and is composed of fine rock material and mineral particles. Its composition is variable depending on the source. It is defined by size, being finer than gravel and coarser than silt. Locally available zone-2 sand.

Specific gravity: 2.6

Is code: IS-393-1970

Fig 4.5 Fine aggregates

4.6 Water:

The water used for preparation of Fibre reinforced concrete is portable water.

CHAPTER -V

MIX DESIGN

(M20 GRADE CONCRETE)

5.1 MIX PROPORTIONS

EXPERIMENTAL PROCEDURE

In the present experimental investigation ceramic waste has been used as partial replacement of coarse aggregate in concrete mixes and addition of steel fibre. On replacing coarse aggregate with different percentage of steel fibres and glass fibres of 0%, 5%, 10%, 15%. The compressive strength, split tensile strength and is studied at different ages of concrete cured in normal water.

5.2 BATCHING

Measuring the quantities of constituents of concrete required for the preparation of concrete mix is called Batching. Weight batch method is used to measure the quantities. The quantities of fine aggregate, Natural coarse aggregate, steel fiber, glass fibers, cement, water and admixture for each batch were measured by a weighing balance according to the mix proportions obtained by the mix design.

The process of measuring ingredients or materials to prepare concrete mix is known as batching of concrete. Batching can be done by two methods, volume batching and weight batching. Batching should be done properly to get quality concrete mix.

5.3 MIXING

The objective of mixing is to coat the surface of all aggregate particles with Cement paste and to blend all the ingredients of concrete into a uniform mass. Though mixing of the materials is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in color and consistency. At first dry mixing is necessary of the uniform distribution of the fiber. Then the required amount of water is added to the mix. Through mixing is necessary to get the consistent slurry of concrete. Admixture is added to the mix at the later stage and after few minutes of mixing, the concrete becomes ready for placing.

S.No	Fiber Content (%)	Water/ Cement ratio	Cement (Kg/m^3)	Sand (Kg/m^3)	Aggregates (Kg/m^3)
1.	0	0.5	356.4	584	1224
2.	1	0.5	352.8	584	1224

5.4 CASTING:

The specimens are casted in the ratio of 0%, 5% 10%, 15%, the mix design is based on strength criteria and durability criteria for mild environmental exposure. The ratios by weight of cement, fine aggregates, coarse aggregate, steel fiber are obtained and mixed thoroughly in dry condition. Then water required is added to the dry mix and mixed thoroughly till to obtain uniform mixture. Superplasticizer is added to the mix to maintain the workability of fresh concrete. The concrete is filled into the mould in 3 layers. Each layer is compacted with tamping rod, for 25 blows each time. After the top layer has been compacted the surface of the concrete is brought to the finished. After the casting process, the cubes, prisms, and cylinders were kept for 24 hours and demoulded, and they were cured for 7days and 28 days.

Cube size: 150mmx150mmx150mm

Fig :5.4.1 Cube

Prism size: 150mmx150mmx700mm

Fig: 5.4.2 Prism

5.5 PROCEDURE FOR CASTING CUBES

Clean the cube mould properly with a cloth and apply a coat of firm oil on the inner surfaces of the mould. No excess oil should be visible on the inner surfaces. Fix the nuts & bolts tightly with base plate and side plates, no gaps should be seen within the parts of cube mould. It is necessary that the cube mould should be placed on a clean, level & firm surface for filling the concrete in it.

Concrete for specimen should be collected from three or four random mixes according to the preferred mix design of M20 grade. Place the concrete mix into the mould in each layer of maximum 50 mm thick. Level off the top with the steel float & clean any concrete from around the mould and leave the mould undisturbed for 24 hours. Give number & casting date of the specimens on the top surface after 30 minutes. Remove the cube from the mould after 24 hours. The specimen should be put straight into a tank of clean water. The specimen should be fully submerged under water. After 7 and 28 days, send the specimen to the testing laboratory to determine the compressive strength of concrete.

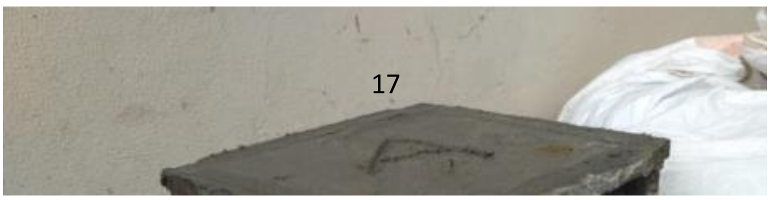


Fig :5.5 casting of cube

5.6 PROCEDURE FOR CASTING PRISM

Clean the prism mould properly with a cloth and apply a coat of firm oil on the inner surfaces of the mould. No excess oil should be visible on the inner surfaces. Fix the nuts & bolts tightly with base plate and side plates, no gaps should be seen within the parts of prism mould. It is necessary that the mould should be placed on a clean, level & firm surface for filling the concrete in it. Concrete for specimen should be collected from three or four random mixes according to the preferred mix design of M20 grade. Place the concrete mix into the mould in three layers and then perform the compaction process by using mechanical vibrator. Level off the top with the steel float & clean any concrete from around the mould and leave the mould undisturbed for24 hours. Give number & casting date of the specimens on the top surface after 30minutes. Remove the prism from the mould after 24 hours. The specimen should be put straight into at an of clean water. The specimen should be fully submerged under water. After 7 and 28 days, send the specimen to the testing laboratory to determine the flexural strength of concrete

Fig :5.6 casting of prism

5.7 CURING

The specimens shall be removed from the moulds at the end of 24 hours and immersed in clean water till the 7 and 28-days age of testing. The specimens shall be tested in the saturated and surface dry condition. For the true representation of actual strength of concrete in the structure, extra specimens shall be cast, stored, and cured as per the identical conditions of that structure, and tested at required age.

.

Fig :5.7 curing tank

5.8 SIEVE ANALYSIS OF SAND

Am: To determine fineness modulus of sand.

Apparatus: The apparatus consists of eight different types of sieves i.e. 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ and 75µ sieve for fine aggregate.

Materials used: 500gram sample of sand.:

Procedure:

The sample shall be brought to an air-dried condition before weighing and sieving.

Measure 3000 gram of the sand.

Arrange sieve in descending order of size from the top.

Put the sand in sieve 4.75mm, and shake for 10 minutes. Material shall not be forced through the sieve by hand pressure.

After 10 minutes stop the shaker and separate the sieve 4.75mm from the apparatus. Then with the help of balance measure the weight of retained particles, note this weight in the table.

Measure the weight of the particles retained in each sieve and notes them in the table.

calculate the percentage of weight retained on each sieve.

Find the percentage of the weight which has passed through each sieve.

Table 5.8: Observations of sieve analysis of aggregates

Sieve size (mm)	Weight retained (gm)	Percentage Weight retained (gm)	Cumulative Percentage of weight retained	Cumulative percentage of weight passed
4.75	22	0.6	0.6	99.4
2.36	32	0.76	1.32	98.68
1.18	144	3.6	4.92	95.08
600 µ	973	12.28	17.2	82.8
300 µ	2000	57.5	74.7	25.3
150 µ	1170	24.1	98.8	1.2
75 µ	480	1.2	99.99	0.01
Pan	5	0.033	100	0
Total			**275**	

Result: Hence the Fineness modulus of sand is calculated as 2.75

5.9 WORKABILITY TEST

5.9.1 SLUMP CONE TEST:
This test is used extensively in site all over the world. The slump test does not measure the workability of concrete, but the test is very useful in detecting variations in the unifor-mity of a mix of given nominal proportions.
The slump test is done as prescribed by IS: 516.

The apparatus for conducting the slump test essential consists of a metallic mould in the form of a cone having the internal dimensions as under Bottom diameter: 200 mm Top diameter: 100 mm
The mould for slump is a frustum of a cone, 300 mm high. It is placed on a smooth surface with the smaller opening at the top, and filled with concrete in three layers. Each layer is tamped twenty-five times with a standard 16 mm diameter steel rod, rounded at the end, and the top surface is stricken off by means of sawing and rolling motion of the tamping rod. The mould must be firmly fixed against its base during the entire operation; this is facilitated by handles or foot-rests brazed to the mould. Immediately after filling, the cone is slowly lifted vertically up, and the unsupported concrete will now slump – hence the name of the test. The difference in level between the height of the mould and that of highest point of subsided concrete is measured. This difference in height in mm is taken as slump of concrete. If instead of slumping evenly all rounds as in a true slump one half of the cone slides down an Inclined plane, a shear slump is said to have taken place and test should be replaced. If shear slump persists, as may be the case with harsh mixes, this is an inclination of lack of cohesion in the mix.
Mixes off stiff consistency have a zero slump, so that in the rather by range, no variation can be detected between mixes of different workability. Rich mixes behave satisfactorily, their slump being sensitive

to variations in workability however, in a lean mix a with a tendency to harshness, a true slump can easily change to the shear type, or even to collapse and widely different values of slump can be obtained in different samples from the same mix.
Despite these limitations, the slump test is very useful at the site to check on the batch or hour- to- hour variation in the materials being fed into mixer, as increase in slump may mean, for instance, that the moisture content of aggregate has unexpectedly increased; another cause would be a change in the grading of the aggregates, such as a defiance of sand. too low and too high slump gives immediate waning and enables the mixer operator to remedy the situation. This application of the slump test as well as its simplicity is responsible for its widespread use. A mini slump test was developed for the purpose of assessing the influence of various water- reducing admixtures and super plasticizers on neat cement paste. The test may be useful for the specific purpose, but it is important to remember that workability of concrete is affected also by factors other than the flow properties of the constituent cement paste.

Figure 5.9.1: Slump cone test

CHAPTER -VI
TESTING OF SPECIMENS

The cured specimens are taken from the curing tank and placed outside until it gets dried. Later, the entire specimens were tested in the laboratory for 7 days and 28 days. The tests conducted are;

- Compression test
- Flexural test

6.1 COMPRESSIVE STRENGTH:

Compressive strength of concrete is the Strength of hardened concrete measured by the compression test. The compression strength of concrete is a measure of the concrete's ability to resist loads which tend to compress it. It is measured by crushing concrete cube specimens in compression testing machine.

The compressive strength of concrete can be calculated by the failure load divided with the cross-sectional area resisting the load and reported in mega pascals (MPa) in SI units. Concrete's compressive strength requirements can vary from 17 MPa for residential concrete to 28 MPa and higher in commercial structures. Higher strengths up to and exceeding 70 MPa are specified for certain applications.

For cube test two types of specimens either cubes of 150mm X 150mm X 150mm or 100mm X 100mm x 100mm depending upon the size of aggregate are used. For most of the works cubical moulds of size 150mm x 150mm x 150mm are commonly used.

This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. These specimens are tested by compression testing machine after 7 days curing and 28 days curing. Load should be applied gradually till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Compressive strength of concrete= Load at which specimen fails
Cross section area of cube

Fig :6.1.1 compression test

Fig 6.1.2 Tested specimen on cube

6.2 FLEXURE TEST

Flexure tests are generally used to determine the flexural modulus or flexural strength of a material. A flexure test is more affordable than a tensile test and test results are slightly different. The beam is laid horizontally over two points of contact (lower support span) and then a force is applied to the top of the material through one points of contact (upper loading span) till the sample failed. The force at failure is taken and tabulated.

Prepare the test specimen by filling the concrete into the mould in 3 layers of approximately equal thickness. Tamp each layer 35 times using the tamping bar as specified above. Tamping should be distributed uniformly over the entire cross section of the beam mould and throughout the depth of each layer.

Clean the bearing surfaces of the supporting and loading rollers, and remove any loose sand or other material from the surfaces of the specimen where they are to contact the rollers

Circular rollers manufactured out of steel having cross section with diameter 38 mm will be used for providing support and loading points to the specimens. The length of the rollers shall be at least 10 mm more than the width of the test specimen. A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes. The distance between the outer rollers (i.e., span) shall be 3d and the distance between the inner rollers shall be d. The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic.

The specimen stored in water shall be tested immediately on removal from water; whilst they are still wet. The test specimen shall be placed in the machine correctly centred with the longitudinal axis of the specimen at right angles to the rollers. For moulded specimens, the mould filling direction shall be normal to the direction of loading.

The load shall be applied at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens.

Fig 6.2.1 flexural strength test

CHAPTER-VII
RESULTS

7.1 WORKABILTY TESTS:

The ideal concrete is the one which is workable in all conditions i.e., can prepared easily placed, compacted and moulded. In this project ceramic waste and steel fibre is added in concrete mix and workability is tested by doing slump cone and compaction factor test. From the results obtained, the addition of ceramic waste and steel fibre does not affect the workability of concrete.

7.1.1 SLUMP CONE TEST:

The test was conducted for fresh concrete prepared before the molding process.
Workability Results obtained from slump cone test for M25 grade of concrete for replacement of coarse aggregate with various proportions of ceramic waste and addition of 2% of steel fiber are listed below.

Table 7.1.1: Observations for slump cone test

S. NO.	Specimen Designation	Slump Value In mm	Type Of Slump
1	CS0	55	True

2	CS5	58	True
3	CS10	63	True
4	CS15	69	True

7.1.2 COMPACTION FACTOR TEST:

The compaction factor test for replacement of coarse aggregate with various proportions of ceramic waste and addition of steel fiber are listed below

.Table 7.1.2: Observation for compaction factor test

Sl. No.	Specimen Designation	Compaction factor
1	CS0	0.91
2	CS5	0.86
3	CS10	0.89
4	CS15	0.84

7.2MECHANICAL PROPERTY TEST:

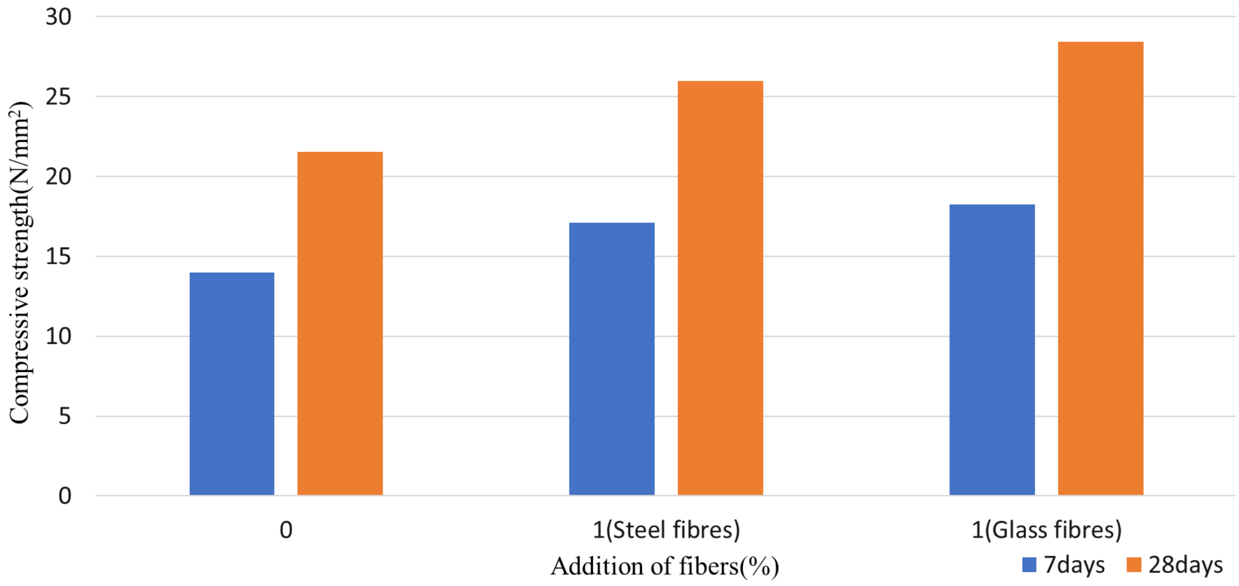
7.2.1 Compression Strength of Cubes:

Size 150 x 150 x 150mm were casted and tested for 7 days and 28 days testing of the specimens for each percentage after conducting the workability tests. The results are tabulated below:

Table : 7.2.1Compressive strength results at 7 days& 28 days

S.No	Addition of fibers(%)	Compressive strength(N/mm^2) (at 7 days)	Compressive Strength(N/mm^2) (at 28 days)
1	0	14.00	21.16
2	1(Steel fibres)	16.52	26.00
3	1(Glass fibres)	18.24	28.46

Fig : 1 COMPRESSIVE STRENGTH OF M20 GRADE CONCRETE

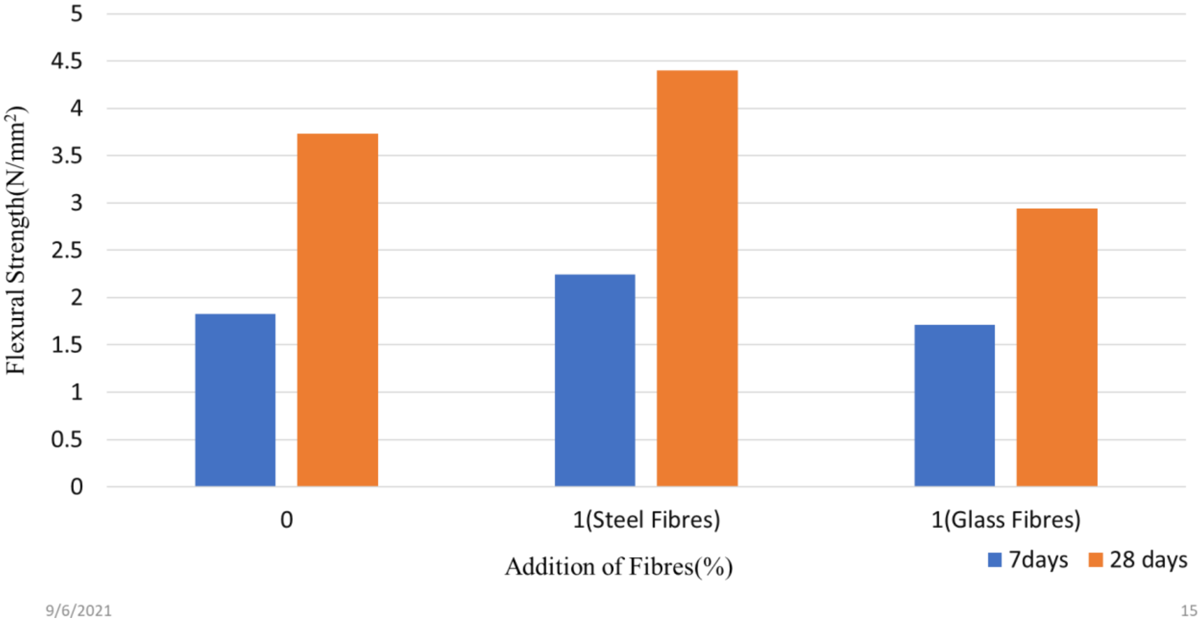


7.2.2 <u>FLEXURAL STRENGTH TEST</u>

Table :7.2.2 Flexural strength results at 7 days & 28 days

.No	ddition of fibres (%)	Flexural rength(N/mm^2) (at 7 days)	Flexural strength(N/mm^2) (at 28 days)
		.83	73
	(Steel fibres)	.12	4
	(Glass fibres)	.71	94

Fig : 2 FLEXURAL STRENGTH OF M20 GRADE CONCRETE



CHAPTER-VIII

CONCLUSION AND FUTURE ENHANCEMENT

- It has been reported that the concrete containing steel and glass fibers have achieved 18 – 20% and 30 -32% more compressive strength respectively at 7days and 28 days tests.
- It has also been reported that the concrete containing steel fibers have achieved 15 -17% more flexural strength at 7 days and 28 days test.
- It is concluded that compressive strength can be increased by adding glass fibers and flexural strength can be increased by adding steel fibers to the concrete.
- Fibers increases the concrete's durability.
- It reduces crack growth and increases impact strength.
- Fiber-reinforced concrete improves resistance against freezing and thawing.
- This is crucial for an outside environment application for weather that experience tremendous amount of moisture, wet and dry through rain and dry season.
- Fiber-reinforced concrete also have high fire-resistant properties thus reducing the loss of damage during fire accidents.

CHAPTER -XI

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ESTIMATION OF RESILIENT MODULUS FOR STABILIZED SUBGRADE USING GENETIC ALGORITHM AND ARTIFICIAL NEURAL NETWORK

INDUSTRIAL ORIENTED MAJOR PROJECT WORK REPORT SUBMITTED TO

JAWAHARLAL NEHURU TECHNOLOGICAL UNIVERSITY, HYDERABAD

In partial fulfilment for the award of degree of

BACHELOR OF TECHNOLOGY

IN

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DECLARATION

We VALLAPU SHIVAKRISHNA, SAYARI TEJA SRI, CHINNOLLA VASANTHA, SOLLETI AKHILREDDY here by declare that the project report entitled **"ESTIMATION OF RESILENT MODULUS FOR STABILIZED SUBGRADE USING GENETIC ALGORITHM AND ARTIFICIAL NEURAL NETWORK"** Under the guidance of Mr. N. VIJAYKUMAR (Assistant Professor), Civil Engineering Department, St. Martin's Engineering College, is submitted in partial fulfilment of the requirements for the award of degree of BACHELOR OF TECHNOLOGY in Civil Engineering. This is a record of bonafide work carried out by me and results embodied in this project have not reproduced or copied from any source. This result embodied in this project have not been submitted award to any other university for the award of any degree or diploma**.**

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We VALLAPU SHIVAKRISHNA, SAYARI TEJA SRI, CHINNOLLA VASANTHA, S. AKHIL REDDY students of final year and department of civil engineering belonging to the" **ESTIMATION OF RESILENT MODULUS FOR STABILIZED SUBGRADE USING GENETIC ALGORITHM AND ARTIFICIAL NEURAL NETWORK"** expressing thanks to our beloved project guide Mr. N VIJAY KUMAR (Assistant Professor) active participation and excellence guidance at every stage and high dynamic and motivate encouragement is help me to successfully completing this project. We are thankful to our beloved Head of the Civil Engineering Department Ms J K SANDHYA KIRAN, for his cooperation and encouragement in completing this project. Finally, we thank all the unmentioned names and Invisible hands who helped us in bringing this INDUSTRIAL ORIENTED MAJOR PROJECT Report to the present form.

ABSTRACT

Generally, civil Engineers are in search of new competitive materials, The fly ash is one of the waste materials of thermal power stations and it is an important industrial by-product of coke combustion, The utilization of the waste besides treating the problematic soil will also solve the dumping issue of the waste itself and will reduce the environmental hazards. In the present study, clay soil was stabilization for the construction of durable urban roads is investigated using fly ash. and are also used as various percentages to improve the strength of locally available highly compressible clay soil and to determine the soil bearing capacity with and without groundnut shell ash by plate load test. This was achieved by subjecting the soil to one dimensional consolidation. Other tests such as Atterberg's limits, specific gravity and particle size distribution were also carried out on the soil sample. Expansive clays are one of the most widely found soil type across the globe known for their low strength behaviour. The effect of abundantly available fly ash, on the index properties namely liquid and plastic limits, and free swell of natural deposits of Indian black cotton soil. And the compaction characteristics and unconfined compressive strength of an artificially-mixed soil were examined, the addition of binder was shown to bring about a significant improvement in these soil properties. And concerted efforts have been initiated in the laboratory to understand the effect of fly ash addition on the California Bearing Ratio (CBR) values of black cotton soil both for un soaked and soaked conditions. The soil stabilization or modification of soil-fly ash mixes is of great importance and hence the compaction behaviour of soil-fly ash mixes is studied in detail from the economical side of the material use.

Key words: Soil stabilization, fly ash, Black cotton soil, Resilient modulus, soil properties, Genetic algorithm and Artificial neural network.

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CHAPTER-1

1. INTRODUCTION:

1.1 GENERAL:

At present 110-150 million tons of coal fly ash is generated from 120 existing coal based TPP in India. Presently the annual production of fly ash in India is about 112 million tons with 6500 acres of land being occupied by ash ponds and it was crossed 125 million tons by the year 2017-18FY. And also, it is expected 150 million tons by the year 2020.The demand of power supply has exponentially heightened these days due to increasing urbanization and industrialization phenomena. Subsequently, this growth has resulted in the increase in number of powers supplying thermal power plants that use coal as a burning fuel to produce electricity. The mineral residue that is left behind after the burning of coal is the fly ash. The Electro Static Precipitator (ESP) of the power plants collect these fly ashes.

Fly ash is generally considered as a waste material, that is produced as a by-product of coal combustion process. Fly ash production has increased up to 900 million tonnes per year by 2008 and it is anticipated to increase up to about 2000 million tonnes in year 2020 (Malhotra 2008). In Australia alone, about 12 million tonnes of fly ash is produced annually by both brown coal and black coal combustion (Morrison et al. 2005). About 43 percent of this ash is re-used for various applications while the rest is being dumped as waste. Disposal of fly ash in open dumps cause massive environmental problems such as ground water contamination, spills of bulk storage and ground pollution by heavy metals. It may create various health problems.

Therefore, utilization of fly ash as a useful product is essential in today's world for a sustainable coal industry. Since fly ash shows a wide range of physical and chemical properties, similar to cement, American Society for Testing and Materials (ASTM), as cited in French & Smitha (2007), classifies main types of fly ash for various applications. They are Class F and Class C which are categorized depending upon chemical properties of fly ash. Class F fly ash, is available in larger quantities, which is generally low in lime, less than 15%, and contains greater combination of silica, alumina and iron (more than 70%) compared to Class C fly ash. Class F is a solution to a wide range of summer concreting problems and it is often recommended for using where concrete may

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be exposed to sulphate ions in soil and ground water. Class C fly ash normally comes from coal which produces an ash with higher lime content, generally more than 15%, often as high as 30%. Also, high Calcium Oxide CAO gives Class C unique self-hardening characteristics. Class C is mostly used in situations where higher early strengths are important.

Expansive clayey soils with high potential of swelling are mostly found in arid and semi-arid regions all over the world. These soils are highly susceptible to the variation of their water content and cause huge problems to pavements, embankments, drinking water networks, irrigation open canals, railways, mining structures (e.g., overland conveyors), and light residential buildings for excessive settlement and expansion. Globally, billions of dollars have been spent on either financial losses or treatment work of these problematic soils every year [1-3]. Generally speaking, the cost of damage to the structures due to shrinkage and swelling of expansive clays is even greater than the cumulative cost of damage caused by all-natural disasters such as hurricanes, volcanic eruptions, earthquakes, floods, and tornadoes [4, 5]. The damage to structures can be eliminated or significantly mitigated by stabilization of expansive clays prior to construction of the structures on problematic soils. The stabilizer agents can be used to improve the engineering properties and to reduce the swelling and shrinkage potential of expansive clays. Based on the usage frequency of the stabilizers and the popularity of them amongst engineers, they may be categorized into two major groups: Traditional and non-traditional stabilizers. Traditional stabilizers comprising cement, hydrated lime, zeolite, industrial waste, fly ash and gypsum are frequently used in industrial projects and extensive case studies as well as laboratory tests have been performed on the ability of these additives to improve the compressibility of soft clayey soils and alleviate the swelling pressures [6- 13].

The history of stabilization of soil has a long background with hundreds of research results. Several research results with waste materials such as fly ash, plastics; rice husk ash has also been published with their benefits. Some of the recent relevant research work has briefly mentioned here, Alhassan (2008) [8] has shown the potential benefits of using RHA with the natural soil. It has been reported that both CBR as well as unconfined compression values has increased with the addition of RHA with natural soil. Also, the OMC (Optimum Moisture Content) increase while MDD (Maximum Dry Density) has decreased due to RHA mixed with natural soil. Brooks (2009) [8] reported the soil stabilization with RHA and fly ash mixed with natural soil. In this study also showed improvement in CBR values and unconfined compression strength. The effect of marble dust with RHA in a mix with expansive soil has been studied by Sebat and Nanda (2011). It has been seen that with addition of RHA and marble dust

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with soil, the MDD deceases and OMC increases. Also, the CBR and UCS values increase substantially due to adding these two with the natural soil

The development and the use of environmentally friendly binders as an alternative solution to traditional binders in a low carbon agenda is of prime importance particularly in the construction sector. The use of novel and efficient binders for geotechnical applications is a promising issue in terms of sustainability since it reduces the carbon footprint and allows reusing secondary by-products such as artificial pozzolans. These by-products can be involved in soil improvement as cementing agents if properly activated, inducing a mechanical improvement which allows the reuse of soils not suitable in their natural state as construction materials for earthworks. The recycling of waste materials such as by-products from industrial process to synthesize a new binder favours a closed loop of material use, which minimizes waste generation and reduces production costs [14]. Differently from the use of lime and cement for soil improvement, experimental research about the use of alkali activated binders in soil improvement is still limited [15]; nevertheless, recent studies highlight the relevant potential of novel binders for geotechnical purposes. Cristelo et al. (2011) [16] researched the optimum fly ash—based alkaline activated binder for the improvement of soil to be used in rammed earth construction through a parametric analysis using laboratory tests. Rios et al. (2016) [17] compared the mechanical behaviour of samples of sand improved by alkali activated fly ash binder and by cement, highlighting the effective increase of shear strength soil properties induced by alkali activated binders.

In view of the environmentally friendly process, namely the energy efficiency and excellent engineering properties, alkali-activated binders are fast emerging as materials of choice for high demand civil engineering applications. Nevertheless, studies regarding the particular application on soil stabilization remain limited. For instance, a few published papers on alkaline activation [13-17] addressed the effectiveness of alkaline activation (AA) on soil stabilization. Based on the microstructural analysis, the researchers discovered that the binding gel (N-A-SH) evolved inside the soil voids, leading to improved compressive strength and formation of more compact microstructures. Inevitably, low calcium fly ash is one of the most abundantly produced waste materials in tropical regions with a high content of silica and alumina. Specifically, fly ash is A by-product produced from burning pulverized coal in electric power generating plants. It consists of inorganic and incombustible matter present in coal which transforms into a glassy amorphous structure during combustion.

In this study the objectives are; Evaluation of Compressive Strength (CBR) of Fly Ash Stabilized Sub-Grade Soil, to identify factors affecting Compressive Strength (CBR) of Stabilized Sub-Grade Soil containing Fly Ash and Sensitivity Analysis of Sub-Grade Soil CBR is using Genetic Algorithm. Fly Ash is the

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residual remains after the combustion of coal which is made up of very fine particles of Silicon Dioxide (SiO2) (Amorphous & Crystalline), Aluminium Oxide (Al2O3), Iron Oxide (Fe2O3) and Calcium Oxide Cao. It has various applications in the field of Construction such as Concrete Production, in Cement Clinkers, Substitute Material in Brick Manufacturing, Mineral Filler in Bituminous Concrete, etc. One such application is Sub-grade Soil Stabilization for Road Construction. Fly Ash Mix with Lime and/or Cement can be used for stabilizing of sub-grade soil having poor compressive strength for Road Construction. After it has been added the reactions that take place between fly ash, lime and water gives rise to cementitious products which bonds the soil particles together. Soils having high amounts of clay in their composition require a high lime/fly ash ratio to ensure an abundant supply of lime for the lime-fly ash reaction and for lime-clay stabilization. Pavement engineers have long recognized long-term benefits of increasing the strength and durability of pavement subgrade soil by mixing in a cementitious binder during reconstruction or new construction. Millions of dollars can be saved by soil subgrade stabilization in comparison to cutting out and replacing the unstable subgrade soil. When included in pavement design, stabilizing the subgrade can result in reducing the thickness of other pavement layers. Finding an alternative with the most cost effective or highest achievable performance under the given constraints, by maximizing desired factors and minimizing undesired ones. In comparison, maximization means trying to attain the highest or maximum result or outcome without regard to cost or expense. Putting together a portfolio in such a way that return is maximized for a given risk level, or risk is minimized for a given expected return level. An optimization tool that allows us to generate an entire trade-off curve in a single iteration will be more useful to the decision-making process that generates just a single point at a time [3]. Many human inventions were inspired by nature. Artificial neural networks are one example. Another example is Genetic Algorithms (GA). Genetic Algorithms search by simulating evolution. It starts from an initial set of solutions or hypotheses, then generating successive generations of solutions. This particular branch of Artificial Intelligence was inspired by the way living things evolved into more successful organisms in nature. Thus, identifying different factors that affect the strength of soil by the addition of fly ash in different proportion of sand and then inserting the data into Evolver will result into prediction of soil strength is the present scope of the study.

1.2 TYPES OF FLY ASH:

Generally, **fly ash** are divided by two **types** which are:

1.**fly ash** Class **C**

2. **fly ash** Class **F**

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Fly ash Class **C:** It is usually formed from the combustion of younger lignite or subbituminous fly ash normally produced burning lignite or subbituminous coal. Some class c fly ash may Cao contents in excess of 10% in addition to pozzolanic properties.

Class C fly ash generally contains more than 20% lime Cao. Alkali(so4) contents

C fly ashes. **Fly ash** Class **F:** It is produced from the burning of harder bituminous coal and older anthracite

Fly ash normally produced by burning anthracite or bituminous coal, usually less than 5% Cao. Class F fly ash has pozzolanic properties only

In other words, burning of harder, older anthracite and bituminous coal typically produce class F fly ash. This fly ash is pozzolanic in nature and contains less than 20% lime Cao Classification **of fly ash:**

Two classes of fly ash are defined by ASTM i.e., Class C fly ash and Class F fly ash. The chief difference between them is the amount of calcium, silica, alumina and iron content in fly ash.

1.3 Black cotton soil:
Black cotton soils are inorganic clays of medium to high compressibility and form a major soil group in India. They are characterized by high shrinkage and swelling properties. Because of its high swelling and shrinkage characteristics.

Black cotton soil is a highly clayey soil. The black colour in Black cotton soil is due to the presence of titanium oxide in small concentration. The Black cotton soil (**BC** soil) has a high percentage of clay, which is predominantly montmorillonite in structure and black or blackish grey in colour. And these expansive clays are one of the most widely found soils across the globe. Expansive clays have produced various challenges to the civil engineers due to their unfavourable engineering characteristics such as high swelling and low strength behaviour.

The black cotton soils possess low strength and undergo excessive volume changes, making their use in the constructions very difficult. The properties of the black cotton soils may be altered in many ways viz. mechanical, thermal, chemical and other means. Modification of black cotton soils by chemical admixtures is a common stabilisation method for such soils (Bell, 1993). Among various admixtures available lime, fly ash and cement are most widely and commonly used for the stabilisation of the black cotton soils. Fly ash contains siliceous and aluminous materials (pozzolans) and also certain amount of lime. When mixed with black cotton soils, it reacts chemically and forms cementitious

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compounds. The presence of free lime and inert particles in fly ash suggests that it can be used for stabilisation of expansive soils

Soil has been used as a construction material from time immortal. Being poor in mechanical properties, it has been putting challenges to civil engineers to improve its properties depending upon the requirement which varies from site to site. The roads laid on BC soil bases develop undulations at the road surface due to loss of strength of the sub grade through softening during monsoon. Soaked laboratory CBR values of Black Cotton soils are generally found in the range of 2 to 4%. Due to very low CBR values on sub grade BC soil, excessive pavement thickness is required for designing for flexible pavement. Research & Development (R&D) efforts have been made for a long time to improve the strength characteristics of BC soil with new technologies During last 25 years, much work has been done on strength deformation behaviour of fly ash and fibre reinforced soil and it has been established beyond doubt that addition of fibre and fly ash in soil improves the overall engineering performance of soil

In the recent past, many researchers have carried out experimental and field studies for the stabilization of expansive soils using fly ash, and the pozzolanic fly ashes can be advantageously made use of to improve the geotechnical properties of black cotton soils. Modification of black cotton soils by chemical admixtures is commonly adopted method for stabilizing the swell-shrink tendency of expansive soils and these black cotton soil samples were collected from the locations of pragathinagar Kukatpally, medchal, Telangana area were studied for their expansive characters. Applied to increase the strength of two expansive soils by using fly ash. It was revealed from the test result that increase of fly ash percentage, decrease plasticity, linear shrinkage strains and free swell of soil. On addition of the materials such as fly ash, the unconfined compressive strength was increased. The result show that the dry density and unit weight of soil will be reduced due to inclusion of fly ash with soil. Besides, the shear strength, cohesion, angle of internal friction and CBR value of the mixture were also increased.
In recent years, a number of stabilizers from various industries have been developed for the purpose of soil stabilization. improved the unconfined compressive strength of containing soils by stabilizing them with fly ash.

Research and Development efforts have been made for a long time to improve the strength characteristics of BC soil with new technologies During last 25 years, much work has been done on strength deformation behaviour of fly ash and fly ash in soil improves the overall engineering performance of soil.

1.4 Characteristics of B.C. Soil Black cotton soils are generally reddish brown to black in colour and occur from 0.5m to 10m deep and have high

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compressibility. The generally observed characteristics of black cotton soils are recorded in table below;

Geotextile layer increases the CBR value of soil and this increase is maximum corresponding to 4 layers of Jute Geotextile layers. Hence there is a significant increase in CBR value of soil due to inclusion of Jute Geotextile layers as a reinforcement.

A K Choudhary et al (Dec 2010) In this study disposal of an industrial waste like fly ash formed from burning of coals in thermal power stations requires a large land area. The decreasing availability of good construction site has led to the increased use of low-lying areas filled up with industrial wastes whose bearing capacity is low. In-situ treatment of such industrial waste fills; in order to improve their bearing capacity with reinforcements is a good replacement to other conventional methods of stabilization. In comparison with systematically reinforced soil, randomly distributed discrete fibre reinforced soil mimics soil stabilization by admixture and exhibit some advantages.

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CHAPTER -2

2.LITERATURE REVIEW:

In this experimental study was conducted on locally available (Hyderabad, Telangana, India) soil stabilized with Jute In this study the soil samples were prepared at its MDD corresponding to its OMC in the CBR mould with and without reinforcement. The percentage of Jute by dry weight of soil was carried as 0.25%, 0.5%, 0.75% and 1%. In the present investigation the lengths of was carried as 30 mm, 60 mm and 90 mm and two various diameters, 1 mm and 2 mm were considered for each length.

Tests result shows that CBR value of soil increases with the increase in content. It was also observed that increasing the length and diameter of further increases the CBR value of reinforced soil and this increase is substantial at content of 1 % for 90 mm length having diameter 2mm.Thus there is significant increase in CBR value of soil reinforced with increase in CBR value will substantially reduce the thickness of pavement subgrade. The Geotextile layers are arranged within the soil sample in different combination such as 1 layer, 2 layers, 3 layers, 4 layers etc. and laboratory CBR values were determined in both soaked and unsoaked conditions corresponding to each combination of reinforcing layer. Further, these test results were compared with that of unreinforced soil. It was observed that inclusion of Jute Geotextile layer increases the CBR value of soil and this increase is maximum corresponding to 4 layers of Jute Geotextile layers. Hence there is a significant increase in CBR value of soil due to inclusion of Jute Geotextile layers as a reinforcement.

Subgrade soils are an essential component of pavement structures, and inadequate subgrade performance is the cause of many premature pavement failures. Clay subgrades in particular may provide inadequate support, particularly when saturated. Soils with significant plasticity may also shrink and swell substantially with changes in moisture conditions. These changes in volume can cause the pavement to shift or heave with changes in moisture content, and may cause a reduction in the density and strength of the subgrade, accelerating pavement deterioration. There is a substantial history of use of soil stabilisation admixtures to improve poor subgrade soil performance by controlling volume change and increasing strength. Lime and cement have been used successfully for many decades, and more recently Class C fly ash has been used as an economical alternative to improve subgrade performance. The benefits of Class C fly ash may be divided into three categories (a) Drying agent. Fly ash

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hydrates when exposed to water. As a water consumer, it can be used as a drying agent for wet soils when acceleration of the drying process is desired. al / Procedia Engineering b) Control of volume change. Fly ash reduces shrink/swell behaviour because it does not experience significant volume change itself, so its addition acts to dilute the effects of the swelling clays that are present. It also contains some lime, which acts through ion exchange to affinity for water. (c) Increase strength. Fly ash acts as a weak cementing agent that increases the strength of the treated soil. Much of this strength gain occurs very quickly; however, for some soil ash combinations there may be additional strength gains over time owing to pozzolanic reactions as with lime. The immediate strength gain is of particular value because it results in a subgrade that serves as a superior working platform for asphalt paving and compaction equipment. The permanence of these improvements is uncertain. McCallister and Petry (1991) [12] showed in laboratory testing that stabilisation with an inadequate amount of lime could yield improvements in soil behaviour that were non-permanent. Laboratory research by Parsons and Milburn (2003a) showed some evidence that the plasticity of fly ash stabilised soils can also revert to native levels with leaching. However, Ferguson and Zey (1992) [12] found that fly ash stabilised soils performed well in the field after a period of two years.

Fly Ash for improving soil properties

Physical & chemical properties of soil due to fly-ash amendment vary according to the original properties of soil and fly ash but certain generalization could be made in most cases has been reviewed. Some of the general changes in properties of soil can be observed from the properties such as Soil Texture, Bulk Density, Water Holding Capacity and Soil Ph Application of high rates of fly-ash can change the surface texture of soils, usually by increasing the silt content. Fly-ash addition at70t/ha has been reported to alter the texture of sandy & clayey soil to loamy. Addition of fly-ash at 200t/acre improved the physical and chemical properties of soil and shifted the textural class of the refuge from sandy loam to silt loam. The particle size range of fly-ash similar to silt & changes the bulk density of soil. Application of fly-ash at 0%, 5%, 10% and weight in clay soil significantly reduced the bulk density and improved the soil structure, which in turn improves porosity, workability, root penetration and moisture-retention capacity of the soil. Fly-ash application to sandy soil could permanently alter soil texture, increase micro-porosity and improve the water-holding capacity as it is mainly comprised of silt-sized particles. Fly-ash generally decreased the bulk density of soils leading to improved soil porosity, workability &enhanced water-retention capacity, Base et al. (2009) [3]. A gradual increase in fly-ash concentration in the normal field soil (0, 10, 20 up to 100% v/v) was reported to increase the porosity, water-holding capacity, conductivity and cation exchange

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capacity. Depending on the source, fly-ash can be acidic or alkaline, which could be useful to buffer the soil Ph.

Pallavi1, Pradeep Tiwari2, Dr P D Poorer (2016): The conclusions drawn from these studies are as follows:

1.The consistency indices value of the black cotton soil reduces with mixing of fly ash. Initially the LL, PL and PI values of raw soil are 71.20%, 30.50 % and 40.70 % respectively which on mixing fly ash in ranges from 10 % to 40 % gradually decreased. With 40 % addition of fly ash to the soil, the LL, Pl and PI values are obtained as 45.50%, 23.60 % 21.90 % respectively. Thus, the soil plasticity is reduced on mixing of fly ash and the soil became less problematic.

2. The mixing of fly ash has pronounced effect on compaction characteristics also. In Modified

Proctor's Compaction Test, the MDD value of raw soil is achieved as 1.57 gm/cc at OMC of 18.20 %. It got increased to 1.90 gm/cc at OMC of 17.38 % on 20% addition of fly ash. However, further addition of fly ash causes reduction in MDD.

3. The soaked CBR value of the raw soil is 1.71 and after mixing of fly ash in the soil, there is remarkable change in CBR value. The addition of 20 % fly ash increased the CBR value from 1.71 to 4.95, but further addition of fly ash caused decrease in CBR value. Thus, the optimum quantity of fly ash i.e., after which the CBR value starts decreasing, is 20 %. 4.When the soil is mixed with optimum quantity of fly ash and Nylon Fibre of 0.40 mm diameter at different aspect ratio and fibre content the results obtained area. At aspect ratio of 40 with 0.75 % fibre content in 20 % fly ash mixed soil, the maximum value of CBR is achieved which is 7.18. It is 4.20 times greater than the CBR value of raw soil. Irrespective of the aspect ratio, the soaked CBR value of the fly ash mixed soil increases up to 0.75 % content and after this value it starts decreasing.

5. Thus, for the black cotton soil used in the present study, the optimum quantity of fly ash and Nylon Fibre are 20 % and 0.75 % (at aspect ratio of 40) respectively for achieving maximum soaked CBR.

6. CBR tests were also carried out for the combination of fly ash mixed soil and the fly ash nylon fibre mixed soil. The Top portion of mould was filled with the optimum mix of Nylon Fibre, fly ash and soil and bottom is filled with only optimum percentage of fly ash and the soil. It is found that a combination of ½: ½ gave CBR as 6.18 which is an impressive value as the CBR of raw soil is only 1.71. Thus, mixing of fiber only in the top portion of fly ash mixed soil would be an economical proposition in construction of road in poor black cotton spoil areas.

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Swati Sucharita Rout, Monoswi Manini Sahoo and Rupashree Ragini Sahoo (November 2017): In this study the current review, the appropriateness of fly ash and coir fiber blend as a soil stabilizer for soft soil was studied. The accompanying conclusions can be drawn from observations. I. OMC increase with increases of fly ash and percentage of coir fiber. Percentage of fly ash increases with the increase of MDD value. MDD estimation of soil decreases, when the percentage of fiber increments. ii. The inclusion of fly ash is improving UCS and CBR value of all the mixed proportion, but there is an abrupt hike in CBR at 10% fly ash content. iii. Addition of coir fiber increases the CBR value and UCS value in soil+10% fly ash. The present study suggests that 5% of coir fiber with l/d=40, seemed, by all accounts, to be most extreme. iv. From the investigation, it is studied that the mixture of soil, 10% fly ash and 5% coir fiber is optimum percentage and economic. Based on the result obtained, it is recommended that coir waste can be utilized as reinforced material and the fly ash can be used as additive for soil stabilization. This provided an efficient and economical way to dispose of fly ash and coir waste. It can elevate rustic economy and prompt to helpful impact in engineering construction.

Tan Teing Teing1, Bujang B.K. Huat2 , Sanjay Kumar Shukla3 , Vivi Anggraini4 and HaslindaNahazanan(jan2019):
In this study, the use of alkali-activated binders for soil stabilization enabled the researchers to utilize locally available by-products in an efficient way in order to fully eliminate traditional cementitious binder (i.e., cement and lime), thus significantly reducing energy consumption while protecting the environment. Primarily, this study investigated the effectiveness of alkaline activation reaction on residual soil with different percentages of fly ash with a concentration of 10 molars of potassium hydroxide. Interestingly, it can be deduced from the results that an appropriate quantity of source binder (fly ash) will contribute to higher strength developments. Consequently, the curing time was also affected the strength development of the treated soil. The curing time was depending on the source binders and activator used.

Based on the microstructural analysis, it can be concluded that the simultaneous formation of ASH gel and CSH gel increased the interaction between soil and alkali-activated binders.

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Farzad Habibbeygi1 and Hamid Nikraz (FEB 2018): In this study, the following conclusions were drawn:

Adding MgCl2 as a stabilizer to the clayey soil decreases the consistency limits (i.e. liquid limit and plastic limit). However, the tendency is decreasing for both of consistency limits, the decreasing effect is greater for the liquid limit rather than the plastic limit.

ii. The swell strain of the treated samples with MgCl2 is decreasing considerably to one-fifth of the initial value of the untreated sample. The swell strain remains nearly constant for the MgCl2 content higher than 8%. iii. Zero-deformation test results show that the swell pressure of the treated expansive clays decreases from 83 kPa to 16 kPa with the use of 8% of MgCl2 as the stabilizer. The tendency is decreasing with the increase of additive content; however, the use of higher values of MgCl2 (> 8%) slightly alleviates the swell potential of the treated samples in comparison with the sample treated with 8% of MgCl2. iv. The zero-deformation test and the free swell test results show that the swell curves can be divided into three separate stages of initial, primary and secondary swelling. However, the swell displacement mainly occurs in the primary stage, a 510 % of the total displacement happens in the secondary stage because of the existence of smectite in the clay mineralogy

K. Venkatraman, P. Dayakar, Dr.R. Venkatakrishnaiah (2018): The efficiency of the soil depends on the settlement behaviour in them and the admixed used in this study shows the load carrying capacity of the soil is improved by adding GSA to them. From this study it can be concluded that the settlement behaviour of the soil sample which is executed by plate load test the ultimate load increases by the 12 to 14 times when compare to the case1 of loose state of the soil with case 3 and 5 to 7 times when compared to the case 1 of medium dense state of the soil with case 3 and 15 to 17 times when compared to the case1 of the dense state of the soil with case 3. It can be concluded that using the GSA in the soil gives the settlement behaviour and the bearing capacity of the soil will be increased.

C. C. Ikeagwuani (2016): Investigation into the compressibility characteristics of black cotton soil has indicated that it can achieve an optimum performance in its useful life if admixed with a combination of 6%SDA and 4% lime by weight of the black cotton soil. The result obtained from this research work agreed with that of [16] for the stabilization of black cotton for use as subgrade material.

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Further test carried out included the specific gravity, which improved from 2.34 to 2.37, liquid limit, which decreased from 84.2 to 40.6% and plastic limit, which increased from 28.0 to 33.3%. Thus, the overall plasticity index was down from 56.2 to 7.3%. The differential free swell also improved with a decreased from 79 to 25.2%

John Nelson, Debora J. Miller (FEB 1997): Essential technical information for building on expansive soils--complete with practical, proven design methods. Expansive Soils examines factors that influence the design off foundation and pavements built on expansive soils, and explores key design procedures and remedial measures that address these factors effectively. Backed by the authors' extensive research and experience --including interviews with practicing engineers working with expansive soils --this authoritative volume is an important reference text for geotechnical and foundation engineers, geologists, construction professionals, and students. Easy to understand and apply, Expansive Soils contains: * Site investigation techniques for identification and classification of expansive soils * Heave prediction methods using different types of data –with rigorous treatment of soil suction theory and measurement, oedometer tests, and more * Alternative design procedures for drilled pier and slab-on grade foundations, highway and airfield pavements * Treatment and chemical stabilization techniques
--including salt treatment; moisture barriers.

Niraj Singh Parihar, Ashok Kumar Gupta (2020): The study shows the potential of limed leather waste ash for improvement of compaction and strength of the expansive soil .it is found that the waste ash has the capability to form a compact matrix with the expansive clayey soils which helped to improve the density of the mix. The maximum dry density increased initially on LLWA mixture contrary to the trend of lime treatment. The soil mix attained its maximum density at 6% additive content which decreased with the excessiveness of the ash particles in further additions of the waste ash. The OMC of the mix also experienced a continuous downfall despite the hydration requirements of the mix. There was a substantial increase in the unconfined compressive strength with and without curing of the mix with the maximum strength achieved at 10% additive concentration in both cases. The immediate compressive strength rose by almost 40% in uncured state and by 77% and 150% for curing periods of 4 and 28 days respectively as compared to the UCS of the plain soil sample. The primary reason behind rise of the strength was generation of the CSH gel resulting in agglomeration of the particles of the soil mix. The SEM analysis showed the presence of montmorillonite and kaolinite as major minerals in the soil. The SEM

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results further confirmed the formation of CSH gel due to reaction of lime present in the ash and silica content of the clayey soil which increased with the additive content and also with the curing of mix. Therefore, it may be established from the study that the LLWA contains stabilization characteristics of lime and it can be well utilized to counter the low strength of expansive soils which will also reduce the major dumping problems of the leather industry.

Anil Sharma (March 2016): In this study, an artificially-mixed expansive soil was stabilized with different amounts of binder, primarily consisting of fly ash and GGBS at a mixing ratio of 7:3. The objective of this research was to assess the effect of fly ash-GGBS based binder on the physical properties and unconfined compressive strength of the soil. Based on the results presented in this paper, the following conclusions are made:

(1) The addition of binder or lime–binder to the soil decreased liquid limit and plasticity index while increasing the shrinkage limit. It is found that the addition of binder causes flocculation of clay particles and increases the number of coarser particles which help in reducing the Atterberg limits.

(2) The optimum moisture content (OMC) was found to decrease while the maximum dry density (MDD) increased with increasing binder content

(3) The unconfined compressive strength of soil was found to increase with increasing binder content as well as a longer curing period. The addition of a small quantity of lime (1%) increased the strength significantly. The optimum content of the binder for the effective stabilization of the artificially mixed expansive soil was found to be 20%.

(4) SEM and XRD studies confirm the formation of reaction products such as C–S–H and calcium hydroxide, which contributed to strength development in the stabilized soil.

(5) This study has shown that fly ash mixed with GGBS has the potential to improve the properties of expansive soil with a minimum requirement of chemical additives such as lime. Considering the high cost of lime and cement, the use of fly ash/GGBS mixtures can represent a significant saving in the construction costs as well as reduce the environmental pollution problem.

This study presents a framework for the evaluation of soil additives/binders. The results showed that the type and amount of additives play a major role in the stabilization process. In the present world, where a variety of industrial by-products are available in abundant quantities, it is very important to select the additives based on different properties, and the chemical composition is the most

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important among these properties. Various industrial by-products can be amended together based on their chemical compositions.

Eng. Forat AL-Sahar1, Eng.Mohemmed Erdini (2019):

1. The ideal proportion of the residues of cement residues must be not exceed 15 % with good bearing strength.

2. The additives to the soil makes it more elastic.

3. Economically, the cost of paving using cement residues, Portland cement, sand, and water is not more than 55% of the value of asphalt used for asphalt paving, which provides at least 45% of the cost 4. Increase structural integrity and loading capacity (CBR).

5. Improve long-term performance of un-surfaced and surfaced roads.

6. Offer a cost-effective alternative to asphalt.

7. Improve aging control to reduce cracking and moisture damage.

Tanaya Deb1, Sujit Kumar Pal (2014): The following conclusions are made based on the above results and discussions:

- In general, decrease in values of specific gravity, plasticity index and linear shrinkage in the soil-fly ash mix samples irrespective of fly ash type.
- With the increase of ash content in the soil-ash mix samples, MDD decreases and OMC increases irrespective of ash type.
- With the increase of ash content in the soil-ash mix, initial void ratio increases, and degree of saturation decreases irrespective of ash type.
- In general, hydraulic conductivity values increases with higher percentage of fly ash content in the mix and maximum value attain 1×10-7 cm/sec. Local silty clay soil-fly ash mixed samples with fly ash content of 10, 15, 20, 25 and 30% can be used as liner material.
- With higher fly ash content in the mix UCS values gradually decrease irrespective of ash type, but as a whole the 7 th day UCS values are showing increasing trend than 1st day values.
- As the ash content increases the swelling potential and free swelling index, both decreases.

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- 30% of fly ash contents or above in local silty clay soil-fly ash mixed sample, this material may be used as land filling and embankments in the field of geotechnical engineering construction

Adetoro A. Ezekiel, Dada O. Michael (2015): From the above results of this study, the following conclusions were drawn: The soil is lateritic in nature identified by [6] to be A – 7 – 6 soil group. It is silt – clayey soil of high plasticity;

2. The treatment with the GSA content showed increase in the coarse particles of the soil through cementation;

3. There was also improvement in the mechanical strength of the soil as the CBR value (of 6% before treatment) increased to 18% after treatment. It is therefore recommended that it should be employed with other additive like cement for the formation of secondary cementitious compounds which will be produced from the cement hydration. A further study should be engaged.

Enza Vitale 1, * ID, Giacomo Russo 1, Gianfranco Dell'Agli 1 ID , Claudio Ferone 2 ID and Chiara Bartolomeo 2(2017): An insight into the mechanical improvement induced by alkali-activated binders based on the activation of two different type of fly ashes on a clayey soil has been presented. One-dimensional compression tests performed on treated sample highlighted the effectiveness of alkali activated binders to promote an improvement of the mechanical behaviour of treated soil. A reduction of compressibility an increase of the yield stress soil was observed since the very short term. The macroscopic behaviour of treated soil has been linked to the experimental evidences at microscale. Microstructural analyses show a high reactivity of the alkali activated fly ashes as alumino-silicate source promoting the precipitation of new mineralogical phases forming chains and networks with cementitious properties. The reactions kinetic controlling the chemo-physical evolution of alkali activated binders and therefore the macroscopic evolution of soil properties depends on fly ashes mineralogy, as evidenced by the compressive behaviour of the treated samples as function of curing times and binder contents.

Fusheng Zha Æ Songyu Liu Æ Yanjun Du Æ Kerui Cui (2008): Based on the experimental study of the stabilization of Hefei expansive soil using fly ash and lime-fly ash, the following conclusions can be drawn:

1.Fly ash and lime-fly ash treatments reduce the swell potential and shrinkage of the soils. The free swell, swell potential, swelling pressure, and linear shrinkage

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decreased with the increase in fly ash and lime-fly ash content. The swell potential and swelling pressure of both fly ash and lime-fly ash treated soils decreased with increase in curing time.

1. With an increase in fly ash and lime-fly ash content, the optimum water content and the maximum dry unit weight decreased.

2. There are negligible changes in the unconfined compressive strength with the increase in the fly ash content without curing. However, with the addition of lime, shear strength increased significantly. The optimum content of fly ash is found to be 9–12% for the treated soils with curing time of 7 days.

3. A simple plasticity index ratio method has been put forward for the prediction of the swell-shrinkage properties of treated expansive soils with fly ash and lime-fly ash.

Manway Kumar Mohanty (2015): Based on the results obtained and comparisons made in the present study, the following conclusions can be drawn:

1. The Maximum Dry Density (MDD) value of the black cotton soil initially decreased with the addition of fly ash. Then, it showed increment with increasing fly ash content in the soil-fly ash mixture. The maximum value of MDD was observed for a mixture of soil and 30% of fly ash content by weight. The MDD values consistently decreased thereafter.

2. The Unconfined Compressive Strength (UCS) of the soil with variation of fly ash content showed similar trend as that of the MDD values, except the fact that the peak value was observed for a fly ash content of 20% by weight.

3. In un-soaked California Bearing Ratio (CBR) tests of soil conducted with varying fly ash content, the CBR increased gradually with the increase in fly ash content till its valuation was 20% by weight of the total mixture; it decreased thereafter.

4. The change in case of soaked California Bearing Ratio (CBR) tests of soil with varying fly ash content was, however, uneven. It decreased with the initial addition of fly ash (10% by weight of total mixture), and then increased till fly ash content reached 30% by weight of total mixture. The values decreased thereafter.

5. With the increasing fly ash content in the soil-fly ash mixture, the decrease in value of free swell ratio was remarked. This decrease was also reciprocated by the plasticity index values. Plasticity index values are directly proportional to percent swell in an expansive soil, thus affecting the swelling behaviour of the soil-fly ash mixture.

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6. Thus, fly ash as an additive decreases the swelling, and increases the strength of the black cotton soil. **zala yashwanth (2015):** Based on the present tests, the following conclusions can be drawn:

a. As the locally available borrow soil has generally high plasticity (LL > 50) it was difficult to construction on it.

b. The inclusion of different percentage of fly ash in natural soil generally resulted in some increasing in unconfined compressive stress. 9

c. The unconfined compressive stress of natural soil without fly ash which was 114kN/m2, increased to 123 kN/m2 at 20% fly ash in natural soil showing 7.89 % improvement.

d. A liquid limit was decreases with increases in percentage of fly ash up 30% in natural soil which was 74.4%, decreased to 72.5%, showing 2.56 % decreased.

e. Plastic limit was decreases with increases in percentage of fly ash up 30% in natural soil which was

38.4%, decreased to 32.93 %, showing 14.24 % decreased.

f. Maximum dry density was increase with increases in percentage of fly ash up 30% in natural soil which was 1.68gm/cc, increase to 1.71gm/cc at 14% OMC showing 1.78 % increase. g. As per grain size analysis the percentage of gravel 1.11%, percentage of sand 9.89% and percentage of fines 89%.

B.A. Alabadan, 1 C.F. Njoku and M.O. Yusuf (2015): From the results of the tests carried out in this work, it can be concluded that:

1. Groundnut Shell Ash contains some of the oxides found in pozzolanas and Portland cement.
2. Groundnut Shell Ash up to 30% replacement of ordinary Portland cement in concrete would be acceptable.

Bryan Yien Fu Wong1 , Kwong Soon Wong1*, Ignatius Ren Kai Phang1(2019): The current paper reviewed on geopolymerisation to stabilize soil. Geopolymers have become the centre of attention as they appear to use solid waste and by-products, thereby offering cost-effective solutions to issues involving hazardous residue that needs to be treated and stored. The alkaline activation of aluminasilicate materials (geopolymerisation) is already being seen as a viable replacement for OPC, as these new materials are able to overcome most of the familiar drawbacks of using OPC. It has been confirmed that an enhanced reaction between source material and solution can be achieved if a solution of sodium silicate is added to

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the solution of sodium hydroxide being used for alkaline liquid. The FA-CCR geopolymer-stabilized soil demonstrates efficiency than FA geopolymerstabilized soil due to two geopolymerisation products coexist: Sodium Aluminosilicate Hydrate (N-AS-H) and Calcium Silicate Hydrate (C-S-H).

N. Gamage1*, K. Liyanage2 , S. Fragomeni1 , S. Setunge3 (2011): Utilization of fly ash in manufacturing building materials has increased significantly due to its increasing availability and massive environmental problems caused by disposal of fly ash. Two types of fly ash have been defined as class F and class C in which high lime content is identified. Physical properties of fly ash may vary depending on the nature of coal; rank, mineral matter chemistry and mineralogy, furnace design, furnace operation and method of particulate control, while chemical properties are less dependent on those factors. Fly ash has been incorporated in many different ways in manufacturing bricks, concrete and cementcomposites such as slabs, beams, columns, wall panels, sheets, pipes etc. Generally it is recommended to use around 25% of fly ash as replacement of cement in order to obtain effective resultant end products. Fly ash improves workability, freeze/thaw durability, density and pumpability while it reduces unwanted effects such as water demand, permeability and alkali/silica reaction in concrete.

A Wardhono(2017): The strength development for class F fly ash and class C fly ash non-cement mortars were investigated experimentally from 7 to 28 days. The main conclusions may be drawn based on this study are:

- Class C non-cement mortar demonstrates a higher compressive strength compared to class F at ambient temperature due to the high calcium content in class C raw fly ash material.
- Class F non-cement mortars fail to achieve its structural integrity at ambient temperature.
- High temperature significantly affects the strength development of class F non-cement mortar.
- Class F non-cement mortar exhibits a better strength performance to that class C non-cement mortar at high temperature.

By Udayashankar D.Hakari, S.C.Puranik(2012): The study of variations of different parameters viz. liquid limit, plastic limit, plasticity index, shrinkage limit, maximum dry density, optimum moisture content, unconfined compressive strength and California bearing ratio with the addition of Dandeli fly ash suggest that, for each parameter of the study soil samples, there exists an optimum Dandeli fly ash percentage for mixing with the soil under consideration; at which

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the respective parameter attains its most desirable value from geotechnical point of view

The California bearing ratio of the study soils increase gradually with the addition of Dandeli fly ash up to a certain percentage of Dandeli fly ash, beyond which, further increase in Dandeli fly ash percentage is observed to cause a decreasing trend in the California bearing ratio values. The improvement in the California bearing ratio value of the black cotton soil upon the addition of Dandeli fly ash suggests that, it can be effectively used in bulk as sub-base material in combination with the study soils, for the road construction works.

The unconfined compressive strength of these soils increases upon the addition of Dandeli fly ash. The trend of improvement in the unconfined compressive strength is observed to be more pronounced with the curing of the soil + fly ash mix. A curing period of 28 days is observed to yield the maximum enhancement in the unconfined compressive strength.

Jyoti S. Trivedia *Sandeep Nairb r Chakradhar Iyyunnia (2013): As a result, it can be observed that soil containing 20% Fly ash gave the best results of Soil Stabilization as compared to other proportions. The Evolver model has the capability to integrate the consequence of every input constraint for any required output constraint concurrently. The Evolver Model created to apply Genetic Algorithm for predicting CBR values returned values with good amount of accuracy. This indicates the relevance & effectiveness of Genetic Algorithm Models for solving various kinds of research problems.

The current model is only limited to predicting the CBR values of the soil based on the experimental data of index properties of the soil which were OMC, LL & PI. This model will be helpful for all types of agencies involved in road construction like NHAI, Infrastructure Developers and Construction Contracting Organizations to pre-determine the soil stabilization achieved due to fly ash for a particular type of sub-grade soil.

Another advantage of this model will be that it can predict the amount of fly ash needed for a particular value of CBR by applying it in a reverse manner. From various experiments conducted by eminent researchers of this field it has been found that the maximum value of CBR attained by adding fly ash in different types of soils are in the range of 15-20%. So, from this model the fraction of fly ash to be added for different types of soil for maximum stabilization can be determined.

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CHAPTER-

3. OBJECTIVE OF STUDY:

Objectives of the study the present study was under taken with the following objectives:

- To study the effect of varying percentage of fly ash on properties of Black Cotton Soil.
- To study the variation of Liquid Limit, Plastic Limit, Plasticity Index, Dry density, OMC, CBR (Soaked) of clayey soil with and without fly ash with different aspect ratio.
- To determine optimum percentage quantity of fly ash aspect ratio.

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CHAPTER-4

SITE VISIT:

4.1 COLLECTION OF MATERIALS:

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The soil is procured from “pragathi nagar lake”.it is located reasonably near 5km from Kukatpally,Hyderabad,about 7m depth soil were collected by open excavation from the natural ground level.

4.1.1 **SOIL:** Soil is an accumulation or deposit of earth material, derived naturally from the disintegration of rocks or decay of vegetation that can be excavated readily with power equipment in the field or disintegrated by gentle mechanical means in the laboratory. The supporting soil beneath pavement and its special under courses is called sub grade. Undisturbed soil beneath the pavement is called natural sub grade. Compacted sub grade is the soil compacted by controlled movement of heavy compactors. The desirable properties of sub grade soil as a highway material are • Stability • Incompressibility • Permanency of strength .Minimum changes in volume and stability under adverse conditions of weather and ground water • Good drainage, and • Ease of compaction The soil used in this investigation is an expansive clay, one type of most problematic soil for sub grade constructions is used in this research work which is locally available Black Cotton Soil collected from pragathi nagar,Kukatpally,medchal,Telangana.

4.1.2 **Fly ash:** Fly ash is one of the residues generated in the combustion of coal. Fly ash is generally captured from the chimneys of coal-fired power plants, and is one of two types of ash that jointly are known as coal ash; the other, bottom ash, is removed from the bottom of coal furnaces. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous

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and crystalline) and calcium oxide Cao, both being endemic ingredients in many coal bearing rock strata. The fly ash used in this research work is collected from thermo power plant at Bhupalpally, Telangana.

FLY ASH; FLY ASH IS PROCURED FROM THE THERMAL POWER PLANT, WHICH IS LOCATED IN BHUPALPALLY.ITS AROUND 5 KM FROM THE MAIN CITY BHUPALPALLY.

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CHAPTER-5

5.0 METHODOLOGY:

- SPECIFIC GRAVITY [IS 2720-Part III-1984]
- HYDROMETER ANALYSIS [IS 2720-Part IV-1985]
- FREE SWELL INDEX TEST
- ATTERBERG LIMITS [IS 2720-Part V-1985]
- STANDARD PROCTOR TEST [IS 2720-Part VII-1980]
- UNCONFINED COMPRESSIVE STRENGTH (UCS) [IS 2720 – part X-1991]
- CALIFORNIA BEARING RATIO TEST
- RESILIENT MODULUS TEST

5.1 SPECIFIC GRAVITY TEST:

SCOPE:

This test is performed to determine the specific gravity of soil by using a pycnometer. Specific gravity is the ratio of unit weight of soil at a stated temperature to the unit weight of same volume of gas-free distilled water at a stated temperature.

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DEFINATION:

The specific gravity, is the ratio of the density of a substance to the density of a given reference material. Specific gravity for liquids is nearly always measured with respect to water at its densest; for gases, the reference is air at room temperature.

APPARATUS:

1. Pycnometer with a conical cap screwed at its top

2. Balance, sensitive to 0.2 g

3.Wash bottle with deaired, distilled water

4.Glass rod, about 150 mm and 3 mm diameter

5. Thermometer with 0 - 50oC range and accurate to 1oC

6. Thermostatically controlled oven.

PROCEDURE:

1.Clean the Pycnometer, and dry it. Find the mass of the Pycnometer with its cap and washer, accurate to 1.0 g (Ml).

2.Introduce about 400 g of oven dried coarse-grained soil in to the Pycnometer. Record the mass of the Pycnometer with its cap and washer along with the soil (M2).

3. Fill the Pycnometer with distilled water to half its height, and mix it thoroughly with the soil using the glass rod. Keep the entire system aside for about 4 hrs. At the end of this period, fill the Pycnometer with water up to the top of the conical cap. Dry the Pycnometer from outside and record its mass (M3).

4.Clean the Pycnometer thoroughly. Fill it with distilled water up to the top of conical cap. Dry the Pycnometer from outside and record its mass to the nearest 0.2 g (M4).

5. Repeat the steps (2) and (3) thrice.

6. Calculate the specific gravity of the soil at the room temperature as well as at 27oC.

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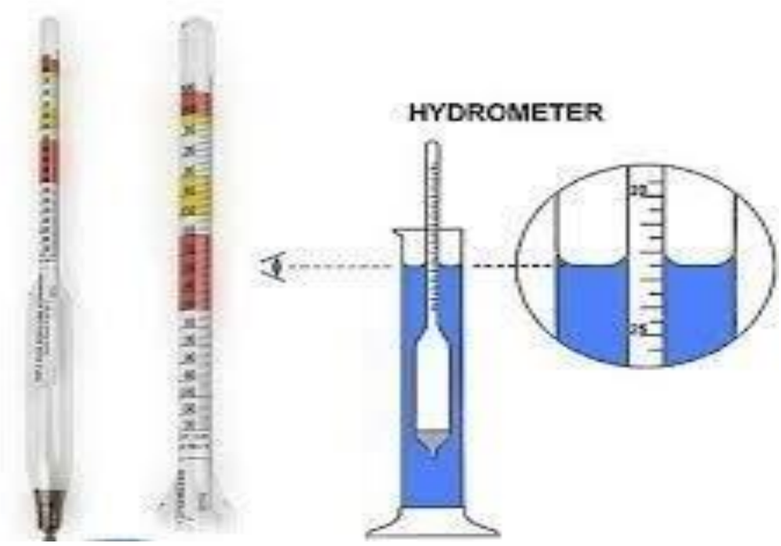
5.2 HYDROMETER ANALYSIS TEST:



SCOPE:

To determining the grain size distribution of soil sample, usually mechanical analysis (sieve analysis) is carried out in which the finer sieve used is 75 micron or the nearer opening. One form of the analysis is hydrometer analysis.

DEFINATION:

A hydrometer analysis is the process by which fine-grained soils, silts and clays, are graded, the hydrometer also determines the specific gravity (or density) of the suspension, and this enables the percentage of particles of a certain equivalent particle diameter to be calculated.

APPARATUS:

1. Three 1000 ml capacity measuring jars
2. Hydrometer
3. Mechanical stirrer
4. Balance
5. Dispersion agents- Sodium hexa-meta phosphate and sodium carbonate
6. Thermostatically controlled hot air oven
7. Stop watch

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PROCEDURE:

1. Calibrate the hydrometer to be used in the test.
2. Determine the meniscus correction.
3. Take about 50 g of oven dried soil sample passing 75 µ IS sieve.
4. Subject the soil to pre-treatment to remove soluble salts or organic matter or calcium compounds, if necessary.
5. Dissolve 3.3 g of sodium hexa-meta phosphate and 0.7 g of sodium carbonate in 100 ml distilled water. Transfer the solution to 1000 ml capacity jar and add distilled water to make the volume of the solution to 1000 ml (This dispersion agent solution is required for getting the composite correction).
6. Take the measured quantity of soil in a beaker. Add 100 ml of solution prepared by dissolving 3.3 g of sodium hexa-meta phosphate and 0.7 g of sodium carbonate in distilled water to the beaker.
7. Warm the soil suspension gently for about 10 minutes.
8. Transfer the soil suspension to the cup of a mechanical stirrer using about 100 ml of distilled water. Stir the suspension for about 15 minutes.
9. Transfer the stirred soil suspension to another 1000 ml capacity measuring jar. Add distilled water to the suspension to make its volume to 1000 ml.
10. Place suitable covers on the top of the two 1000 ml measuring jars – one containing the dispersion agent solution and the other containing the soil suspension. Shake the contents in the two jars vigorously and place them slowly on a level platform. Start a stop watch immediately.
11. Insert the hydrometer in to the jar containing the soil suspension slowly and allow it to float freely.
12. Note down the hydrometer readings corresponding to upper meniscus after suitable time intervals or note down the time intervals corresponding to well defined hydrometer readings.
13. After 4 minutes reading, take out the hydrometer from the jar, rinse it with distilled water and allow it to stand in another 1000 ml jar containing distilled water.
14. Insert the hydrometer in to the jar containing soil suspension from time to time and note down the hydrometer readings and corresponding time

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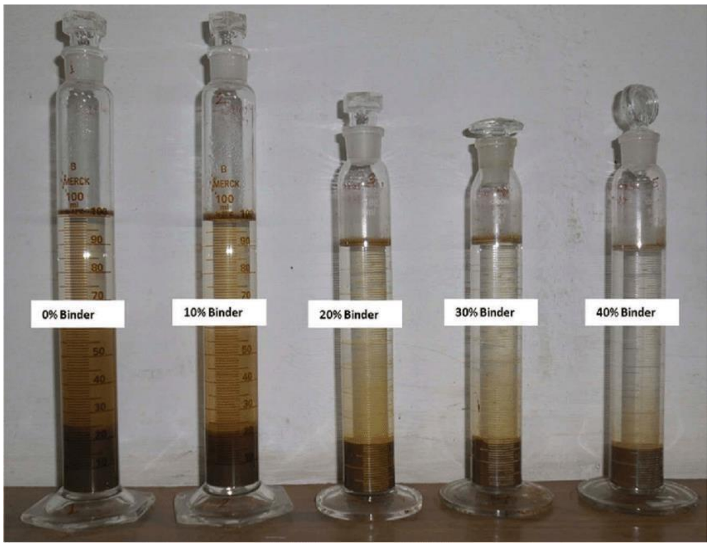
intervals. After removing the hydrometer from the jar each time, rinse it with distilled water and store it in the jar containing distilled water.

15. Record the temperature of the soil suspension and the composite correction in the beginning of the test and also after each time the hydrometer reading is taken beyond 15 minutes period

Note: Recording of composite correction: Insert the hydrometer in to the 1000 ml jar containing the dispersion agent solution; allow it to float freely; note down the hydrometer reading corresponding to upper meniscus. Record the negative of this reading as the composite correction.

16. Calculate the equivalent diameter of the soil particles corresponding to the noted time intervals (D) and also the corresponding values of percentage finer based on the dry mass of the soil sample taken for the test (N') and based on the total mass of the dry soil sample taken for the grain size analysis(N).
17. Carry out the test till the equivalent diameter of the particles is less than 2 µm.
18. Using the values of equivalent diameter of the particles (D) and the values of corresponding percentage finer (N), plot the grain size distribution curve. From the plotted curve, note down the percentage of silt size and clay size fractions present in the soil.

5.3 FREE SWELL INDEX TEST



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SCOPE:

To determine the free swell index of soil as per IS: 2720 (Part XL) – 1977. Free swell or differential free swell, also termed as free swell index, is the increase in volume of soil without any external constraint when subjected to submergence in water.

DEFINATION:

Free swell is the increase in volume of a soil, without any external constraints, on submergence in water. The possibility of damage to structures due to swelling of expensive clays need be identified, at the outset, by an investigation of those soils likely to possess undesirable expansion characteristics. Inferential testing is resorted to reflect the potential of the system to swell under different simulated conditions. Actual magnitude of swelling pressures developed depends upon the dry density, initial water content, surcharge loading and several other environmental factors.

APPARATUS:

1. 425 microns IS sieve.

2. Graduated glass cylinders 100 ml capacity 2Nos (IS: 878 -1956).

3. Glass rod for stirring.

4. Balance of capacity 500grams and sensitivity 0.01 gram.

PROCEDURE:

1. Take two 10 g soil specimens of oven dry soil passing through 425 micron IS Sieve.
2. Each soil specimen shall be poured in each of the two glass graduated cylinders of 100 ml capacity.
3. One cylinder shall then be filled with kerosene oil and the other with distilled water up to the 100 ml mark. After removal of entrapped air (by gentle shaking or stirring with a glass rod), the soils in both the cylinders shall be allowed to settle. Sufficient time (not less than 24 h) shall be allowed for the soil sample to attain equilibrium state of volume without any further change in the volume of the soils.
4. The final volume of soils in each of the cylinders shall be read out.

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5.4 ATTERBERG LIMITS TEST:

5.4.1 Determination of liquid limit (Casagrande method)

SCOPE:

The natural moisture content of soil is closer to liquid limit, the soil can be considered as soft if the moisture content is lesser than liquids limit, the soil can be considered as soft if the moisture content is lesser than liquid limit. The soil is brittle and stiffer.

DEFINATION:

Liquid Limit (LL) is the water content at which soil changes from a plastic to a liquid state when the soil specimen is just fluid enough for a groove to close when jarred in a specified manner.

APPARATUS:

1. Casagrande liquid limit apparatus
2. Casagrande grooving tool of standard dimensions (Type A)
3. Glass plate, 10 mm thick and about 45 cm square

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4. Spatula

5. Balance, sensitive to 0.01 g

6. Thermostatically controlled hot air oven

7. Airtight and non-corrodible containers for moisture content determination.

8. Wash bottle containing distilled water.

9. 425 microns IS sieve.

PROCEDURE:

Figure 5.2.1: LIQUID LIMIT TEST

1. Using the gauge on the handle of the grooving tool or a separate gauge, adjust the height through which the cup of the Casagrande apparatus is lifted and dropped so that the point on the cup which comes in content with the base falls through exactly one centimetre for one revolution of the handle. Then, tighten the adjustment screws.

2. Take about 120 g of soil sample passing through 425 microns IS sieve and mix it thoroughly with distilled water on the glass plate to form uniform paste. Allow sufficient time to ensure uniform moisture distribution throughout the soil mass.

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3. Remix the soil thoroughly. Take a portion of the soil paste with the spatula and place it in the central portion of the cup and spread it into position with the spatula so that the soil surface is parallel to the rubber base with the maximum depth of the soil as 1.0 cm at the centre.

4. With the help of the grooving tool, divide the soil paste in the cup along the diameter of the cup (through the centre line of the cam follower) to get a clean, sharp groove of proper dimensions.

5. Turn the handle of the apparatus at a rate of 2 revolutions per second until the two parts of the soil paste come in contact at the bottom of the groove for a distance of about 12 mm and record the number of revolutions to achieve this.

6. Collect a representative sample of the soil by moving the spatula normal to the groove, width wise from the portion of the groove where the soil flowed together and put it in a container and determine its water content by oven drying method.

7. Transfer the remaining soil in the cup back on to the glass plate. Dry the soil by kneading the wet soil using spatula.

8. Repeat the steps 3 to 6 to get a minimum of 5 trials. The trials are conducted such that the number of blows is in the range 25 ± 10.

9. Plot a "flow curve" on a semi-log sheet with water content on y-axis (arithmetic scale) and number of blows on x-axis (log scale). Draw a well-defined straight line through the points. Record the moisture content corresponding to 25 blows and round off to the nearest whole number and report it as the liquid limit of the soil. Measure the slope of the line, which represents the flow index (If).

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5.4.2 Determination of plastic limit:

SCOPE:

Plastic limit test is one of the laboratory tests used internationally to differentiate or classify soils into groups. When the water content or moisture content of soil increases beyond a limit then the soil starts to behave as liquid.

DEFINATION:

The plastic limit of a soil is the moisture content at which soil begins to behave as a plastic material. At this water content (plastic limit), the soil will crumble when rolled into threads of 3.2mm(1/8in) in diameter.

APPARATUS:

1. Flat glass plate, 10 mm thick and about 45 cm square.
2. Spatula
3. Balance, sensitive to 0.01 g
4. Thermostatically controlled oven
5. Airtight and non-corrodible containers for moisture content determination.
6. Wash bottle containing distilled water
7. 425 microns IS sieve

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8. 3 mm diameter rod of about 10 cm length.

PROCEDURE:

(1) Weigh the remaining empty moisture cans with their lids, and record the respective weights and can numbers on the data sheet.

(2) Take the remaining 1/4 of the original soil sample and add distilled water until the soil is at a consistency where it can be rolled without sticking to the hands.

(3) Form the soil into an ellipsoidal mass. Roll the mass between the palm or the fingers and the glass plate. Use sufficient pressure to roll the mass into a thread of uniform diameter by using about 90 strokes per minute. (A stroke is one complete motion of the hand forward and back to the starting position.) The thread shall be deformed so that its diameter reaches 3.2 mm (1/8 in.), taking no more than two minutes.

(4) When the diameter of the thread reaches the correct diameter, break the thread into several pieces. Knead and reform the pieces into ellipsoidal masses and re-roll them. Continue this alternate rolling, gathering together, kneading and re-rolling until the thread crumbles under the pressure required for rolling and can no longer be rolled into a 3.2 mm diameter thread.

(5) Gather the portions of the crumbled thread together and place the soil into moisture can, and then cover it. If the can does not contain at least 6 grams of soil, add soil to the can from the next trial. Immediately weigh the moisture can containing the soil, record its mass, remove the lid, and place the can into the oven. Leave the moisture can in the oven for at least 16 hours.

Repeat steps three, four, and five at least two more times. Determine the water content from each trial by using the same method used in the first laboratory. Remember to use the same balance for all weighing.

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5.5 STANDARD PROCTOR TEST:

SCOPE:

Determination of the relationship between the moisture content and density of soils compacted in a mould of a given size with a 2.5 kg rammer dropped from a height of 30 cm. the results obtained from this test will be helpful in increasing the bearing capacity of foundations, Decreasing the undesirable settlement of structures, control undesirable volume changes, Reduction in hydraulic conductivity, Increasing the stability of slopes and so on

DEFINATION:

In geotechnical engineering, soil compaction is the process in which a stress applied to a soil causes densification as air is displaced from the pores between the soil grains. It is an instantaneous process and always takes place in partially saturated soil (three phase system). The Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density.

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APPARATUS:

1.Cylindrical Metal Mould, having internal diameter 4” (10.16 cm) or 6” (15.24 cm), the internal effective height of 4.6” (11.7 cm); and the mould should have detachable base plate & collar of 2 inches (5.08 cm).

2.Rammer, weighing 5.5 lbs (2.5 kg) & having fall of 12 inches (30.5 cm), with a flat circular face of 2” diameter.

3.Sensitive Balance, sensitivity ranging from 0.1 gram to 1 gram.

4. Thermostatically controlled oven (105°C +- 110°C)

5. Steel straight edge.

6. Moisture containers.

7. Sieve No.4.

8. Tray & scoop.

9. Graduated cylinder.

10. Mixing tools. (Spoon, trowel, spatula).

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PROCEDURE:

Figure 5.5: STANDARD PROCTOR TEST

1. Take sufficient quantity of representative soil, air dry & pulverize it with a rubber mallet. Sieve the soil through No: 4 sieve & reject the coarser material.

2. Take about, 3 kg of soil, add water to bring its water content to about 5% below the estimated optimum moisture content. (For coarse-grained soil 4% initial water content & for fine-grained soil 10% initial water content is preferable). Then Mix it thoroughly.

3. Clean the mould, measure its diameter & height & weigh it without the collar.

4. Fit the collar & compact the moist soil in three equal layers by the rammer with evenly distributed blows to each layer. Use 25 blows for 4 inches diameter & 56 blows for 6 inches diameter mould to the total height of mould with collar.

5. Remove the collar trim the compacted soil even with the top of the mould with a straight steel edge. Clean outside of the mould & base plate & weigh it.

6. Remove the soil from the mould, split it & take about 100 grams sample for water content determination.

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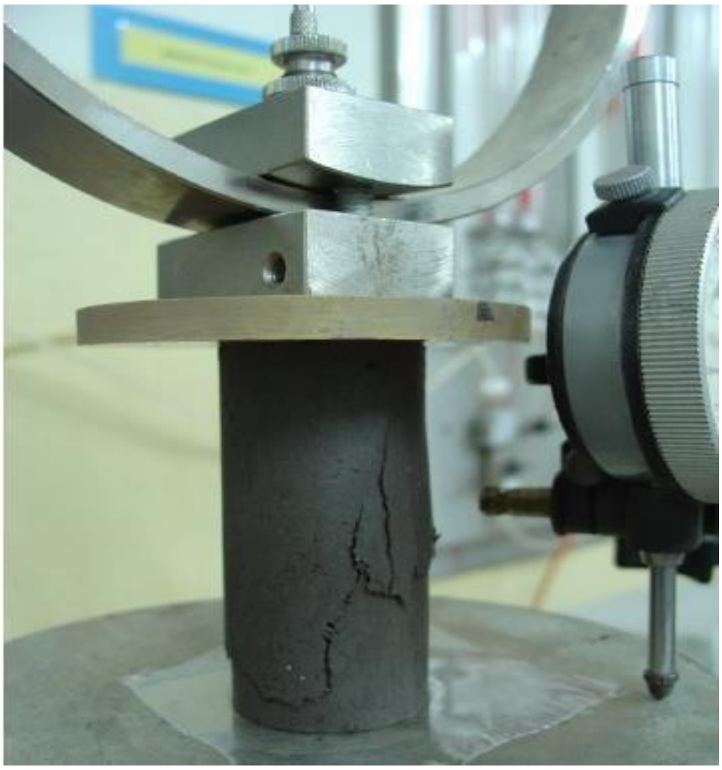
7. Break the soil lamps, mix it with remaining soil in the tray. Add more water to increase the water content by 2 to 3% & repeat the compaction procedure for each increment of water until the mass of the compacted soil decreases.
8. Calculate Water content for each trail & corresponding dry density.
9. Plot the compaction curve between water-content as abscissa & dry density as ordinate.
10. Note the water content against the peak of the curve as optimum moisture content & the corresponding dry density as maximum dry density.

5.6 UNCONFINED COMPRESSIVE STRENGHT TEST:



SCOPE:

According to the ASTM standard, the unconfined compressive strength (qu) is defined as the compressive stress at which an unconfined cylindrical specimen of soil will fail in a simple compression test.

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DEFINATION:

A measure of a material's strength. The unconfined compressive strength (UCS) is the maximum axial compressive stress that a right-cylindrical sample of material can withstand under unconfined conditions the confining stress is zero.

APPARATUS

1. Compression device of suitable type
2. Sample ejector
3. Deformation measuring dial gauge
4. Remoulding apparatus – for specimen preparation
5. Thermostatically controlled oven
6. Balance with weights
7. Vernier callipers.
8. Air tight, non-corrodible containers for water content determination.

PROCEDURE:

1. Measure the initial length, diameter and mass of the specimen.

1. Measure the initial length, diameter and mass of the specimen.

2. Place the specimen on the bottom plate of the loading device. Adjust the upper plate to make contact with the specimen. Set the load dial gauge (i.e., proving ring dial) and the compression dial gauge to zero.
3. Apply axial compressive load so as to produce axial strain at a rate of 0.5 to 2 percent per minute. Take the proving ring dial readings corresponding to compression dial readings at suitable intervals.
4. Compress the specimen until failure surfaces have definitely developed or the stress- strain curve is well past its peak or until an axial strain of 20% is reached, whichever occurs first.
5. Stop loading; Remove the failed specimen; Sketch the failure pattern; Keep the soil sample taken from the failure zone for moisture content determination.

5.7 CALIFORNIA BEARING RATIO TEST(CBR):

SCOPE:

The California Bearing Ratio test is penetration test meant for the evaluation of subgrade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers.

DEFINATION:

The California Bearing Ratio test is a penetration test used to evaluate the subgrade strength of roads and pavements. The results of these tests are used with the curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement.

APPARATUS:

1. CBR mould with detachable perforated base plate
2. Spacer disc with a removable handle (to be placed inside the mould)
3. Collar of 50mm high
4. Penetration plunger of 50 mm diameter

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5. One annular and a few slotted surcharge masses 2.5 kg each
6. Rammer (2.6 kg with 310mm drop for standard proctor results) and (4.89 kg with 450mm drop for modified proctor results)
7. Straight cutting edge
8. Loading machine of 50 kN capacity fitted with a calibrated proving ring to which plunger has to be attached
9. Penetration measuring dial gauge of 0.01mm accuracy
10. Soaking tank
11. Swelling gauge consisting of perforated plate with adjustable extension stem

PROCEDURE:

Figure 5.7: CALIFORNIA BEARING RATIO TEST

1. Remoulded specimen: The test material should pass 19 mm IS sieve and retained on 4.75 mm IS sieve. The dry density for a remoulding shall be either the field density or the value of the maximum dry density estimated by the

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compaction test (Heavy Compaction Test as per IS 2720 (Part-8) - 1983, for Railway Formation). The water content used for compaction shall be the optimum water content or the field moisture as the case may be.

1. Dynamic Compaction: A representative sample of the soil weighing approximately 4.5 kg or more for fine grained soil and 5.5 kg or more for granular soil shall be taken and mixed thoroughly with water. If the soil is to be compacted to the maximum dry density at the optimum moisture content, the exact mass of the soil required shall be taken and the necessary quantity of water added so that the water content of the soil sample is equal to the determined optimum moisture content.

2. Fix the extension collar and the base plate to the mould. Insert the spacer disc over the base. Place the filter paper on the top of the spacer disc.

3. Apply Lubricating Oil to the inner side of the mould. Compact the mix soil in the mould using heavy compaction. i.e., compact the soil in 5 layers with 55 blows to each layer by the 4.89 kg rammer.

4. Remove the extension collar and trim the compacted soil carefully at the level of top of mould, by means of a straight edge. Any holes developed on the surface of the compacted soil by removal of the coarse material, shall be patched with the smaller size material. Remove the perforated base plate, Spacer disc and filter paper and record the mass of the mould and compacted soil specimen. Place a disc of coarse filter paper on the perforated base plate, invert the mould and compacted soil and clamp the perforated base plate to the mould with the compacted soil in contact with the filter paper.

5. Place a filter paper over the specimen and place perforated plate on the compacted soil specimen in the mould. Put annular weights to produce a surcharge equal to weight of base material and pavement, to the nearest 2.5 kg.

6. Immerse the mould assembly and weights in a tank of water and soak it for 96 hours. Mount the tripod for expansion measuring device on the edge of the mould and record initial dial gauge reading. Note down the readings every day against time of reading. A constant water level shall be maintained in the tank throughout the period.

7. At the end of soaking period, note down the final reading of the dial gauge and take the mould out of water tank.

8. Remove the free water collected in the mould and allow the specimen to drain for 15 minutes. Remove the perforated plate and the top filter paper. Weigh the soaked soil sample and record the weight.

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Procedure for Penetration Test:

1. Place the mould assembly with test specimen on the lower plate of penetration testing machine. To prevent upheaval of soil into the hole of the surcharge weights, 2.5 kg annular weight shall be placed on the soil surface prior to seating the penetration plunger after which the remainder of the surcharge weights shall be placed.
2. Seat the penetration piston at the centre of the specimen with the smallest possible load, but in no case in excess of 4 kg so that full contact of the piston on the sample is established.
3. Set the load and deformation gauges to read zero. Apply the load on the piston so that the penetration rate is about 1.25 mm/min.
4. Record the load readings at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 4.0, 5.0, 7.5, 10 and 12.5 mm.
5. Raise the plunger and detach the mould from the loading equipment. Take about 20 to 50 g of soil from the top 30 mm layer and determine the moisture content.

5.8 RESILENT MODULUS TEST:

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SCOPE:

Resilient modulus is the elasticity modulus of a material under repeated loads and is a measure of the distribution of the loads through pavement layers. The pavement materials are normally not elastic, each load repetition produce a small amount of plastic (permanent) deformation.

DEFINATION:

The Resilient modulus is a fundamental material property used to characterize unbound pavement materials. It is a measure of material stiffness and provides a mean to analyse stiffness of materials under different conditions, such as moisture, density and stress level.

APPARATUS:

1. The GDS resilient modulus testing system (RMTS).

2. Triaxial pressure chamber.

3. Periodic system calibration.

4. The permanent deformation of unbound base / sub-base pavement materials to be determined.

5. Triaxial cell

PROCEDURE:

1. Modulus sample preparation and testing the information presented here is based on the federal highway administrations protocol p 46 resilient modulus of unbound granular based sub-base materials and subgrade soils p 46 in this video were developed as part of the long-term pavement performance program first we'll cover sample preparation protocol p 46 greatly simplifies the diversity among the materials you'll be testing it divides them all into two types.
2. Which it refers to as type 1and type 2 there are detailed specifications in p 46 for both types but in summary type 1 is a coarse grain and type 2 is fine-grained there are several things you need to do before you actually mode either type of sample for testing first you need to establish moisture and density target values based either on your own proctor test or on a predetermined value.

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3. Provided with the sample next sieve the sample if less than 10 % of the material is oversized discard the large material p 46 defines oversized for type 1 and type 2 if more than 10 % of the material is over sized p 46 is not applicable.
4. The resilient modulus will have to be determined in some other way now mix the remaining material until it's relatively uniform adding water to achieve the target moisture content then weigh the material for a type 1 sample you may now go right ahead with the procedure or you may let the material stand for a maximum of two days but for type 2 samples it's in to be sure moisture is evenly distributed throughout the material so you must allow type 2 samples to stand at least overnight but no longer than two days if you do let the material stand weigh it again when you remove it from storage then you're ready to mould a specimen for testing whether you're preparing.
5. A type 1 or type 2 specimen the specimen must be a cylinder whose height is twice its diameter use a split mould to prepare a type 1 specimen place a rubber membrane into the mould and put the mould in a vibratory compactor apply a vacuum build the specimen from the bottom up in six equal lifts to achieve the target density use the static loading method to prepare a type 2 specimen working from the centre of the mould build the specimen in five lifts first build toward one end then flip the specimen and build toward the other end being sure to compact each lift correctly p 46 states that all specimens must be tested within 5 days of being moulded .
6. If you are going to store the specimen before testing weigh it before and after stories to determine if there is any moisture loss if moisture loss during storage is more than 1% you must discard the specimen but you may reuse its material to make a new specimen remember that in preparing all test specimens your goal is to achieve the target moisture and density values the next part of the process after moulding is to prepare the specimen and the apparatus for testing the procedure here is similar for type 1 and type 2 specimens and for base subbase or subgrade materials in the following scenes we'll show a type 2 specimen that is one for which no membrane was used in moulding first place a drive for a stone disc on the bottom platen and lay a paper filter on top of the stone then place the specimen on the filter paper expand a membrane with a vacuum expander and carefully palace the membrane over.
7. The specimen then release the vacuum and remove the expander seal the membrane to the bottom platen with an O-ring next put a paper filter on top of the specimen and a second porous stone disk on top of the paper filter then fold the membrane up and seal it to the top platen with a second O-ring check to be sure the top platen is level the next step so to check for leaks in

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the sealed specimen assembly to do that connect the bottom drainage line to a vacuum source through a bubble chamber your goal is zero bubbles.

8. If there are bubbles check for leakage caused by poor connections holes in the membrane or imperfect O-ring seals you may be able to eliminate leakage by coating the membrane with liquid rubber latex or by using a second membrane when you've eliminated leakage disconnect the vacuum supply place the transparent cylinder chamber on the tri-axial cell base plate and place the cover plate with the attached loading piston on the chamber tighten.

9. The chamber tie rods and check to be sure the cover plate is level then slide the assembly into position under the axial loading device during loading it's critical to achieve.

10. Vertical alignment finally fasten the tri-axial chamber to the load frame base plate and check the top of the chamber to be sure it's level when the specimen the test chamber and all other equipment are correctly assembled and connected you're ready for the next part of the process a series of loading cycles that will condition the specimen p 46 specifies 500 to 1000 repetitions details on the confining pressure and the magnitude and waveform of the load pulses are NP 46 there are three reasons for running these conditioning loadings.

11. First you need to achieve the best possible contact and seating between the many components under load second you monitor the two LVDT s to be sure they're being displaced similar distances if the displacements do not meet the specification in p 46 it usually means there some misalignment of the system which you must investigate and correct before continuing and third you run the conditioning to determine if the test specimen was correctly compacted during preparation p 46 suggests that a permanent vertical strain of 5% or more during conditioning may mean the specimen was inadequately compacted if you do record that much strain you must stop the test investigate the preparation process and remove the specimen after conditioning you're ready to run.

12. The resilient modulus test itself the test on each specimen consists of up to 15 loading sequences in each loading sequence you run 100 cycles with varying axial stresses and confining pressures each cycle consists of a hammer sine shape defaults for a tenth of a second followed by a rest period of nine tenths of a second if the permanent vertical strain caused by the actual test that is not including strain caused by the conditioning sequence exceeds.

13. Five percent at any time during the test you must stop the test the confining pressure to zero remove the specimen conduct a moisture content test and report results if there's < 5% vertical strain.

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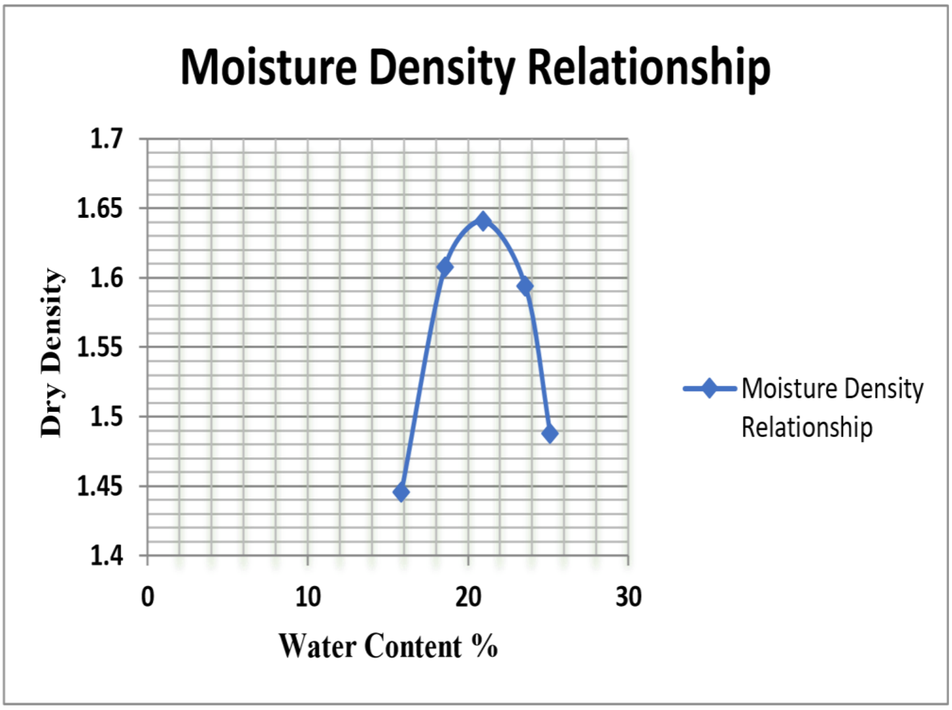
CHAPTER-6

ANALYSIS AND RESULTS

6.1 SPECIFIC GRAVITY TEST(CALCULATION) :

S. No	Dry Density	Water Content%
1	1.446	15.85
2	1.608	18.57
3	1.641	20.95
4	1.594	23.58
5	1.488	25.13



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HYDROMETER ANALYSIS TEST(CALCULATION)

Weight of the total sample	55	grams
Weight of the soil sample passing from no 40 sieve	48	grams
Specific gravity of solids (Gs)	2.65	grams
Meniscus corr.(cm)	0.0005	g/cm2
Volume of hydrometer	55	Cm3
Area of cylinder	28.274	Cm2
P agent	0.002	g/cm3
T ref	22	C
H1	16	cm
H2	6	cm
P1	1.000	g/cm3
P2	1.040	g/cm3

Density of fluid rf (g/cc) calculation: Fluid is water + sodium hexametaphosphate solution. In our experiment, we have assumed that temperature is constant during the process, so density of fluid will remain constant during the test. For this example, temperature is equal to 22 0C and water density is 0.99777 g/cc at this temperature

$$\rho f = \rho w@T + \Delta\rho agent = 0.99777 + 0.002 = 0.99977\ g/cm3$$

Density of Suspension (g/cc): In this step, you need to calculate density of the slurry for each hydrometer reading. The reading taken from the hydrometer is specific gravity of the slurry so you need to multiply the reading with density of the water which hydrometer is calibrated. Hydrometer is calibrated at 19.5 0C distilled water. The density of water at 19.5 0C is 0.9983 g/cm3 . Thus, for a hydrometer reading 1.026 density of suspension should be calculated as follows;

$$\rho suspension = (1.026 + 0.0005) * 0.9983 = 1.0248\ g/cm$$

In the above calculation, 0.0005 is meniscus correction cm.

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Height of Fall H(cm): Height of fall is the distance between slurry surface and centroid of the hydrometer. For any hydrometer reading, height of fall must be calculated in compliance with the interpolation formula written in Lab Sheet part 7.3. For Gs=1.026, height of fall can be calculated as follows:

$$H = 16 + (6 - 16)\ (1.040 - 1.000) * (1.0248 - 1.000) - 55\ 2 * 28.274 = 8.83\ cm$$

Particle Diameter D, (mm): The particle diameter passing from the centroid of the hydrometer at time t can be calculated with the given formula below:

$$D = \sqrt{\frac{18 \cdot \mu}{\rho_f \cdot g \cdot (G_s - 1)} \cdot \frac{H}{t}}$$

In the above formula,

m is the viscosity of the water and for our example it is equal to 0.961 MPa.s for 22 0C temperature,

rf is the density of the fluid that is calculated as 0.99977 g/cm3 ,

g is the gravitational acceleration and equals to 981 cm/s2 ,

Gs is the specific gravity of solids, in our example it is 2.65,

H is the height of fall and for this example it is 8.83cm,

t is time in seconds. Since our reading 1.026 is taken at t = 2 minutes, t is equal to 120 sec. Putting everything together on the formula;

$$D = \sqrt{\frac{18 * 0.961 * 8.83}{0.99977 * 981 * (2.65 - 1) * 120}} = 0.02805\ mm$$

Percent Finer Than D (%): With this calculation, you can find the percentage finer than particle diameter calculated as 0.02805 mm

$$\%finer\ than\ 0.02805\ mm = \frac{2.65}{2.65 - 1} * \frac{1000}{48} * (1.0248 - 0.99977) * 100 = 83.75\%$$

Thus, %83.75 of the soil is finer than 0.02805mm.

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Scaling the results to the entire soil sample: Above formulation will give you fractions of sample that goes into hydrometer test. Since some of the particles remain on the number 40 sieve, a scaling must be done to find real fractions. For this example, to find which fraction of the total sample (55 grams) is smaller than 0.02805 mm, following procedure can be done. 48 grams out of 55 grams of the soil specimen is used in the hydrometer test. In order to calculate adjusted percentage finer than 0.02805 mm, we need to multiply 83.75 with the ratio 48/55.

Adjusted percentage finer than D= 83.75* 48/55 = 73.09%

73.09% of the 55 grams is smaller than 0.02805 mm.

Below chart shows particle diameter limits for silt and clay. Numbers are in mm.

Clay size	less than 0.002
Silt size	0.002–0.075

FREE SWELL INDEX TEST CALCULATION:

Free swell index = $[V_d - V_k] / V_k \times 100\%$
where,
V_d = volume of soil specimen read from the graduated cylinder containing distilled water.
V_k = volume of soil specimen read from the graduated cylinder containing kerosene.

Free Swell Index	***Degree of expansiveness***	***LL***	***PL***	***SL***
<20	Low	0.50	0-35%	>17%
20-35	Moderate	40-60%	25-50%	8-18%
35-50	High	50-75%	35-65%	6-12%
>50	Very high	>60%	>45%	<10%

ATTERBERG LIMITS

LIQUID LIMIT:

S.NO	No of blows	water content %
1	36	53.7
2	28	57.9

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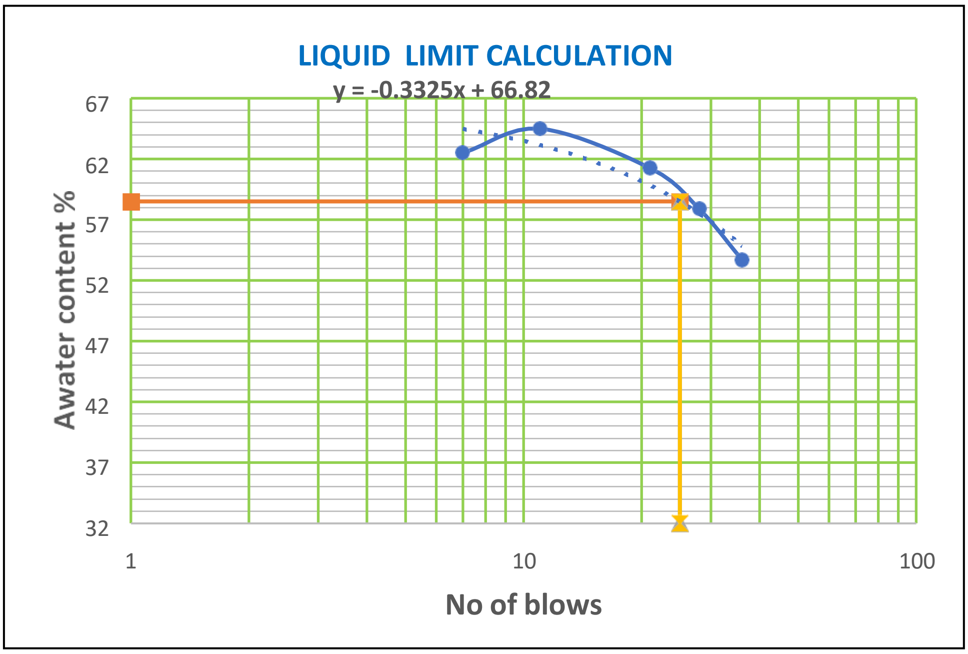
3	21	61.25
4	11	64.5
5	7	62.50



LIQUID LIMIT (10% FLY ASH):

S.NO	No of blows	water content %
1	44	42.7
2	32	44.1
3	19	46.12
4	12	51.25

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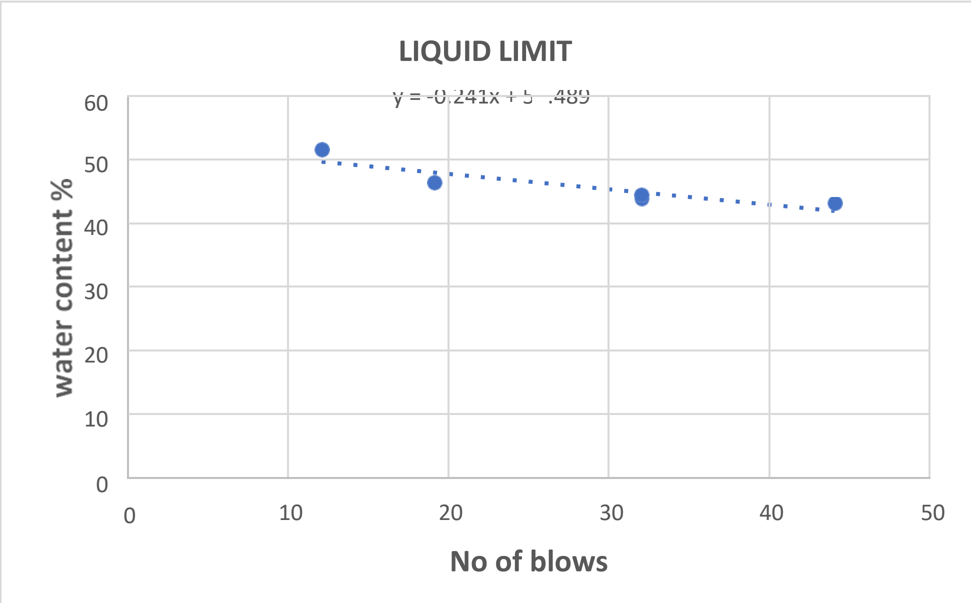

LIQUID LIMIT (20% FLY ASH):

S.NO	No of blows	water content %
1	45	38.75
2	36	40.91
3	25	41.16
4	14	46.99
5	10	55.19

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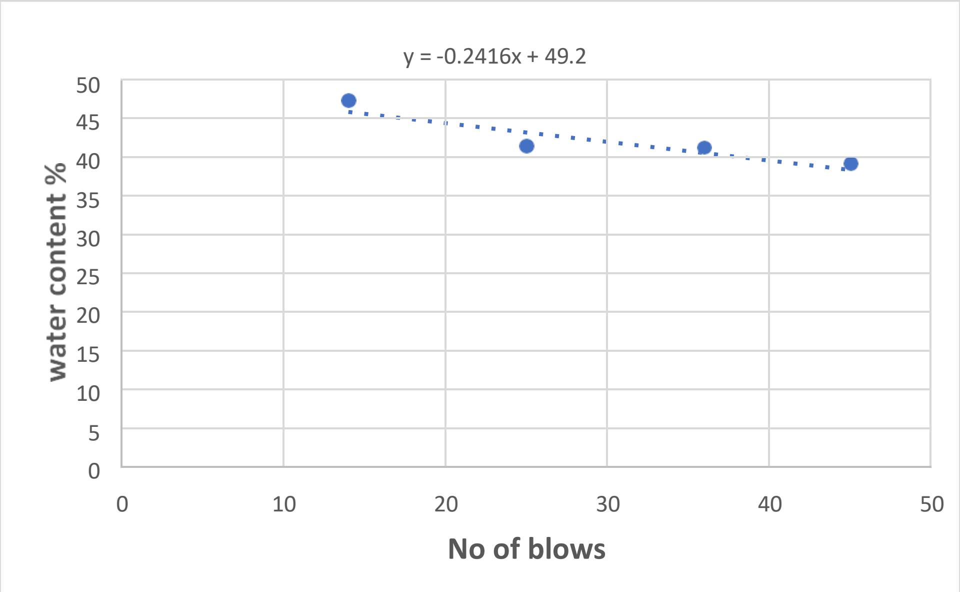
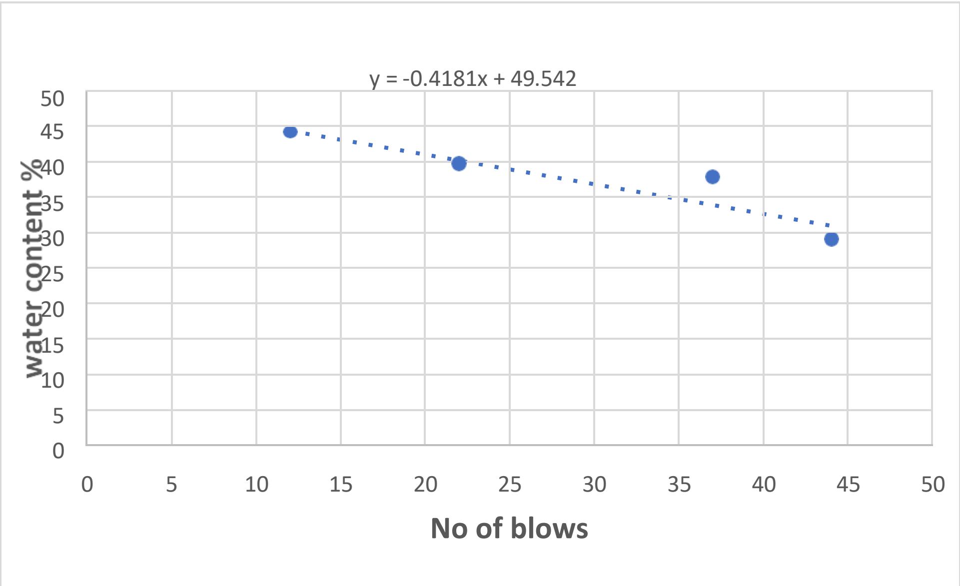


LIQUID LIMIT (30% FLY ASH):

S.NO	No of blows	water content %
1	44	28.57
2	37	37.57
3	22	39.85
4	12	44.10



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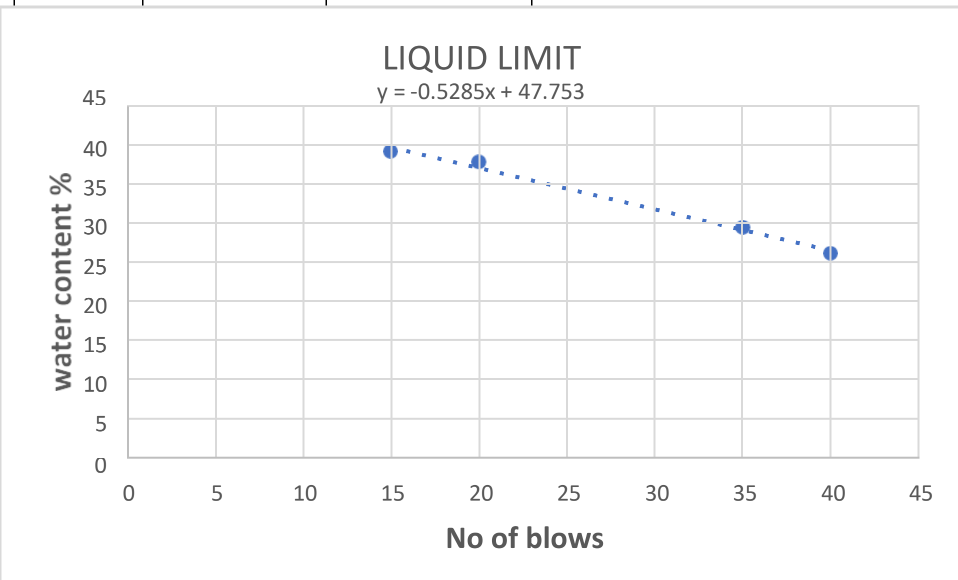
LIQUID LIMIT (40% FLY ASH):

S.NO	No of blows	water content %
1	40	26.23
2	35	29.57
3	20	37.85
4	15	39.23



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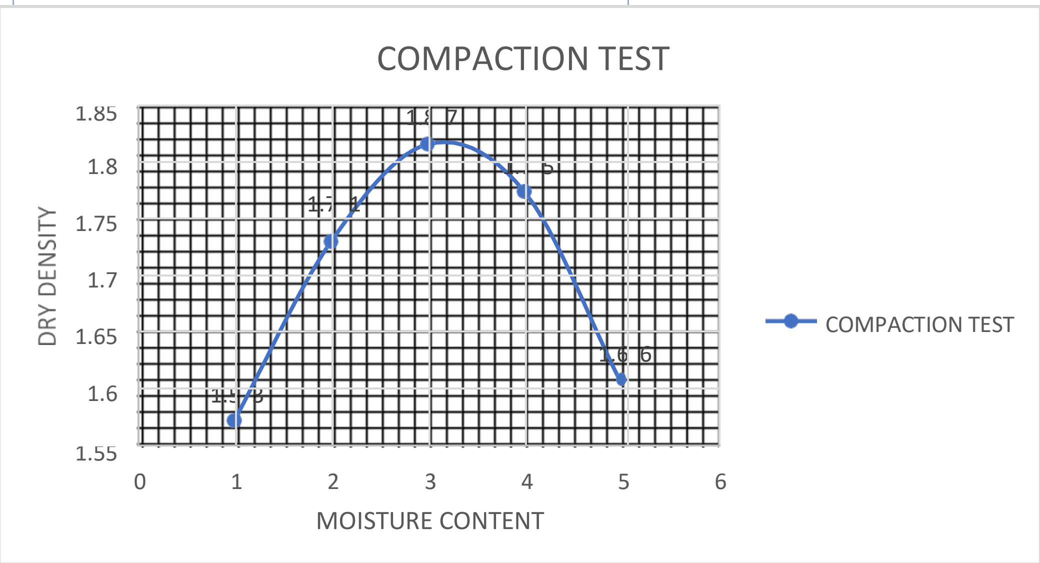
STANDARD PROTRACTOR TEST(CALCULATION)

COMPACTION TEST (0% FLY ASH):

S.NO	Dry density	Moisture content
1	1.573	10.04
2	1.731	13
3	1.817	16.78
4	1.775	18.37
5	1.606	21.73



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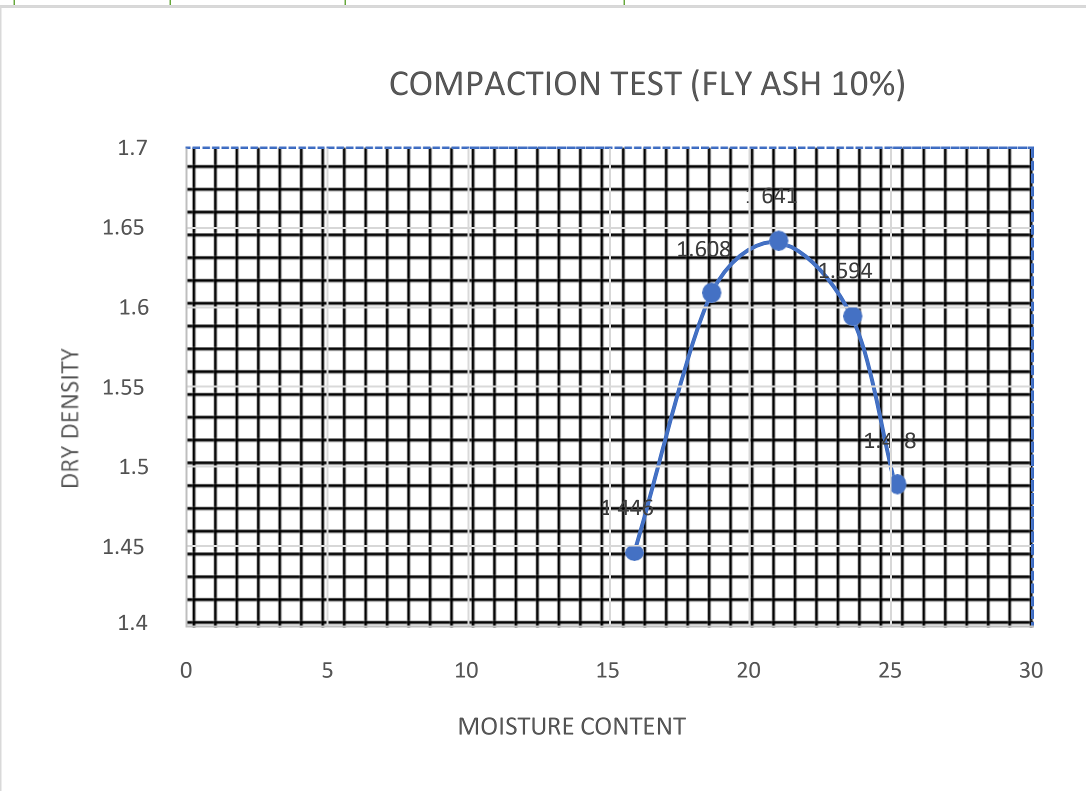
COMPACTION TEST (10% FLY ASH):

S.NO	DRY DENSITY	MOISTURE CONTENT
1	1.446	15.85
2	1.608	18.57
3	1.641	20.95
4	1.594	23.58
5	1.488	25.13



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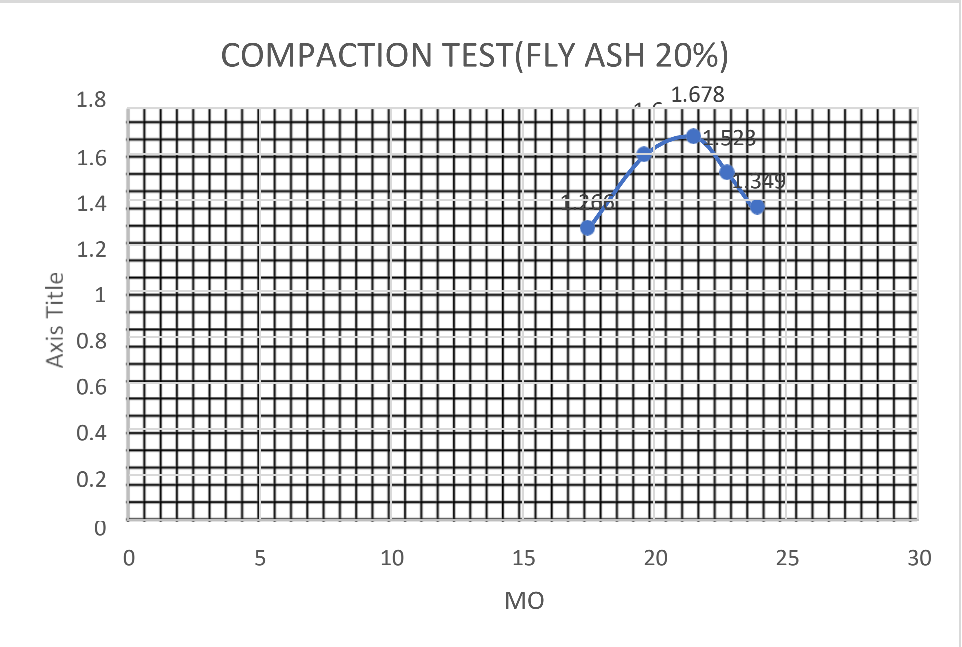
COMPACTION TEST (20% FLY ASH):

S.NO	DRY DENSITY	MOISTURE CONTENT
1	1.266	17.46
2	1.6	19.68
3	1.678	21.56
4	1.523	22.8
5	1.349	23.89



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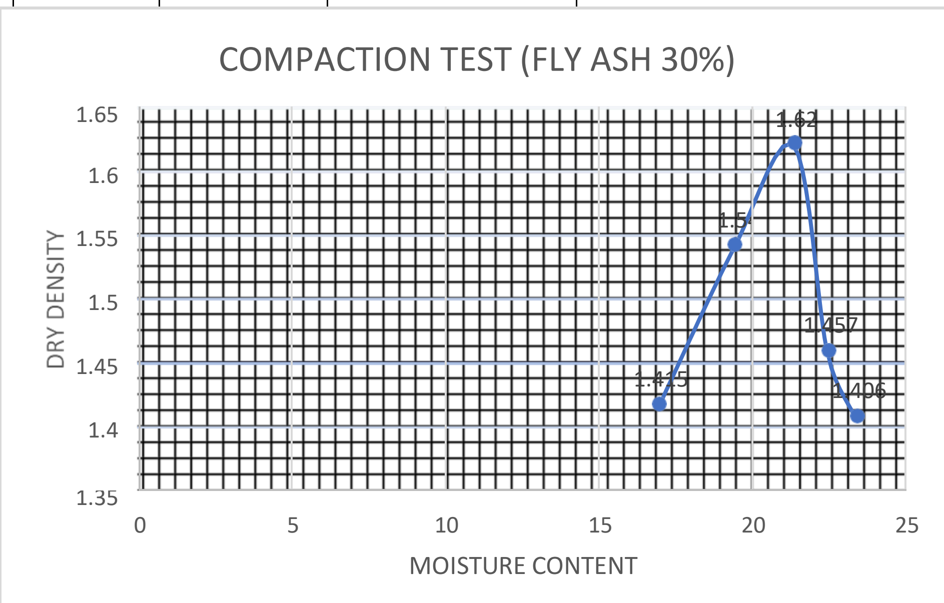
COMPACTION TEST (30% FLY ASH):

S.NO	DRY DENSITY	MOISTURE CONTENT
1	1.415	16.97
2	1.54	19.44
3	1.62	21.4
4	1.457	22.5
5	1.406	23.43



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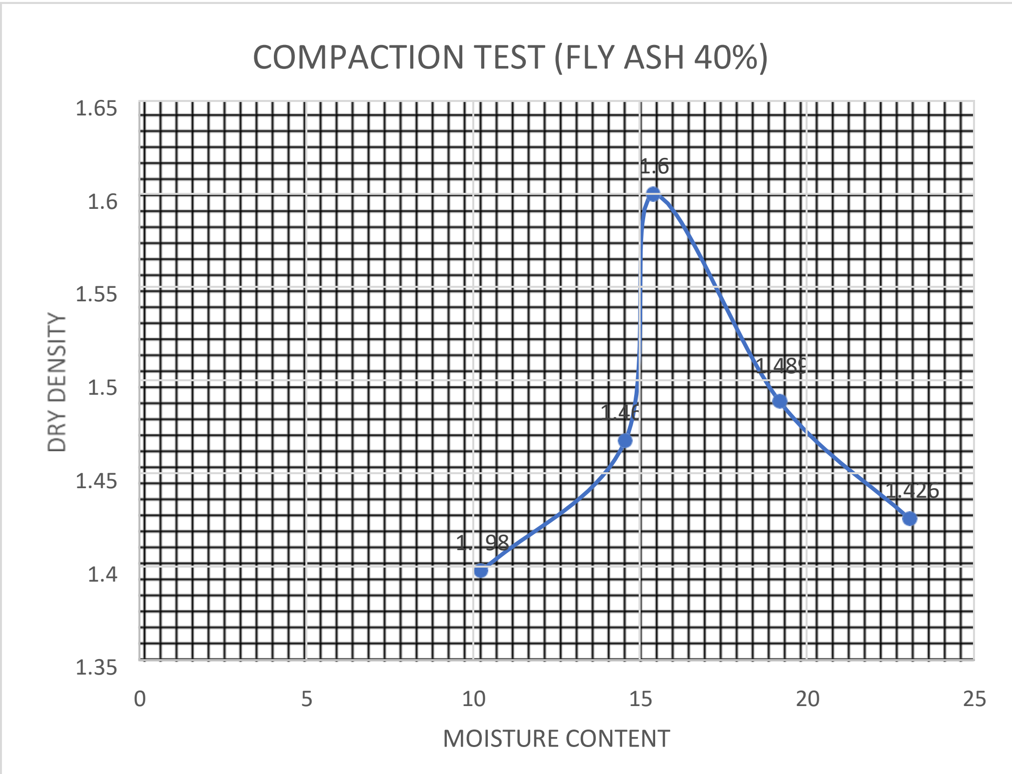
COMPACTION TEST (40% FLY ASH):

S.NO	DRY DENSITY	MOISTURE CONTENT
1	1.398	10.24
2	1.468	14.56
3	1.6	15.4
4	1.489	19.2
5	1.426	23.1



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UN CONFINED COMPRESSIVE STRENGTH:

S.NO	STRAIN (0%FLY ASH)	COMPRESSIVE STRENGTH
1	0	0
2	0.6	0.017
3	1.3	0.044
4	1.9	0.085
5	2.6	0.123
6	3.3	0.135
7	3.9	0.158
8	4.6	0.178
9	5.3	0.189
10	5.9	0.196
11	6.6	0.197
12	7.2	0.197
13	7.9	0.196
14	8.5	0.193
15	9.2	0.191
16	9.8	0.189
17	10.5	0.185
18	11.2	0.184
19	11.8	0.18
20	12.5	0.178

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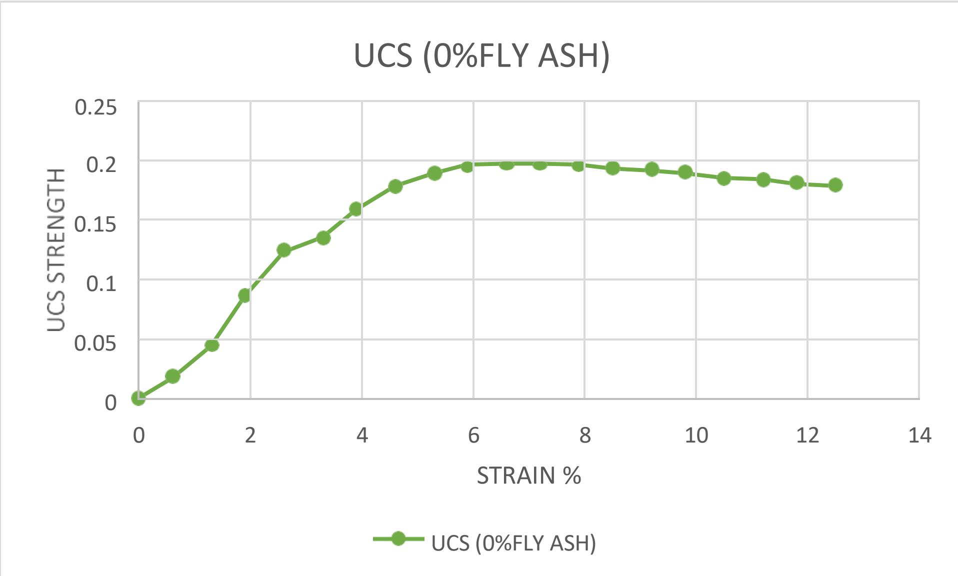
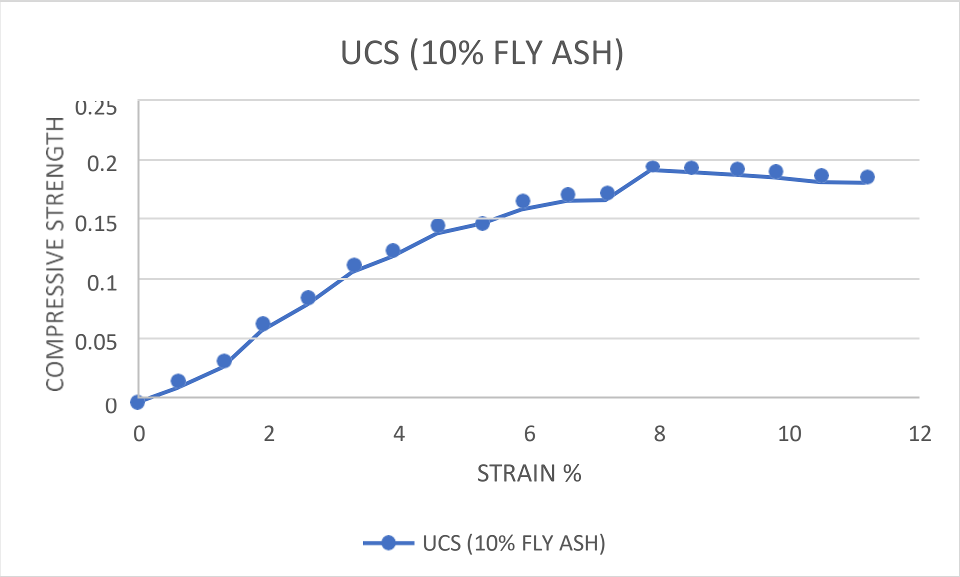


UNCONFINED COMPRESIVE STRENGTH (10% FLY ASH):

S.NO	STRAIN %	COMPRESSIVE STRENGTH
1	0	0
2	0.6	0.012
3	1.3	0.029
4	1.9	0.06
5	2.6	0.082
6	3.3	0.109
7	3.9	0.122
8	4.6	0.142
9	5.3	0.15
10	5.9	0.162
11	6.6	0.169

•

12	7.2	0.17
13	7.9	0.195
14	8.5	0.193
15	9.2	0.191
16	9.8	0.189
17	10.5	0.185
18	11.2	0.184



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UNCONFINED COMPRESSIVE STRENGTH (20 % FLY ASH):

S.NO	STRAIN %	COMPRESSIVE STRENGTH
1	0	0
2	0.6	0.013
3	1.3	0.043
4	1.9	0.087
5	2.6	0.119
6	3.3	0.132
7	3.9	0.159
8	4.6	0.183
9	5.3	0.195
10	5.9	0.201
11	6.6	0.203
12	7.2	0.206
13	7.9	0.204
14	8.5	0.204
15	9.2	0.201
16	9.8	0.198
17	10.5	0.196
18	11.2	0.194
19	11.8	0.191

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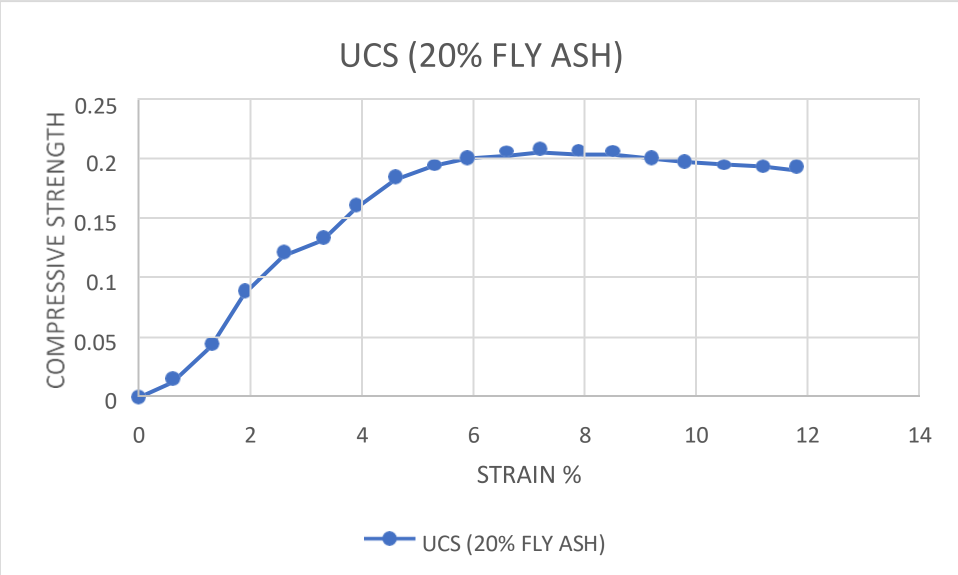
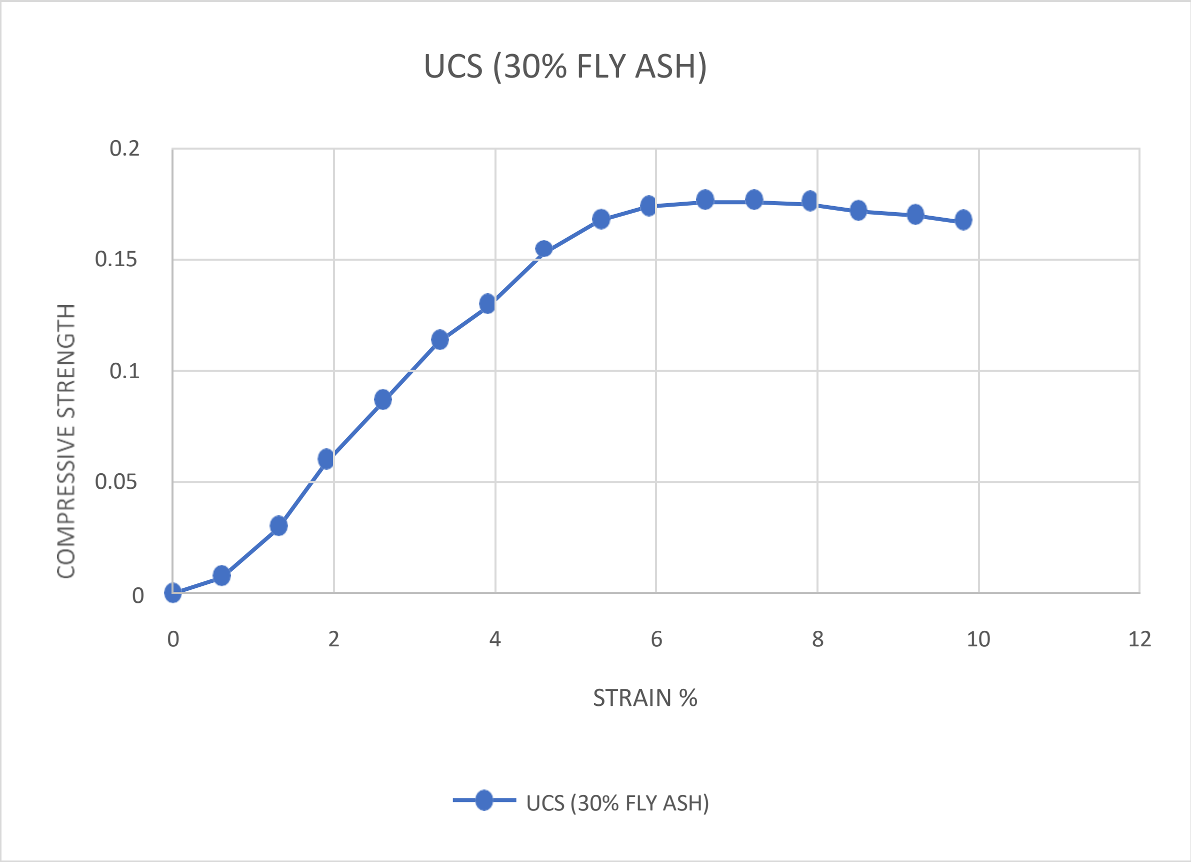


UNCONFINED COMPRESSIVE STRENGTH (30% FLY ASH):

S.NO	STRAIN %	COMPRESSIVE STRENGTH
1	0	0
2	0.6	0.007
3	1.3	0.029
4	1.9	0.059
5	2.6	0.086
6	3.3	0.113
7	3.9	0.129
8	4.6	0.153
9	5.3	0.168
10	5.9	0.174

-

11	6.6	0.176
12	7.2	0.176
13	7.9	0.175
14	8.5	0.172
15	9.2	0.17
16	9.8	0.167



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UNCONFINED COMPRESSIVE STRENGTH (40% FLY ASH):

S.NO	STRAIN %	COMPRESSIVE STRENGTH
1	0	0
2	0.6	0.01
3	1.3	0.026
4	1.9	0.057
5	2.6	0.087
6	3.3	0.111
7	3.9	0.137
8	4.6	0.158
9	5.3	0.166
10	5.9	0.17
11	6.6	0.17
12	7.2	0.169
13	7.9	0.168
14	8.5	0.165
15	9.2	0.163

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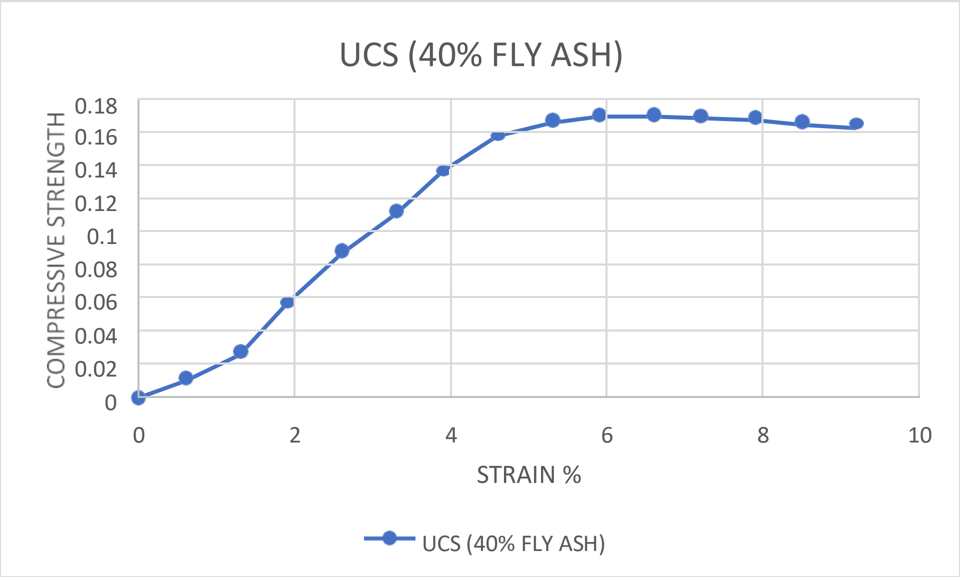

CALIFORNIA BEARING RATIO TEST:

S.NO	PENETRATION	APPLIED LOAD
1	0	0
2	0.5	7.41
3	1	22.24
4	1.5	37.07
5	2	49.42
6	2.5	56.83
7	3	64.25

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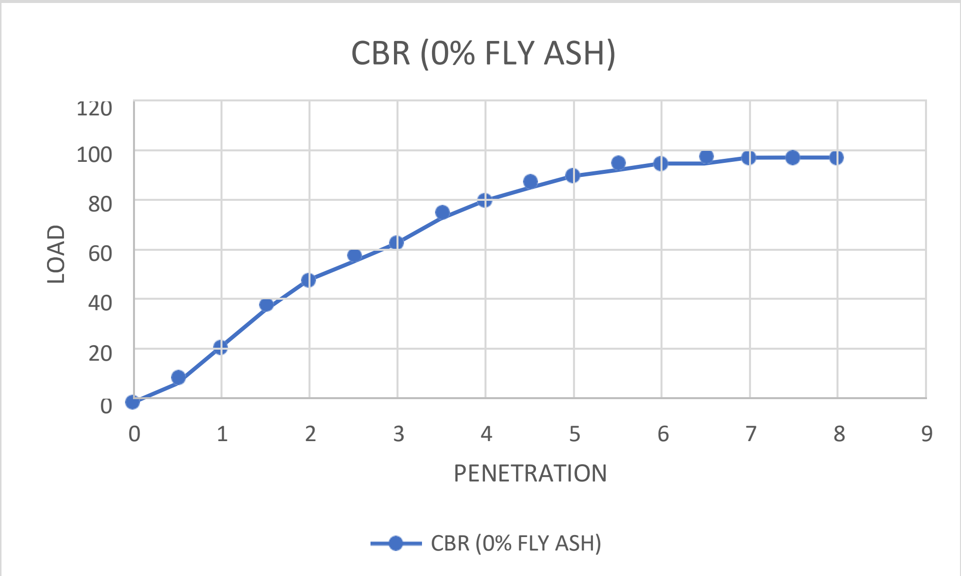
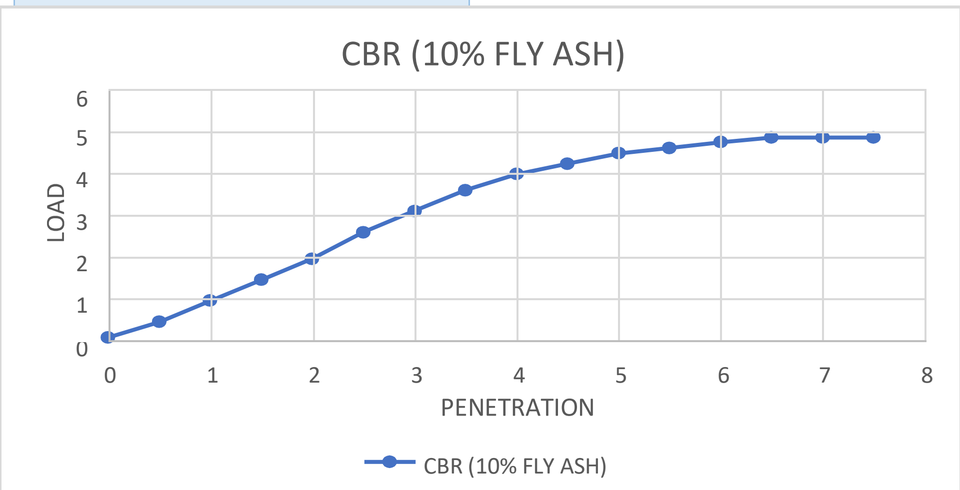
8	3.5	74.13
9	4	81.54
10	4.5	86.49
11	5	91.43
12	5.5	93.9
13	6	96.37
14	6.5	96.37
15	7	98.84
16	7.5	98.81
17	8	98.81



- CALIFORNIA BEARING RATIO (10% FLY ASH):

S.NO	PENETRATION	LOAD
1	0	0.13
2	0.5	0.5
3	1	1.01
4	1.5	1.51
5	2	2.01
6	2.5	2.64
7	3	3.15
8	3.5	3.65
9	4	4.03
10	4.5	4.28
11	5	4.53
12	5.5	4.66
13	6	4.8
14	6.5	4.91
15	7	4.91
16	7.5	4.91



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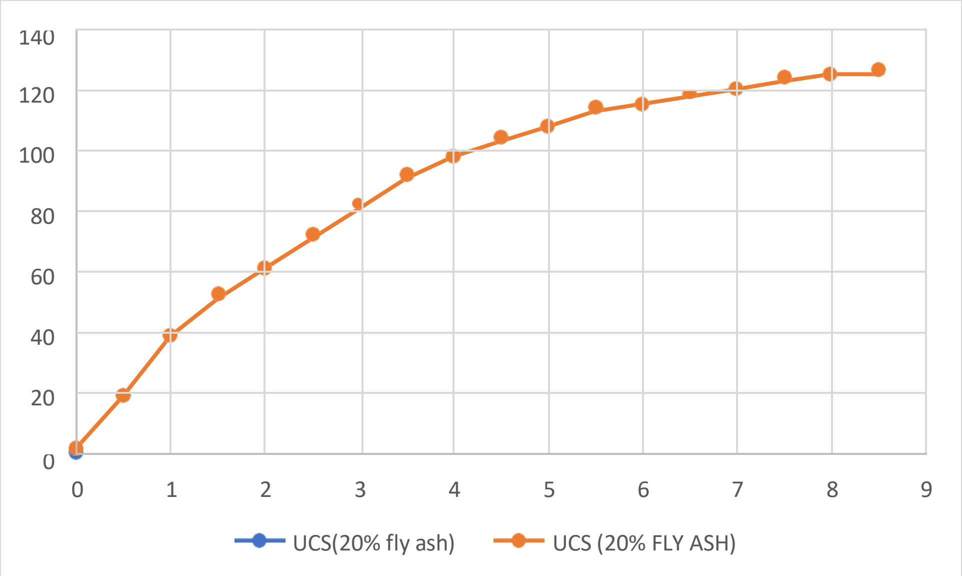
CALIFORNIA BEARING RATIO (20% FLY ASH):

S.NO	PENETRATION	LOAD
1	0	2.47
2	0.5	19.77
3	1	39.54
4	1.5	51.89
5	2	61.78
6	2.5	71.66
7	3	81.54
8	3.5	91.43
9	4	98.84
10	4.5	103.78
11	5	108.72
12	5.5	113.67
13	6	116.14
14	6.5	118.61
15	7	121.08
16	7.5	123.55
17	8	126.02
18	8.5	126.02



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CALIFORNIA BEARING RATIO (30% FLY ASH):

s.no	penetration	load
1	0	2.47
2	0.5	14.83
3	1	32.12
4	1.5	49.42
5	2	64.25
6	2.5	74.13
7	3	88.96
8	3.5	98.84
9	4	103.78
10	4.5	111.2
11	5	113.67
12	5.5	118.61
13	6	123.55
14	6.5	126.02
15	7	128.49
16	7.5	130.96
17	8	133.43
18	8.5	133.43

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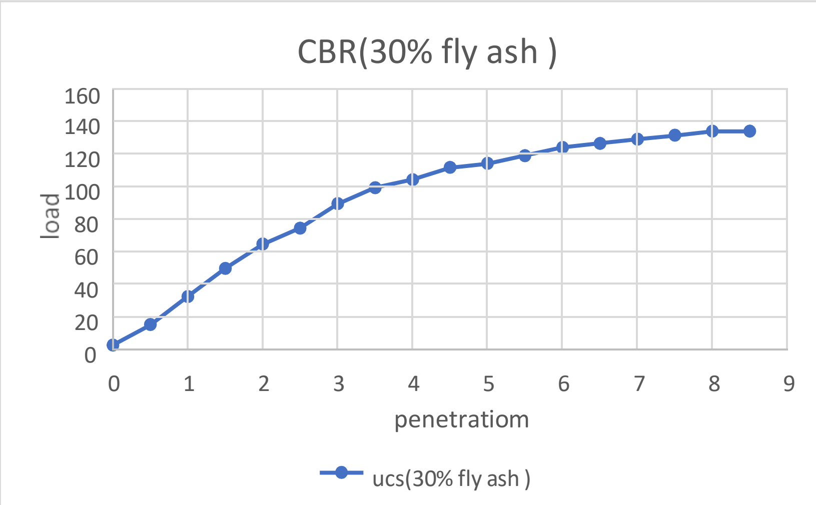

CALIFORNIA BEARING RATIO (40% FLY ASH):

s.no	penetration	load
1	0	2.47
2	0.5	7.41
3	1	14.83
4	1.5	24.71
5	2	37.07
6	2.5	49.42
7	3	59.3
8	3.5	69.19
9	4	74.13
10	4.5	79.07
11	5	84.01
12	5.5	86.49
13	6	88.96
14	6.5	93.9
15	7	96.37
16	7.5	96.37

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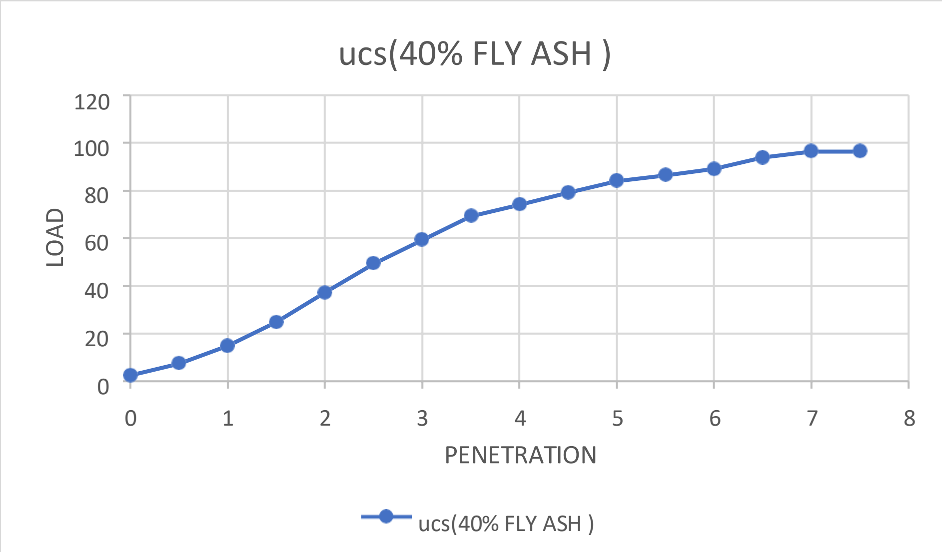

FINAL RESULT OF RESILIENT MODULUS TEST(TRIAXIAL):

DEVIATORIC STRESS (kpa)	RESILIENT MODULUS(Mpa)
10.2	130
14.5	160
22.6	270
36.3	230
52.9	340

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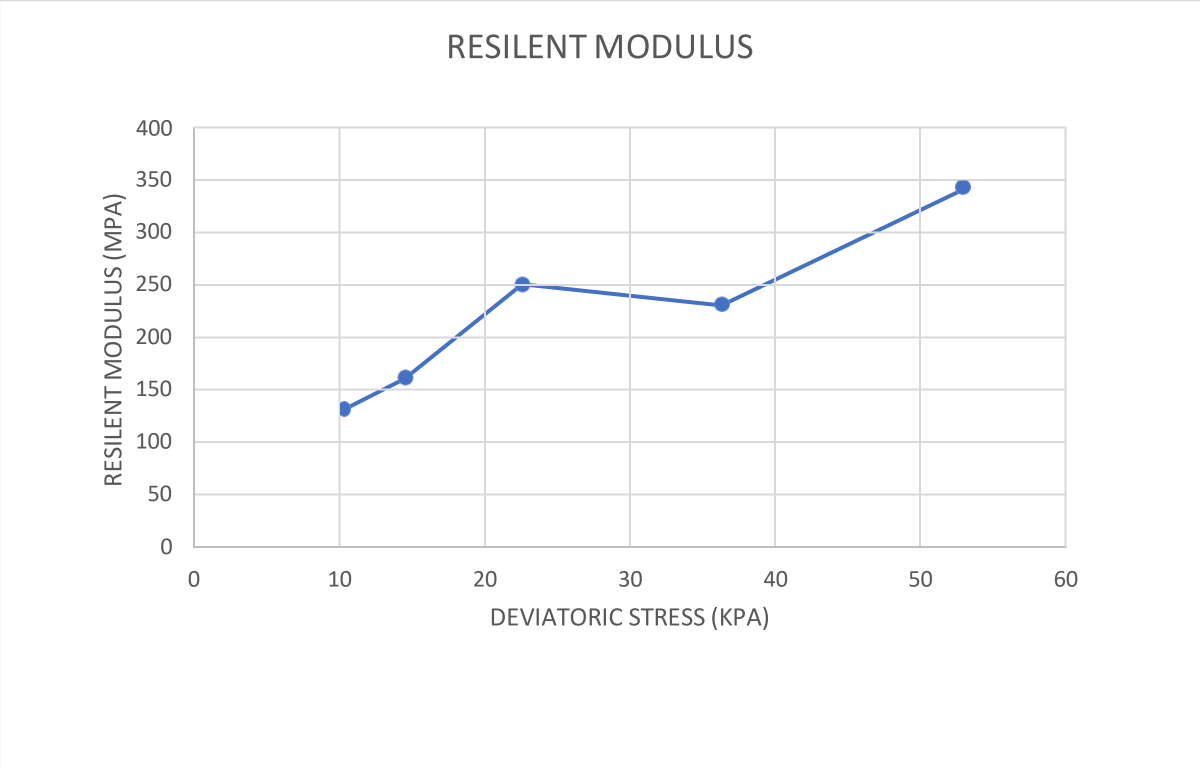

Resilient modulus Tabular form:

S.NO	FLY-ASH ADDED (%)	RESILENT MODULUS (MPA)
1	0	170
2	10	260
3	20	240
4	30	320
5	40	350

The sub grade which is needed to be stabilized undergoes various tests in Geo Technical lab by adding successive amounts of fly ash to different samples of same BCS sub grade and favorable amount of fly ash is found. Then for this stabilized sun grade resilient modulus is found and the values are optimized using GA and ANN.

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CHAPTER-7

CONCLUSIONS:

In the present research work, which is described black cotton soil of Pragati Nagar which is highly compressible in nature is mixed with the varying percentages of fly ash (taken from thermal power plant from bhupalapally, Telangana.) ranging from 10 % to 40 % by weight of soil and changes on behaviour of soil is studied including soaked CBR. The combination of soil and fly ash that gave maximum CBR value is regarded as the optimum percentage of fly ash i.e., less than or more than this percentage of fly ash addition in soil, reduces the CBR value. Now, this optimum percentage of fly ash mixed soil is added with varying percentage of nylon fibre of 0.40 mm diameter. The percentage of fibre content varied from 0.25 % to 1.50 % on different aspect ratios of 20, 40, 60 and 80 and soaked CBR value in each case was determined. The percentage of fly ash giving maximum strength at specific aspect ratio is identified and termed as optimum percentage of fly ash.

The main objective of the research work was to study the effect of adding FLY ASH on the engineering properties of a sample of test soil similar to a clay soil. Extensive experimental work was carried out on the engineering properties of the test soil. Major changes were observed in some of the engineering properties of the test soil on the addition of FLY ASH and lime. Four analytical techniques were used to identify the nature of the reaction products and to understand how the engineering properties of the test soil were changed after the addition of FLY ASH The analytical tests used were found to be very useful in helping to develop an understanding of how the FLY ASH stabilized the test soil and also to identify the reaction products. From the study it can be concluded that the addition of FLY ASH alone to the test and pure clay test soils slightly decreased the liquid limit while the plastic limit increased slightly, thus significantly decreasing the plasticity index. Also, the addition of FLY ASH has slightly increased the dry density and optimum moisture content. Adding FLY ASH has dramatically increased the unconfined compressive strength of the test soil.

The mixing of fly ash has pronounced effect on the compaction characteristics.

Proctor's Compaction Test, the MDD value of raw soil is achieved as 1.57 gm/cc at OMC of 18.20 %. It got increased to 1.90 gm/cc at OMC of 17.38 % on 20% addition of fly ash. The soaked CBR value of the raw soil is 1.71 and after mixing of fly ash in the soil, there is remarkable change in CBR value. The addition of

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20 % fly ash increased the CBR value from 1.71 to 4.95, but further addition of fly ash caused decrease in CBR value. Thus. CBR tests were also carried out for the combination of fly ash mixed soil and the fly ash nylon fibre mixed soil. The Top portion of mould was filled with the optimum mix of, fly ash and soil and bottom is filled with only optimum percentage of fly ash and the soil. It is found that a combination of ½: ½ gave CBR as 6.18 which is an impressive value as the CBR of raw soil is only 1.71. Thus, mixing of fly ash only in the top portion of fly ash mixed soil would be an economical proposition in construction of road in poor black cotton spoil areas., the optimum quantity of fly ash i.e., after which the CBR value starts decreasing, is 20 %.

The experimental of Fly ash and lime-fly ash treatments reduce the swell potential and shrinkage of the soils. The free swell, swell potential, swelling pressure, and linear shrinkage decreased with the increase in fly ash and lime-fly ash content. The swell potential and swelling pressure of both fly ash and lime-fly ash treated soils decreased with increase in curing time. 2. With an increase in fly ash and lime-fly ash content, the optimum water content and the maximum dry unit weight decreased. 3. There are negligible changes in the unconfined compressive strength with the increase in the fly ash content without curing. However, with the addition of lime, shear strength increased significantly. The optimum content of fly ash is found to be 9–12% for the treated soils with curing time of 7 days. 4. A simple plasticity index ratio method has been put forward for the prediction of the swell-shrinkage properties of treated expansive soils with fly ash.

In general, decrease in values of specific gravity, plasticity index and linear shrinkage in the soil-fly ash mix samples irrespective of fly ash type. With the increase of ash content in the soil-ash mix samples, MDD decreases and OMC increases irrespective of ash type. With the increase of ash content in the soil-ash mix, initial void ratio increases, and degree of saturation decreases irrespective of ash type. In general, hydraulic conductivity values increases with higher percentage of fly ash content in the mix and maximum value attain 1×10-7 cm/sec. Local silty clay soil-fly ash mixed samples with fly ash content of 10, 15, 20, 25 and 30% can be used as liner material. With higher fly ash content in the mix UCS values gradually decrease irrespective of ash type, but as a whole the 7 th day UCS values are showing increasing trend than 1 st day values. As the ash content increases the swelling potential and free swelling index, both decreases. 30% of fly ash contents or above in local silty clay soil-fly ash mixed sample, this material may be used as land filling and embankments in the field of geotechnical engineering construction.

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The unconfined compressive strength of these soils increases upon the addition of Dandeli fly ash. The trend of improvement in the unconfined compressive strength is observed to be more pronounced with the curing of the soil + fly ash mix. A curing period of 28 days is observed to yield the maximum enhancement in the unconfined compressive strength. The study of variations of different parameters viz. liquid limit, plastic limit, plasticity index, shrinkage limit, maximum dry density, optimum moisture content, unconfined compressive strength and California bearing ratio with the addition of Dandeli fly ash suggest that, for each parameter of the study soil samples, there exists an optimum Dandeli fly ash percentage for mixing with the soil under consideration; at which the respective parameter attains its most desirable value from geotechnical point of view.

An insight into the mechanical improvement induced by alkali-activated binders based on the activation of two different type of fly ashes on a clayey soil has been presented. One-dimensional compression tests performed on treated sample highlighted the effectiveness of alkali activated binders to promote an improvement of the mechanical behaviour of treated soil. A reduction of compressibility an increase of the yield stress soil was observed since the very short term. The macroscopic behaviour of treated soil has been linked to the experimental evidences at microscale. Microstructural analyses show a high reactivity of the alkali activated fly ashes as alumino6-silicate source promoting the precipitation of new mineralogical phases forming chains and networks with cementitious properties. The reactions kinetic controlling the chemo-physical evolution of alkali activated binders and therefore the macroscopic evolution of soil properties depends on fly ashes mineralogy, as evidenced by the compressive behaviour of the treated samples as function of curing times and binder content, With the increasing fly ash content in the soil-fly ash mixture, the decrease in value of free swell ratio was remarked. This decrease was also reciprocated by the plasticity index values. Plasticity index values are directly proportional to percent swell in an expansive soil, thus affecting the swelling behaviour of the soil-fly ash mixture. Thus, fly ash as an additive decreases the swelling, and increases the strength of the black cotton soil

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CHAPTER -8

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