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**RECOMMENDATION OF FOUNDATION FOR THE CONSTRUCTION OF EWS
TENEMENTS (G+5 FLOORS) AT GOYYATHOPPE IN CORPORATION DIVISION 63,
ZONE V OF GREATER CHENNAI CORPORATION.**

Job. No. SM&FE 195 / Consultancy / 2021

Date: 23.09.2021

CLIENT:

The Executive Engineer,
Division – IV,
Tamil Nadu Slum Clearance Board,
T.P. Chatram (Opp. K6 Police Station),
Chennai – 600 010.

Reference : The Executive Engineer, TNSCB, Chennai, Lr. No. 561/AE(P)/Dn-IV/2021
Dated 23.06.2021

1. INTRODUCTION

The Tamil Nadu Slum Clearance Board (TNSCB), Division – IV, T.P. Chatram, Chennai – 600 010 has proposed to construct EWS Tenements (G+5 floors) at Slum Tenements at Goyyathoppe in Corporation Division 63, zone V of Greater Chennai Corporation. The officials of TNSCB, Division – IV, T.P. Chatram, Chennai – 600 010 have approached the Head, Division of Soil Mechanics and Foundation Engineering, Department of Civil Engineering, College of Engineering, Guindy (CEG), Anna University, Chennai - 25 to carryout soil investigation in the proposed site and to recommend the most suitable foundation system for the proposed construction of EWS Tenements (G+5 floors) at Slum Tenements at Goyyathoppe in Corporation Division 63, zone V of Greater Chennai Corporation. Accordingly, the work was taken up and field investigation was carried out during 21st August 2021 to 31st August 2021 by M/s VRR Engineering Consultancy, Chennai under the supervision of Faculty members of Division of Soil Mechanics and Foundation Engineering, Department of Civil Engineering, Anna

University, Chennai, Executive Engineer, Asst. Executive Engineer and Assistant Engineer of TNSCB, Division – IV, T.P. Chatram, Chennai – 600 010. This report comprises the details of soil investigation, analysis of field and laboratory test results on soil and recommendation of suitable foundation system.

2. SITE CONDITION AND EXPERIMENTAL PROGRAMME

The proposed site is located at Goyyathoppe in Corporation Division 63, zone V of Greater Chennai Corporation. The site is a plain terrain. The total number of borehole locations has been decided as '4', as agreed by the Officials of Executive Engineer of TNSCB, Division – IV, T.P. Chatram, Chennai and the Professor cum Project Co-ordinator, Division of Soil Mechanics and Foundation Engineering, Department of Civil Engineering, Anna University, Chennai, such that these locations are coming well within the proposed construction area. The nature of field tests includes standard penetration tests, disturbed soil sampling through split spoon sampler, identification of different soil layers, retrieving of rock core samples, location of ground water table, complete logging of the borehole etc,. Laboratory investigation consists of classification tests such as grain size distribution, Atterberg limits, specific gravity and free swell index of soil samples.

The boreholes were advanced from the existing ground level using rotary boring technique supplemented by bentonite mud circulation. Mud circulation was used to stabilize the sides and bottom of the boreholes and then to bring the soil cuts to the surface. Bentonite slurry would also help to minimize the disturbance of the soil at the bottom of the borehole while drilling operation is in progress. In general, rotary boring technique with bentonite mud circulation is found most suitable to make exploratory boreholes of diameter 150 mm (IS 1892 : 1979). During boring operation, borehole was always kept full with the drilling mud so as to prevent any disturbance to the soil within the test zone (Plate 1 of Annexure – 1).

Standard penetration tests were conducted at every 1.0 m interval up to 6.0 m depth and thereafter 1.5 m interval in all the borehole locations. These SPT tests were carried out using Winch and Auto-trip free fall device for which the expected energy level is approximately 60% to 70%. The 'N' value resulting from this procedure may be considered as N_{60} . Disturbed soil samples collected through the split spoon sampler were preserved and transported to the soil testing laboratory for detailed identification

tests. During the progress of soil investigation at the proposed site, the site was monitored by the Professor of Division of Soil Mechanics and Foundation Engineering, Department of Civil Engineering, CEG Campus, Anna University, Chennai – 25.

All field and laboratory tests were conducted as per the Indian Standard Testing procedure (SP 36 Part I: 1987 & Part II: 1988). All the field test results recorded in the bore logs are illustrated in figures A-1 to A-4. The field 'N' values at different depths and samples collected at these depths are mentioned in the bore logs. Laboratory test results (index and engineering properties) of soil samples collected through split spoon sampler are summarized in table A-1 to table A-4 of this report.

3. REVIEW OF FIELD AND LABORATORY TEST RESULTS OF SOIL PROFILE

Figures 1 show the variation of SPT 'N' value of different soil layers with respect to depth in BH 1 to BH 4 of the proposed site. It could be seen from figure 1 that the variations of SPT 'N' values are almost uniform in all the four bore holes, indicating the homogeneity of soil layer (Plate 2 of Annexure – 2).

3.1 Summary of Soil Profile in BH 1 and BH 2 Locations

1. Brown Silty Sand was found from top 1.0 m depth to 9.0 m depth in all four bore-hole locations with SPT 'N' value varying from 9 to 12.
2. Silty Clay was encountered from 12.0 m to 13.5 m depth in BH 1, 3.0 m to 4.0 m depth in BH 2 location and from 10.5 m to 12.0 m depth in BH 2, BH 3 and BH 4 locations with SPT 'N' value varying from 3 to 17.
3. Greyish Brown weathered sediment layer was observed in 19.0 m depth in BH 1 location, 19.37 m depth in BH 2 location, 16.6 m depth in BH 3 location and in 18.0 m to 18.6 m depth in BH 4 location with SPT 'N' values of >100.
4. Brownish Grey Weathered Gneiss Rock layer are found from 23.5 m to 25.0 m in BH 1 location, from 20.87 m to 23.87 m depth in BH 2 location, from 18.1 m to 21.1 m depth in BH 3 location and from 19.5 m to 22.5 m depth in BH 4 location.
5. The ground water table was observed from 3.5 m to 4.1 m depth at the time of In-situ Soil Investigation work.

Thus, it is evident that the soil profile is homogeneous with reference to relative density / consistency in the proposed site as reflected from BH 1 to BH 4 locations (Figure 1).

4.0 SHEAR STRENGTH PROPERTIES AND ELASTICITY MODULUS VALUES ' E_s ' OF SOIL SAMPLES .

The Geotechnical design parameters required to determine the bearing capacity and settlement of foundation system are arrived by analyzing the Field Bore-Log profile and Laboratory test results and listed in table - 1 to table - 4. The ' E_s ' values are computed based on Bowles 1997 correlation.

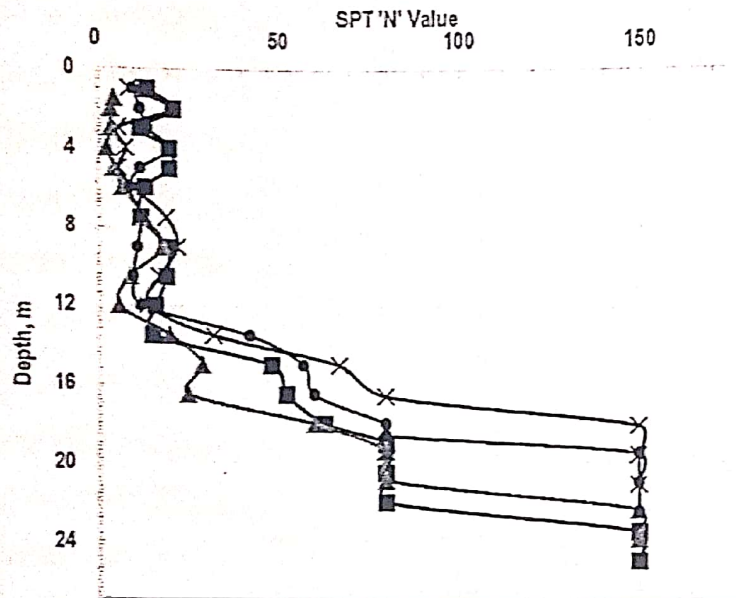


Figure (1) Variation of SPT 'N' value of different soil layers with respect to depth in Different Borehole Locations of the Site

5.0 COMPUTATION OF SAFE PILE CARRYING CAPACITY

The top 6.0 m depth layer is loose / soft silty sand / clayey sand of SPT ' N ' values of 3 to 10, especially in BH 2 and BH 3 locations. These layers are having low shear strength properties (table A-2 and table A-3). Provision of either footings or Raft foundation may not be feasible at shallow depth range of 3.0 m to 4.0 m depth for the construction of G+5 floors at Slum Tenements at Goyyathoppe. Hence attempts are made to suggest pile foundation for varying pile diameter. For computing the load carrying capacity of pile, Indian Standard IS 2911 (Part 1/Sec. 2) 2010 method and Meyerhof 1959 formula (Based on SPT ' N ' Value) are used. The diameters of piles are assumed as 450 mm, 500 mm, 600 mm, 700 mm and 900 mm and the length of the pile is taken as 20.0 m to 23.0 m. Safe pile carrying capacity computations were made

for all four-borehole data. The Indian Standard IS 2911 (2010) specifies that the base resistance should not exceed 1000 to 1100 t/m² for bored cast-in-situ piles and 1500 t/m² for precast driven piles.

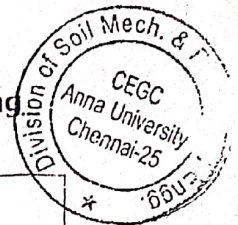
For calculating the skin friction along the pile length of 20.0 m to 23.0 m, the design 'N' values and shear strength parameters for the respective depths were used. The soil layers in top 3 m depth may induce settlement of surrounding soil while pile driving which in turn may cause negative skin friction. Hence, the safe frictional resistance is computed by neglecting these layer's frictional capacity and the negative skin friction value was suitably deducted in the computation of safe bearing capacity of piles. The safe end bearing resistance and safe skin frictional resistance are together added for different pile diameter and the total safe load carrying capacity of pile thus computed is shown in Table 1. The calculations of pile carrying capacity by static formula (IS 2911: 2010) and Meyerhof formula (1959) are presented in Annexure 2. The factor of safety of 2.5 has been used for determining safe end bearing and also frictional capacity of bored cast-in-situ piles.

The uplift capacity of a pile is given by sum of the frictional resistance and the weight of the pile (buoyant or total as relevant) as per Section 6.3.2 of IS 2911 (Part 1/Sec. 2) 2010. As per codal provisions, the recommended factor of safety is 3.0 in the absence of any pull-out test results and 2.0 with pullout test results. Uplift capacity can be obtained from static formula by ignoring end-bearing, but adding weight of the pile (buoyant or total as relevant). The safe uplift capacities of pile for varying diameter are given in Table 2.

TABLE 1 Safe Load carrying capacity of Bored Cast-In-Situ Pile of 20.0 to 23.0 m Length for varying Diameter

Borehole Location Diameter of Pile (mm)	Pile capacity for Bored Cast-In-Situ Piles, (kN) IS 2911 Part-I 2010 Static Formula									
	Based on Shear Strength Parameters ('c' and 'Φ')					Based on SPT 'N' Values				
	450	500	600	700	900	450	500	600	700	900
BH 1	1276	1497	1984	2535	3825	1161	1369	1831	2356	3595
BH 2	1128	1331	1786	2304	3527	1065	1262	1703	2207	3403
BH 3	1132	1336	1792	2310	3536	1036	1230	1664	2162	3345
BH 4	1142	1347	1805	2326	3556	1076	1274	1718	2224	3425

TABLE 8 Safe Uplift Capacity of 20.0 to 23.0 m Length Pile for varying Diameter (IS 2911 (Part 1/Sec. 2) 2010)



Borehole Location	Safe Uplift Capacity (kN) IS 2911 (Part 1/Sec. 2) 2010				
Diameter of Pile (mm)	450	500	600	700	900
BH 1	618	698	865	1041	1420
BH 2	487	551	686	830	1141
BH 3	487	551	685	827	1133
BH 4	495	560	696	839	1150

6. CONCLUSIONS AND RECOMMENDATIONS

Based on the discussions made in sections 3, 4, 5 and 6, the following recommendations are furnished for the construction of EWS Tenements (G+5 floors) at Slum Tenements at Goyyathoppe in Corporation Division 63, zone V of Greater Chennai Corporation.

- 1) The recommended type of pile foundation is **"Bored Cast-In-Situ Pile"**
- 2) The recommended safe vertical and lateral pile carrying capacity of the 20.0 m to 23.0 m length of 'bored cast in-situ pile' for varying diameter is shown in Table 3. The required number of piles may be varied with respect to the varying column loads.
- 3) The bored cast in-situ pile shall be terminated at 20.0 m to 23.0 m in Brownish Grey Weathered Gneiss Stratum.
- 4) With regard to execution of bored cast-in-situ pile, procedure outlined in IS 2911 Part 1 Section 2: 2010 may be referred and scrupulously followed.
- 5) Pile load test shall be conducted to ensure the designed pile carrying capacity. The minimum grade of concrete for pile foundation shall be M 30 to M 40.



TABLE 8 Safe Load carrying capacity and Lateral Load Capacity of Bored Cast-In-Situ Pile for varying diameter and for a length of 20.0 to 23.0 m from the existing ground level (Borehole level)

Diameter of Pile (mm)	Recommended Safe Load carrying capacity of Bored Cast-In-Situ Piles, (kN)	Recommended Lateral Load Capacity for 5 mm deflection, (kN)	Depth of fixity from bore-hole level (m)
450	1000	43.40	4.24
500	1200	51.50	4.61
600	1600	69.00	5.33
700	2000	88.30	6.03
900	3200	131.70	7.38

M. Mutharam 23/9/2021

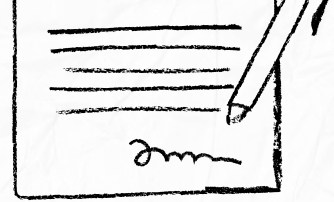
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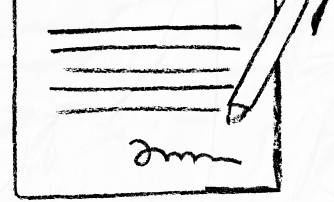
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