Subsurface Geotechnical mapping for disaster resilience housing in Colombo Municipal Council Area

EMRCL Boyagoda
Geotechnical Engineering Division, National Building Research Organisation

LUM Kankanamge
Geotechnical Engineering Division, National Building Research Organisation

JMCK Jayasundara
Geotechnical Engineering Division, National Building Research Organisation

ABSTRACT: Although there are number of studies carried out with regard to housing in hilly areas which have a significant tendency of being prone to landslides, still there are no such rigorous studies conducted on housing in low land areas. Whereas with the increasing population the amount of land available for housing development is getting decreased at an alarming rate. Consequently, it is of utmost importance to utilize the available land areas efficiently and effectively. In this respect it is always a benefit to have a general idea about subsurface conditions prior to commence any sort of a construction. Especially for those who are involving with construction activities without proper guidance. Therefore, to fulfill the above requirement this study was carried out to map the subsurface conditions in Colombo Municipal Council area using the available borehole data. A model has been developed to predict the subsurface conditions including the type of existing soil layers, depth to the ground water table, bearing capacity of the soil and some kind of an idea about the type of suitable foundation with adequate guideline to be used as a tool for identifying possible unfavorable impacts. The data has been processed using the RockWorks Software and 2-D and 3-D models have been developed to certain extent to interpret the data.

1 INTRODUCTION

National Building Research Organisation is the only government institution dealing with investigations, analysis, monitoring, early warning related to landslide, conducting research, landslide and geotechnical engineering related issues in Sri Lanka over the past few decades. Therefore, to concentrate the available geotechnical data and investigation experience to one focal point we thought to deliver a research base output which will ultimately result in creating more reliable and effective outcome from the community perception.

In this regard, we have focused on developing a 3D model to predict the available borehole data in Colombo Municipal Council area as this would be vital in future construction since there are new proposals being put forward to develop Colombo as a metropolitan city.

When it comes to selection of lands for certain constructions there are number of factors to be concerned. The suitability of the land, available infrastructure, total consumable area, capital cost of investment and most importantly the subsurface conditions. Almost all the above mentioned factors are perceptible in terms of cost and based on other Threshold Limits except the subsurface conditions.

There is no pre-defined way to obtain a proper idea about the underground conditions without carrying out a borehole investigation or another type of geophysical survey. But this would result in incurring an additional cost to the buyer and in case if the borehole investigation or geophysical survey reveals that the land is not suitable for the type of construction which the client is opting, the total cost would be in vain. Therefore, the proposed study would assist the client to get a general idea on the investment that he is going to perform beforehand.

The 3-D analysis for site characterization is mainly relevant for major construction works, for areas of already existing engineering constructions and in studies on aggregate resources. Generally the process of interpretation of site investigation data comprises of subsurface characterization and engineering analysis. A proper geotechnical characterization would help in differentiating and spatially defining geotechnical units and predicting the variability within the engineering units. Engineering analysis is performed to evaluate in quantitative terms interaction between the subsurface and the proposed engineering construction. Also these results could effectively be used to forecast the potential geotechnical failures of already existing buildings due to land subsidence, liquefaction and etc.

2 OBJECTIVES

The objectives of this research are as follows:

- Develop a 3-D model associated with corresponding 2-D maps with the data acquired from borehole logs
- Determine and interpret all possible geotechnical changes and behavior leading to a damage
- Introduce an appropriate construction guideline to meet requirements of safer built environments

3 LITERATURE REVIEW

A plane surface representation, generally in horizontal projection, of geologic data or features beneath the Earth's surface is known as a subsurface map. There are many types of subsurface maps, such as structure contour maps, isopachous maps, and maps showing variations in lithology, or proportions of different types of lithology in rocks not exposed at the surface.

There are certain techniques which are being used to map certain geological data. Stereographic projections bore logs and subsurface profiles have been used predominantly to interpret subsurface data. In the recent past, there are several software which have been especially developed for this purpose with sophisticated and user friendly options. These software play a vital role in subsurface data interpretation and particularly in applications related to mining.

Efforts have been made using certain software to characterize the subsurface conditions. 3D-GIS is one such software which has been used for modeling purposes. Characterization of a subsurface when done by a computer requires an integrated tool. The models created in this manner provide an improved basis to predict the interaction between the engineering structures and the subsurface.

The human influence on the upper part of the lithosphere is varying and can be classified under mechanical, physical, chemical and biological influences. Man made influences may ultimately result in negative consequences on the development and functioning of the urban areas.

Engineering geology studies of urban areas can be discussed under several categories. Price (1972) distinguishes four broad group of problems related to existing urban areas and urban development.

1. Ground stability
2. Bearing capacity in foundation design
3. Excavation
4. Water supply and waste disposal.

Modelling of the spatial variability of engineering properties within the subsurface can be done in two ways.

Interpolation

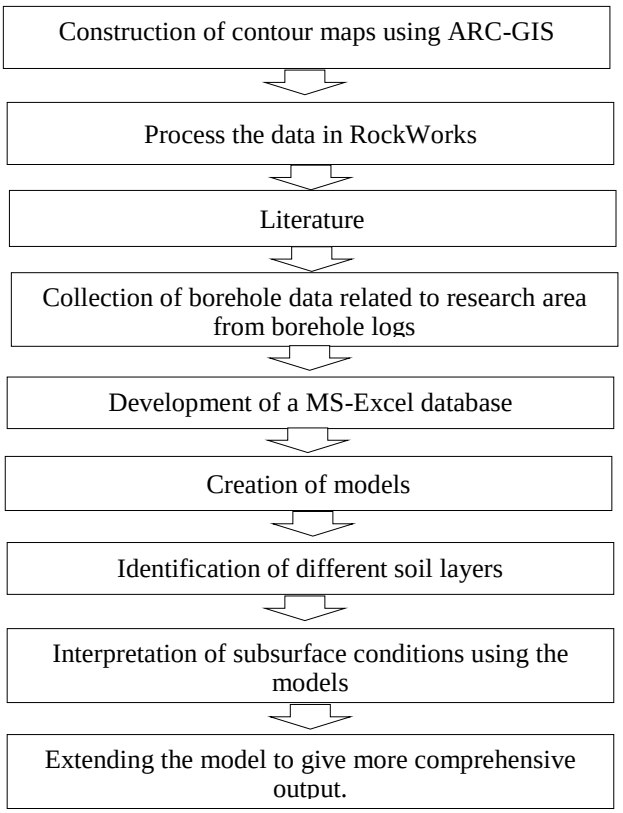
Interactive attribution of properties to the defined units

Interpolation requires a sufficiently large data set. But when dealing with complex geological structures it is difficult to use interpolation algorithms. Therefore, it is the expertise of the interpreter which matters in such situations.

There are certain geotechnical models which have been developed to planning the redevelopment of existing urban areas. These models have been used to predict the settlement of existing structures and determine the depths of pile foundations of proposed structures. The outcome of the 3-D models is compared with the results obtained from 2-D analysis which are based on the interpolation of site investigation data.

4 METHODOLOGY

Development of a solid methodology for data analyzing purposes is always a challenge due to the lack of previous data. Therefore, a methodology was developed through discussions with experts and comprehensive analysis of borehole data.



5 RESULTS

In this research the available data set included 166 borehole results which were drilled to obtain subsurface data for foundation design purposes. The topography of the area is flat and low-lying.

5.1 *Geological Characteristics of the Study Area*

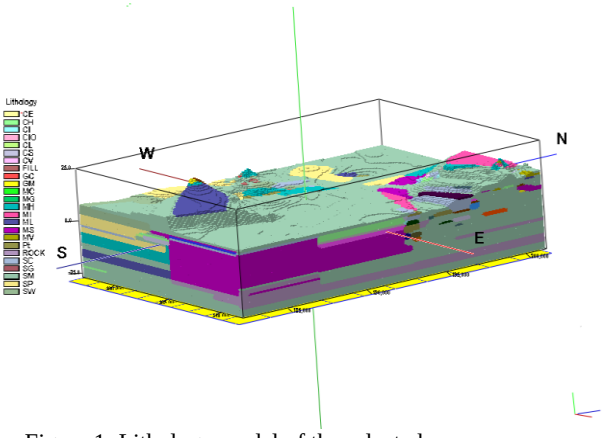


Figure 1: Lithology model of the selected area

The **Figure 1** above depicts the lithology of the selected area. The borehole data shows some organic formations of the area at a depth of around 15m which indicates that this area formed an estuary of *Kelani* river and *Kalu ganga* River, the two main rivers drain into the sea on the western coast. The top most layers are occupied by sands, silts and a mix of sands and silts.

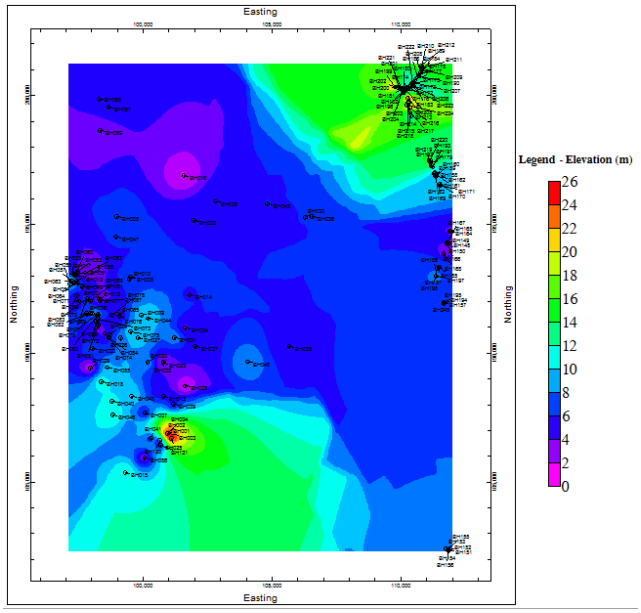


Figure 2: Elevation map of the area with respect to mean sea level

The Colombo district which incorporates the project area falls into the lowest peneplain of Sri Lanka. The elevation variation of the area of concern ranges to a maximum elevation of 26 m with respect to mean sea level. The terrain in Colombo largely consists of gently undulating plains and low-lying flatlands with a high density of drainage paths formulating a geography consisting of a mix of land and water.

6 CONCLUSION

The outcome of the proposed research will contribute to development of geotechnical hazard zonation maps, which can be later developed at national level similar to landslide hazard zonation maps produced for construction areas. The current research will address all the issues related to geotechnical engineering aspects leading for hazards such as ground subsidence/settlements, liquefaction etc.

Users may use them in identifying degree of vulnerability against specific underground issues in order to manage or control damages, unnecessary expenditure incurred with unexpected situation caused.