DEVELOPMENT OF SOIL SUITABILITY MAP USING GIS

Arun Murugan R B [1]
Stalin V.K [2]

[1] Researcher, [2] Professor, Division of Soil Mechanics and Foundation Engineering, College of Engineering Guindy, Anna University, Chennai 600 025, E-mail: arunmurugan18@gmail.com, staliniisc@yahoo.co.in

ABSTRACT: The amount of subsurface information that can be effectively collected and manipulated is abundant. The use of information and database management system can help in the problem solving process for the engineer. In this paper South Chennai, India between the village boundaries Perungudi and Kelambakkam were selected to develop geotechnical zonation maps using Geographical Information System (GIS). Based on sampled geotechnical data values, an estimated value is assigned to all other locations using surface creation function (Topo to Raster interpolation process) in GIS. The study area was contoured for SPT N values, soil classification and bearing capacity (kN/m^2). Information from various interpolation techniques has been checked by cross validation. SPT 'N' values and bearing capacities for various footing breadths at different depths could be computed using this GIS map. This study realizes the potential of GIS to find the solution of phenomena that was very tedious by any other means, not only in terms of accuracy but also by the use of derived information as the input for other correlation analysis. Furthermore the system can be used as a decision support for geotechnical engineers.

KEYWORDS: *Geographical Information System, Arc GIS, Interpolation, N-Value, Soil Classification, Bearing Capacity*

1 INTRODUCTION

Geotechnical engineering project typically concentrates on the subsurface site condition and the interaction of man-made structure with the earth mass. For this purpose, the geotechnical engineer is required to collect a wide range of information. The sources of information are the subsurface data obtained from direct methods such as boring, test pits, plate load test, sounding, etc and indirect methods such as electrical conductivity test, seismic refraction, etc. The multiple types of geotechnical data that is available are in various formats and are widely scattered. So, the use of information and data base management system can help in the problem solving process for geotechnical engineer and can be a cost and time effective. This necessitates the collection of enormous geotechnical data which are available from various sources and their framing in a single GIS model that could be used by a whole range of geotechnical fraternities. In general, geotechnical zonation maps answer many, if not most of the questions that arise during the early planning stages of construction programs. With increasing development and growing awareness regarding safety and economy of the geotechnical engineering projects, it has now become essential that a comprehensive effort be made to prepare geotechnical zonation maps.

Roch Player (2000) has studied about the preliminary geotechnical site investigations for transportation projects using GIS to create a model of the geotechnical conditions and considerations facing a project which can be used to analyze the project and to make project decisions. In preliminary geotechnical site evaluations, GIS can be used in four ways: 1) data integration, 2) data visualization and analysis, 3) planning and summarizing site activities, and 4) data presentation. Rogers and Luna (2004) studied the impact of Geographical Information Systems (GIS) on geotechnical engineering and they concluded that, over the last four decades GIS have emerged as the predominant medium for graphic representation of geo-spatial data, including geotechnical, geologic and hydrologic information routinely used by geotechnical and geo environmental engineers. Sitharam et al. (2004) have developed a detailed soil map containing 850 borehole data up to a maximum depth of 40 m, generated in 3D for Bangalore region, India, based on GIS. The GIS model created consists of solid stratification with their geotechnical properties along the depth. The map entities have been developed to locate the boring logs to the maximum accuracy on a scale of 1:20000 and for identification of boring logs by end user. The map has been developed with the several layers of information such as boundaries, contours, highways, major roads, minor roads, streets, rail roads, water bodies, drains, landmarks and bore locations. The map has been created in such a way that, when viewed in 3D, the geotechnical information on any borehole at any depth can be obtained by clicking at that level. A web-based geotechnical database management system (GDBMS) is developed by Okunade (2010) for Nigerian soils. Habibullah et al. (2012) have created GIS-Based soil liquefaction hazard zonation due to earthquake using geotechnical data for Satte city, Japan. These maps can be useful for assessing the approximate areas affected by hazards and for disaster prevention planning. In this paper, an attempt is made to develop soil suitability map for South Chennai city, India so that it can serve for urban planners to plan and design various urban development projects.

2 METHODOLOGY

2.1 Details about the Study Area

Rajiv Gandhi Salai, erstwhile called as Old Mahabalipuram Road (OMR) or IT Corridor is an important road in suburban Chennai, India, starting from Madhya Kailash temple and going southward till Mahabalipuram terminating in East Coast Road. This is popularly called as 'IT Corridor' due to the fact that this road has become the home to most of the IT companies in Tamilnadu, India. The burgeoning population of information technology professionals is having a logical influence on real estate development, with a slew of residential apartments coming up along the IT Corridor. The base map of the study area is shown in figure 1

2.2 Development of user friendly Soil Suitability Map using GIS

The various stages involved in the development of spatial model are shown in figure 2. The conceptual flow chart for developing user friendly soil suitability map using Geographic Information System (GIS) is shown in figure 3. GIS package is the core of the database as both spatial and non-spatial data are to be handled. In this paper Arc GIS 10.3 was used to create the data base.

3 RESULTS AND DISCUSSION

Sampling points were located using hand held GPS as per grid point method in the surrounding Study area. Latitude and longitude of all 900 borehole locations were observed to interpret the sampling location in digitized location map. The ground water table depth is obtained from the bore-log report. The variations of N-value with respect to depth are analyzed and the distributions of N-value are shown in figure 4. These N-value maps can be used to determine N-values in un-sampled locations by knowing the latitude, longitude and depth of the respective layer. The variations of soil classification based on Unified Soil Classification System with respect to depth are analyzed and the soil classification maps were prepared. Figure 5 shows the soil classification map of 2.25 m depth. The allowable bearing capacity map was developed based on the IS Equation for varying foundation width (1 B, 2 B, 3 B and 4.5 B).

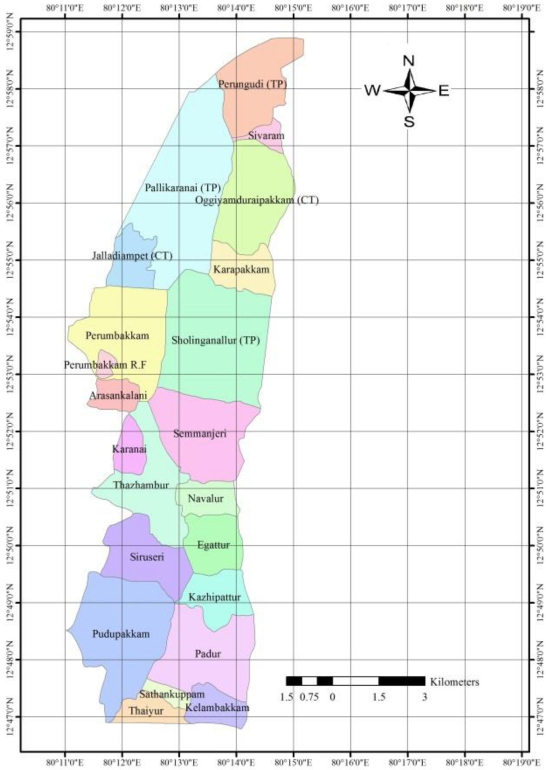

Fig. 1 Base map of the study area – South Chennai, India

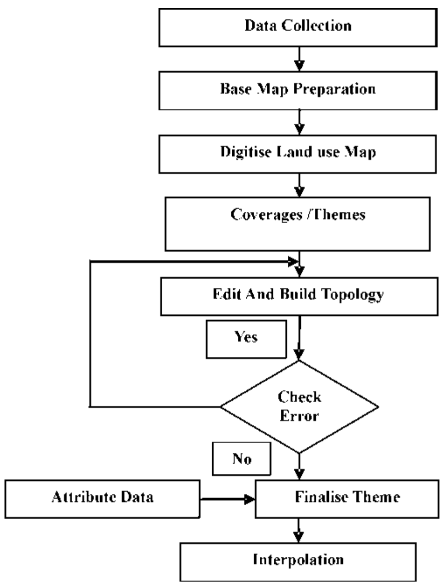

Fig. 2 Flowchart for theme creating process for generating spatial models

The average shear strength parameters of the subsequent layer up to the influence depth of 1 B were taken for the determination of allowable bearing capacity and the map is developed for different depths of 1.5 m, 2.25 m, 3.0 m, 3.75 m and 4.5 m. These bearing capacity maps can be used to suggest allowable bearing capacity for different depths in the study area by knowing the latitude and longitude of the site location. Figure 6 shows the allowable bearing capacity map of various zones at a depth of 2.25 m.

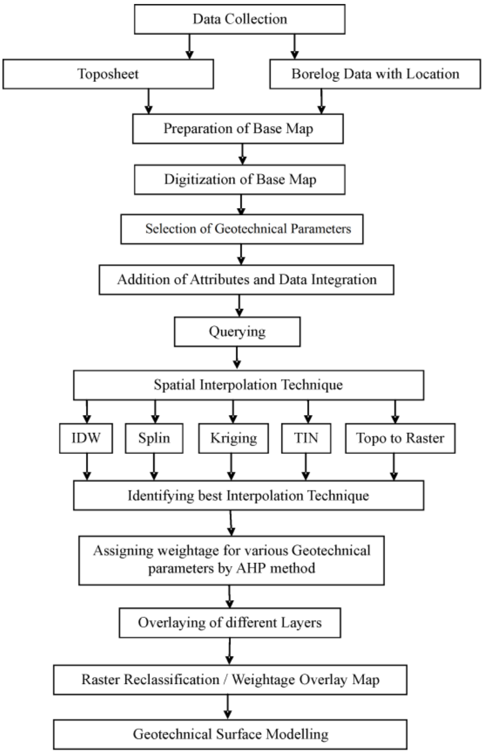

Fig. 3 Conceptual flow chart for developing user friendly soil suitability map by geographic information system (GIS)

3.1 Validation of the Soil Suitability Map

The validation of the developed maps has been done by predicting the geotechnical properties at 90 borehole locations (control points) in the field which are not included in the developed maps. The various geotechnical parameters such as N-value, soil classification, ground water table depth and allowable bearing capacity were taken from the developed maps and compared to properties of the 90 locations that are not included in GIS analysis. It is found that the observed values from developed maps were in close agreement with the actual values in the boring logs and laboratory reports. Figure 7 shows the predicted and actual N-values observed in the field at 2.25 m depth.

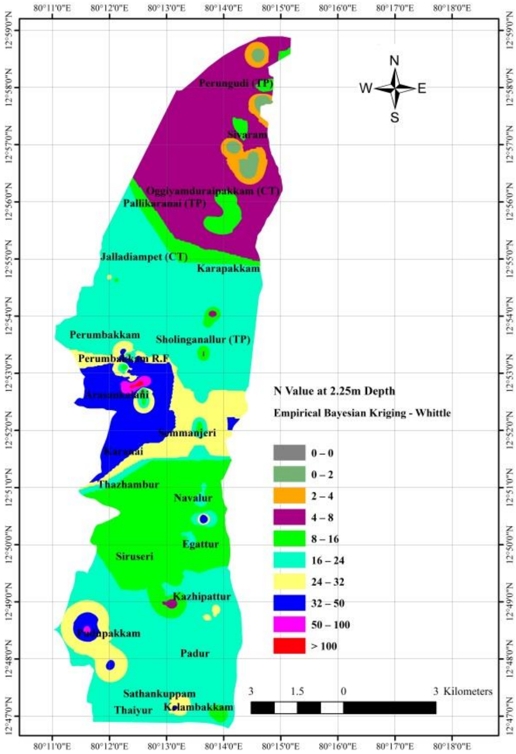

Fig. 4 SPT 'N' Value Map at 2.25 m Depth

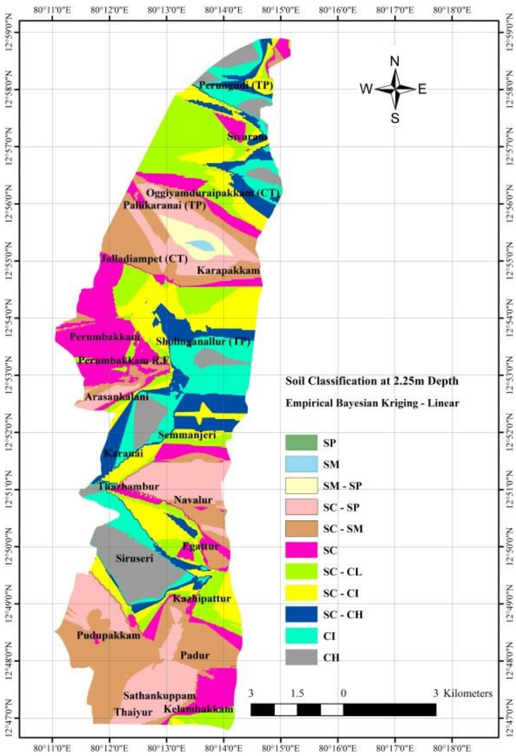

Fig. 5 Soil Classification Map at 2.25 m Depth

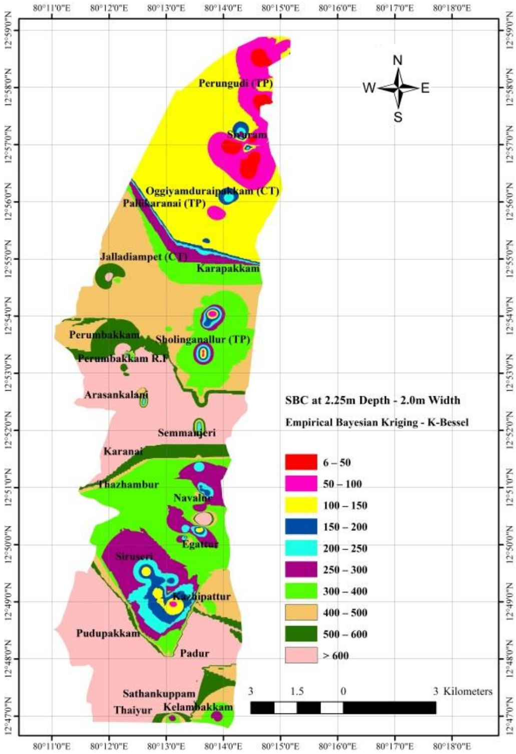

Fig. 6 SBC Map (kN/m^2) at 2.25 m Depth for 2 m Wide Footing

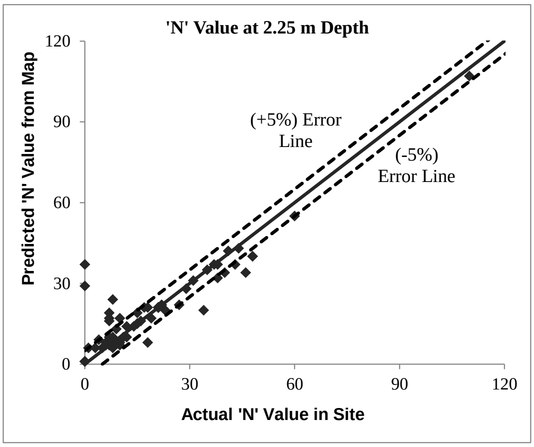

Fig. 7 Comparison of predicted 'N' values taken from gis map and actual 'N' value observed in the field

4 CONCLUSION

Sufficient reliable geotechnical data regarding physical properties, classification and shear strength characteristics of soils were collected. From this data, the physical and engineering properties like bearing capacity, ground water table depth, unified soil classification system (USCS) and SPT N-values were set out in a GIS Map. These developed maps can be used significantly for preliminary design, investigation, estimation, analysis and design of foundations for various structures and site selection for location of important structures. The following information and general conclusions may be drawn from the above study,

1) The allowable bearing capacity for varying footing sizes can be computed from the developed GIS maps for various depths.
2) It is inferred that Empirical Bayesian Krging is the best interpolation technique for developing soil suitability maps.
3) In the entire study area there were no problematic soils such as expansive clays, dispersible soils and volume change soils which may induce special problems during and after construction.
4) The developed maps can be used by civil engineers, geotechnical engineers and geologists for planning, designing, investigation, analysis and design of various structures. By using these maps, the soil exploration for small structures can almost be eliminated and for large projects it can serve as a basic tool in properly planning and executing the site investigation work.

References

Roch Player (2000), Using GIS in Preliminary Geotechnical Site Investigations for Transportation Projects, *Proceedings of Mid-Continent Transportation Symposium 2000*, pp 174-177.

David Rogers. J and Ronaldo Luna (2004), Impact of Geographical Information Systems on Geotechnical Engineering, *Proceedings of Fifth International Conference on Case studies in Geotechnical Engineering, New York, NY*, April 13-17 2004, pp 1 - 23.

Sitharaman T G., Sudarshan M.S., Narashimha Raju P.S.R., Shamanth Kuchangi and Mahesh G.U (2004),"Geotechnical Site Characterization Map in 3D for Bangaore City, *Proceedings of Indian Geotechnical Conference 2004*, NIT, Warangel, India, pp. 33-36.

Emmanuel Akintunde Okunade (2010), Design and Implementation of a Web-Based Geotechnical Database Management System for Nigerian Soils, *Modern Applied Science*, Vol. 4, No. 11, November 2010, pp.36-42.

Bhuyan Md. Habibullah, Rama Mohan Pokhrel, Jiro Kuwano and Shinya Tachibana (2012), GIS-Based Soil Liquefaction Hazard Zonation due to Earthquake Using Geotechnical Data, *International Journal of GEOMATE*, March, Vol. 2, No. 1 (Sl. No. 3), pp. 154-160.