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DIVISION OF SOIL MECHANICS AND FOUNDATION ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING
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SOIL INVESTIGATION REPORT

NAME OF WORK : **RECOMMENDATION OF FOUNDATION FOR THE RECONSTRUCTION OF DILAPIDATED SLUM TENEMENTS (G+5 FLOORS) AT COX COLONY TENEMENTAL SCHEME IN CORPORATION DIVISION 63, ZONE V OF GREATER CHENNAI CORPORATION.**

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

JOB No : SM&FE 207 / Consultancy / 2021

DATE : 17th November 2021



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**RECOMMENDATION OF FOUNDATION FOR THE RECONSTRUCTION OF DILAPIDATED
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1. INTRODUCTION

The Tamil Nadu Slum Clearance Board (TNSCB), Division – IV, T.P. Chatram, Chennai – 600 010 has proposed to reconstruct dilapidated Slum Tenements (G+5 Floors) at Cox Colony 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 carry out soil investigation in the proposed site and to recommend the most suitable foundation system for the reconstruction of dilapidated Slum Tenements (G+5 Floors) at Cox Colony in Corporation Division 63, zone V of Greater Chennai Corporation. Accordingly, the work was taken up and field investigation was carried out during 24th October 2021 to 2nd November 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 Cox Colony 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 '3', 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-3. 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-3 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 3 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, BH 2 and BH 3 Locations

1. Brown Silty Sand was found from top 1.0 m depth to 7.5 m depth in all three bore-hole locations with SPT 'N' value varying from 2 to 23.
2. Silty Clay was encountered at 9.0 m depth in BH 2 and BH 3 locations with SPT 'N' value varying from 4 to 10.
3. Greyish Brown Silty / Clayey Sand was observed from 13.5 m to 15.0 m depth in BH 1 location, from 10.5 m to 16.5 m in BH 2 location and from 12.0 m to 16.5 m in BH 3 location with SPT 'N' value varying from 11 to 35.
4. Greyish Brown weathered sediment layer was observed at 18.0 m to 23.0 m depth in BH 1 location with SPT 'N' values of >100.
5. Brownish Grey Weathered Gneiss Rock layer was found from 23.0 m to 28.5 m in BH 1 location, from 21.0 m to 25.5 m depth in BH 2 location and from 19.5 m to 24.0 m depth in BH 3 location.
6. The ground water table was observed from 2.15 m to 2.5 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 3 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 - 3. The ' E_s ' values are computed based on Bowles 1997 correlation.

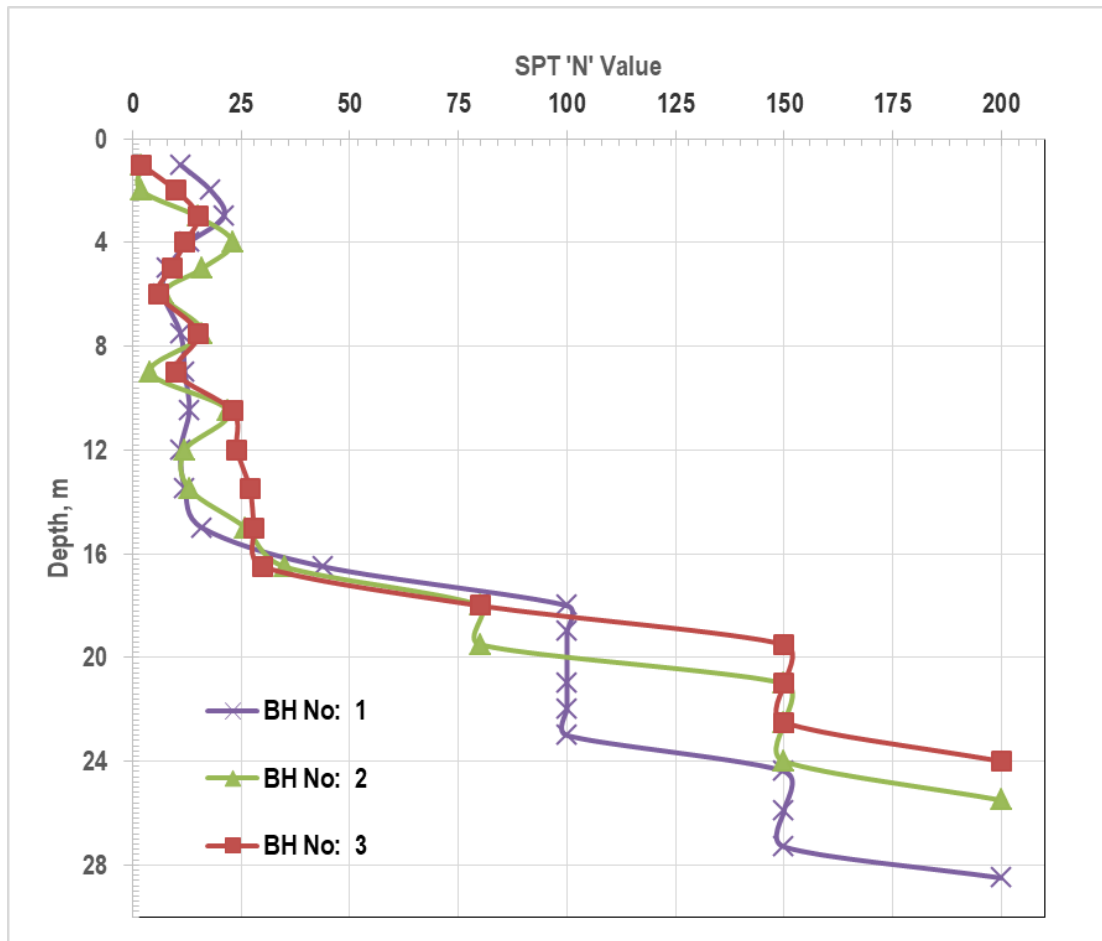


Figure (1) Variation of SPT 'N' value of different soil layers with respect to depth in Different Borehole Locations of the Site

5.0 COMPUTATION OF SAFE PILE CARRYING CAPACITY

The top 6.0 m to 9.0 m depth layer is loose / Medium Dense Silty sand / Clayey Sand of SPT ' N ' values of 3 to 23, 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 feasible at shallow depth range of 3.0 m to 4.0 m depth for the construction of G+5 floors Slum Tenements at Cox Colony. 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 23.0 m to 25.0 m. Safe pile carrying capacity computations were made for all three-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 23.0 m to 25.0 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 23.0 to 25.0 m Length for varying Diameter

Borehole Location	Pile capacity for Bored Cast-In-Situ Piles, (kN) IS 2911 Part-I 2010 Static Formula									
Diameter of Pile (mm)	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	1317	1542	2039	2599	3907	1112	1314	1766	2280	3497
BH 2	1219	1433	1908	2446	3710	1136	1340	1797	2316	3544
BH 3	1202	1414	1885	2419	3676	1106	1307	1757	2269	3483

TABLE 2 Safe Uplift Capacity of 23.0 to 25.0 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	660	746	925	1113	1520
BH 2	575	650	808	974	1333
BH 3	560	634	787	950	1303

6. CONCLUSIONS AND RECOMMENDATIONS

Based on the discussions made in sections 3, 4, and 5 the following recommendations are furnished for the reconstruction of dilapidated Slum Tenements (G+5 Floors) at Cox Colony 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 23.0 m to 25.0 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 23.0 m to 25.0 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 3 Safe Load carrying capacity and Lateral Load Capacity of Bored Cast-In-Situ Pile for varying diameter and for a length of 23.0 to 25.0 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	48.30	4.09
500	1300	57.60	4.44
600	1700	77.00	5.14
700	2100	98.20	5.82
900	3400	147.20	7.11

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REFERENCES

- [1] SP 36 Part I: 1987, "Laboratory Testing on Soil for Civil Engineering Purpose", Compendium on Indian Standards on Soil Engineering, Bureau of Indian Standards.
- [2] SP 36 Part II: 1988, "Field Testing of Soils for Civil Engineering Purpose", Compendium on Indian Standards on Soil Engineering, Bureau of Indian Standards.
- [3] IS 8764-1998 "Method for Determination of Point Load Strength Index of Rocks"
- [4] IS 2911, Part 1 (2010), "Code of Practice for Design and Construction of Pile Foundations", Bureau of Indian Standards.
- [5] Varghese P.C., Foundation Engineering, Prentice – Hall of India Private Limited, New Delhi, 2005.
- [6] Bowles, J. (1997). Foundation Analysis and Design. 5th Ed., The McGraw-Hill Companies, Inc., New York, 308.
- [7] Cole, K.M. and Stroud, M.A. (1977), Rock Socket Piles at Coventry Point – Piles in Weak Rocks, Proc. Inst. of Civil Engineers, London.
- [8] Karl Terzaghi, Ralph B. Peck and Gholamrezra Mesri (1996), "Soil Mechanics in Engineering Practice", 3rd Edition, A Wiley Interscience Publication, John Wiley & Sons, Inc, New York.
- [9] IS 1904 - 1986 (Reaffirmed 1995), "Code of Practice for Design and Construction of Foundations in Soils: General Requirements", Bureau of Indian Standards.
- [10] IS 12070 – 1987 (Reaffirmed 2010), "Code of Practice for Design and Construction of Shallow Foundations on Rocks", Bureau of Indian Standards.
- [11] IS 4464 – 1985 (Reaffirmed 2004), "Code of Practice for Presentation of Drilling Information and Core Description in Foundation Investigation", Bureau of Indian Standards.
- [12] Varghese P.C., Foundation Engineering, Prentice – Hall of India Private Limited, New Delhi, 2005.
- [13] Richard E. Goodman (1989), "Introduction to Rock Mechanics", John Wiley & Sons, New York.
- [14] IS 16700:2017, "Code of Practice for Criteria for Structural Safety of Tall Concrete Buildings", Bureau of Indian Standards.

Annexure - A-1
Field Borelog Profile

FIELD BORE LOG PROFILE

Project : Reconstruction of Dilapidated Slum Tenements (G+5 Floors) at Cox Colony Tenemental Scheme in Corporation Division 63, Zone V of Greater Chennai Corporation.

BH NO		BH 1		DATE OF START				24-10-2021
SITE		Cox Colony		DATE OF COMPLETION				27-10-2021
DIA OF BORING		100 / 150 mm		GROUND WATER LEVEL (m)				2.25
TYPE OF BORING		Rotary - Auto Trip SPT		RL with respect to Bed Level (m)				-
Depth below EGL(m)	Soil / Rock Profile	Description / Classification of Soil and Rock / Weathering Grade of Rock as per IS 4464	Standard Penetration Test (SPT) / UDS / Core Drilling				Relative Density or Consistency of Soil / Strength of Rock	
			15	30	45	N		
1.0		Brown Silty Sand (SM-SP)	3	4	7	11	Medium Dense	
2.0		Brown Silty Sand (SM-SP)	7	9	9	18	Medium Dense	
3.0		Brown Silty Sand (SM-SP)	8	10	11	21	Medium Dense	
4.0		Brown Silty Sand (SM-SP)	7	6	7	13	Medium Dense	
5.0		Brown Silty Sand (SM-SP)	4	5	3	8	Loose	
6.0		Greyish Brown Sand (SP)	3	3	4	7	Loose	
7.5		Greyish Brown Silty Sand (SM-SP)	4	5	6	11	Medium Dense	
9.0		Greyish Silty / Clayey Sand (SC)	5	4	8	12	Medium Dense	
10.5		Greyish Silty Sand (SM-SP)	4	5	8	13	Medium Dense	
12.0		Brownish Grey Silty Sand (SM-SP)	6	4	7	11	Medium Dense	
13.5		Brownish Grey Silty / Clayey Sand (SC)	5	5	7	12	Medium Dense	
15.0		Greyish Silty / Clayey Sand (SC)	3	7	9	16	Medium Dense	
16.5		Greyish Brown Silty Sand (SM-SP)	9	19	25	44	Dense	
18.0		Brown Weathered Sediments (Grade VI)	55 _(0 cm) Rebound				>100	Hard / Very Weak
19.0		Brown Weathered Sediments (Grade VI)	55 _(0 cm) Rebound				>100	Hard / Very Weak
21.0		Brown Weathered Sediments (Grade VI)	50 _(0 cm) Rebound				>100	Hard / Very Weak
22.0		Brown Weathered Sediments (Grade VI)	50 _(0 cm) Rebound				>100	Hard / Very Weak
23.0		Brown Weathered Sediments (Grade VI)	50 _(0 cm) Rebound				>100	Hard / Very Weak
24.39		Greyish Brown Weathered Gneiss (Grade V)	20 _(0 cm) Rebound; TCR=6%; RQD=0%				>100	Weak
25.89		Greyish Brown Weathered Gneiss (Grade V)	20 _(0 cm) Rebound; TCR=20%; RQD=0%				>100	Weak
27.30		Greyish Brown Weathered Gneiss (Grade V)	15 _(0 cm) Rebound; TCR=22%; RQD=0%				>100	Weak
28.50		Greyish Brown Weathered Gneiss (Grade III)	20 _(0 cm) Rebound; TCR=56%; RQD=37%				>100	Moderately Strong
Bore hole has been terminated at 28.5 m from the existing ground level (EGL). Nx Size Core Barrel with Diamond Cutter was used to drill from 23.0 m to 28.5 m depth Rock Stratum.								

Figure A-1

FIELD BORE LOG PROFILE

Project : Reconstruction of Dilapidated Slum Tenements (G+5 Floors) at Cox Colony Tenemental Scheme in Corporation Division 63, Zone V of Greater Chennai Corporation.								
BH NO		BH 2			DATE OF START			29-10-2021
SITE		Cox Colony			DATE OF COMPLETION			31-10-2021
DIA OF BORING		100 / 150 mm			GROUND WATER LEVEL (m)			2.15
TYPE OF BORING		Rotary - Auto Trip SPT			RL with respect to Bed Level (m)			-
Depth below EGL(m)	Soil / Rock Profile	Description / Classification of Soil and Rock / Weathering Grade of Rock as per IS 4464	Standard Penetration Test (SPT) / UDS / Core Drilling				Relative Density or Consistency of Soil / Strength of Rock	
			15	30	45	N		
1.00		Brown Sand (SP)	1	1	1	2	Loose	
2.00		Brown Sand (SP)	1	1	1	2	Loose	
3.00		Greyish Brown Silty Sand (SM-SP)	7	7	8	15	Medium Dense	
4.00		Brown Silty Sand (SM-SP)	9	10	13	23	Medium Dense	
5.00		Brown Sand (SP)	7	8	8	16	Medium Dense	
6.00		Greyish Brown Silty Sand (SM-SP)	2	3	4	7	Loose	
7.50		Brownish Grey Silty Sand (SM-SP)	6	2	14	16	Medium Dense	
9.00		Greyish Silty / Clayey Sand (CH)	3	2	2	4	Soft	
10.50		Brown Silty / Clayey Sand (SC)	7	9	13	22	Medium Dense	
12.00		Brown Silty Sand (SM-SP)	7	7	5	12	Medium Dense	
13.50		Brown Silty / Clayey Sand (SC)	5	7	6	13	Medium Dense	
15.00		Brownish Grey Silty / Clayey Sand (SC)	9	9	17	26	Medium Dense	
16.50		Whitish Grey Silty / Clayey Sand (SC)	10	14	21	35	Dense	
18.00		Brown Silty Sand (SM-SP)	55 _(20 cm) Rebound			>100	Very Dense	
19.50		Brown Silty Sand (SM-SP)	55 _(5 cm) Rebound			>100	Very Dense	
21.00		Greyish Brown Weathered Gneiss (Grade V)	20 _(0 cm) Rebound; TCR=8.6%; RQD=0%			>100	Weak	
22.50		Greyish Brown Weathered Gneiss (Grade V)	20 _(0 cm) Rebound; TCR=20%; RQD=0%			>100	Weak	
24.00		Greyish Brown Weathered Gneiss (Grade V)	15 _(0 cm) Rebound; TCR=23%; RQD=0%			>100	Weak	
25.50		Greyish Brown Weathered Gneiss (Grade IV)	15 _(0 cm) Rebound; TCR=40%; RQD=26.6%			>100	Moderately Weak	
Bore hole has been terminated at 25.50 m from the existing ground level (EGL). Nx Size Core Barrel with Diamond Cutter was used to drill from 19.5 m to 25.5 m depth Rock Stratum.								

Figure A-2

FIELD BORE LOG PROFILE

Project : Reconstruction of Dilapidated Slum Tenements (G+5 Floors) at Cox Colony Tenemental Scheme in Corporation Division 63, Zone V of Greater Chennai Corporation.								
BH NO		BH 3			DATE OF START			01-11-2021
SITE		Cox Colony			DATE OF COMPLETION			02-11-2021
DIA OF BORING		100 / 150 mm			GROUND WATER LEVEL (m)			2.5
TYPE OF BORING		Rotary - Auto Trip SPT			RL with respect to Bed Level (m)			-
Depth below EGL(m)	Soil / Rock Profile	Description / Classification of Soil and Rock / Weathering Grade of Rock as per IS 4464	Standard Penetration Test (SPT) / UDS / Core Drilling				Relative Density or Consistency of Soil / Strength of Rock	
			15	30	45	N		
1.0		Brown Silty Sand (SM-SP)	1	1	1	2	Loose	
2.0		Brown Silty Sand (SM-SP)	2	4	6	10	Loose	
3.0		Brown Silty Sand (SM-SP)	6	8	7	15	Medium Dense	
4.0		Brown Sand (SP)	4	7	5	12	Medium Dense	
5.0		Greyish Silty / Clayey Sand (SC)	1	3	6	9	Loose	
6.0		Greyish Silty / Clayey Sand (SC)	2	3	3	6	Loose	
7.5		Brownish Grey Silty Sand (SM-SP)	2	6	9	15	Medium Dense	
9.0		Greyish Silty / Clayey Sand (CH)	3	5	5	10	Stiff	
10.5		Greyish Brown Silty Sand (SM-SP)	6	10	13	23	Medium Dense	
12.0		Greyish Silty / Clayey Sand (SC)	4	9	15	24	Medium Dense	
13.5		Brownish Grey Silty / Clayey Sand (SC)	7	9	18	27	Medium Dense	
15.0		Brownish Grey Silty / Clayey Sand (SC)	6	10	18	28	Medium Dense	
16.5		Brownish Grey Silty / Clayey Sand (SC)	8	11	19	30	Medium Dense	
18.0		Brown Silty Sand (SM-SP)	55 _(8 cm) Rebound			>100	Very Dense	
19.5		Greyish Brown Weathered Gneiss (Grade V)	20 _(0 cm) Rebound; TCR=12%; RQD=0%			>100	Weak	
21.0		Greyish Brown Weathered Gneiss (Grade V)	20 _(0 cm) Rebound; TCR=10%; RQD=0%			>100	Weak	
22.5		Greyish Brown Weathered Gneiss (Grade V)	20 _(0 cm) Rebound; TCR=13%; RQD=0%			>100	Weak	
24.0		Brownish Grey Weathered Gneiss (Grade III)	20 _(0 cm) Rebound; TCR=44%; RQD=40%			>100	Moderately Strong	
Bore hole has been terminated at 24.0 m from the existing ground level (EGL). Nx Size Core Barrel with Diamond Cutter was used to drill from 18.0 m to 24.0 m depth Rock Stratum.								

Figure A-3

Annexure - A-2
Laboratory Test Results

Table A-1

Project : Reconstruction of Dilapidated Slum Tenements (G+5 Floors) at Cox Colony Tenemental Scheme in Corporation Division 63, Zone V of Greater Chennai Corporation.

BH No:	1	Ground Water Table Depth (m):														2.25	
LABORATORY TEST RESULTS																	
Depth (m)	SPT 'N' Value	Description / Classification of Soil and Rock / Weathering Grade of Rock as per IS 4464	Index Properties						Specific Gravity	Grain Size Analysis (%)						Direct Shear / Terzaghi and Peck (1974) - Shear Strength Parameters	
			Natural Moisture Content, %	Bulk Density (kN/m ³)	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Free Swell Index		Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines		Cohesion (c), kN/m ²	Angle of Friction (φ) in Degrees
														Silt	Clay		
1.0	11	Brown Silty Sand (SM-SP)	19	17.2	NP	NP	NP	NP	2.63	0	0	26	58	16	0	27	
2.0	18	Brown Silty Sand (SM-SP)	20	18.9	NP	NP	NP	NP	2.64	0	7	41	40	12	0	31	
3.0	21	Brown Silty Sand (SM-SP)	17	19.5	NP	NP	NP	NP	2.64	0	0	34	45	21	0	32	
4.0	13	Brown Silty Sand (SM-SP)	19	17.7	NP	NP	NP	NP	2.63	0	8	34	46	12	0	28	
5.0	8	Brown Silty Sand (SM-SP)	18	16.1	NP	NP	NP	NP	2.63	0	5	56	27	12	0	25	
6.0	7	Greyish Brown Sand (SP)	18	15.7	NP	NP	NP	NP	2.64	0	8	52	31	9	0	25	
7.5	11	Greyish Brown Silty Sand (SM-SP)	19	17.2	NP	NP	NP	NP	2.65	0	0	49	41	10	0	27	
9.0	12	Greyish Silty / Clayey Sand (SC)	28	17.5	42	16	26	40	2.66	0	0	33	22	45	18	24	
10.5	13	Greyish Silty Sand (SM-SP)	19	17.7	NP	NP	NP	NP	2.64	0	1	46	36	17	0	28	
12.0	11	Brownish Grey Silty Sand (SM-SP)	17	17.2	NP	NP	NP	NP	2.63	0	1	62	25	12	0	27	
13.5	12	Brownish Grey Silty / Clayey Sand (SC)	17	17.5	61	17	44	100	2.65	0	1	31	30	38	18	24	
15.0	16	Greyish Silty / Clayey Sand (SC)	17	18.5	51	17	34	85	2.65	0	2	55	21	22	24	27	
16.5	44	Greyish Brown Silty Sand (SM-SP)	13	22.0	NP	NP	NP	NP	2.64	27	6	22	13	32	0	40	
					Porosity of Rock (%)				Strength of Rock								
									UCS, kN/m ²		I _s , kN/m ²						
18.00	>100	Brown Weathered Sediments (Grade VI)	-	22.0	-			2.66	-		-		0	44			
19.00	>100	Brown Weathered Sediments (Grade VI)	-	22.0	-			2.67	-		-		0	44			
21.00	>100	Brown Weathered Sediments (Grade VI)	-	22.0	-			2.66	-		-		0	44			
22.00	>100	Brown Weathered Sediments (Grade VI)	-	22.0	-			2.66	-		-		0	44			
23.00	>100	Brown Weathered Sediments (Grade VI)	-	22.0	-			2.67	-		-		0	44			
24.39	>100	Greyish Brown Weathered Gneiss (Grade V)	1.69	26.5	2.72			2.68	-		256		0	44			
25.89	>100	Greyish Brown Weathered Gneiss (Grade V)	1.65	27.9	2.69			2.67	-		1153		0	44			
27.30	>100	Greyish Brown Weathered Gneiss (Grade V)	1.59	28.0	2.65			2.68	-		1245		0	44			
28.50	>100	Greyish Brown Weathered Gneiss (Grade III)	1.48	28.1	2.51			2.68	21215		3382		0	45			

Table A-2

Project : Reconstruction of Dilapidated Slum Tenements (G+5 Floors) at Cox Colony Tenemental Scheme in Corporation Division 63, Zone V of Greater Chennai Corporation.

BH No:	2	Ground Water Table Depth (m):												2.15			
LABORATORY TEST RESULTS																	
Depth (m)	SPT 'N' Value	Description / Classification of Soil and Rock / Weathering Grade of Rock as per IS 4464	Index Properties						Specific Gravity	Grain Size Analysis (%)						Direct Shear / Terzaghi and Peck (1974) - Shear Strength Parameters	
			Natural Moisture Content, %	Bulk Density (kN/m ³)	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Free Swell Index		Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines		Cohesion (c), kN/m ²	Angle of Friction (Φ) in Degrees
														Silt	Clay		
1.0	2	Brown Sand (SP)	19	12.3	NP	NP	NP	NP	2.63	0	11	55	27	7	0	19	
2.0	2	Brown Sand (SP)	17	12.3	NP	NP	NP	NP	2.62	17	6	35	33	9	0	19	
3.0	15	Greyish Brown Silty Sand (SM-SP)	22	18.2	NP	NP	NP	NP	2.61	0	5	22	55	18	0	29	
4.0	23	Brown Silty Sand (SM-SP)	19	19.8	NP	NP	NP	NP	2.63	0	7	35	43	15	0	33	
5.0	16	Brown Sand (SP)	20	18.5	NP	NP	NP	NP	2.64	0	2	38	51	9	0	30	
6.0	7	Greyish Brown Silty Sand (SM-SP)	20	15.7	NP	NP	NP	NP	2.62	0	10	43	34	13	0	24	
7.5	16	Brownish Grey Silty Sand (SM-SP)	18	18.5	NP	NP	NP	NP	2.63	0	4	37	45	14	0	30	
9.0	4	Greyish Silty / Clayey Sand (CH)	41	14.1	75	24	51	55	2.61	0	0	35	12	53	25	0	
10.5	22	Brown Silty / Clayey Sand (SC)	23	19.6	38	16	22	60	2.66	0	1	38	23	38	33	30	
12.0	12	Brown Silty Sand (SM-SP)	22	17.5	NP	NP	NP	NP	2.64	0	0	43	43	14	0	27	
13.5	13	Brown Silty / Clayey Sand (SC)	21	17.7	35	15	20	25	2.63	0	8	46	20	26	20	25	
15.0	26	Brownish Grey Silty / Clayey Sand (SC)	16	20.3	70	19	51	60	2.64	0	0	29	33	38	39	32	
16.5	35	Whitish Grey Silty / Clayey Sand (SC)	16	21.5	48	19	29	60	2.63	0	4	39	32	25	53	35	
18.0	>100	Brown Silty Sand (SM-SP)	18	22.0	NP	NP	NP	NP	2.64	0	11	33	26	30	0	42	
19.5	>100	Brown Silty Sand (SM-SP)	12	22.0	NP	NP	NP	NP	2.64	34	8	19	17	22	0	42	
					Porosity of Rock (%)					Strength of Rock							
										UCS, kN/m ²		I _s , kN/m ²					
21.0	>100	Greyish Brown Weathered Gneiss (Grade V)	1.69	27.6	2.71				2.67	-		185		0	44		
22.5	>100	Greyish Brown Weathered Gneiss (Grade V)	1.66	27.9	2.69				2.68	-		254		0	44		
24.0	>100	Greyish Brown Weathered Gneiss (Grade V)	1.62	28.4	2.67				2.68	-		1295		0	44		
25.5	>100	Greyish Brown Weathered Gneiss (Grade IV)	1.59	28.5	2.58				2.68	52085		4973		0	45		

Table A-3

Project : Reconstruction of Deteriorated Slum Tenements (G+5 floors) at Cox Colony Tenemental Scheme in Corporation Division 03, Zone V of Greater Chennai Corporation

BH No:	3	Ground Water Table Depth (m):	2.50
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LABORATORY TEST RESULTS

Depth (m)	SPT 'N' Value	Description / Classification of Soil and Rock / Weathering Grade of Rock as per IS 4464	Index Properties						Specific Gravity	Grain Size Analysis (%)						Direct Shear / Terzaghi and Peck (1974) - Shear Strength Parameters	
			Natural Moisture Content, %	Bulk Density (kN/m ³)	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Free Swell Index		Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines		Cohesion (c), kN/m ²	Angle of Friction (Φ) in Degrees
														Silt	Clay		
1.0	2	Brown Silty Sand (SM-SP)	23	12.3	NP	NP	NP	NP	2.62	0	16	24	38	22	0	18	
2.0	10	Brown Silty Sand (SM-SP)	20	16.9	NP	NP	NP	NP	2.63	0	7	20	46	27	0	26	
3.0	15	Brown Silty Sand (SM-SP)	19	18.2	NP	NP	NP	NP	2.63	0	11	46	33	10	0	29	
4.0	12	Brown Sand (SP)	20	17.5	NP	NP	NP	NP	2.64	0	4	42	46	8	0	28	
5.0	9	Greyish Silty / Clayey Sand (SC)	24	16.5	31	13	18	25	2.65	0	1	45	24	30	14	22	
6.0	6	Greyish Silty / Clayey Sand (SC)	25	15.3	32	16	16	30	2.65	0	6	45	28	21	9	20	
7.5	15	Brownish Grey Silty Sand (SM-SP)	19	18.2	NP	NP	NP	NP	2.63	0	2	43	40	15	0	29	
9.0	10	Greyish Silty / Clayey Sand (CH)	37	16.9	52	18	34	45	2.62	0	0	20	20	60	63	0	
10.5	23	Greyish Brown Silty Sand (SM-SP)	19	19.8	NP	NP	NP	NP	2.64	0	0	38	37	25	0	33	
12.0	24	Greyish Silty / Clayey Sand (SC)	23	20.0	41	16	25	25	2.66	0	3	33	34	30	36	31	
13.5	27	Brownish Grey Silty / Clayey Sand (SC)	18	20.4	48	18	30	70	2.65	0	0	33	28	39	41	32	
15.0	28	Brownish Grey Silty / Clayey Sand (SC)	15	20.6	56	19	37	75	2.65	0	8	36	28	28	42	33	
16.5	30	Brownish Grey Silty / Clayey Sand (SC)	15	20.9	34	16	18	70	2.65	0	5	31	19	45	45	33	
18.0	>100	Brown Silty Sand (SM-SP)	13	22.0	NP	NP	NP	NP	2.67	32	11	21	16	20	0	42	
					Porosity of Rock (%)					Strength of Rock							
										UCS, kN/m ²			I _s , kN/m ²				
19.5	>100	Greyish Brown Weathered Gneiss (Grade V)	1.71	26.6	2.72				2.67	-			192			0	44
21.0	>100	Greyish Brown Weathered Gneiss (Grade V)	1.69	26.7	2.68				2.68	-			227			0	44
22.5	>100	Greyish Brown Weathered Gneiss (Grade V)	1.65	26.9	2.65				2.67	-			1000			0	44
24.0	>100	Brownish Grey Weathered Gneiss (Grade III)	1.58	27.2	2.59				2.68	25197			1254			0	45

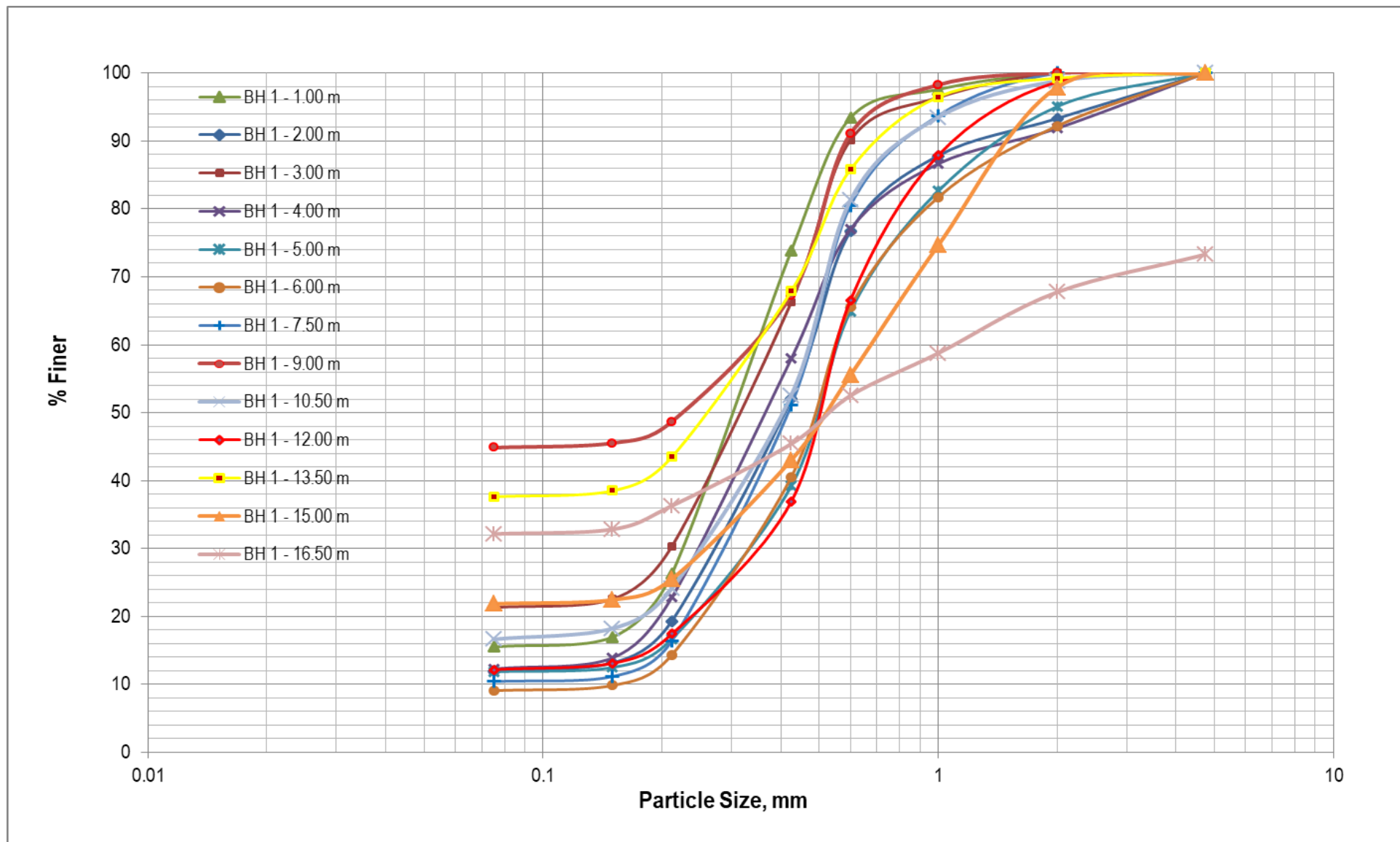


Figure C- 1 Grain Size Distribution of Soil Samples collected in BH 1 Location

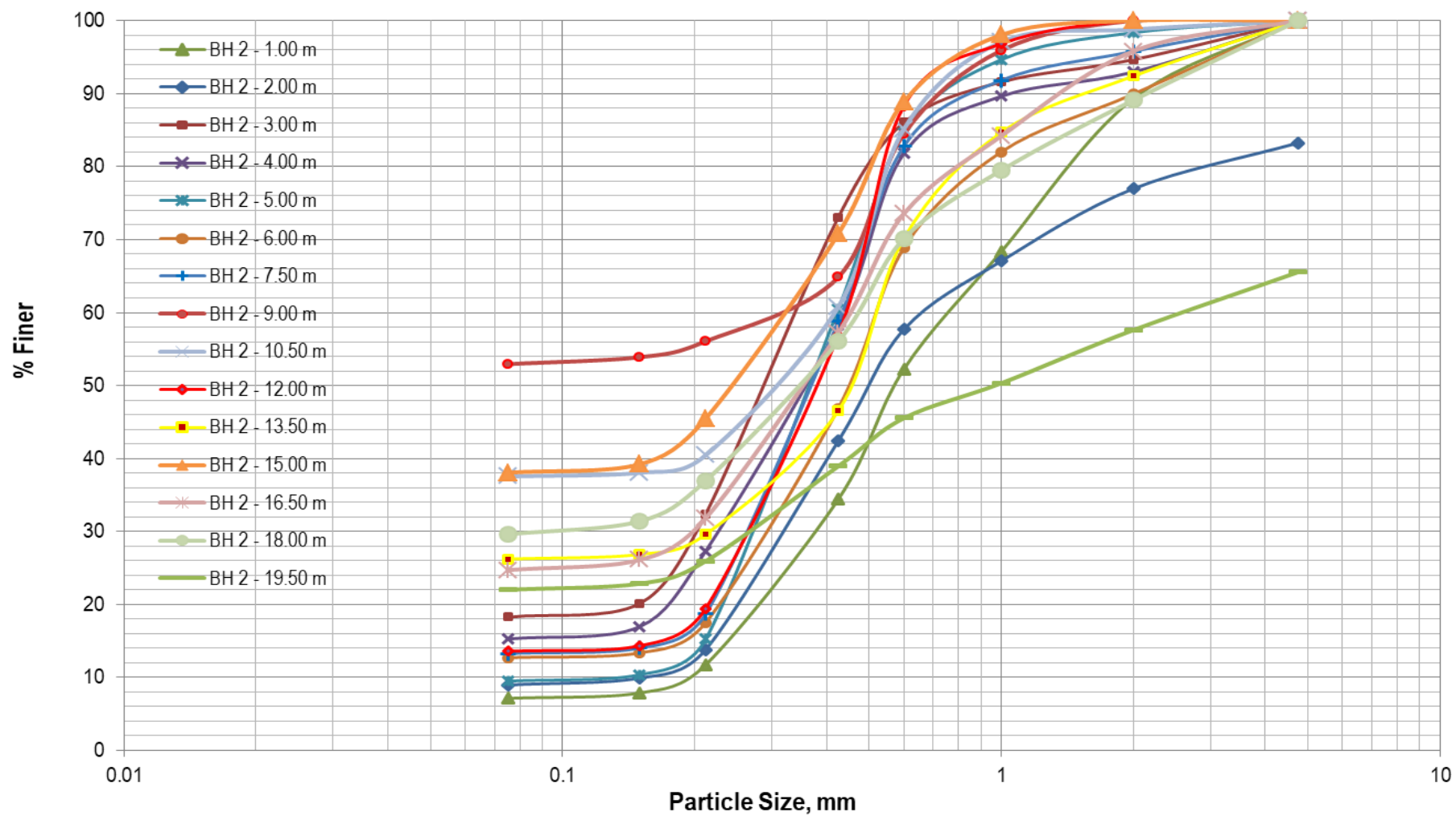


Figure C-2 Grain Size Distribution of Soil Samples collected in BH 2 Location

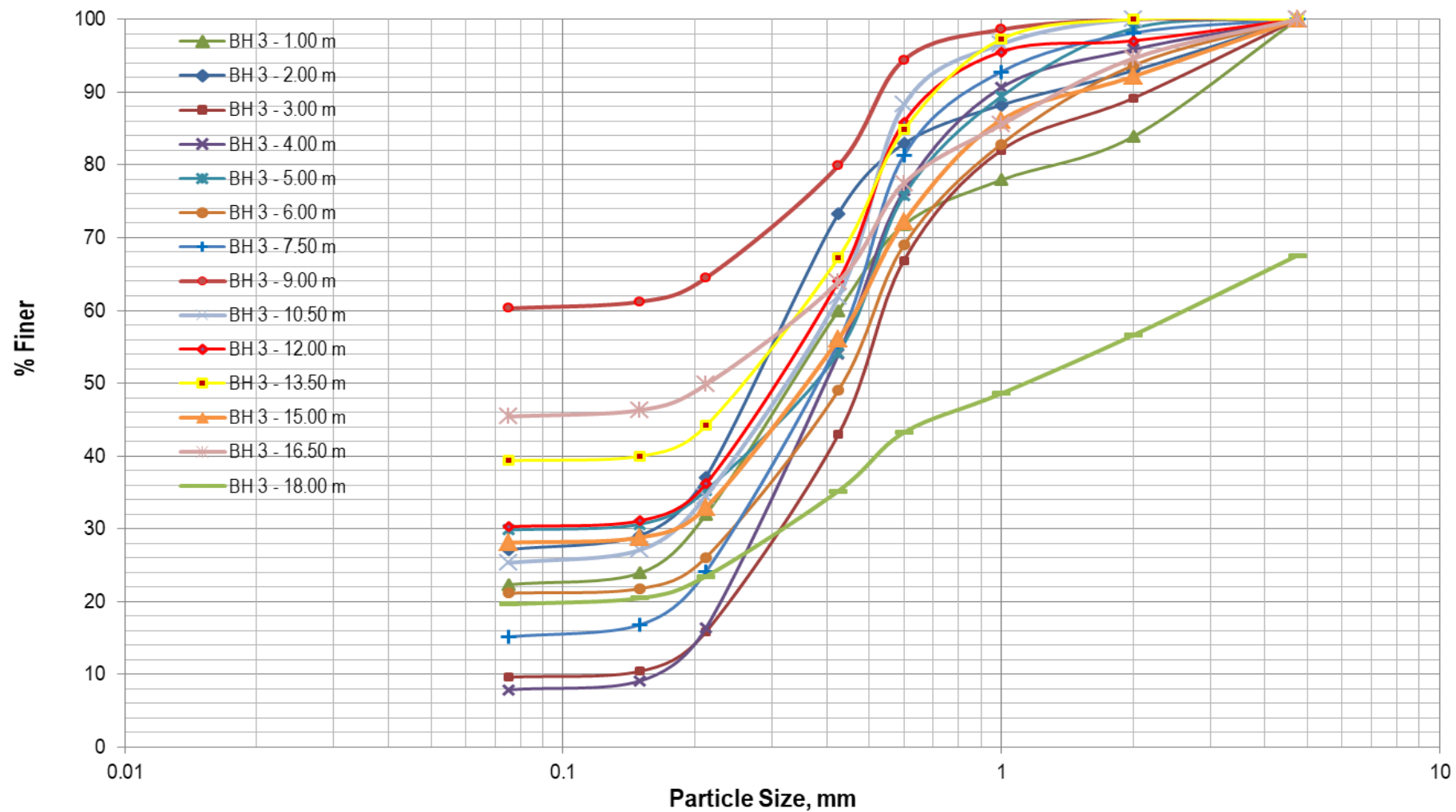


Figure C-3 Grain Size Distribution of Soil Samples collected in BH 3 Location

Annexure – 1 View of Soil Samples collected in BH 1 to BH 3 Locations of the Reconstruction of Dilapidated Slum Tenements at Cox Colony Tenemental Scheme in Corporation Division 63, Zone V of Greater Chennai Corporation.

Plate – 1 Soil Sample Collected by conducting SPT in BH-01 Location



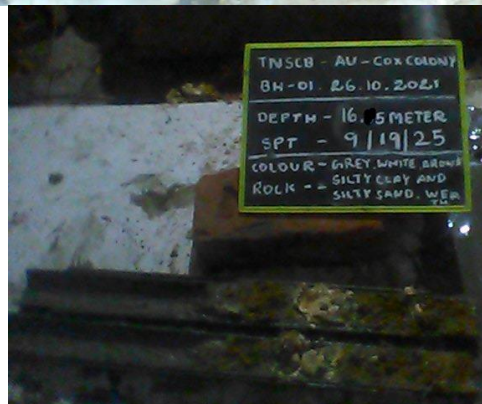
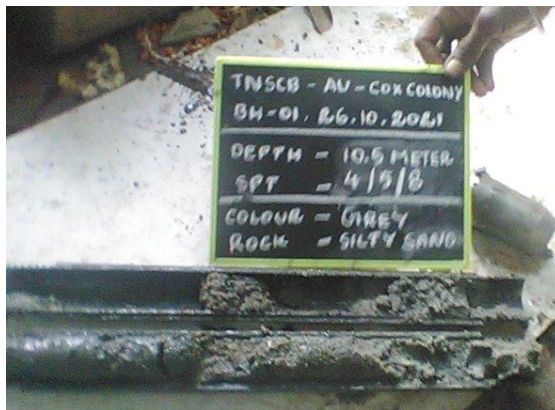
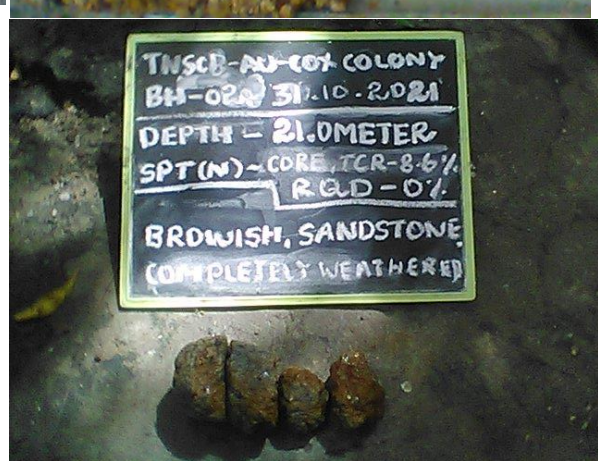
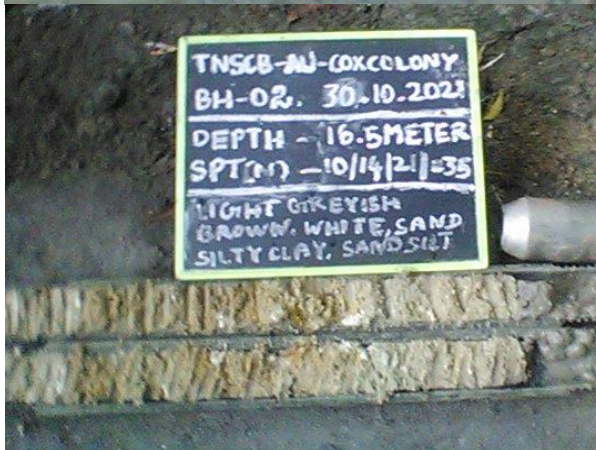
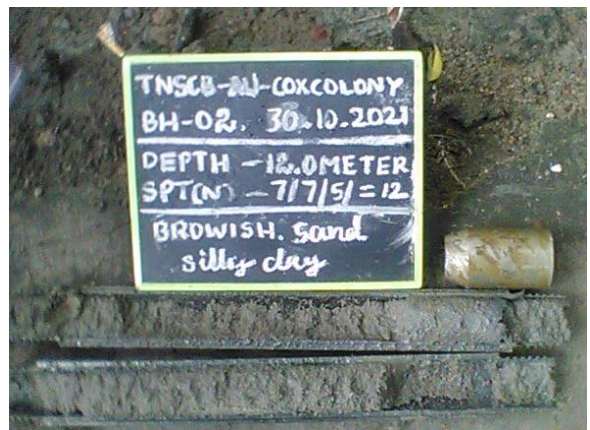
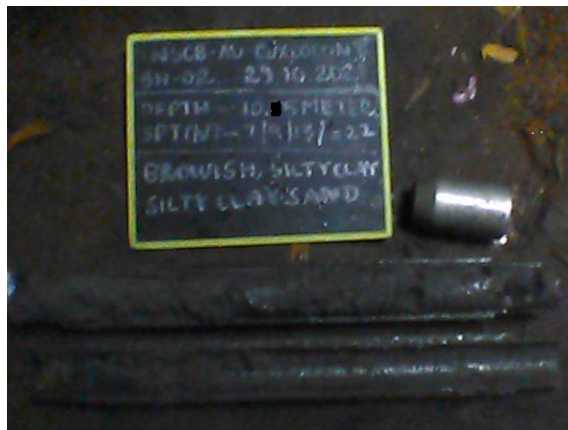


Plate – 2 Soil Sample Collected by conducting SPT in BH-02 Location





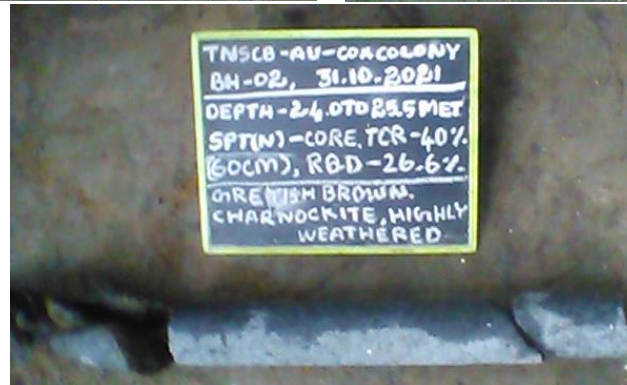
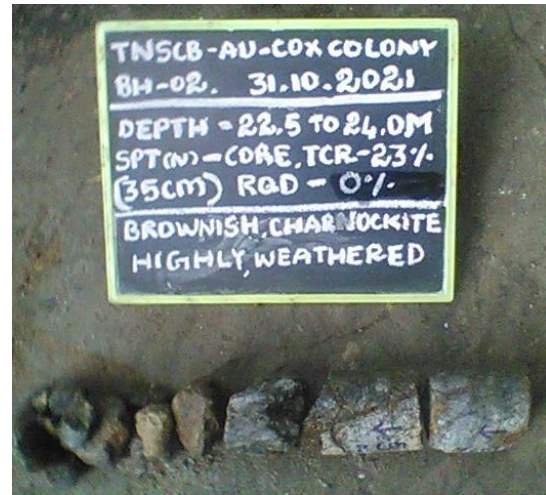
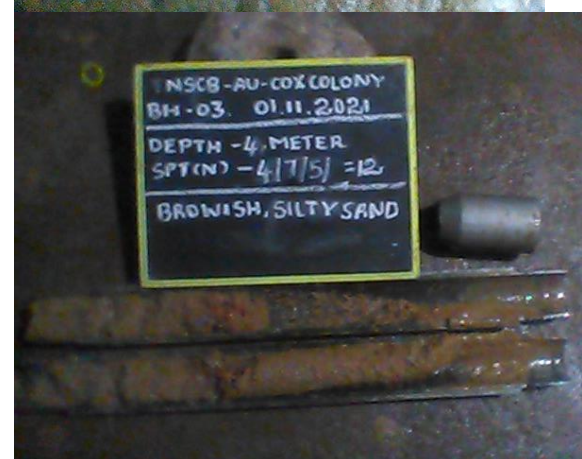
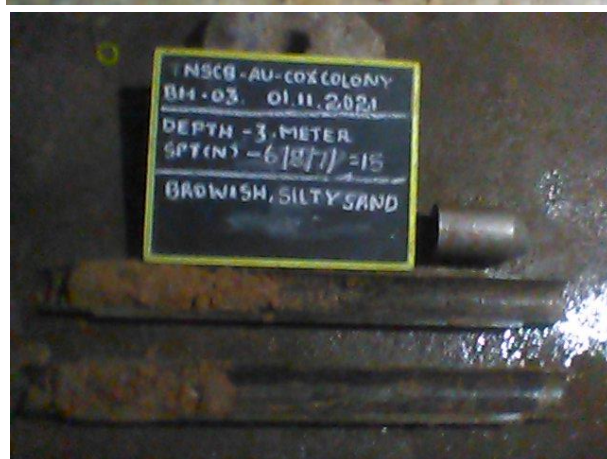
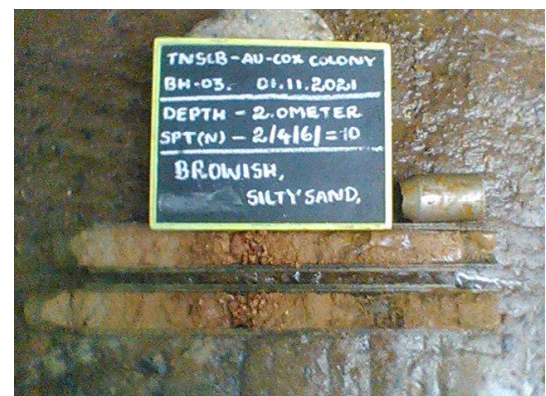
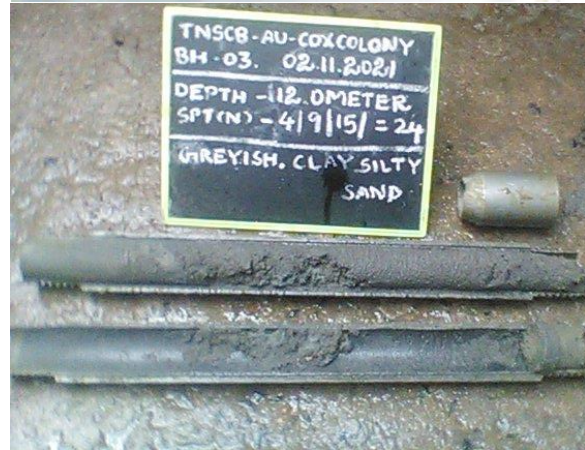
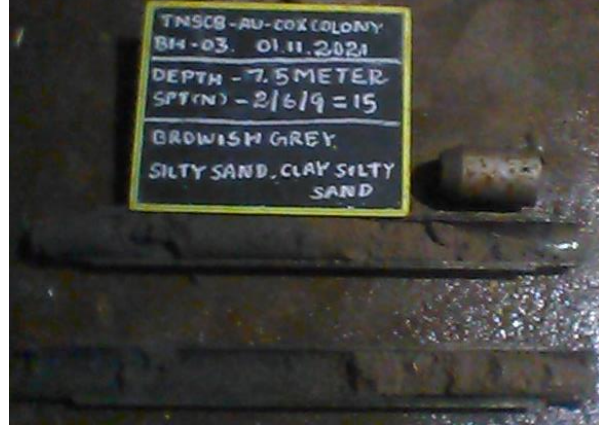
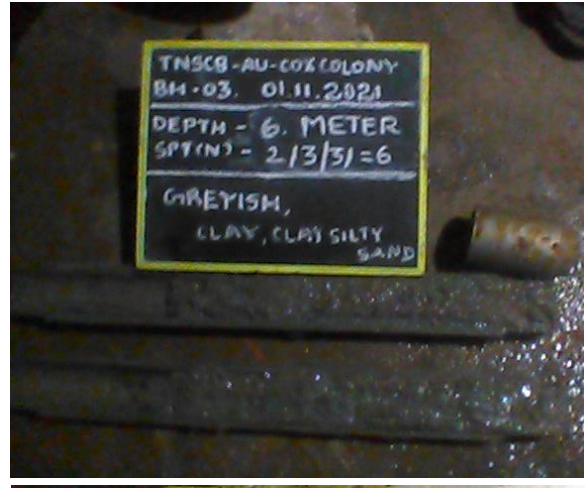
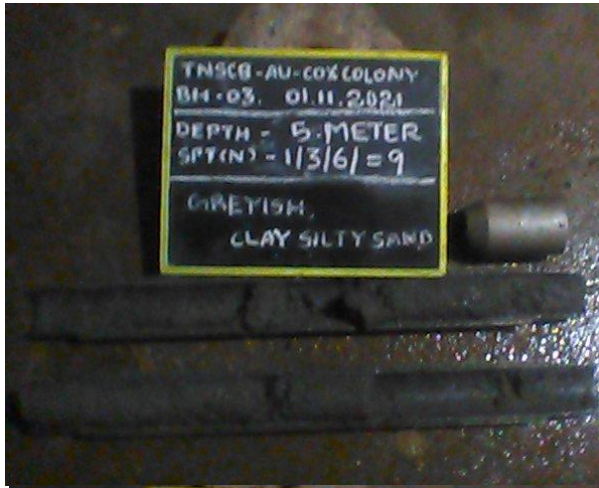
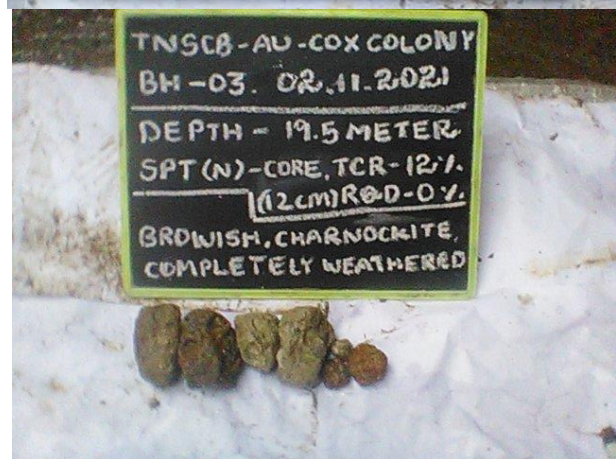
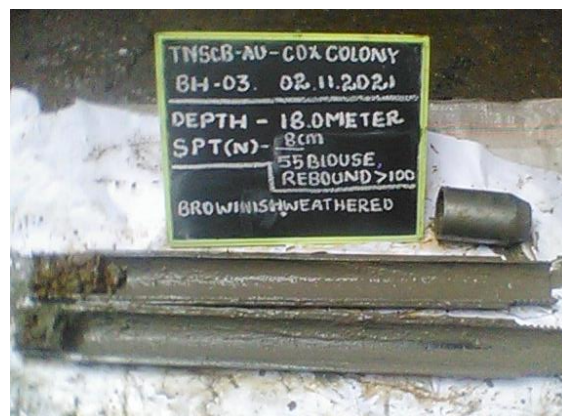


Plate – 3 Soil Sample Collected by conducting SPT in BH-03 Location







Annexure – 2
Site Photographs



Plate 1 SPT test is in progress at the Reconstruction of Dilapidated Slum Tenements at Cox Colony Tenemental Scheme in Corporation Division 63, Zone V of Greater Chennai Corporation.



Plate 2 View of Soil / Rock Samples collected in 3 borehole locations of the proposed site



Plate 3 View of Rock Samples tested for Point Load Strength Index and Unconfined Compression Strength

GEOTECHNICAL DESIGN PARAMETERS OF DIFFERENT LAYERS BELOW GROUND LEVEL**PROJECT: Reconstruction of Dilapidated Slum Tenements (G+5 Floors) at Cox Colony Tenemental Scheme in Corporation Division 63, Zone V of Greater Chennai Corporation.**

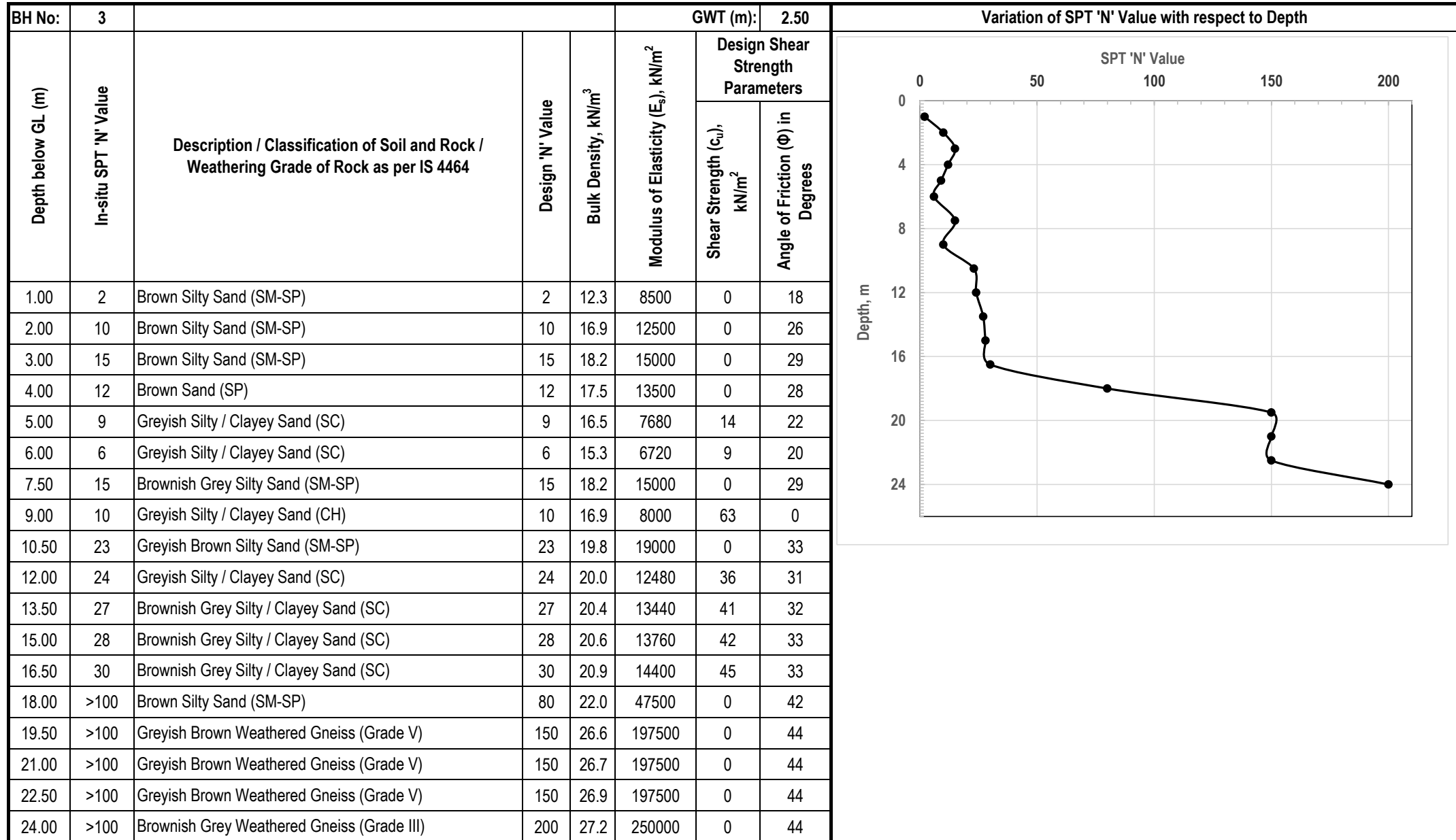
BH No:	1					GWT (m):	2.25	Variation of SPT 'N' Value with respect to Depth	
Depth below GL (m)	In-situ SPT 'N' Value	Description / Classification of Soil and Rock / Weathering Grade of Rock as per IS 4464	Design 'N' Value	Bulk Density, kN/m ³	Modulus of Elasticity (E _s), kN/m ²	Design Shear Strength Parameters			
						Shear Strength (c _u), kN/m ²	Angle of Friction (Φ) in Degrees		
1.00	11	Brown Silty Sand (SM-SP)	11	17.2	13000	0	27		
2.00	18	Brown Silty Sand (SM-SP)	18	18.9	16500	0	31		
3.00	21	Brown Silty Sand (SM-SP)	21	19.5	18000	0	32		
4.00	13	Brown Silty Sand (SM-SP)	13	17.7	14000	0	28		
5.00	8	Brown Silty Sand (SM-SP)	8	16.1	11500	0	25		
6.00	7	Greyish Brown Sand (SP)	7	15.7	11000	0	25		
7.50	11	Greyish Brown Silty Sand (SM-SP)	11	17.2	13000	0	27		
9.00	12	Greyish Silty / Clayey Sand (SC)	12	17.5	8640	18	24		
10.50	13	Greyish Silty Sand (SM-SP)	13	17.7	14000	0	28		
12.00	11	Brownish Grey Silty Sand (SM-SP)	11	17.2	13000	0	27		
13.50	12	Brownish Grey Silty / Clayey Sand (SC)	12	17.5	8640	18	24		
15.00	16	Greyish Silty / Clayey Sand (SC)	16	18.5	9920	24	27		
16.50	44	Greyish Brown Silty Sand (SM-SP)	44	22.0	29500	0	40		
18.00	>100	Brown Weathered Sediments (Grade VI)	100	22.0	145000	0	44		
19.00	>100	Brown Weathered Sediments (Grade VI)	100	22.0	145000	0	44		
21.00	>100	Brown Weathered Sediments (Grade VI)	100	22.0	145000	0	44		
22.00	>100	Brown Weathered Sediments (Grade VI)	100	22.0	145000	0	44		
23.00	>100	Brown Weathered Sediments (Grade VI)	100	22.0	145000	0	44		
24.39	>100	Greyish Brown Weathered Gneiss (Grade V)	150	26.5	197500	0	45		
25.89	>100	Greyish Brown Weathered Gneiss (Grade V)	150	27.9	197500	0	45		
27.30	>100	Greyish Brown Weathered Gneiss (Grade V)	150	28.0	197500	0	45		
28.50	>100	Greyish Brown Weathered Gneiss (Grade III)	200	28.1	250000	0	45		

GEOTECHNICAL DESIGN PARAMETERS OF DIFFERENT LAYERS BELOW GROUND LEVEL**PROJECT: Reconstruction of Dilapidated Slum Tenements (G+5 Floors) at Cox Colony Tenemental Scheme in Corporation Division 63, Zone V of Greater Chennai Corporation.**

BH No:	2					GWT (m):	2.15	Variation of SPT 'N' Value with respect to Depth	
Depth below GL (m)	In-situ SPT 'N' Value	Description / Classification of Soil and Rock / Weathering Grade of Rock as per IS 4464	Design 'N' Value	Bulk Density, kN/m ³	Modulus of Elasticity (E_s), kN/m ²	Design Shear Strength Parameters			
						Shear Strength (c_u), kN/m ²	Angle of Friction (Φ) in Degrees		
1.00	2	Brown Sand (SP)	2	12.3	8500	0	19	SPT 'N' Value Depth, m	
2.00	2	Brown Sand (SP)	2	12.3	8500	0	19		
3.00	15	Greyish Brown Silty Sand (SM-SP)	15	18.2	15000	0	29		
4.00	23	Brown Silty Sand (SM-SP)	23	19.8	19000	0	33		
5.00	16	Brown Sand (SP)	16	18.5	15500	0	30		
6.00	7	Greyish Brown Silty Sand (SM-SP)	7	15.7	11000	0	24		
7.50	16	Brownish Grey Silty Sand (SM-SP)	16	18.5	15500	0	30		
9.00	4	Greyish Silty / Clayey Sand (CH)	4	14.1	6080	25	0		
10.50	22	Brown Silty / Clayey Sand (SC)	22	19.6	11840	33	30		
12.00	12	Brown Silty Sand (SM-SP)	12	17.5	13500	0	27		
13.50	13	Brown Silty / Clayey Sand (SC)	13	17.7	8960	20	25		
15.00	26	Brownish Grey Silty / Clayey Sand (SC)	26	20.3	13120	39	32		
16.50	35	Whitish Grey Silty / Clayey Sand (SC)	35	21.5	16000	53	35		
18.00	>100	Brown Silty Sand (SM-SP)	80	22.0	47500	0	42		
19.50	>100	Brown Silty Sand (SM-SP)	80	22.0	47500	0	42		
21.00	>100	Greyish Brown Weathered Gneiss (Grade V)	150	27.6	197500	0	44		
22.50	>100	Greyish Brown Weathered Gneiss (Grade V)	150	27.9	197500	0	44		
24.00	>100	Greyish Brown Weathered Gneiss (Grade V)	150	28.4	197500	0	44		
25.50	>100	Greyish Brown Weathered Gneiss (Grade IV)	200	28.5	250000	0	44		

GEOTECHNICAL DESIGN PARAMETERS OF DIFFERENT LAYERS BELOW GROUND LEVEL

PROJECT: Reconstruction of Dilapidated Slum Tenements (G+5 Floors) at Cox Colony Tenemental Scheme in Corporation Division 63, Zone V of Greater Chennai Corporation.



Annexure - 2 (DETERMINATION OF PILE CARRYING CAPACITY AS PER IS 2911:2010)

LOAD-CARRYING CAPACITY OF PILES — STATIC ANALYSIS - IS 2911 : 2010

PILES IN GRANULAR SOILS

The ultimate load capacity (Q_u) of piles, in kN, in granular soils is given by the following formula:

$$Q_u = A_p (\frac{1}{2} D \gamma N_\gamma + P_D N_q) + \sum_{i=1}^n K_i P_{Di} \tan \delta_i A_{si}$$

The first term gives end-bearing resistance and the second term gives skin friction resistance.

where

A_p = cross-sectional area of pile tip, in m^2 ;

D = diameter of pile shaft, in m;

γ = effective unit weight of the soil at pile tip, in kN/m^3 ;

N_γ = bearing capacity factors depending upon
and N_q the angle of internal friction, ϕ at pile tip;

P_D = effective overburden pressure at pile tip, in kN/m^2 (see Note 5);

$\sum_{i=1}^n$ = summation for layers 1 to n in which pile is installed and which contribute to positive skin friction;

K_i = coefficient of earth pressure applicable for the i th layer (see Note 3);

P_{Di} = effective overburden pressure for the i th layer, in kN/m^2 ;

δ_i = angle of wall friction between pile and soil for the i th layer; and

A_{si} = surface area of pile shaft in the i th layer, in m^2 .

NOTES

1 N_γ factor can be taken for general shear failure according to IS 6403.

2 N_q factor will depend on the nature of soil, type of pile, the L/B ratio and its method of construction. The values applicable for bored piles are given in Fig. 1 of IS 2911 : 2010 Part I

3 K_i , the earth pressure coefficient depends on the nature of soil strata, type of pile, spacing of pile and its method of construction. For driven piles in loose to dense sand with ϕ varying between 30° and 40° , K_i values in the range of 1 to 1.5 may be used.

4 δ , the angle of wall friction may be taken equal to the friction angle of the soil around the pile stem.

5 In working out pile capacity by static formula, the maximum effective overburden at the pile tip should correspond to the critical depth, which may be taken as 15 times the diameter of the pile shaft for $\phi \leq 30^\circ$ and increasing to 20 times for $\phi \geq 40^\circ$.

6 For piles passing through cohesive strata and terminating in a granular stratum, a penetration of at least twice the diameter of the pile shaft should be given into the granular stratum.

Annexure - 2 (DETERMINATION OF PILE CARRYING CAPACITY AS PER IS 2911:2010)

PILES IN COHESIVE SOILS

The ultimate load capacity (Q_u) of piles, in kN, in cohesive soils is given by the following formula:

$$Q_u = A_p N_c c_p + \sum_{i=1}^n \alpha_i c_i A_{si}$$

The first term gives the end-bearing resistance and the second term gives the skin friction resistance.

where

- A_p = cross-sectional area of pile tip, in m^2 ;
- N_c = bearing capacity factor, may be taken as 9;
- c_p = average cohesion at pile tip, in kN/m^2 ;
- $\sum_{i=1}^n$ = summation for layers 1 to n in which the pile is installed and which contribute to positive skin friction;
- α_i = adhesion factor for the i th layer depending on the consistency of soil, (see Note);
- c_i = average cohesion for the i th layer, in kN/m^2 ; and
- A_{si} = surface area of pile shaft in the i th layer, in m^2 .

B-3.3 Ultimate skin friction resistance can be approximated to local side friction (f_s), in kN/m^2 , obtained from static cone resistance as given in Table 1.

Table 1 Side Friction for Different Types of Soil

Sl No. (1)	Type of Soil (2)	Local Side Friction, f_s kN/m^2 (3)
i)	q_c less than 1 000 kN/m^2	$q_c/30 < f_s < q_c/10$
ii)	Clay	$q_c/25 < f_s < 2q_c/25$
iii)	Silty clay and silty sand	$q_c/100 < f_s < q_c/25$
iv)	Sand	$q_c/100 < f_s < q_c/50$
v)	Coarse sand and gravel	$q_c/100 < f_s < q_c/150$
q_c = cone resistance, in kN/m^2 .		

USE OF STATIC CONE PENETRATION DATA

When full static cone penetration data are available for the entire depth, the following correlation may be used as a guide for the determination of ultimate load capacity of a pile.

Ultimate end bearing resistance (q_u), in kN/m^2 , may be obtained as:

$$q_u = \frac{\frac{q_{c0} + q_{c1}}{2} + q_{c2}}{2}$$

where

- q_{c0} = average static cone resistance over a depth of $2D$ below the pile tip, in kN/m^2 ;
- q_{c1} = minimum static cone resistance over the same $2D$ below the pile tip, in kN/m^2 ;
- q_{c2} = average of the envelope of minimum static cone resistance values over the length of pile of $8D$ above the pile tip, in kN/m^2 ; and
- D = diameter of pile shaft.

NOTE — The value of adhesion factor, α_i depends on the undrained shear strength of the clay and may be obtained from Fig. 2 of IS 2911 : 2010 Part I

Table 2 Co-relation Between N and q_c for Different Types of Soil

Sl No. (1)	Type of Soil (2)	q_c/N (3)
i)	Clay	150-200
ii)	Silts, sandy silts and slightly cohesive silt-sand mixtures	200-250
iii)	Clean fine to medium sand and slightly silty sand	300-400
iv)	Coarse sand and sands with little gravel	500-600
v)	Sandy gravel and gravel	800-1 000

Annexure - 2 (DETERMINATION OF PILE CARRYING CAPACITY AS PER IS 2911:2010)

PILE CARRYING CAPACITY BASED ON SHEAR STRENGTH PARAMETERS ('c' and 'Φ') (IS 2911: 2010)

$$Q_u = A_p (cN_c + P_D N_q + 0.5\gamma DN_\gamma) + \sum A_{si}(\alpha_i c_i + K P_{Di} \tan \Phi)$$

Where,

Q_u - Ultimate Pile Capacity, kN

A_p - Cross Sectional Area of Pile, m²

c_i - Cohesion value of soil at pile base, kN/m²

P_D - Effective overburden pressure at pile base, kN/m²

γ - Unit weight of soil, kN/m³

D - Diameter of pile, m

A_{si} - Surface Area of Pile at respective soil layers, m²

α_i - Adhesion factor

c - Cohesion value of soil at respective soil layers, kN/m²

K_i - Co-efficient of earth pressure at respective soil layers

P_{Di} - Effective overburden pressure at respective soil layers, kN/m²

Φ - Friction angle, degrees

N_c, N_q, N_γ - Bearing capacity factors based on IS 2911: 2010 and

IS 6403 -1981

PILE CARRYING CAPACITY OF SOCKETED PILES BY COLE AND STROUD APPROACH (1977) - IS 2911 : 2010

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

where

c_{u1} = shear strength of rock below the base of the pile, in kN/m² (see Fig. 3);

N_c = bearing capacity factor taken as 9;

F_s = factor of safety usually taken as 3;

α = 0.9 (recommended value);

c_{u2} = average shear strength of rock in the socketed length of pile, in kN/m² (see Fig 3);

B = minimum width of pile shaft (diameter in case of circular piles), in m; and

L = socket length of pile, in m.

Type of Soil	Limiting Frictional Resistance (t/m ²)
Sand	6
Silt	6
Clay	7

Limiting End Bearing Resistance (t/m ²) as per IS 2911	
Bored Piles	Driven Piles
1000 - 1100	1500

Annexure - 2 (Determination of Pile Carrying Capacity as Per IS 2911:2010)

DETERMINATION OF PILE CARRYING CAPACITY AS PER IS 2911 : 2010

Borehole Location	BH 1					
Length of Pile (L), m	=	25.00	m	From Existing Borehole Level		
Angle of Internal Friction (ϕ) in Degrees	=	44.00				
Undrained cohesion value at PileTip (c_p), kN/m ²	=	0.00	kN/m ²			
Submerged Unit Weight at PileTip (γ_p), kN/m ²	=	17.90	kN/m ²			
Ground Water Table Depth (GWT), m	=	0.00	m	Submerged Condition		
Bearing Capacity Factor (N_c)	=	9.00				
Bearing Capacity Factor (N_q)	=	300.00		Taken from Figure 1 of IS 2911:2010 Part 1 Sec.2		
Bearing Capacity Factor (N_γ)	=	224.63				
Factor of Safety (FS)	=	2.50				
Diameter of Pile (D), mm	=	450	500	600	700	900
Critical Depth of Pile (20 x D), m	=	9	10	12	14	18
Effective overburden pressure at Pile Tip (P_D), kN/m ²	=	67.98	79.38	90.55	101.58	143.95
End Bearing Resistnace of Pile (q_p), kN/m ² using 'c' and ' ϕ '	=	21297.22	24817.74	28371.29	31879.83	44994.43
End Bearing Resistnace of Pile (q_p), kN/m ² using 'N' values	=	60000.00	60000.00	60000.00	60000.00	60000.00
Limiting End Bearing Resistnace of Pile (q_p), kN/m ²	=	10000.00	10000.00	10000.00	10000.00	10000.00
Ultimate End Bearing Capacity of Pile (Q_p), kN using 'c' and ' ϕ ' values	=	1590.43	1963.50	2827.43	3848.45	6361.73
Ultimate End Bearing Capacity of Pile (Q_p), kN using 'N' values	=	1590.43	1963.50	2827.43	3848.45	6361.73
Safe End Bearing Capacity of Pile (Q_p), kN using 'c' and ' ϕ ' values	=	636.17	785.40	1130.97	1539.38	2544.69
Safe End Bearing Capacity of Pile (Q_p), kN using 'N' values	=	636.17	785.40	1130.97	1539.38	2544.69
Ultimate Frictional Capacity of Pile (Q_p), kN using 'c' and ' ϕ ' values	=	1802.12	2002.36	2402.83	2803.30	3604.25
Ultimate Frictional Capacity of Pile (Q_p), kN using 'N' values	=	1484.40	1649.34	1979.20	2309.07	2968.81
Negative Skin Friction of Pile (Q_{nf}), kN using 'c' and ' ϕ ' values	=	39.74	44.15	52.99	61.82	79.48
Negative Skin Friction of Pile (Q_{nf}), kN using 'N' values	=	117.81	130.90	157.08	183.26	235.62
Safe Frictional Capacity of Pile (Q_p), kN using 'c' and ' ϕ ' values	=	681.11	756.79	908.15	1059.50	1362.22
Safe Frictional Capacity of Pile (Q_p), kN using 'N' values	=	475.95	528.83	634.60	740.37	951.90
Self Weight of Pile (W), kN	=	99.40	122.72	176.71	240.53	397.61
Safe Pile Carrying Capacity of Pile (Q_{safe}), kN ('c' and ' ϕ ')	=	1317	1542	2039	2599	3907
Safe Pile Carrying Capacity of Pile (Q_{safe}), kN ('N' values)	=	1112	1314	1766	2280	3497
Recommended Safe Pile Carrying Capacity of Pile (Q_{safe}), kN	=	1215	1428	1902	2439	3702
Safe Uplift Capacity of Pile (Q_{up}), kN using 'c' and ' ϕ ' values	=	660	746	925	1113	1520

Annexure - 2 (Determination of Pile Carrying Capacity as Per IS 2911:2010)

Depth (m)	Soil Description	H _i (m)	'c' kN/m ²	'φ'	'γ' kN/m ³	'γ _{sub} ' kN/m ³	P _{Di} (kN/m ²)	'α _i '	'K _i '	N' Value
1.00	Brown Silty Sand (SM-SP)	1.00	0	27	17.20	7.20	7.20	0.00	1.00	11
2.00	Brown Silty Sand (SM-SP)	1.00	0	31	18.90	8.90	15.25	0.00	1.00	18
3.00	Brown Silty Sand (SM-SP)	1.00	0	32	19.50	9.50	24.45	0.00	1.00	21
4.00	Brown Silty Sand (SM-SP)	1.00	0	28	17.70	7.70	33.05	0.00	1.00	13
5.00	Brown Silty Sand (SM-SP)	1.00	0	25	16.10	6.10	39.95	0.00	1.00	8
6.00	Greyish Brown Sand (SP)	1.50	0	25	15.70	5.70	47.28	0.00	1.00	7
7.50	Greyish Brown Silty Sand (SM-SP)	1.50	0	27	17.20	7.20	56.95	0.00	1.00	11
9.00	Greyish Silty / Clayey Sand (SC)	1.50	18	24	17.50	7.50	67.98	0.30	1.00	12
10.50	Greyish Silty Sand (SM-SP)	1.50	0	28	17.70	7.70	79.38	0.00	1.00	13
12.00	Brownish Grey Silty Sand (SM-SP)	1.50	0	27	17.20	7.20	90.55	0.00	1.00	11
13.50	Brownish Grey Silty / Clayey Sand (SC)	1.50	18	24	17.50	7.50	101.58	0.30	1.00	12
15.00	Greyish Silty / Clayey Sand (SC)	1.50	24	27	18.50	8.50	113.58	0.30	1.00	16
16.50	Greyish Brown Silty Sand (SM-SP)	1.50	0	40	22.00	12.00	128.95	0.00	1.00	44
18.00	Brown Weathered Sediments (Grade VI)	1.00	0	44	22.00	12.00	143.95	0.00	1.00	100
19.00	Brown Weathered Sediments (Grade VI)	2.00	0	44	22.00	12.00	161.95	0.00	1.00	100
21.00	Brown Weathered Sediments (Grade VI)	1.00	0	44	22.00	12.00	179.95	0.00	1.00	100
22.00	Brown Weathered Sediments (Grade VI)	1.00	0	44	22.00	12.00	191.95	0.00	1.00	100
23.00	Brown Weathered Sediments (Grade VI)	1.39	0	44	22.00	12.00	206.29	0.00	1.00	100
24.39	Greyish Brown Weathered Gneiss (Grade V)	1.50	0	45	26.50	16.50	227.01	0.00	1.00	150
25.89	Greyish Brown Weathered Gneiss (Grade V)	1.41	0	45	27.90	17.90	252.00	0.00	1.00	150
27.30	Greyish Brown Weathered Gneiss (Grade V)	1.20	0	45	28.01	18.01	275.43	0.00	1.00	150
28.50	Greyish Brown Weathered Gneiss (Grade III)	1.50	0	45	28.13	18.13	228.23	0.00	1.00	200

Annexure - 2 (Determination of Pile Carrying Capacity as Per IS 2911:2010)

Depth (m)	Soil Description	Ultimate Frictional Capacity, kN using 'c' and 'φ' values						Ultimate Frictional Capacity, kN using 'N' values					
		q _s (kN/m ²)	450 mm	500 mm	600 mm	700 mm	900 mm	q _s (kN/m ²)	450 mm	500 mm	600 mm	700 mm	900 mm
1.00	Brown Silty Sand (SM-SP)	3.67	5.19	5.76	6.92	8.07	10.37	18.33	25.92	28.80	34.56	40.32	51.84
2.00	Brown Silty Sand (SM-SP)	9.16	12.95	14.39	17.27	20.15	25.91	30.00	42.41	47.12	56.55	65.97	84.82
3.00	Brown Silty Sand (SM-SP)	15.28	21.60	24.00	28.80	33.60	43.20	35.00	49.48	54.98	65.97	76.97	98.96
4.00	Brown Silty Sand (SM-SP)	17.57	24.84	27.60	33.12	38.65	49.69	21.67	30.63	34.03	40.84	47.65	61.26
5.00	Brown Silty Sand (SM-SP)	18.63	26.34	29.26	35.11	40.97	52.67	13.33	18.85	20.94	25.13	29.32	37.70
6.00	Greyish Brown Sand (SP)	22.04	46.75	51.94	62.33	72.72	93.49	11.67	24.74	27.49	32.99	38.48	49.48
7.50	Greyish Brown Silty Sand (SM-SP)	29.02	61.53	68.37	82.04	95.72	123.07	18.33	38.88	43.20	51.84	60.48	77.75
9.00	Greyish Silty / Clayey Sand (SC)	35.66	75.63	84.03	100.84	117.65	151.26	20.00	42.41	47.12	56.55	65.97	84.82
10.50	Greyish Silty Sand (SM-SP)	42.20	89.50	99.44	119.33	139.22	179.00	21.67	45.95	51.05	61.26	71.47	91.89
12.00	Brownish Grey Silty Sand (SM-SP)	46.14	97.84	108.71	130.45	152.19	195.68	18.33	38.88	43.20	51.84	60.48	77.75
13.50	Brownish Grey Silty / Clayey Sand (SC)	50.62	107.35	119.28	143.14	166.99	214.70	20.00	42.41	47.12	56.55	65.97	84.82
15.00	Greyish Silty / Clayey Sand (SC)	65.07	127.23	141.37	169.65	197.92	254.47	26.67	56.55	62.83	75.40	87.96	113.10
16.50	Greyish Brown Silty Sand (SM-SP)	108.20	127.23	141.37	169.65	197.92	254.47	73.33	127.23	141.37	169.65	197.92	254.47
18.00	Brown Weathered Sediments (Grade VI)	139.01	84.82	94.25	113.10	131.95	169.65	166.67	84.82	94.25	113.10	131.95	169.65
19.00	Brown Weathered Sediments (Grade VI)	156.39	169.65	188.50	226.19	263.89	339.29	166.67	169.65	188.50	226.19	263.89	339.29
21.00	Brown Weathered Sediments (Grade VI)	173.78	84.82	94.25	113.10	131.95	169.65	166.67	84.82	94.25	113.10	131.95	169.65
22.00	Brown Weathered Sediments (Grade VI)	185.36	84.82	94.25	113.10	131.95	169.65	166.67	84.82	94.25	113.10	131.95	169.65
23.00	Brown Weathered Sediments (Grade VI)	199.21	117.90	131.00	157.21	183.41	235.81	166.67	117.90	131.00	157.21	183.41	235.81
24.39	Greyish Brown Weathered Gneiss (Grade V)	227.01	127.23	141.37	169.65	197.92	254.47	250.00	127.23	141.37	169.65	197.92	254.47
25.89	Greyish Brown Weathered Gneiss (Grade V)	252.00	119.60	132.89	159.47	186.05	239.20	250.00	119.60	132.89	159.47	186.05	239.20
27.30	Greyish Brown Weathered Gneiss (Grade V)	275.43	101.79	113.10	135.72	158.34	203.58	250.00	101.79	113.10	135.72	158.34	203.58
28.50	Greyish Brown Weathered Gneiss (Grade III)	228.23	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47

Annexure - 2 (Determination of Pile Carrying Capacity as Per IS 2911:2010)

DETERMINATION OF PILE CARRYING CAPACITY AS PER IS 2911 : 2010

Borehole Location	BH 2					
Length of Pile (L), m	=	23.00	m	From Existing Borehole Level		
Angle of Internal Friction (ϕ) in Degrees	=	44.00				
Undrained cohesion value at PileTip (c_p), kN/m ²	=	0.00	kN/m ²			
Submerged Unit Weight at PileTip (γ_p), kN/m ²	=	17.90	kN/m ²			
Ground Water Table Depth (GWT), m	=	0.00	m	Submerged Condition		
Bearing Capacity Factor (N_c)	=	9.00				
Bearing Capacity Factor (N_q)	=	300.00		Taken from Figure 1 of IS 2911:2010 Part 1 Sec.2		
Bearing Capacity Factor (N_γ)	=	224.63				
Factor of Safety (FS)	=	2.50				
Diameter of Pile (D), mm	=	450	500	600	700	900
Critical Depth of Pile (20 x D), m	=	9	10	12	14	18
Effective overburden pressure at Pile Tip (P_D), kN/m ²	=	56.63	66.90	79.73	91.13	138.60
End Bearing Resisrtnce of Pile (q_p), kN/m ² using 'c' and ' ϕ '	=	17892.22	21075.24	25123.79	28744.83	43389.43
End Bearing Resisrtnce of Pile (q_p), kN/m ² using 'N' values	=	60000.00	60000.00	60000.00	60000.00	60000.00
Limiting End Bearing Resisrtnce of Pile (q_p), kN/m ²	=	10000.00	10000.00	10000.00	10000.00	10000.00
Ultimate End Bearing Capacity of Pile (Q_p), kN using 'c' and ' ϕ ' values	=	1590.43	1963.50	2827.43	3848.45	6361.73
Ultimate End Bearing Capacity of Pile (Q_p), kN using 'N' values	=	1590.43	1963.50	2827.43	3848.45	6361.73
Safe End Bearing Capacity of Pile (Q_p), kN using 'c' and ' ϕ ' values	=	636.17	785.40	1130.97	1539.38	2544.69
Safe End Bearing Capacity of Pile (Q_p), kN using 'N' values	=	636.17	785.40	1130.97	1539.38	2544.69
Ultimate Frictional Capacity of Pile (Q_p), kN using 'c' and ' ϕ ' values	=	1484.56	1649.51	1979.42	2309.32	2969.13
Ultimate Frictional Capacity of Pile (Q_p), kN using 'N' values	=	1360.70	1511.89	1814.27	2116.65	2721.40
Negative Skin Friction of Pile (Q_{nf}), kN using 'c' and ' ϕ ' values	=	11.08	12.31	14.77	17.23	22.16
Negative Skin Friction of Pile (Q_{nf}), kN using 'N' values	=	44.77	49.74	59.69	69.64	89.54
Safe Frictional Capacity of Pile (Q_p), kN using 'c' and ' ϕ ' values	=	582.75	647.50	777.00	906.50	1165.49
Safe Frictional Capacity of Pile (Q_p), kN using 'N' values	=	499.51	555.01	666.02	777.02	999.03
Self Weight of Pile (W), kN	=	91.45	112.90	162.58	221.29	365.80
Safe Pile Carrying Capacity of Pile (Q_{safe}), kN ('c' and ' ϕ ')	=	1219	1433	1908	2446	3710
Safe Pile Carrying Capacity of Pile (Q_{safe}), kN ('N' values)	=	1136	1340	1797	2316	3544
Recommended Safe Pile Carrying Capacity of Pile (Q_{safe}), kN	=	1177	1387	1852	2381	3627
Safe Uplift Capacity of Pile (Q_{up}), kN using 'c' and ' ϕ ' values	=	575	650	808	974	1333

Annexure - 2 (Determination of Pile Carrying Capacity as Per IS 2911:2010)

Depth (m)	Soil Description	H _i (m)	'c' kN/m ²	'φ'	'γ' kN/m ³	'γ _{sub} ' kN/m ³	P _{Di} (kN/m ²)	'α _i '	'K _i '	N' Value
1.00	Brown Sand (SP)	1.00	0	19	12.30	2.30	2.30	0.00	1.00	2
2.00	Brown Sand (SP)	1.00	0	19	12.30	2.30	4.60	0.00	1.00	2
3.00	Greyish Brown Silty Sand (SM-SP)	1.00	0	29	18.20	8.20	9.85	0.00	1.00	15
4.00	Brown Silty Sand (SM-SP)	1.00	0	33	19.80	9.80	18.85	0.00	1.00	23
5.00	Brown Sand (SP)	1.00	0	30	18.50	8.50	28.00	0.00	1.00	16
6.00	Greyish Brown Silty Sand (SM-SP)	1.50	0	24	15.70	5.70	36.53	0.00	1.00	7
7.50	Brownish Grey Silty Sand (SM-SP)	1.50	0	30	18.50	8.50	47.18	0.00	1.00	16
9.00	Greyish Silty / Clayey Sand (CH)	1.50	25	0	14.10	4.10	56.63	0.80	1.00	4
10.50	Brown Silty / Clayey Sand (SC)	1.50	33	30	19.60	9.60	66.90	0.30	1.00	22
12.00	Brown Silty Sand (SM-SP)	1.50	0	27	17.50	7.50	79.73	0.00	1.00	12
13.50	Brown Silty / Clayey Sand (SC)	1.50	20	25	17.70	7.70	91.13	0.30	1.00	13
15.00	Brownish Grey Silty / Clayey Sand (SC)	1.50	39	32	20.30	10.30	104.63	0.30	1.00	26
16.50	Whitish Grey Silty / Clayey Sand (SC)	1.50	53	35	21.50	11.50	120.98	0.30	1.00	35
18.00	Brown Silty Sand (SM-SP)	1.50	0	42	22.00	12.00	138.60	0.00	1.00	80
19.50	Brown Silty Sand (SM-SP)	1.50	0	42	22.00	12.00	156.60	0.00	1.00	80
21.00	Greyish Brown Weathered Gneiss (Grade V)	1.50	0	44	27.60	17.60	178.80	0.00	1.00	150
22.50	Greyish Brown Weathered Gneiss (Grade V)	1.50	0	44	27.90	17.90	205.43	0.00	1.00	150
24.00	Greyish Brown Weathered Gneiss (Grade V)	1.50	0	44	28.40	18.40	232.65	0.00	1.00	150
25.50	Greyish Brown Weathered Gneiss (Grade IV)	1.50	0	44	28.51	18.51	232.73	0.00	1.00	200

Annexure - 2 (Determination of Pile Carrying Capacity as Per IS 2911:2010)

Depth (m)	Soil Description	Ultimate Frictional Capacity, kN using 'c' and 'φ' values						Ultimate Frictional Capacity, kN using 'N' values					
		q _s (kN/m ²)	450 mm	500 mm	600 mm	700 mm	900 mm	q _s (kN/m ²)	450 mm	500 mm	600 mm	700 mm	900 mm
1.00	Brown Sand (SP)	0.79	1.12	1.24	1.49	1.74	2.24	3.33	4.71	5.24	6.28	7.33	9.42
2.00	Brown Sand (SP)	1.58	2.24	2.49	2.99	3.48	4.48	3.33	4.71	5.24	6.28	7.33	9.42
3.00	Greyish Brown Silty Sand (SM-SP)	5.46	7.72	8.58	10.29	12.01	15.44	25.00	35.34	39.27	47.12	54.98	70.69
4.00	Brown Silty Sand (SM-SP)	12.24	17.31	19.23	23.07	26.92	34.61	38.33	54.19	60.21	72.26	84.30	108.38
5.00	Brown Sand (SP)	16.17	22.85	25.39	30.47	35.55	45.71	26.67	37.70	41.89	50.27	58.64	75.40
6.00	Greyish Brown Silty Sand (SM-SP)	16.26	34.48	38.32	45.98	53.64	68.97	11.67	24.74	27.49	32.99	38.48	49.48
7.50	Brownish Grey Silty Sand (SM-SP)	27.24	57.76	64.17	77.01	89.84	115.51	26.67	56.55	62.83	75.40	87.96	113.10
9.00	Greyish Silty / Clayey Sand (CH)	20.00	42.41	47.12	56.55	65.97	84.82	20.00	42.41	47.12	56.55	65.97	84.82
10.50	Brown Silty / Clayey Sand (SC)	48.52	102.90	114.33	137.20	160.07	205.80	36.67	77.75	86.39	103.67	120.95	155.51
12.00	Brown Silty Sand (SM-SP)	40.62	86.14	95.71	114.86	134.00	172.28	20.00	42.41	47.12	56.55	65.97	84.82
13.50	Brown Silty / Clayey Sand (SC)	48.49	102.83	114.26	137.11	159.96	205.66	21.67	45.95	51.05	61.26	71.47	91.89
15.00	Brownish Grey Silty / Clayey Sand (SC)	77.08	127.23	141.37	169.65	197.92	254.47	43.33	91.89	102.10	122.52	142.94	183.78
16.50	Whitish Grey Silty / Clayey Sand (SC)	100.61	127.23	141.37	169.65	197.92	254.47	58.33	123.70	137.44	164.93	192.42	247.40
18.00	Brown Silty Sand (SM-SP)	124.80	127.23	141.37	169.65	197.92	254.47	133.33	127.23	141.37	169.65	197.92	254.47
19.50	Brown Silty Sand (SM-SP)	141.00	127.23	141.37	169.65	197.92	254.47	133.33	127.23	141.37	169.65	197.92	254.47
21.00	Greyish Brown Weathered Gneiss (Grade V)	172.67	127.23	141.37	169.65	197.92	254.47	250.00	127.23	141.37	169.65	197.92	254.47
22.50	Greyish Brown Weathered Gneiss (Grade V)	198.38	127.23	141.37	169.65	197.92	254.47	250.00	127.23	141.37	169.65	197.92	254.47
24.00	Greyish Brown Weathered Gneiss (Grade V)	224.67	127.23	141.37	169.65	197.92	254.47	250.00	127.23	141.37	169.65	197.92	254.47
25.50	Greyish Brown Weathered Gneiss (Grade IV)	224.75	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47

Annexure - 2 (Determination of Pile Carrying Capacity as Per IS 2911:2010)

DETERMINATION OF PILE CARRYING CAPACITY AS PER IS 2911 : 2010

Borehole Location	BH 3					
Length of Pile (L), m	=	23.00	m	From Existing Borehole Level		
Angle of Internal Friction (ϕ) in Degrees	=	44.00				
Undraind cohesion value at PileTip (c_p), kN/m ²	=	0.00	kN/m ²			
Submerged Unit Weight at PileTip (γ_p), kN/m ²	=	16.90	kN/m ²			
Ground Water Table Depth (GWT), m	=	0.00	m	Submerged Condition		
Bearing Capacity Factor (N_c)	=	9.00				
Bearing Capacity Factor (N_q)	=	300.00		Taken from Figure 1 of IS 2911:2010 Part 1 Sec.2		
Bearing Capacity Factor (N_γ)	=	224.63				
Factor of Safety (FS)	=	2.50				
Diameter of Pile (D), mm	=	450	500	600	700	900
Critical Depth of Pile (20 x D), m	=	9	10	12	14	18
Effective overburden pressure at Pile Tip (P_D), kN/m ²	=	57.98	70.50	85.35	100.65	149.70
End Bearing Resisrtnce of Pile (q_p), kN/m ² using 'c' and ' ϕ '	=	18246.67	22099.08	26743.90	31523.71	46618.35
End Bearing Resisrtnce of Pile (q_p), kN/m ² using 'N' values	=	60000.00	60000.00	60000.00	60000.00	60000.00
Limiting End Bearing Resisrtnce of Pile (q_p), kN/m ²	=	10000.00	10000.00	10000.00	10000.00	10000.00
Ultimate End Bearing Capacity of Pile (Q_p), kN using 'c' and ' ϕ ' values	=	1590.43	1963.50	2827.43	3848.45	6361.73
Ultimate End Bearing Capacity of Pile (Q_p), kN using 'N' values	=	1590.43	1963.50	2827.43	3848.45	6361.73
Safe End Bearing Capacity of Pile (Q_p), kN using 'c' and ' ϕ ' values	=	636.17	785.40	1130.97	1539.38	2544.69
Safe End Bearing Capacity of Pile (Q_p), kN using 'N' values	=	636.17	785.40	1130.97	1539.38	2544.69
Ultimate Frictional Capacity of Pile (Q_p), kN using 'c' and ' ϕ ' values	=	1457.22	1619.14	1942.96	2266.79	2914.44
Ultimate Frictional Capacity of Pile (Q_p), kN using 'N' values	=	1332.43	1480.48	1776.57	2072.67	2664.86
Negative Skin Friction of Pile (Q_{nf}), kN using 'c' and ' ϕ ' values	=	17.14	19.04	22.85	26.66	34.28
Negative Skin Friction of Pile (Q_{nf}), kN using 'N' values	=	63.62	70.69	84.82	98.96	127.23
Safe Frictional Capacity of Pile (Q_p), kN using 'c' and ' ϕ ' values	=	565.75	628.61	754.33	880.06	1131.50
Safe Frictional Capacity of Pile (Q_p), kN using 'N' values	=	469.35	521.50	625.81	730.11	938.71
Self Weight of Pile (W), kN	=	91.45	112.90	162.58	221.29	365.80
Safe Pile Carrying Capacity of Pile (Q_{safe}), kN ('c' and ' ϕ ')	=	1202	1414	1885	2419	3676
Safe Pile Carrying Capacity of Pile (Q_{safe}), kN ('N' values)	=	1106	1307	1757	2269	3483
Recommended Safe Pile Carrying Capacity of Pile (Q_{safe}), kN	=	1154	1360	1821	2344	3580
Safe Uplift Capacity of Pile (Q_{up}), kN using 'c' and ' ϕ ' values	=	560	634	787	950	1303

Annexure - 2 (Determination of Pile Carrying Capacity as Per IS 2911:2010)

Depth (m)	Soil Description	H _i (m)	'c' kN/m ²	'φ'	'γ' kN/m ³	'γ _{sub} ' kN/m ³	P _{Di} (kN/m ²)	'α _i '	'K _i '	N' Value
1.00	Brown Silty Sand (SM-SP)	1.00	0	18	12.30	2.30	2.30	0.00	1.00	2
2.00	Brown Silty Sand (SM-SP)	1.00	0	26	16.90	6.90	6.90	0.00	1.00	10
3.00	Brown Silty Sand (SM-SP)	1.00	0	29	18.20	8.20	14.45	0.00	1.00	15
4.00	Brown Sand (SP)	1.00	0	28	17.50	7.50	22.30	0.00	1.00	12
5.00	Greyish Silty / Clayey Sand (SC)	1.00	14	22	16.50	6.50	29.30	0.30	1.00	9
6.00	Greyish Silty / Clayey Sand (SC)	1.50	9	20	15.30	5.30	36.53	0.30	1.00	6
7.50	Brownish Grey Silty Sand (SM-SP)	1.50	0	29	18.20	8.20	46.65	0.00	1.00	15
9.00	Greyish Silty / Clayey Sand (CH)	1.50	63	0	16.90	6.90	57.98	0.65	1.00	10
10.50	Greyish Brown Silty Sand (SM-SP)	1.50	0	33	19.80	9.80	70.50	0.00	1.00	23
12.00	Greyish Silty / Clayey Sand (SC)	1.50	36	31	20.00	10.00	85.35	0.30	1.00	24
13.50	Brownish Grey Silty / Clayey Sand (SC)	1.50	41	32	20.40	10.40	100.65	0.30	1.00	27
15.00	Brownish Grey Silty / Clayey Sand (SC)	1.50	42	33	20.60	10.60	116.40	0.30	1.00	28
16.50	Brownish Grey Silty / Clayey Sand (SC)	1.50	45	33	20.90	10.90	132.53	0.30	1.00	30
18.00	Brown Silty Sand (SM-SP)	1.50	0	42	22.00	12.00	149.70	0.00	1.00	80
19.50	Greyish Brown Weathered Gneiss (Grade V)	1.50	0	44	26.60	16.60	171.15	0.00	1.00	150
21.00	Greyish Brown Weathered Gneiss (Grade V)	1.50	0	44	26.70	16.70	196.13	0.00	1.00	150
22.50	Greyish Brown Weathered Gneiss (Grade V)	1.50	0	44	26.90	16.90	221.33	0.00	1.00	150
24.00	Brownish Grey Weathered Gneiss (Grade III)	1.50	0	44	27.16	17.16	196.47	0.00	1.00	200

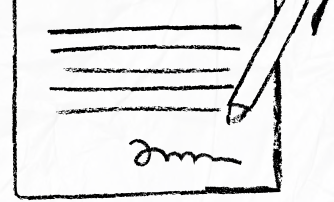
Annexure - 2 (Determination of Pile Carrying Capacity as Per IS 2911:2010)

Depth (m)	Soil Description	Ultimate Frictional Capacity, kN using 'c' and 'φ' values						Ultimate Frictional Capacity, kN using 'N' values					
		q _s (kN/m ²)	450 mm	500 mm	600 mm	700 mm	900 mm	q _s (kN/m ²)	450 mm	500 mm	600 mm	700 mm	900 mm
1.00	Brown Silty Sand (SM-SP)	0.75	1.06	1.17	1.41	1.64	2.11	3.33	4.71	5.24	6.28	7.33	9.42
2.00	Brown Silty Sand (SM-SP)	3.37	4.76	5.29	6.34	7.40	9.52	16.67	23.56	26.18	31.42	36.65	47.12
3.00	Brown Silty Sand (SM-SP)	8.01	11.32	12.58	15.10	17.61	22.65	25.00	35.34	39.27	47.12	54.98	70.69
4.00	Brown Sand (SP)	11.86	16.76	18.63	22.35	26.08	33.53	20.00	28.27	31.42	37.70	43.98	56.55
5.00	Greyish Silty / Clayey Sand (SC)	16.04	22.67	25.19	30.23	35.27	45.35	15.00	21.21	23.56	28.27	32.99	42.41
6.00	Greyish Silty / Clayey Sand (SC)	15.99	33.92	37.69	45.22	52.76	67.83	10.00	21.21	23.56	28.27	32.99	42.41
7.50	Brownish Grey Silty Sand (SM-SP)	25.86	54.83	60.93	73.11	85.30	109.67	25.00	53.01	58.90	70.69	82.47	106.03
9.00	Greyish Silty / Clayey Sand (CH)	40.95	86.84	96.49	115.78	135.08	173.68	50.00	106.03	117.81	141.37	164.93	212.06
10.50	Greyish Brown Silty Sand (SM-SP)	45.78	97.09	107.87	129.45	151.02	194.17	38.33	81.29	90.32	108.38	126.45	162.58
12.00	Greyish Silty / Clayey Sand (SC)	62.08	127.23	141.37	169.65	197.92	254.47	40.00	84.82	94.25	113.10	131.95	169.65
13.50	Brownish Grey Silty / Clayey Sand (SC)	75.19	127.23	141.37	169.65	197.92	254.47	45.00	95.43	106.03	127.23	148.44	190.85
15.00	Brownish Grey Silty / Clayey Sand (SC)	88.19	127.23	141.37	169.65	197.92	254.47	46.67	98.96	109.96	131.95	153.94	197.92
16.50	Brownish Grey Silty / Clayey Sand (SC)	99.56	127.23	141.37	169.65	197.92	254.47	50.00	106.03	117.81	141.37	164.93	212.06
18.00	Brown Silty Sand (SM-SP)	134.79	127.23	141.37	169.65	197.92	254.47	133.33	127.23	141.37	169.65	197.92	254.47
19.50	Greyish Brown Weathered Gneiss (Grade V)	165.28	127.23	141.37	169.65	197.92	254.47	250.00	127.23	141.37	169.65	197.92	254.47
21.00	Greyish Brown Weathered Gneiss (Grade V)	189.40	127.23	141.37	169.65	197.92	254.47	250.00	127.23	141.37	169.65	197.92	254.47
22.50	Greyish Brown Weathered Gneiss (Grade V)	213.73	127.23	141.37	169.65	197.92	254.47	250.00	127.23	141.37	169.65	197.92	254.47
24.00	Brownish Grey Weathered Gneiss (Grade III)	189.73	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47

Annexure - 2 (Determination of Pile Carrying Capacity as Per IS 2911:2010)

DETERMINATION OF LATERAL PILE CARRYING CAPACITY AS PER IS 2911 : 2010

Length of Pile (L), m	=	24.00 m	From Existing Borehole Level				
Type of Fixity	=	Fixed Head by Pile Cap					
Cantilever Length above Ground Level (e), m	=	0.00 m	Point of application of Lateral Load (Assumed)				
Allowable Deflection as per IS 2911 Part 4 : 1985, Page No. 10 in mm	=	5.00 mm					
Modulus of Subgrade Reaction of Soil (η_h)	=	1200.00 kN/m ³	From Table 3 of IS 2911 Part 1 Sec. 2				
Grade of Concrete	=	30.00 N/mm ²	M 30				
Young's Modulus of Pile Material (E), kN/m ²	=	27386127.88 kN/m ²					
Diameter of Pile (D), mm	=	450	500	600	700	900	
Moment of Inertia of Pile Section (I), m ⁴	=	0.00201	0.00307	0.00636	0.01179	0.03221	
Stiffness Factor, (T)	=	2.15	2.34	2.71	3.06	3.74	
Criteria for Behaviour of Pile as per Table 5 of IS 2911 Part I Sec. 2	=	Long Pile	Long Pile	Long Pile	Long Pile	Long Pile	
(e/R)	=	0.00	0.00	0.00	0.00	0.00	
(Z _f /T) from Fig.4 of IS 2911 Part 1 Sec.2	=	1.90	1.90	1.90	1.90	1.90	
Depth of Fixity (Z _f), m	=	4.09	4.44	5.14	5.82	7.11	
Allowable Deflection as per IS 2911 Part 4 : 1985, Page No. 10 in mm	=	5.00	5.00	5.00	5.00	5.00	
Lateral Load Capacity of Pile (H), kN	=	48.30	57.60	77.00	98.20	147.20	



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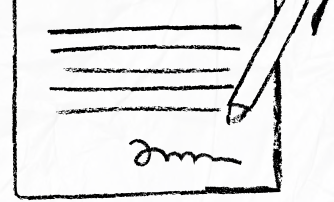
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