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Project: Proposed One - Storied Upasona Room at Biswarjan Ghat, New Town, Kolkata

1. Introduction

Soil exploration, investigation and testing of soil samples for Proposed One-Storied Upasona Room at Biswarjan Ghat, New Town, Kolkata was entrusted to M/s Bose Engineers, at 74/J/1, Sultan Alam Road, Kolkata-700033. The objective was to ascertain the subsoil characteristics and stratification and propose suitable load carrying capacity of the soil and facilitate design of the foundation for the proposed structure. The field work involved in the investigation including boring, recovery of samples and in-situ tests were carried on 25th to 26th November, 2014.

The scope of the work comprised of sinking four boreholes. It included advancing the boreholes by wash and auger equipment. The boreholes were of 150 mm in diameter. The scope also included conducting standard penetration tests (SPT), collecting disturbed samples at regular intervals for identification and logging purposes, collecting undisturbed tube samples at suitable intervals or at change of strata whichever is earlier and testing these in the laboratory.

Based on the above, this report presents the subsoil profile and laboratory and field test results. On the basis of field tests and laboratory test results and their analysis thereof, the most suitable type of foundation with it's safe bearing capacity is suggested. The field profile was sometimes modified in the light of laboratory test results.

2. Field Exploration

Geotechnical Investigation was envisaged in an attempt for optimisation in the design of foundation for the proposed structures to be constructed at this site. The entire Investigation programme had been divided mainly into two parts, I) Field works & II) Laboratory tests.

I) Field works unfold the sub-surface deposit types and their characteristics

II) Laboratory tests part would help determining the relevant physical and geotechnical properties of the sub-surface deposits leading to finalisation of foundation depths of

the structures and the bearing capacity with particular reference to the sub-surface types and their strength parameters and settlement potentials at the site.

A list of the boreholes with the terminating depth and standing water level are presented in a tabular form below:

Bore Hole No.	Terminating Depth (m)	Standing Water Table (m)	Date of commencement	Date of completion
01	25.10	-3.50	25.11.14	25.11.14
02	25.10	-4.00	26.11.14	26.11.14
03	20.10	-4.30	25.11.14	25.11.14
04	20.10	-3.70	26.11.14	26.11.14

The locations of boreholes are shown in Figure 1.

2.1 Boring

Boring was carried out by wash and auger method to sink nominal 150 mm diameter boreholes to desired depths and operated by a team of experienced technicians. Flush jointed seamless casings were used to stabilize the boreholes and prevent caving of the soil inside the boreholes. The casing pipes were advanced by turning in order to minimize the disturbance. Undisturbed soil samples were collected at suitable intervals or at change of strata whichever is met earlier by open drive sampling method since it was intended to ascertain the subsoil characteristics. The standing water table in each borehole was determined at least 24 hours after the termination of boring work.

2.2 Sampling

Nominal 100 mm diameter undisturbed samples were recovered. The sampling equipment used consists of a two-tier assembly of sample tubes 400 mm in length fitted at its lower end. The sampling assembly was driven by means of a jarring link to its full length or as far down as was found practicable. After withdrawal the ends of the tubes were sealed with wax at both ends and capped before transmission to the laboratory. At close intervals in depth, disturbed samples were collected both from

split spoon sampler after the standard penetration test and from cutting edge for identification and logging purpose. These were tagged and packed in polythene packets and transported to the laboratory. The depthwise locations of all the undisturbed and disturbed samples were used in the preparation of borehole log data and for general identification and classification purposes. The details of boring are presented in the Appendix in the form of bore log sheets.

2.3 Standard Penetration Test

Standard Penetration Tests were conducted in the boreholes at suitable intervals as per IS: 2131-1963 using a split spoon sampler. The split spoon sampler used is of a standard design having an outer diameter of 50.8 mm and inner diameter of 35 mm, driving with a monkey weighing 63.5 kgs, falling freely from a height of 75 cm. A record of the number of blows required to penetrate every 15 cm to a maximum depth of 45 cm was made. The first 15 cm of drive was considered to be seating drive and was neglected. The total blows required to effect each 15 cm of penetration was recorded. The "N" values were obtained by counting the number of blows required to drive the spoon from 15 cm to 45 cm. On completion of a test, the split spoon sampler was opened and soil specimens were preserved in polythene bags for logging purpose.

All the boreholes were sunk with winch. However, raising of hammer for SPT was done manually. Hence there will not be any inertia loss and the efficiency of hammer blows should be considered as 100%.

2.4 Measurement of Water Table

Level of water was noted when struck in. This is termed as observed water level. Standing water level after 24 hours of removal of casing was also noted and shown in the profile.

3. Laboratory Testing

For proper identification and classification of the sub-soil deposits and for deriving adequate information regarding its relevant physical and geotechnical properties at the site under investigation, the soil samples from the 10 cm diameter sampling tubes were extracted in the laboratory by pushing out the core by using the extractor frame. The core was jacked out in a direction that corresponded with the soil movement within the tube during sampling. In general, the following laboratory tests were conducted on the soil samples collected from the exploratory bore holes:

a) Grain size distribution (Sieve as well as Hydrometer).
b) Determination of Atterberg Limits.
c) Determination of Natural Moisture Content.
d) Determination of Specific Gravity.
e) Determination of Bulk & Dry Unit Weight.
f) Strength determination by Triaxial Unconsolidated Undrained Test (UU).
g) Strength Determination of Unconfined Compression Test on (UC)
h) One-dimensional Consolidation Test for determining settlement potentiality.

The triaxial tests/unconfined compression test 38 mm diameter x 76 mm long specimens were obtained by jacking out the soil core into thin-walled brass tubes. The inside of the tubs was coated with a thin layer of silicon oil. Self-explanatory test results are presented in the Appendix.

To obtain specimens for consolidation test the odeometer ring was placed on the trimmed horizontal face of the soil within the 10 cm sampling tube and the soil around the cutting edge was gradually removed with a spatula as the ring was gently pushed into the soil. The ring with the soil was then removed by cutting across the soil core with the help of a piano wire saw.

The laboratory tests were done to ascertain the engineering properties of the subsoil and to obtain the necessary data required to design the foundation. These are detailed below. Summary of all the test results are given in a tabular form in Table -1.

3.1 Atterberg Limits and Natural Water Content

Liquid limit, plastic limit and natural water content of the silty clay/clayey silt samples were determined (a) to classify the soil by the IS classification system and (b) to qualitatively assess their consistency and compressibility.

3.2 Bulk density

These were determined by measuring the weight and dimension of triaxial/unconfined compression test samples.

3.3 Undrained Triaxial Test/ Unconfined Compression Test

These were run on the clay/ clayey silt samples to determine their shear strength. The cell pressures employed in triaxial tests were 0.5, 1.0 and 2.0 kg/cm^2. The samples were tested under quick condition at the rate of 1.25 mm/min and were loaded upto a maximum of 20% of axial strain.

3.4 Grain Size Analysis

The grain-size distribution of a quantity of representative samples were determined from sieve analysis/combined sieve analysis and hydrometer analysis. The results are plotted in the Appendix.

3.5 Consolidation Test

Consolidation tests were run in floating ring type odeometers, in an eight unit consolidation frame under standard load increment ratio of one, starting from ¼ kg/cm^2 and going upto 8 kg/cm^2. The e vs. $\log_{10}$p curves are given in the Appendix.

4. Soil Profile and Properties

Based on visual classification and results of field and laboratory tests on the samples recovered the proposed site may be divided into the following major soil strata as described below:

Layer Details				*Average Field N-Value*	*Bulk Density (t/m3)*	*Liquid Limit (%)*	*Plasticity Index (%)*	*Shear strength Parameters*
Stratum No.	*Description*	*Depth below EGL (m)*						
		From	*To*					
I	Filled up by soil, roots etc.	0.00	1.10/1.30	-	-	-	-	-
II	Soft to stiff greyish silty clay with brown spot	1.10/1.30	3.80/4.00	3 to 15	1.84	48	24	C=2.9 t/m^2, ϕ =0 deg
III	Soft to firm grey to dark grey silty clay with decomposed wood.	3.80/4.00	15.80/16.00	2 to 5	1.68	56	28	C=1.7 t/m^2, ϕ =0 deg
IV	Firm to stiff bluish grey silty clay with calcareous nodules.	15.80/16.00	18.80/19.00	7 to 10	1.87*	45	23	C= 4.2* t/m^2, ϕ =0 deg
V	Dense bluish grey to brownish grey silty fine to medium sand with mica.	18.80/19.00	25.10	31 to 50	1.90*	Non-Plastic		C=0 t/m^2, ϕ =30* deg

* Suggested

A profile through the boreholes and the distribution of Field N-value with depth are shown in Figure 2 and Figure 3 respectively.

5. Hydrogeology

The ground water table at the site was found to exist at 3.5m to 4.30m below the ground level for the boreholes explored during the time of investigation work.

6. Calculations

6.1 Shallow Foundation

Bearing Capacity

For a shallow foundation resting on cohesive deposit, the following bearing capacity relations may be used as specified by IS: 6403-1981.

The net ultimate baring capacity –

$$q_{\text{net ultimate}} = C_u .N_c .S_c .d_c .i_c + q.(N_q-1). S_q .d_q .i_q + 0.5.B.\gamma. N_\gamma .S_\gamma .d_\gamma .i_\gamma.W'$$

The net safe bearing capacity is calculated as

$$q_{\text{net safe}} = q_{\text{net ultimate}}/\text{FOS}$$

where, C_u = undrained cohesion of the soil

N_c, N_q, N_γ = bearing capacity factors

S_c, S_q, S_γ = shape factor

d_c, d_q, d_γ = depth factor

i_c, i_q, i_γ = inclination factor

q = effective surcharge at the base level of the foundation

W' = correction factor for water table location

B = least width of the foundation

γ = bulk unit weight of foundation soil

FOS = factor of safety

Settlement

The foundation settlement occurs for cohesive layers of soil which are stressed due to the superstructure loads. The settlements may be computed using the following relations following Is: 8009(Part-I)-1976.

Immediate settlement $\rho_i = \{q_{net} . B.(1-\nu^2).I_p.\}/E$

Consolidation settlement $\rho_c = \sum m_v .\Delta p . H$

where, q_{net} = net pressure on soil

B = least width of the foundation

E = modulus of elasticity of soil

ν = Poisson's ratio

I_p = Influence factor

m_v = co-efficient of volume compressibility

H = Thickness of compressible layer

Δp = effective overburden pressure at the center of the corresponding layer

7. Discussions on Foundation

The structure for which the subsoil exploration was conducted is a One-Storied Building.

Shallow foundation in the form of isolated footings are recommended for the building in discussion. Such shallow foundation shall be placed at 1.3m below E.G.L.

The net allowable bearing capacity for shallow foundation is given below:

Foundation Type	Foundation size	Depth of foundation	Safe bearing capacity (t/m^2)	Estimated settlement (mm)
Isolated footing	2.0mx2.0m	1.3m below E.G.L.	8.8	46
	2.5mx2.5m		8.6	62
	3.0mx3.0m		8.3	75
	3.5mx3.5m		6.9	75
	4.0mx4.0m		5.9	75

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8. Recommendations

- The subsoil characteristic of site at Biswarjan Ghat New Town, Kolkata for the One-Storied Upasona Building to be constructed was determined from soil exploration with four boreholes.
- Shallow foundation in the form of isolated, footings is recommended for the proposed structure to be placed at 1.3m below EGL. The bearing capacities for such shallow foundations shall be governed by the table given in **section 7.**
- The shallow foundation/s should be adequately connected with grade beams to minimize differential settlement. Construction in stages is also advised.
- The final decision regarding the foundation will depend on the judgment of the engineer concerned.

GEOTECHNICAL CONSULTANT

DR. S.K. BOSE
Ph.D., M.C.E. (SOIL), B.C.E. (HONS.), MIGS, MIRC