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Compaction Characteristics Mapping of Kazhakuttam Soil using GIS

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***Abstract*: Trivandrum being the capital city is one of the most developed cities in Kerala. Many major projects took birth here in the capital city during the last few years. One of the major cities in Trivandrum is Kazhakuttam which is now called as "New Trivandrum". Such a growing city does not have a proper Geodatabase which could make the civil engineering works easier. The main objective of this study is to create a database of properties of soil at 0.5m depth from Kazhakuttam area. Evaluation of soil properties is a very time consuming process that also relies on the memory of the personnel that are responsible for maintaining the database. If such a geodatabase is available and easily accessible, it will be of great advantage for civil engineering works. Hence this study aims to investigate the development of a Geographic Information System (GIS) to better manage and disseminate soils information, as developed from soil test results (soil at 0.5m depth was taken).**

***Keywords*: Soil mapping, Geographic information System, Digital Elevation modeling.**

1. Introduction

As technology develops the representation of geotechnical properties of soils also become easier. This makes the common man aware about the soil properties of each area in just a single click. The area mainly focused in my study includes evaluation of soil properties, creation of a database and its representation in the form of map using GIS software.

A. Geographic information system

In the strictest sense, a GIS is a computer system capable of assembling, storing, manipulating and displaying geographically referenced information, i.e. data identified according to their locations. USGS defines a geographic information system (GIS) as a computer based tool for mapping and analysing things that exist and events that happen on earth. Geographic Information System provides efficient tools for inputting data into database, retrieval of selected data items for further processing and software modules which can analyze or manipulate the retrieved data in order to generate desired information on specific form. GIS stores spatial and non-spatial data in two different databases. The geocoded spatial data defines an object that has an orientation and relationship with other objects in two (2D) or three dimensional (3D) space. GIS uses three types of data to represent a map or any geo-referenced data, namely, point type, line type, and area or polygon type. It can work with both the vector and the raster geographic models. The vector model is generally used for describing the discrete features, while the raster model does it for the continuous features. One of the major advantages of the GIS is that it incorporate all type of relevant data either available in aerial photographic data, remote sensing images data, tabular data etc. These and other information are viewed as individual coverage that may be simultaneously overlaid depending on the desired detail of the analysis. Data integration is the linking of information in different forms through a GIS. Applications of GIS in geotechnical engineering includes land classification, surveying land, mapping land, facility monitoring, visual resource assessment, identifying suitable areas for developing agricultural activities, etc.

B. Soil properties

The properties of soil can be divided as Index properties and Engineering properties. The main Engineering properties are shear strength, permeability, and compressibility. Permeability indicates the ease with which the water can flow through soils. Compressibility is related with the deformations which soil undergoes when subjected to compressive loads. The Shear strength helps in determining stability of slopes, bearing capacity of soils and the earth pressures on retaining structures. The specific gravity of soil solids is the ratio of the density of a given volume of soil solids to the greatest density (at +4°C) of an equal volume of pure water. The principal soil grain properties are the size and shape of grains and the mineralogical character of the finer fractions. The most significant aggregate property of cohesion less soils is the relative density, whereas that of cohesive soils is the consistency. Moisture content is that amount of water which is contained in the voids of the soil. It is one of the important factor depending upon which the shear strength of soil will change. Consistency is the property of materials which shows its resistance to flow. When referred to soil, it means, the degree of resistance offered by fine grained soil to deformation. The water content at which the soil changes from one state to another state termed as consistency limits. Dry density of soil mass is the ratio of mass of soil solids to the volume of soil mass. Therefore the properties of soil such as specific gravity, moisture content, dry density, wet density and consistency limits such as liquid limit, plastic limits and shrinkage limits are the essential for determination of engineering properties of soil, which will help to geotechnical

engineer for decision making process of suitability of soil as foundation materials or construction materials. If the properties of soil are properly studied and the results of soil exploration correctly understood and intelligently applied to the design and construction of earthworks and structural foundations, failures usually can be avoided. The soil properties can be found out using the test apparatus and the test procedure specified in the Indian Standard codes.

C. Study area

Kazhakuttam is a major city in Trivandrum district which is now called "The New Trivandrum". The area is covered between $8^0$33'30"N and $8^0$35'30"N latitude and $76^0$51'0"E and $76^0$53'30"E longitude and it covers an area of about The place gained significance because of its proximity to the Vikram Sarabhai Space Centre, Techno park and the Trivandrum International Stadium. But such a prominent city does have a geodatabase of soil properties. The study focuses on mapping compaction characteristics and natural water content of soil of Kazhakuttam ward.

2. Methodology

The project work was done with the help of ARCGIS. Non georeferenced Kazhakuttam ward (study area) map was obtained from Kazhakuttam Corporation Office which was then georeferenced in ArcMap 10.2 version. The ward boundary was then drawn using line feature and the thus obtained shape file is used for further work. During sample collection the geographic coordinates of the area were recorded using a GPS. Point layers were created to represent the location of sample collected. Total 10 samples were collected from different regions of Kazhakuttam ward and these were plotted on ArcMap. Microsoft word 2007 is used for the creation of database of soil properties such as dry density, optimum moisture content and natural water content. The soil properties created on excel file was converted to geodatabase using conversion tools in Arc tool box. Finally the thematic maps of soil properties such as liquid limit, dry density and moisture content were prepared using Interpolation technique in spatial analyst tools. Interpolation techniques used is Inverse Distance Weighted (IDW).

3. Results and discussion

The samples were collected from 10 different sites in Kazhakuttam ward. The Google Earth scene of the ward along with GPS locations of 10 sampling sites are represented on Fig. This was developed after geo referencing the ward map.

Fig. 2 shows the thematic map created using ArcMap 10.2 version. The map is used to represent the locations from where the sample was collected. Each location is marked S_1, S_2, S_3, and so on inside the ward boundary.

Fig. 3. Shows the Digital elevation model of the study area. DEM is the map extracted from the Cartosat DEM data obtained from BHUVAN which is the Indian website handled by the National Remote Sensing Department of Indian Space and Research Organisation (ISRO).

Table 1
Geographic coordinates of sampling locations

Sample no.	Latitude	Longitude
S_1	8.576419444	76.859825
S_2	8.563780556	76.8696972
S_3	8.571094444	76.8798972
S_4	8.579519444	76.8687361
S_5	8.571205556	76.8701222
S_6	8.585491667	76.8661806
S_7	8.576394444	76.8840417
S_8	8.566172222	76.8844389
S_9	8.568627778	76.8648083
S_{10}	8.574688888	76.87515

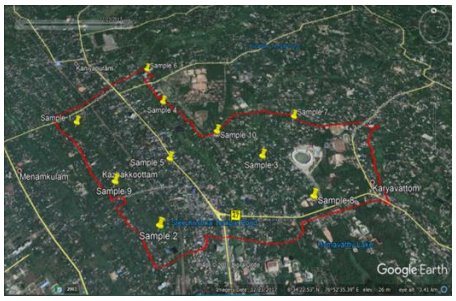

Fig. 1. Google earth scene of sampling locations.

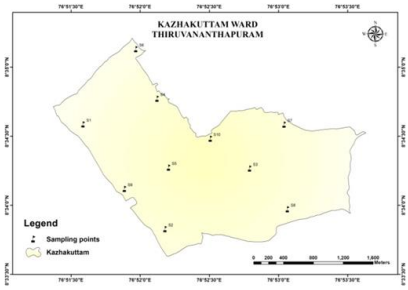

Fig. 2. GIS map showing sampling locations

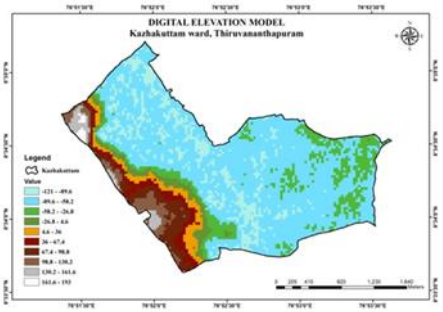

Fig. 3. DEM of the study area

A. Variation in natural water content

The fig. 4 shows the variation in natural water content of soil at different sites in Kazhakuttam ward. Table 2 shows the liquid limit values at different sites. The maximum value of natural moisture content obtained from test is 35.26% for S_8.

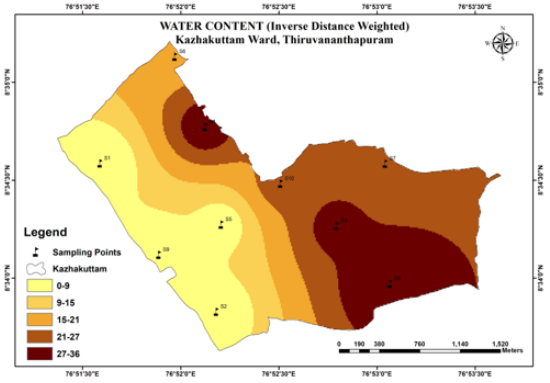

Fig. 4. Thematic map showing variation in natural moisture content of soil in the study area

Table 2
Natural moisture content at different locations

Sample no.	Latitude	Longitude	Natural water content (%)
S_1	8.576419444	76.859825	2
S_2	8.563780556	76.8696972	3.4
S_3	8.571094444	76.8798972	29.375
S_4	8.579519444	76.8687361	31.22
S_5	8.571205556	76.8701222	4.6
S_6	8.585491667	76.8661806	18.21
S_7	8.576394444	76.8840417	21
S_8	8.566172222	76.8844389	35.26
S_9	8.568627778	76.8648083	2.9
S_{10}	8.574688888	76.87515	23.2

Table 3
Optimum moisture content at different locations

Sample no.	Latitude	Longitude	Optimum moisture content (%)
S_1	8.576419444	76.859825	7.56
S_2	8.563780556	76.8696972	6.39
S_3	8.571094444	76.8798972	23.4
S_4	8.579519444	76.8687361	23.9
S_5	8.571205556	76.8701222	8.25
S_6	8.585491667	76.8661806	17
S_7	8.576394444	76.8840417	18.36
S_8	8.566172222	76.8844389	32.61
S_9	8.568627778	76.8648083	8.61
S_{10}	8.574688888	76.87515	10.54

B. Variation in optimum moisture content

The fig. 5 shows the variation in optimum moisture content of soil at different sites in Kazhakuttam ward. Table 3 shows the liquid limit values at different sites. The maximum value of optimum moisture content obtained from test is 32.61% for S_8.

Table 4
Dry density at different locations

Sample no.	Latitude	Longitude	Dry density (gm/cc)
S_1	8.576419444	76.859825	1.623
S_2	8.563780556	76.8696972	1.597
S_3	8.571094444	76.8798972	1.82
S_4	8.579519444	76.8687361	1.864
S_5	8.571205556	76.8701222	1.702
S_6	8.585491667	76.8661806	1.744
S_7	8.576394444	76.8840417	1.744
S_8	8.566172222	76.8844389	1.962
S_9	8.568627778	76.8648083	1.715
S_{10}	8.574688888	76.87515	1.438

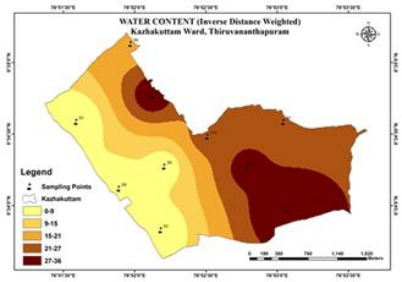

Fig. 5. Thematic map showing variation in optimum moisture content of soil in the study area

C. Variation in dry density

The fig. 6 shows the variation in dry density of soil at different sites in Kazhakuttam ward. Table 4 shows the liquid limit values at different sites. The maximum value of natural moisture content obtained from test is 1.962 gm/cc for S_8.

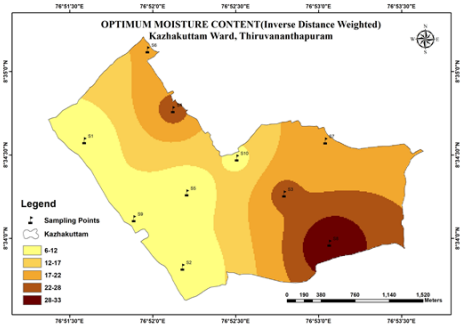

Fig. 6. Thematic map showing variation in dry density of soil in the study area

4. Conclusion

The properties of soil are very important to a geotechnical engineer to take the decision regarding the suitability of soil as good foundation material or construction material. The thematic maps of soil properties were prepared using ArcMap 10.2. These maps can help in reducing the time for soil exploration and cost of construction procedures. However, it is true that the generated GIS maps cannot be the total

replacement for soil exploration but definitely will help in proper planning with minimum loss with a validation of soil properties of Kazhakuttam ward.

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