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Experimental Investigation of Concrete by Replacement of Cement with Nano Silica

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Abstract

This paper is concerned with the experimental investigation of Concrete by partially replacing cement with Nano Silica. Nano Silica is the most abundant material with the chemical composition of SiO_2, which is similar to a diamond structure. It is a new pozzolanic material which in water takes solid or liquid form. It is popularly being used in the concrete industry to determine the viscosity and fill state of the concrete.

The tests were conducted on M25 grade concrete and the proportion of Nano Silica as a partial replacement to cement was taken in the order of 0%, 1%, 2%, 3% and 4% by weight. The laboratory tests which need to be performed on concrete specimens are the Compression strength and Splitting tensile strength test.

Keywords*: - Pozzolonic material, Nano Silica, viscosity, Compression strength, Tensile strength.*

INTRODUCTION

Nanotechnology today is growing very rapidly and has infinite applications in almost everything we do. Nano silica contributes into the strength development up to a certain percentage. Nano silica is the most abundant material that makes the earth. It has the chemical composition of $Si0_2$ which is similar to a diamond structure. It is a white and crystal formed material. Nano silica is one of the most applied nanoparticles in concrete. 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 particles are divided into P-type and S-type according to their structure. The P-type particles are characterized by numerous Nanopores having a pore rate of 0.61 ml/g. The S-type particles have a comparatively smaller surface area. The P-type Nano-silica particles exhibit a higher ultraviolet reflectivity when compared to the S-type. It is a new pozzolanic material which is in water in a solid or liquid form.

In the concrete industry, Nano silica is one of the most famous materials that determine the concrete's viscosity and filling state. The researchers pay attention to Nano silica as a nanotechnology product that plays an important role as a very active pozzolanic in the concrete. Adding nanoparticles of concrete could maintain its strength during physical and chemical reactions and also compress the particles.

LITERATURE REVIEW

B. L.P. Swami, B. SaiKiran, M.V.S.S Sastrietal. (2016) [1] have observed M60 and M70 grade concrete's mechanical properties with micro silica and in combination with colloidal Nano-Silica. They found that concrete composites with superior properties can be produced with the combination of micro-silica and Nano-silica. On resulting observations of the micro-silica morphology, it is noted that the sizes of the micro-silica were not affected due to grinding.

A. Lazaro, G. Quercia, H.J.H.Brouwers et al. (2015)[2], did the work on "Synthesis of a green Nano-silica material using beneficiated waste dunites and its application in concrete". The paper represents that Nano-Silica (NS) is one of the substances that boost Nanomaterials and can be produced by dissolving olivine in acid. The materials and methods are used in these investigations are the composition of different diluted analysed X-Ray Fluorescence (XRF). The steps involved in these investigations are crushing and screening, neutralization, decantation, silica filtration, residual solution, olivine acid, inert materials and the silica. The compressive strength of the standard mortar is affected when cement is replaced with olivine Nano-silica by 7%.

Abolfazl Shamsai, SaberPeroti, Kamal Rahmani et al. (2015) [3], did the work

on "Effect of Water-Cement Ratio on Abrasive Strength, Porosity and Permeability of Nano Silica Concrete". This paper representing that the rapid development of construction of hydraulic structures like bridges, dams, the constituent materials used in concrete and its lifespan (durability) in these kinds of structures has gained dominant interests and importance. In addition, the porosity (n) of the concrete was\ reduced to 13%, while the reduction of the water-cement ratio from 0.50 to 0.33 occurred in this study.

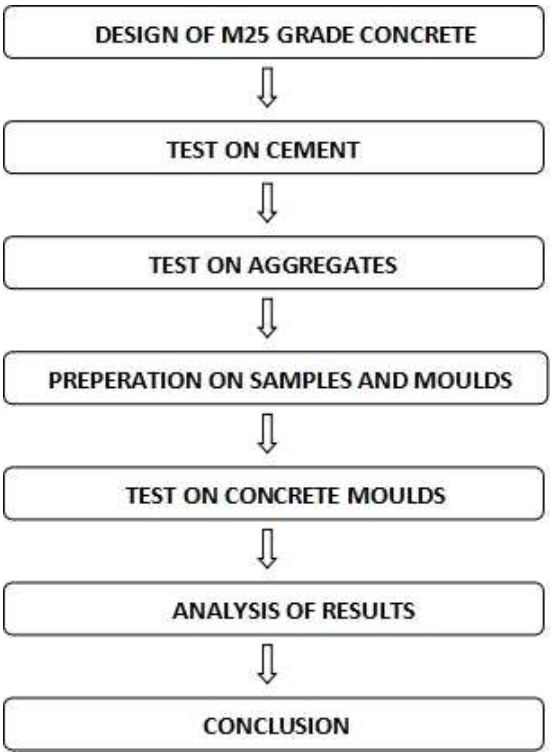
B. Kartikeyan, K. Sumanth, G. Harshavardhan (2014) [4] did the work on "Microstructure analysis and strength properties of concrete with Nano SiO_2". The materials used in this investigation are cement, mineral admixtures, aggregates, superplasticizer, w/c ratio, concrete mixture proportions, and specimen details. The graphs are drawn between UN ground micro silica, micro-silica ground for one hour-100, and micro-silica ground for one hour-50g. The particle size analyser results show the effect due to grinding. It is observed that the size of the micro-silica particles got reduced from 0.638 μm to 156.6 nm when subjected to different hours of grinding with varying quantities of micro-silica (10-6). On resulting observations, the morphology of the micro-silica, it is noted that the sizes of the micro-silica were not affected due to grinding.

OBJECTIVES

- Determination of Workability of concrete specimen.
- Determination of Compaction factor of concrete.
- Determination of Compressive Strength of concrete.
- Determination of Splitting Tensile Strength of Concrete.

METHODOLOGY

The methodology of the project is a stepwise process which can be understand according to the flowchart given below



RESULTS AND DISCUSSION

Mix Design for M25 Grade of Concrete

Table 1

Water	Cement	Fine aggregate	Coarse aggregate
0.5	1	2.10	2.719

Results of Cement

Table 2

S. No	Particulars	Results
1	Specific Gravity	3.13
2	Initial setting time	30 min
3	Final setting time	600 min
4	Normal consistency	34%

Results of Coarse Aggregate and Fine Aggregate

Table 3

S. No	Particulars	Results
1.	Type	Crushed stone
2.	Specific gravity of Coarse aggregate	2.72
3.	Specific gravity of Fine aggregate	2.66
4.	Size of Coarse aggregate	20 mm
5.	Size of Fine aggregate	2.36 mm
6.	Water absorption	0.6%

Slump Cone Test on Concrete

Table 4

S. No	Replacing the Nano Silica	Height of the Slump	Slump Value
1.	NS 0%	29 cm	1 cm
2.	NS 1%	28 cm	2 cm
3.	NS 2%	28.5 cm	2.6 cm
4.	NS 3%	27 cm	3.2 cm
5.	NS 4%	28 cm	2 cm

Compaction Factor Test on Concrete

Table 5

S. No	Replacing the Nano Silica	Compaction factor
1	NS 0%	0.89
2	NS 1%	0.90
3	NS 2%	0.91
4	NS 3%	0.93
5	NS 4%	0.90

Cube Compression Strength Test Results

Table 6

MIX ID	Compressive Strength, MPA		
	7 Days (N/mm^2)	14 Days (N/mm^2)	28 Days (N/mm^2)
NS 0%	19.3	24.1	30.14
NS 1%	21.11	24.5	31.03
NS 2%	24.15	27.63	33.21
NS 3%	26.87	29.42	34.74
NS 4%	25.18	27.34	32.64

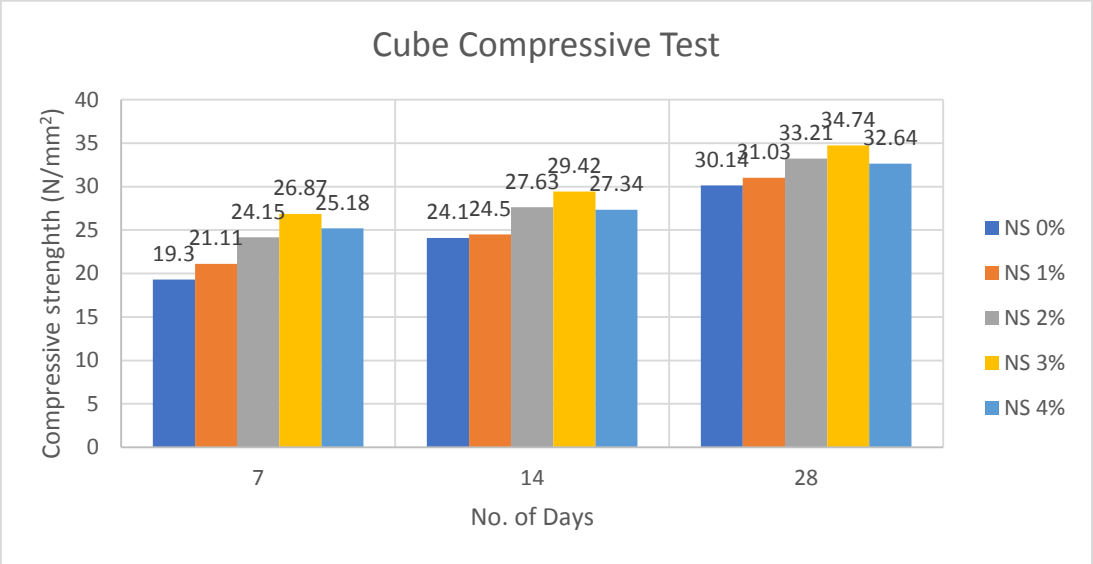


Figure 1

Split Tensile Test Results

Table 7

MIX ID	Split Tensile Strength, MPA		
	7 Days(N/mm^2)	14 Days (N/mm^2)	28 Days (N/mm^2)
NS 0%	2.16	2.98	3.56
NS 1%	2.83	3.26	3.83
NS 2%	3.34	3.78	4.16
NS 3%	3.72	4.05	4.68
NS 4%	3.27	3.80	3.94

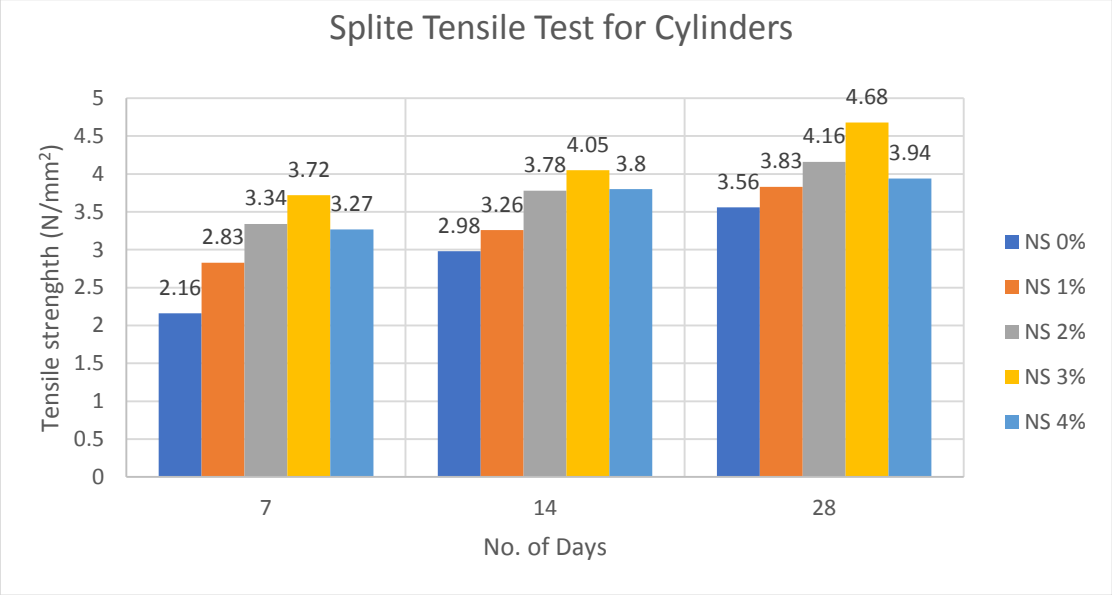


Figure 2

CONCLUSIONS

- Controlled concrete of M25 Grade is prepared and tests were conducted on concrete specimens to obtain compressive strength, split tensile strength and then the results are compared with concrete containing various proportions of Nano-Silica, i.e., 1%, 2%, 3% & 4% as cement replacement.

- It was observed from the results that, the compressive strength of concrete initially increased up to 3% of Nano-Silica replacement and with further increase of Nano-Silica content the compressive strength of concrete decreases.

- Concrete containing lower percentages (3%) of Nano-Silica possess higher values of compressive strength than that of controlled concrete.

- A considerable increase in split tensile strength of Nano-Silica concrete was observed compared to controlled concrete.

- 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 strength and permeability resistance. It can also be

concluded that the permeability of concrete decreases with the increase in the percentage of Nano-Silica up to 3% due to the effect of Nano-Silica filling the voids in concrete.

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