STATISTICAL AND SPATIAL PATTERN OF SOIL FEATURES

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ABSTRACT

Statistical analytical procedures are usually applied for correlation techniques and estimating of soil spatial trends. Euclidean cluster, scoter plot, correlation matrix, and Inverse distance weight are more favorable statistical properties than traditional procedures, the distribution of soil properties experiment are used to understand engineering characteristics and to conclude suitable for engineering construction initial works. The investigational analysis shows the symptomatic properties of statistical analysis estimations. We have been selected three Mandals in Medak district, Telangana state, to situate appropriate places for civil engineering works. The Mandals are Narsingh Mandal, Shankarampet Mandal, Chegunta Mandal. These three mandals have good agriculture fields so it is difficult to recognize good source soil of geo-technical properties. The assessments are preferred to analyze such as liquid limit, plastic limit, compaction properties, and particle size composition, and proctor compaction. The results of soils plotted on thematic maps by using inverse distance weight (IDW) and reclassify techniques. These maps are a good example to quickly identify source places. Cluster I and II groups have suitable geo-technical properties of the region, and Cluster III gathers low strength soil samples. Pearson correlation reveals between matrix theory to understand reasonable and attribute that most suitable parameter in the research region. The liquid limit versus plastic limit R-value is 0.5481then p-value is <0.5. It indicates a positive correlation, The maximum dry density between plastic limit the correlation value R is -0.1395, which indicates a negative correlation and inversely proportional to between plastic maximum dry density to the plastic limit.

Keywords: Geo-Technical Properties, IDW, Remote Sensing, Cluster, Scatter Plots and Medak District.

INTRODUCTION

The spatial executive of suitable constructions site in geotechnical point of view requires that the geotechnical characteristics of soil properties. Prior knowledge of spatial geotechnical engineering maps helps to design a resourceful sampling outline by covering that, each characteristic soil type. The spatial trend is useful to identify and decrease the number of unnecessary soil samples.

The soil has distinct uniqueness depends on geological agents, weathering, erosion, transportation, and deposition. From one to another place soil properties are varies. Precise stuffing of soil properties used to scrutinize and classified (Kazemian & Huat, 2010). These data mostly help for geoengineering works by predicting exact soil for construction, the foundation of infrastructure. Index and engineering properties of soils are particle size distribution, Consistency limits, and Specific gravity of soil particles, permeability, compressibility, moisture content, and shear strength. The shear strength of the soil for eternity depends on the wetness substance of the soil (Terzaghi et al., 1996).

Geo spatial analysis is a without pollute method to achieve relevant information. Remote regions there is no access and difficult to do research. Spatial study provide clear path to understand the soil characteristics. These data can preserve, transfer, calibrate and evaluate for future study and analyze purposes. Remote sensing is a branch widely used in different sectors, Geographic Information System (GIS) computer programming. It is downloading all satellite images, captured data, and scanned data, digitalizing process to be analyzing, storing, and display the required information (Young & Hammer, 2000).

The digital soil mapping application is rarely used in Telangana and adjacent states. GIS software Combined with soil information will help all geotechnical engineers and the construction industry. Any background information can available by a single click. Pedology has a subdivision the name as digital soil mapping (DSM). Every year 12 papers published on this DSM and quotations also expand by 384 citations per year. Mathematical interpretation with soil sources is not new research but producing digital GIS maps is a new concept. It has been released since the 1990s to till to be.

There are many scientists, research scholars, and professors have to be investigating on soil maps, Roger Tomlinson prepared soil maps with polygon tool (Tomlinson, 2007; Best & Westin, 1984; Bie, 1975) are research on digitized soil maps by using STATSGO polygon, Mackenzie and Smith (1977) have used digital elevation model and satellite images for preparation of soil maps.

1. Properties of Soils

There are few properties are determine the soil for engineering works such as permeability, compressibility, and shear strength. The following points describe the engineering and Index properties of soil (Jumikis, 1965; Phadake & Jain 1998; ASTM D422-63, 2002).

- The water flows through soil particles indicates the property of permeability
- While applying compress stress on the soil, how well it bears is called compressibility.
- Stability of slopes, bearing capacity of soils and earth pressures are determined by shear strength of the soil.
- The specific gravity of soils equals the density volume of soil solids versus water (ASTM D854, 2002).
- Sieve analysis gives a detailed information of size, shape, and finer fractions of character.
- Cohesion soil property equal to density and consistency is related to cohesive soil.
- Voids of soils capture the water amount directly reflects on the shear strength of the soil.
- The volume of soil mass is known as the dry density of soil mass.
- Consistency limits changes by water content in soils. Consistency of soil reflects the Flow of resistance.

Geotechnical engineering properties are required such as moisture content, dry density, specific gravity, wet density, liquid limit (ASTM D4318, 2000; BS:1377, 1990), plastic limit, and shrinkage limit (ASTM D427, 1998). These are essential for the determination of soil quality for engineering works. These analysis reports and results will help for infrastructure development, the foundation works, earthworks and construction works (Baecher, 1981).

1.1 Different Index Properties of Soil

The diverse catalogue properties of soil and their internal bonding are shown below. These bonding will be a benefit for the identification of omitted properties of earthen soils (Puri & Murari, 1963; Zhang, 2003). Those are not getting from composed statistics set.

Det Density
$$\gamma\ sat = (1 - \frac{1}{G})\gamma_d + \gamma_\omega$$

Moisture Content
$$\omega = (\frac{1}{\gamma_d} - \frac{1}{G_{\gamma\omega}})\gamma_\omega$$

Porosity
$$n = 1 - \frac{\gamma d}{G_{\gamma d}}$$

Void Ration
$$e = \frac{G_{\gamma\omega}}{\gamma d} - 1$$

Pearson Correlation
$$r = \frac{\sum (x - m_x)(y - m_y)}{\sqrt{\sum (x - m_x)^2 \sum (y - m_y)^2}}$$

1.2 Geographic Information System (GIS)

The computer-based programming of GIS software has well-organized tools; these tools input the data from the sources and recovery of selected data for supplementary processes. GIS modules can be analyzed or systematically control the retrieved information to generate sufficient data on the specific outline. GIS components are covered and analyzed the remote sensing data in illustrates. This module covered spatial and non-spatial data in two various databases. Digital coded satellite information explicit object data orientation and association with other objects in two dimensional and three-dimensional spaces. GIS module has two major data such as Vector and Raster. Vector geo-referenced data has three important data interpretation tools such as line, point, and polygon. Raster has pixel information. Discrete features data usually captured by the vector model and continuous features store the information with the raster model (Adam et. al., 2018, Kumar et al., 2020). GIS module has a great advantage to add in all types of survey techniques to inbuilt and scrutinizes for future works. They are total station, GPS, aerial photographic data, remote sensing images data, tabular data, and scanned datasheets. (Cook & Pocock, 1983).

1.3 Digitized GIS Soil Maps

A digital soil mapping (DSM) survey is the best survey for conventional soils. Environmental protection, management, and public authority projects soil is the main product for foundation and construction work for that DSM survey reveals the solution with the help of digital soil maps. Geographically referenced maps are collected from the soil data from the spatially explicit environment and field laboratories. These quantitative relationships create a digital soil map.

The DSM process inference on observation of soil-forming factors and landscape segments are captured from aerial photographs and high-resolution satellite images. Scientists and research organizations aid to take these units for the mapping process. The existing soil maps have possible to show a fraction of the soil landscape. Traditional soil maps consist of large scale regions by analyzing soil samples. Traditional maps only have possible to observe soils in the landscape regions. in the present scenario soil, data can be stored in soil information systems (SIS) at a major part of soil geo-spatial database. SIS consist of vector data of soil properties, classification of maps include reports, user manual, attribute data and metadata (Bulut et.al., 2012; Labib & Nashed 2013).

Thematic soil maps are reduced cost, time in the engineering site area and it indirectly protects the environment instead of damage. It includes soil properties, color, strength, and bearing capacity. Geographic Information System (GIS) and proper methodology of index soil properties combined to form a good identity for suitable soil. This study helps to explore the geo-technical properties of soil for good foundation materials (Mhaske & Choudhury, 2009).

Mhaske and Choudhury (2011) have analyzed 450 samples in Mumbai city for soil index properties. The integrated GIS, Global positioning system (GPS) and specific gravity, moisture content, and liquid limit to obtain huge soil database. This analysis will help to find a suitable location for a geo-technical engineering design. Remote sensing soil data and terrain mapping prominence on application of soil databases (Mulder et al., 2011) Soil liquefication non-liquefication maps with GIS also source for soil spreading maps (Mhaske & Choudhury, 2010).

Chen et al. (2014). have analyzed soil moisture combined with Normalized Difference Vegetation Index (NDVI) in Australia between 1991 and 2009. They collected satellite images and soil moisture data in different regions (Minasny & McBratney, 2016). They used statistical methods such as windowed cross-correlation, quantile regression, and piecewise linear regression. Finally, they found a good bonding between soil moisture and NDVI. Enhance of wet content in the soil helps grow vegetation in dry regions and the initial stage of moisture area. (Rahman & Tahoun, 2019) Soil maps represent into cluster analysis to find different locations.

GIS database to store descriptive soil data, a geographic information system (GIS) to correlate the boreholes data with reference soil (Swathi & Rani, 2019; Denton et al., 2017). A graphical user interface (GUI) to assist the input, query, and output of information, in addition to drawing, bore logs. GIS has an accessible focus on planar/surface applications. Though, to display depth-wise soil characteristics. They build design-build organizations for analysis of the foundation, construction plan, integration between design and construction (Oloufa et al., 2014).

1.4 Purpose of the Study

Soil exploration one of the major components in civil engineering constructions, upcoming civil engineering projects have to execute the number of soil boreholes data with referred scale and plotting on the paper. They preserve data in a standard report which contains location latitudes and longitudes. Every time taken coordinates is difficult some time data also missing in this regards permanent geographical spreading sheets in a particular region very important. In this paper gathered all coordinate values of location soils samples and execute on the spatial spreading maps. These thematic maps contain all specified soil data text values such as liquid limit, plastic limit, sieve analysis, proctor compaction, and specific gravity.

2. Liquid Limit

The liquid limit is the water content at which the soils behave as a liquid. Soils are performed by water content at the stage of liquid conditions this is known as liquid limit (Zhang, 2003). As we see from table liquid limit is high for Narsingh Mandal soil samples when compared to shankarampet Mandal and chegunta Mandal soil samples. The map which is drawn from the below values shows the liquid limit of each soil sample from the above mandals. From the map, we can say that the high contrast of the map from the narsingh region is due to the high liquid limit.

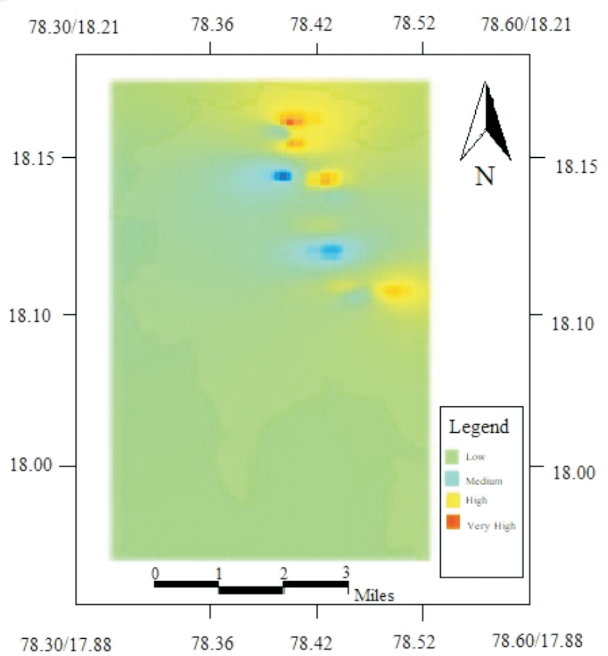


Figure 1. Thematic Map of Liquid Limit Values

Based on such considerations, the algorithm uses a different color image multiplied by the weighting coefficients of different ways to solve the visual distortion, and by embedding the watermark, wavelet coefficients of many ways, enhance the robustness of the watermark.

2.1 Plastic Limit Test

Clayey soils change their behavior while adding the water, once the soil starts changes by adding water it converts into plastic stage material (Casagrande, 1932; IS1498, 2002). We can recognize plastic material once it starts to crumble and shows rolled in 3mm diameter of threads. After that soil loses its plasticity. From the table, we can say that the plastic limit is high in Chegunta Mandal soil Samples. A map is drawn with plastic limit values The high contrast is seen in the chegunta region it's because of the high.

2.2 Sieve Analysis Test

Soils are naturally contained mixed sizes of no uniformity particles. The numerical appearance of particle sizes distinct the ratio by doing sieving, 10 percentage of finer particles have effective size once the diameter of the sieve is taken from gradation curves. The coefficient of uniformity values between one and three indicates sand or gravel it is said to be well graded (Bouyoucos, 1962; Bhattacharyya et al., 1993).

As we see the map the color contrast for the coefficient of uniformity is high in chegunta Mandal when compared to the other two mandals. In the coefficient of curvature interpolation map the blue color contrast is high in narsingh Mandal, this is because of obtaining fewer values for the coefficient of uniformity.

2.3 Proctor Compaction Test

Different soil types contain various moisture contents, Proctor compaction test provide in experimental optimal moisture content in the soil. The high contrast color which is seen in the map is due to high optimum moisture content values which are obtained from below Table.1.

2.4 Cluster Analysis

Cluster analysis reveals that the Geo-technical properties of soil samples have been classified into 3 clusters (Fig. 8), cluster I contain 7 location soil samples, cluster II has 10 soil samples, cluster III represents 9 soil samples these are

S.No	Sample Locations	Specific Gravity	Liquid Limit	Plastic Limit	Optimum Moisture Content	Maximum Dry Density	Coefficient of Uniformity	Coefficient of Curvature	Sample Classification
1	narsingh 1	2.62	48.31	23.16	19.6	1.76	6.1	1.8	Black cotton soil
2	narsingh 2	2.67	34.6	18.6	12.1	0.9	4.5	1.26	Laterite soil
3	narsingh 3	2.72	43.12	22.4	17.1	1.47	5.8	1.3	Black cotton clayey soil
4	narsingh 4	2.69	46.28	21.2	12.1	1.01	6.2	2.6	Black cotton soil
5	narsingh 5	2.64	35.32	19.5	18	1.61	5.7	1.5	Red Soil
6	narsingh 6	2.65	38.5	20.1	17.18	1.48	6.4	1.4	Black cotton soil
7	narsingh 7	2.68	42.1	19.6	18.2	1.03	5.6	2.6	Laterite soil
8	narsingh 8	2.63	44.1	21.2	16.8	1.52	4.8	1.24	Red soil
9	narsingh 9	2.68	46.28	22.4	18.2	1.26	5.3	2.3	Clayey soil
10	narsingh 10	2.74	38.4	19.2	17.5	1.18	4.8	1.24	Black cotton soil
11	shankarampet 1	2.81	37.24	18.8	19.5	1.75	7.36	2.9	Red soil
12	shankarampet 2	2.63	34.6	17.64	13.2	1.12	4.1	1.34	Laterite soil
13	shankarampet 3	2.65	36.4	16.34	24	2.1	6.8	2.3	Red soil
14	shankarampet 4	2.72	45.34	23.12	17.2	1.5	6.2	1.4	Black soil
15	shankarampet 5	2.78	29.4	20.45	16.3	0.43	4.8	1.6	Clayey soil
16	shankarampet 6	2.82	34.2	20.1	18.4	1.62	7.1	1.3	Laterite soil
17	shankarampet 7	2.68	36.5	18.5	14.6	1.74	5.2	1.9	Black cotton soil
18	shankarampet 8	2.74	40.1	17.4	20.8	1.42	6.5	2.1	Red soil
19	shankarampet 9	2.79	38.4	21.4	19.2	2.3	6.8	1.8	Black cotton clayey soil
20	shankarampet 10	2.78	33.5	20.85	20.2	1.6	5.2	1.6	Laterite soil
21	chegunta 1	2.63	39.48	22.8	17.7	1.4	5.5	2.4	Black soil
22	chegunta 2	2.69	32.64	19.8	24	2.23	4.1	1.9	Red soil
23	chegunta 3	2.83	41.32	21.9	20	1.72	5.3	2.6	Red soil
24	chegunta 4	2.74	36.2	17.4	25.1	2.31	7.1	1.8	Black soil
25	chegunta 5	2.71	43.48	22.8	14	1.15	5.8	2.1	Sandy soil
26	chegunta 6	2.63	40.1	20.5	22.4	1.62	5.1	2.3	Black cotton clayey soil
27	chegunta 7	2.45	44.1	19.5	16.8	1.46	4.8	1.7	Laterite soil
28	chegunta 8	2.75	42.6	20.6	14.9	1.18	6.3	2.14	Sandy soil
29	chegunta 9	2.84	39.4	19.2	15.3	1.25	5.9	1.6	Balck cotton soil
30	chegunta 10	2.66	44.1	20.1	16.2	2.1	6.5	1.9	Red soil

Table 1. Soil Classification and Properties of the Study Area

	Specific Gravity	Liquid Limit	Plastic Limit	Optimum Moisture Content	Maximum Dry Density	Coefficient of Uniformity	Coefficient of Curvature
Specific gravity		0.098127	0.89232	0.61221	0.98267	0.04488	0.63851
Liquid Limit	-0.30768		0.0017133	0.28139	0.95115	0.32569	0.17901
Plastic Limit	0.025807	0.54815		0.28149	0.46222	0.76553	0.83477
Optimum Moisture Content	0.096432	-0.20324	-0.2032		3.9503E-05	0.16557	0.21998
Maximum Dry Density	0.004142	-0.011681	-0.1395	0.67724		0.02713	0.59007
Coefficient Of Uniformity	0.36885	0.18577	-0.05682	0.25982	0.40325		0.12266
Coefficient Of Curvature	0.089397	0.25207	0.039917	0.23071	0.10245	0.28807	

Table 2. Correlation Matrix Soil Samples Concerning Linear r Pearson

indicating the different controlling mechanisms (Young & Hammer, 2000). Cluster I and II groups have suitable geo-technical properties of the region. These two clusters have covered good soil strength sample location and Cluster III gathers low strength soil samples then results describe not recognizable for construction.

2.5 Scatter Plot

These graphs data exhibit directly proportion with each other Coefficient of curvature versus liquid limit, plastic limit versus liquid limit, Coefficient of uniformity versus specific gravity, Maximum Dry density versus Optimum moisture content, Coefficient of Uniformity versus Maximum dry Density, Optimum moisture content versus Maximum dry density. Liquid limit versus specific gravity, Maximum Dry

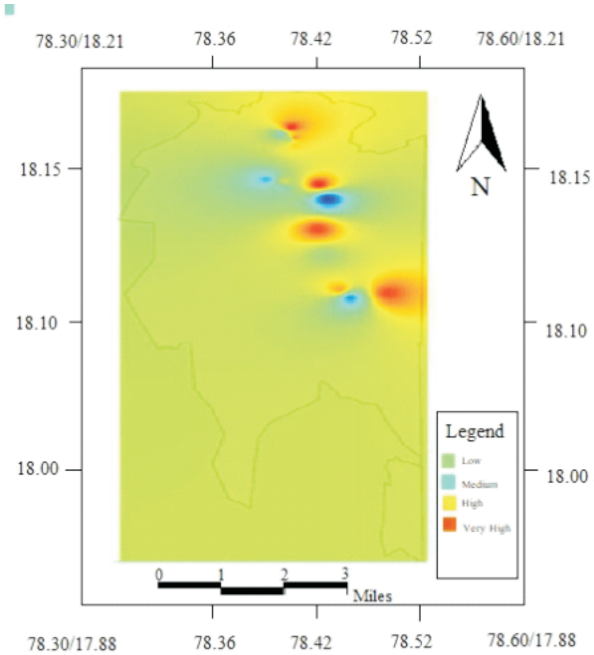


Figure 2. Thematic Soil Map for Plastic Limit Values of Soil Samples

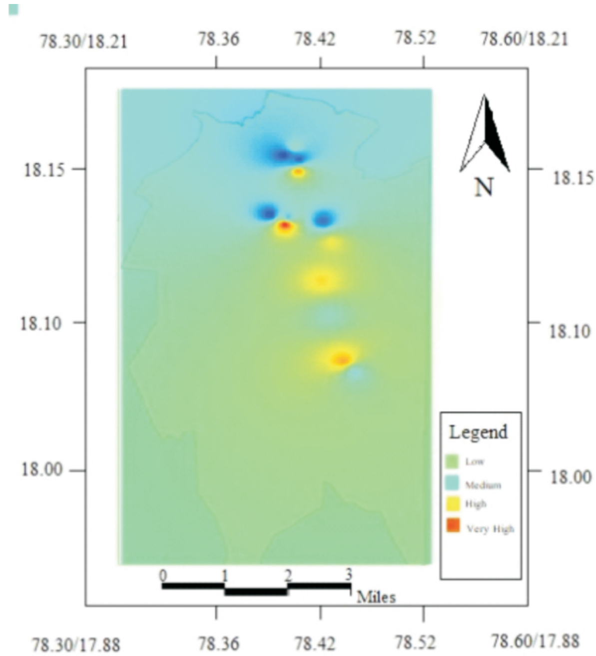


Figure 4. Interpolation Map for Coefficient of Curvature

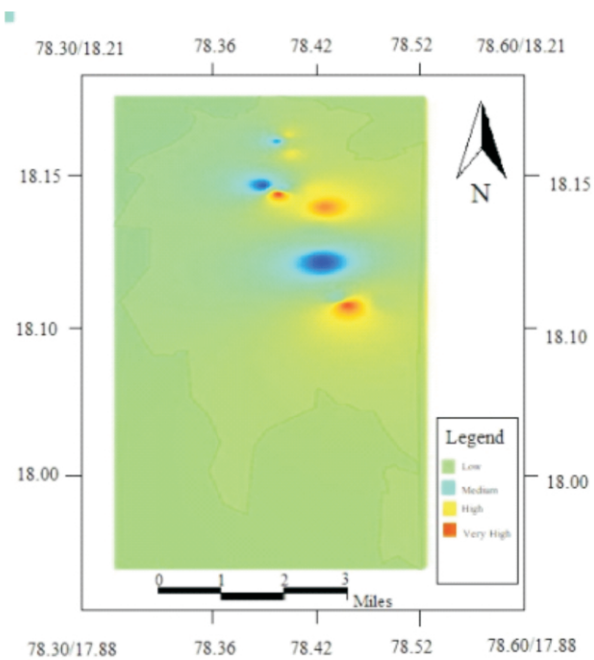


Figure 3. Interpolation Map for the Coefficient of Uniformity

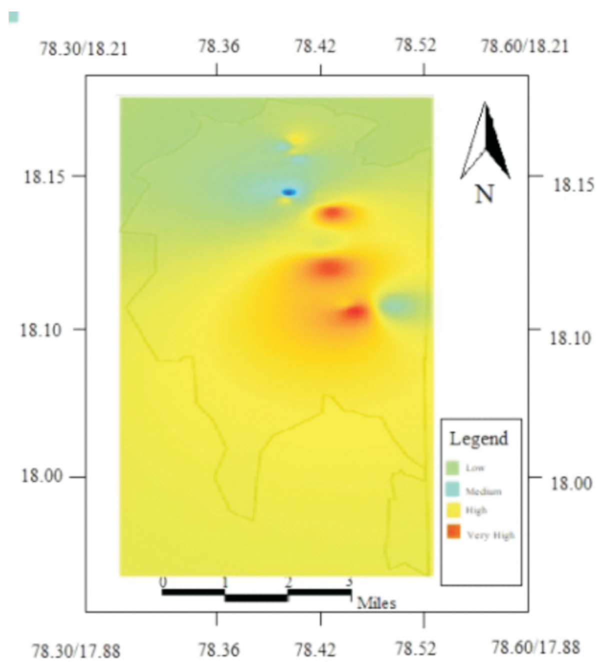


Figure 5. Interpolation Map for Proctor Compaction Test

density versus Plastic limit both are directly proportional in the reverse direction Figure 7.

2.4 Correlation Pearson Matrix

The relationship between soil parameters associated with different ratios (Freedman, 1963), Table 2 shows detail information of matrix of correlation, the high negative value represents between liquid limit (-.030768; (P<0.05)and a highest positive value is Maximum dry density (0.95115; P<0.05). The coefficient of uniformity negative value is -0.05682 between positive values of Maximum dry density. Pearson correlation coefficient between liquid limit versus

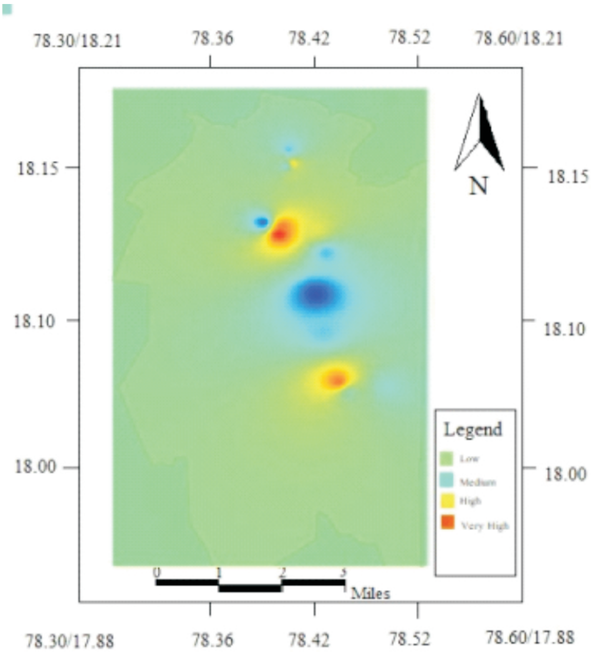


Figure 6. Interpolation Map for Specific Gravity of Soil

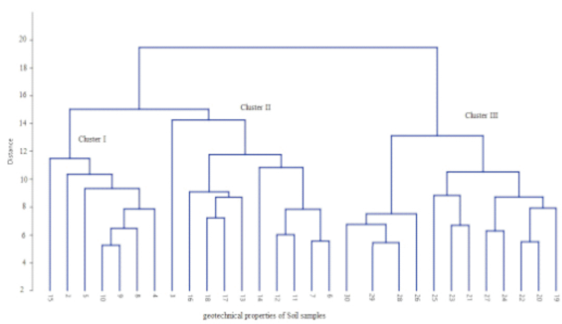
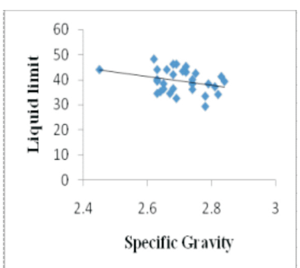
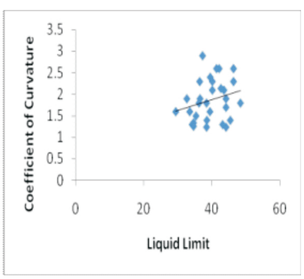


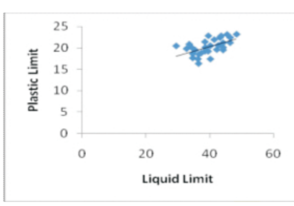
Figure 7. Euclidian Cluster Analysis of Soil Groups



(a)



(b)



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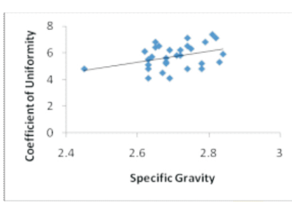
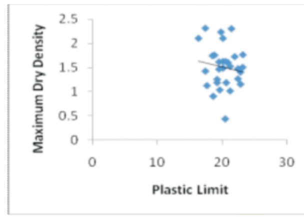


(d)



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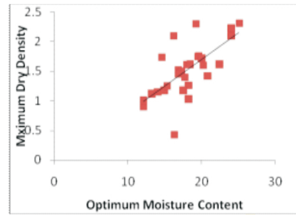
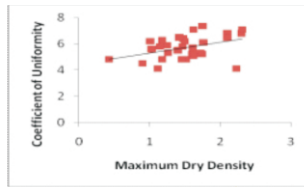
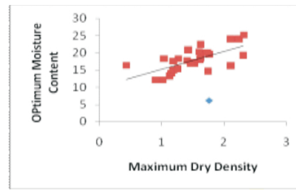


(f)



(g)



(h)

Figure 7. Illustrations of Soil Properties such as
(a) Liquid Limit Versus Specific Gravity
(b) Coefficient of Curvature Versus Liquid Limit
(c) Plastic Limit Versus Liquid Limit
(d) Coefficient of Uniformity Versus Specific Gravity
(e) Maximum Dry Density Versus Plastic Limit
(f) Maximum Dry Density Versus Optimum Moisture Content
(g) Coefficient of Uniformity Versus Maximum Dry Density
(h) Optimum Moisture Content Versus Maximum Dry Density

plastic limit R-value is 0.5481 then p-value is <0.5. It indicates a positive correlation, Liquid limit values directly proportion to plastic limit values. The maximum dry density between plastic limit the correlation value R is -0.1395, which indicates a negative correlation and inversely proportional to between plastic maximum dry density to plastic limit (Soulie et al., 1990).

Conclusion

The experimental study consisting of the field truth data, statistical and spatial analysis have approach optimal spatial soil spreading to find out the good condition of soil for engineering works. In this regard, we prepared maps which show the soil properties layout of the selected area, we have selected Narsingh Mandal, Shankarampet Mandal, Chegunta Mandal, Medak district Telangana and done tests on soils. Interpolated the data using GIS and created soil properties map. Even though if anyone is planning for construction or engineering works they can directly take these maps as a reference. This will save time and also the labor cost. The liquid limit of soil shows Narsingh Mandal has high liquid limit values, these results in high compressibility or high swelling/shrinkage potential. As the moisture content increases the shear strength of the soil decreases, it is the relation between moisture content and shear strength.

By sieve analysis, we have found that Narsingh Mandal has a high amount of well-graded soil. Well graded soils suitable for infrastructure development engineering works, this region has preferred for construction. Optimum moisture content is high for chegunta Mandal and because of that; the compaction of soil during construction can be difficult.

Cluster I and II groups have suitable geotechnical properties of the region. These two clusters have covered good soil strength sample location and Cluster III gathers low strength soil samples then results describe not recognizable for construction. Scatter plots explain correction between two properties of soils such as Liquid limit versus specific gravity, Maximum Dry density versus Plastic limit both are directly proportional in the reverse direction

Pearson correlation reveals between matrix theory to understand reasonable and attribute that most suitable parameter in the research region. The liquid limit versus plastic limit R-value is 0.5481 then p-value is <0.5. It indicates a positive correlation, The maximum dry density between plastic limit the correlation value R is -0.1395, which indicates a negative correlation and inversely proportional to between plastic maximum dry density to plastic limit

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