

CHARACTERIZATION OF SOIL OVER KOLKATA MUNICIPAL AREA

Das Diptendra

PhD Scholar, Bengal Engineering and Science University, Sibpur, Howrah-711 103, India.

E-mail: diptendra_69@yahoo.co.in

B.C. Chattopadhyay

Professor, Bengal Engineering and Science University, Sibpur, Howrah-711 103, India.

E-mail: ccbikash@yahoo.com

ABSTRACT: Kolkata, a megapolis having very high population density and large population living in extremely crowded and congested high rise building is located in a region of quite high seismic activity. Further as the area around Kolkata is situated on the east bank of river Hooghly at a small distance from Bay of Bengal, high tidal actions are also felt through the river over the area. As the landmark in the area has been developed by riverine deposition, the soil below the area exhibits large irregular variation in character both in horizontal and vertical direction. To safeguard the people and structures of the area there is urgent need to develop microzonation mapping of the area from the view point of liquefaction potential. With this view, soil mapping over a depth of 30 m from G.L. was undertaken and sectional profiles along N-S and E-W direction over the area were developed and presented in this paper.

1. INTRODUCTION

Kolkata former capital of British India and presently capital of the State of West Bengal has been grown from a humble city to a megapolis having population over 13 million (census 2001) with very large population density along with large scale development of high rise buildings over this congested city. To cope with growing population and increasing economical and commercial needs, large scale development of infrastructure are also taking place at a first rate. Initially it was thought that Kolkata falls in a region of moderate seismic activity but with I.S. 1893 (2002) it has been found that the city falls in a relatively higher seismic activity zone. To safeguard the safety of constructed infrastructures and residential buildings it is imperative that proper zoning of the Kolkata area should immediately be taken up to consider the liquefaction possibilities, if any existing over the city. Since Kolkata is situated on a alluvial flood plain, soil beneath the city is essentially erratic in nature and as a result proper characterization of the soil within 30 m from the ground level over the Kolkata area should properly be determined and characterization of such soil should be available to take up the next job of microzonation of the area under possible earthquake. Since this region has not experienced any major earthquake over a considerable period of time, it is opined that an earthquake of high intensity may visit such a zone (Kramer S.L. 1996). With the aim of taking up the project of microzonation of Kolkata Municipal area, characterization of soils over KMC area were studied by the authors, result of which are reported in this paper.

2. KOLKATA MUNICIPAL CORPORATION (KMC)

2.1 Location and Extent

Kolkata, the gateway not only to eastern India, but also to South East Asia, is the capital city of the state of West Bengal. It is situated on the east bank of Hooghly river in the famous deltaic Bengal basin, the largest one in the world developed by the action of Ganga-Brahmaputra river system and nearly 120 Km away from the Bay of Bengal. The Central point of the city is located by 20°30' N latitude and 88°30' E longitude. The Kolkata Municipal area covers an extent of 187.33 sq. km. The boundary area of KMC is located in Figure 1. The water table below the area generally exists over a shallow depth from the existing ground level and in rainy season it may reach the G.L. in many parts of the area. Originally the city of Kolkata grew in the North-South direction over the natural levee of the east bank of Hooghly river for over a length of 50 Km. But due to enormous population pressure it has encroached into the back swamp and marshy land to the east by way of filling up extensive areas, especially in the Salt Lake and Rajarhat areas.

2.2 Geology of Kolkata

Kolkata is situated over a huge pericratonic tertiary basin with enormous thickness of fluvio-marine sediments. The basin can be divided into three structural units: The westernmost shelf or platform, the Central hinge or shelf/slope break and deep basinal part in the east and south east that open in the present bay of Bengal. The Kolkata city located over the western part of the hinge zone across which sediment thickness

and facies significantly varies for shelf area in the west to deep basin area in the east. The hinge zone and the shelf area are traversed by many faults; some of them are reported to be tectonically active at present (Nandi 1994). The hinge zone is about 25 Km wide that occurs at a depth of about 45000 m below Kolkata. The total sedimentary thickness below Kolkata is of the order of 7500 m above the crystalline basement; of these the top 350–450 m is Quaternary, followed by 4500–5500 m of tertiary sediments, 500–700 m trap wash of cretaceous trap and 600–800 m permocarboniferous Gondwana rocks.

3. SUB-SOIL CONDITION OF THE KMC AREA

Since the above study was undertaken for microzoning of the area against liquefaction under earthquake, the soil information below, the city was undertaken unto a depth of 30 m for soil mapping. Sub surfaces soil data for the KMC area are mainly obtained through soil exploration data generated for construction activity in KMC area by various soil engineering farms. Data are also obtained through Ground Water Resource Studies by GSI & CGWB and also data generated for underground metro rail project implementation.

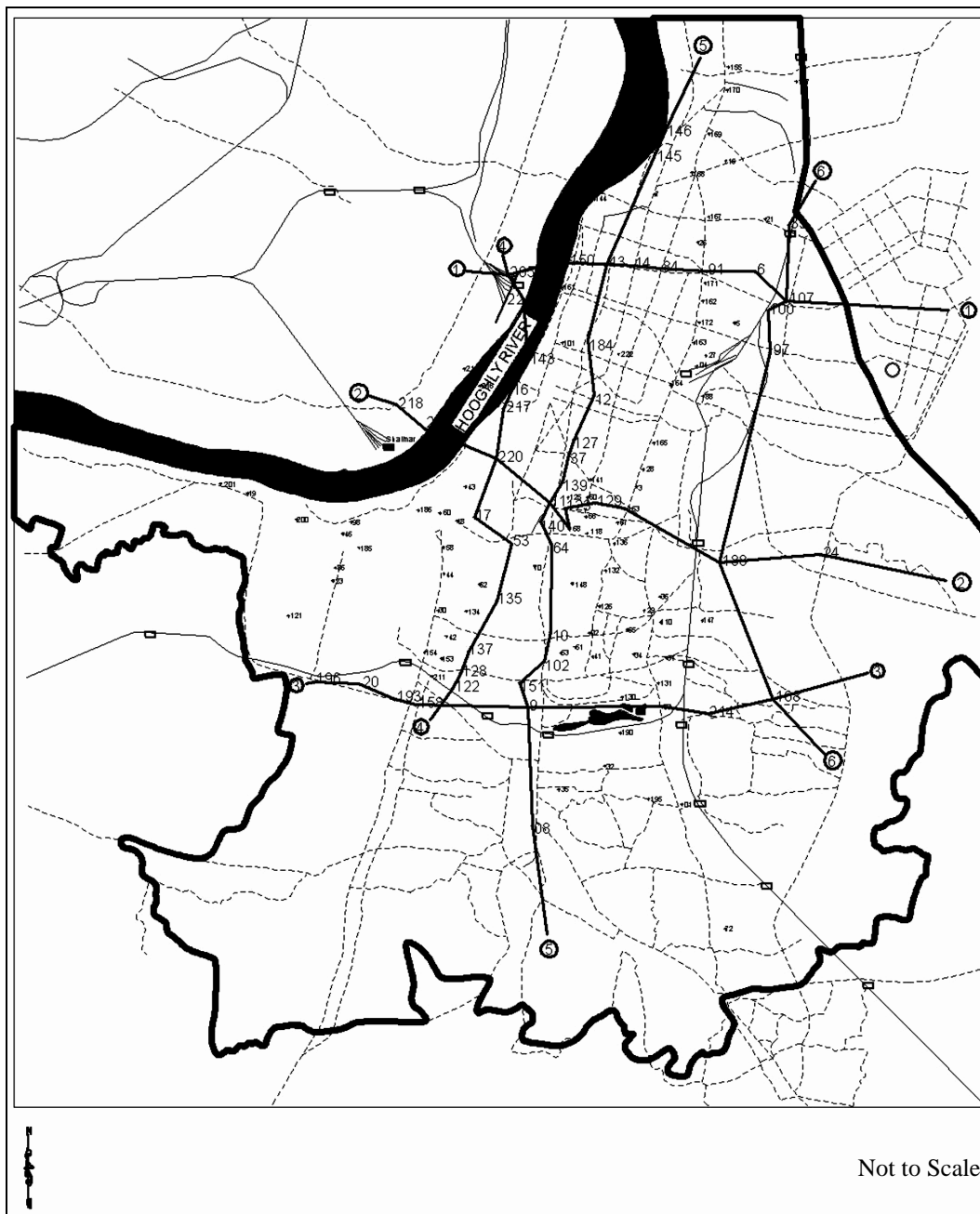


Fig. 1: Bore Hole Location under Kolkata Municipal Corporation

Since KMC area has been developed geologically by deposition of sediments carried by big river system, the soil below the ground is basically erratic in nature. Geomorphologically the area can be divided into fluvial plain, tidal flat, natural levee and aggravated channels (Nandi 2007). It has been observed that the characteristics of the soils in different layers up to a depth of 30m are very important in modifying the earthquake shaking and liquefaction potential (Nath 2006).

Some of the sub-soil informations have been published to reveal the soil profile along a particular vertical section through the KMC area in North-South direction. For construction of Kolkata Metro soil exploration were made along the metro alignment 16.6 Km from Dumdum to Tollygunge indicated very erratic deposition in terms of materials, thickness of layer and bedding planes (Som 1998). Standard Penetration Test conducted in exploratory boreholes at different locations in KMC area reveals that top soil up to a depth of 12–13 M in very much unconsolidated, where N-value varies from 0–3, thereafter N-value increases from 16 to 18 and the plane

at this depth has been identified as a boundary layer between Holocene and Pleistocene deposition (Chatterjee 1964).

3.1 Soil Mapping Over the KMC Area

In view of the erraticness of the subsoil deposition, a detail study was conducted for soil mapping over the whole KMC area. For this purpose the soil exploration data over a depth of 30M below GL conducted over the KMC area by different agencies were gathered and analyzed for generating the soil profiles along various sections in N-S and E-W direction as shown in Figure 1. Large number of borehole data were utilized and locations of these boreholes are also shown in Figure 1. Three typical Sections 1–1, 2–2 and 3–3 were chosen in E-W direction while another three typical sections 4–4, 5–5 and 6–6 were chosen in N-S direction.

The sectional profiles generated along these sections are shown in Figure 2. From the Figure 2 it is seen that the subsoil profiles both in N-S or E-W direction indicates very large erraticness both in horizontal and vertical direction.

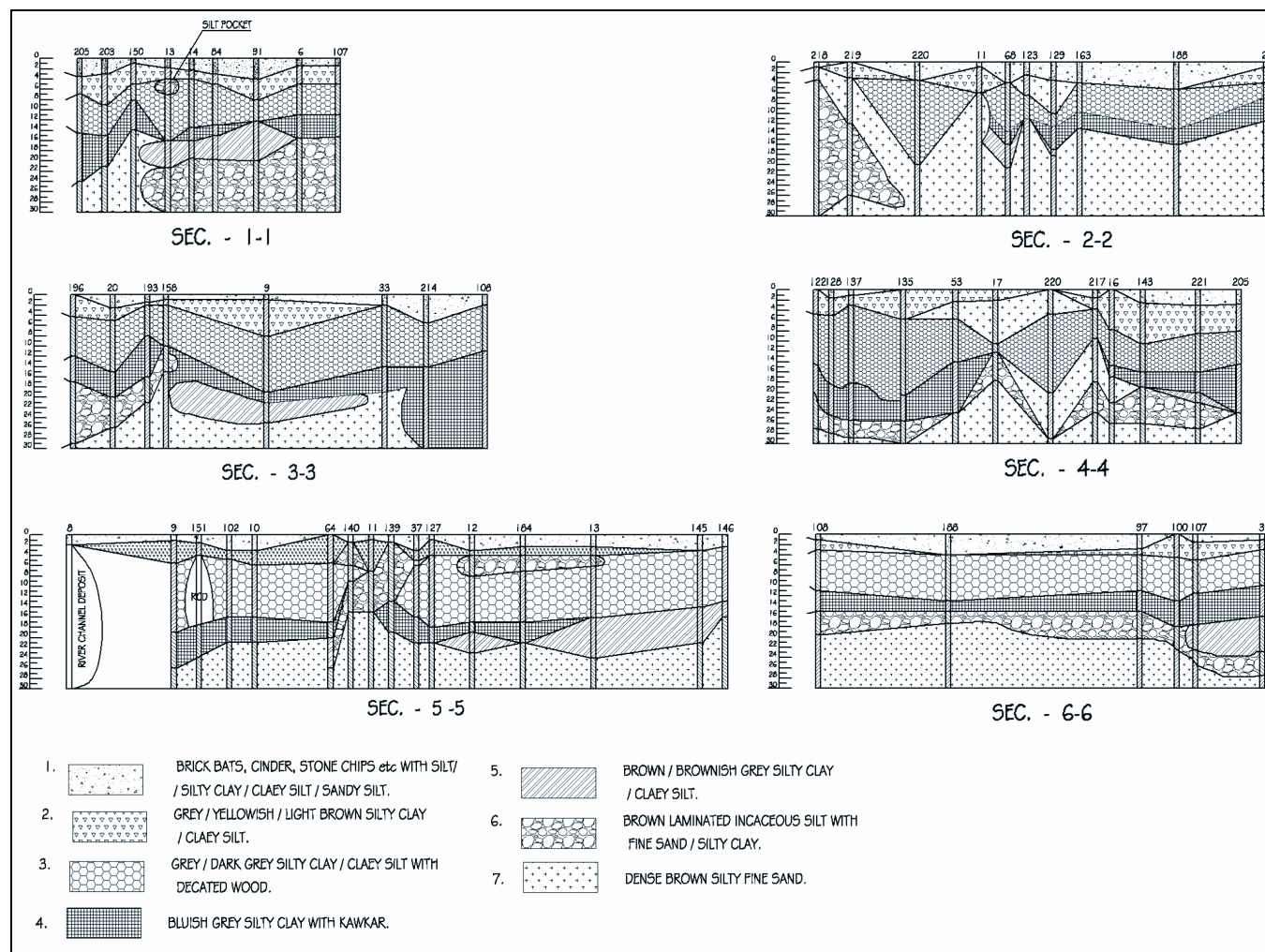


Fig. 2: Soil Profiles in N-S & E-W Direction

A fill layer of varying thickness is observed at the top and its thickness naturally increases to a maximum value of 4m probably due to developing land of low-lying areas. However below this layer a thin layer of light brown silty clay layer exists with varying thickness and extends over all these sections. Below this layer a very weak layer of blackish grey silty clay/clayey silt with decayed wood exists over a consolidated thickness of 8 to 10 m over most of the location.

However the thickness and extent of the layer is also widely varying over different sections. This layer indicates a very low strength indicated by a very low N-value in the range of 0–3. Below this layer bluish grey silty clay exists in most of the section with typical variation in their thickness and extent. Below the above layer, a layer of brown laminated silt with fine sand and dense brown silty fine sand exists in all boreholes over the sections indicating again typical variation in their thickness and extent.

4. CONCLUSION

On the basis of the study made for subsoil condition below KMC area over a depth of 30 M for the existing GL, the following conclusions can be made:

1. Three major soil profiles in N-S direction through western middle and eastern part of the city have been developed. Similarly three major E-W direction soil profiles of the city have been developed for a depth of 30 M, through northern, middle and southern part of the city.

2. The developed soil profile indicates large variation in the soil layers particularly the thickness of the layers varies quite arbitrarily indicating typical alluvial deposition.

REFERENCES

- Bannerjee, M. and Sen, P.K. (1987). "Palaeobiology in Understanding the Change of Sea Level and Coast Line in Bengal Basin during Holocene Period", *Indian Journal of Earth Sciences*, Vol. 14, Nos. 3–4, pp. 307–320.
- Chatterjee, G.C. (1964). "Geology and Ground Water Resources of the Greater Calcutta Industrial Area", West Bengal, *Indian Journal of Geology*, Vol. 69, No. 2 pp. 177–209, Vol. 46, No. 21, pp. 1–149.
- Kramer, S.L. (1996). "Geotechnical Earthquake Engineering", Prentice Hall International Series.
- Nandi, D.R. (1994). "Earthquake Hazard Potential of Central and South Bengal Basin", *Indian Journal of Earth Sciences*, Vol. 21, No. 2, pp. 59–68.
- Nandi, D.R. (2007). "Need for Seismic Microzonation of Kolkata Mega City", Published in the *Proceedings of Workshop on Microzonation by IISC*, Bangalore.
- Roy, S.K. and Chattopadhyay, G.S. (1997). "Quaternary Geology of the Environs of Ganga Delta West Bengal and Bihar", *Indian Journal of Geology*, Vol. 69, No. 2, pp. 177–209.
- Som, N.N. (1998). "Braced Excavation in Soft Clay-Experiences of Calcutta Metro Construction, 21st IGS Annual Lecture", *Indian Geotechnical Journal*, 29(1), 1999.