



Your trusted partner for buying, selling, and managing property,
ensuring hassle-free service with 100% transparency.

3/350/2 Mettukuppam,
OMR Thoraipakkam,
Chennai, India

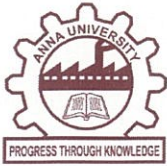
hello@verified.realestate

+91 9996 12 9996

Official Property Record

Digitally Verified Record - Powered by Verified  RealEstate™





DIVISION OF SOIL MECHANICS AND FOUNDATION ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING
College of Engineering Guindy Campus
Anna University, Chennai 600 025



Ph: 044-2235 7549 / 7543

SOIL INVESTIGATION REPORT

NAME OF WORK : **RECOMMENDATION OF FOUNDATION FOR THE
PROPOSED RECONSTRUCTION OF TENEMENTS AT
BARUVA NAGAR, ZONE IX, DIVISION V, GREATER
CHENNAI CORPORATION.**

CLIENT : **The Executive Engineer,**
Division – V,
Tamil Nadu Urban Habitat Development Board,
No. 5, Kamarajar Salai,
Chennai – 600 005.

Reference : The Executive Engineer, TNUHDB, Chennai, Lr. No.
UHDB/368/Dn.V/2022 Dated 07.04.2022

JOB No : SM&FE 226 / Consultancy / 2022

DATE : 21st June 2022



DIVISION OF SOIL MECHANICS AND FOUNDATION ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING
College of Engineering Guindy Campus
Anna University, Chennai 600 025



Ph: 044-2235 7549 / 7543

Dr. M. MUTTHARAM, M.E., Ph.D.
Professor & Head

Dr. V.K. STALIN, M.E., Ph.D.
Professor

**RECOMMENDATION OF FOUNDATION FOR THE RECONSTRUCTION OF TENEMENTS AT
BARUVA NAGAR IN ZONE IX, DIVISION V, GREATER CHENNAI CORPORATION.**

Job. No. SM&FE 226 / Consultancy / 2022

Date: 21.06.2022

CLIENT:

The Executive Engineer,

Division - V, Tamil Nadu Urban Habitat Development Board,
No.5, Kamarajar Salai,
Chennai – 600 005.

Reference : The Executive Engineer, TNUHDB, Chennai, Lr. No. UHDB/368/Dn.V/2022
Dated 07.04.2022.

1. INTRODUCTION

The Tamil Nadu Urban Habitat Development Board (TNUHDB), Division – V, No. 5, Kamarajar Salai, Chennai – 600 005 has proposed to reconstruct Tenements at Baruva Nagar in Division V, TNUHDB, Chennai. The officials of TNUHDB, Division – V, TNUHDB, No. 5, Kamarajar Salai, Chennai – 600 005 have approached the 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 construction site and to recommend the most suitable foundation system for the reconstruction of Tenements at Baruva Nagar in Division V, TNUHDB, Chennai. Accordingly, the work was taken up and field investigation was carried out by M/s VRR Engineering Consultancy, Chennai – 91 during 30th April to 09th May 2022 under the supervision of Professor of Division of Soil Mechanics and Foundation Engineering, Department of Civil Engineering, Anna University, Chennai - 25 in the presence of Officials of Division – V, TNUHDB, No. 5, Kamarajar Salai, Chennai – 600 005. 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 Baruva Nagar in Division V, TNUHDB, Chennai. 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 TNUHDB, Division – V, No. 5, Kamarajar Salai, Chennai – 600 005 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 Appendix – C).

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 Appendix – C).

3.1 Summary of Soil Profile in BH 1 to BH 4 Locations

1. Made up Soil was found in top 1.0 m depth in BH-2, BH-3 & BH-4 locations.
2. Silty Clay was encountered in top 7.5 m depth in all the four borehole locations with SPT 'N' value varying from 1 to 17.
3. Brown Sand / Silty Sand was observed from 9.0 m to 12.0 m depth in all four bore hole locations with SPT 'N' value varying from 4 to 14.
4. Silty / Clayey Sand was found from 13.5 m to 19.5 m depth in all four bore hole locations with SPT 'N' value varying from 4 to 43.
5. Yellowish Brown Shale with Sandstone was observed from 21.0 m to 24.0 m depth in all borehole location SPT 'N' values of >100.
6. The ground water table was observed from 1.5 m to 2.0 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.

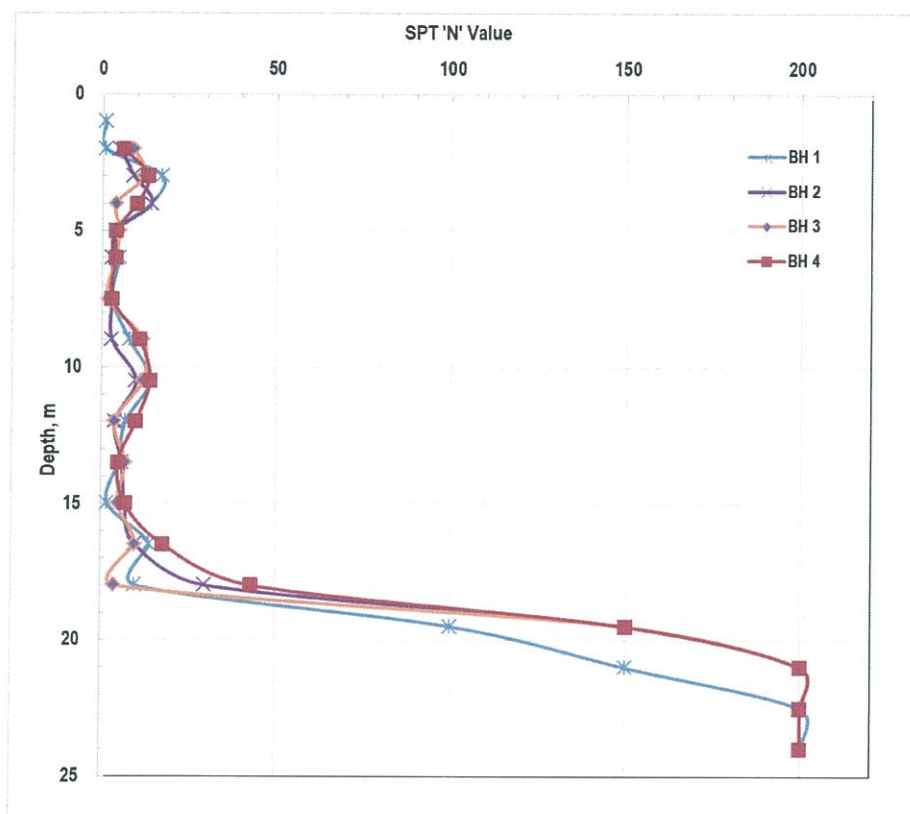


Figure (1) Variation of SPT 'N' value of different soil layers with respect to depth in Different Borehole Locations of the Site

5.0 COMPUTATION OF SAFE PILE CARRYING CAPACITY

By considering high intensity of loads of the proposed structure, provision of shallow foundation system may not be feasible, 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 24.0 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 23.0 m to 24.0 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.

TABLE 1 Safe Load carrying capacity of Bored Cast-In-Situ Pile of 23.0 to 24.0 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	913	1093	1500	1970	3098	879	1055	1455	1917	3031
BH 2	894	1072	1475	1941	3061	913	1093	1500	1970	3099
BH 3	800	967	1349	1794	2872	875	1051	1450	1911	3023
BH 4	931	1113	1525	1999	3135	902	1081	1485	1953	3076

TABLE 2 Safe Uplift Capacity of 23.0 to 24.0 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	306	351	448	555	794
BH 2	284	327	420	521	752
BH 3	199	232	306	388	580
BH 4	321	368	468	578	824

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.

7. CONCLUSIONS AND RECOMMENDATIONS

Based on the discussions made in sections 3, 4, 5 and 6, the following recommendations are furnished for the reconstruction of Tenements at Baruva Nagar in Division V, TNUHDB, Chennai.

- 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 24.0 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 24.0 m in Yellowish Brown Shale with Sand Stone Stratum.

Total piles: 314
37

(10%)

BH1 - 24
BH2 - 22.5
BH3 - 22.5
BH4 - 24

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 24.0 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	800	48.30	4.09
500	950	57.60	4.44
600	1300	77.00	5.14
700	1900	98.20	5.82
900	2800	147.20	7.11

- 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.

M. Muttharam 21/6/22

Dr. M. MUTTHARAM

Professor & Head,
Division of Soil Mechanics &
Foundation Engg.,
Department of Civil Engineering,
CEG Campus,
Anna University, Chennai-25

V. K. Stalin 21/6/22

Dr. V. K. STALIN

Professor,
Division of Soil Mechanics &
Foundation Engg.,
Department of Civil Engineering,
CEG Campus,
Anna University, Chennai-25

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.

LOCATION OF BOREHOLES

Legend

BH





IN-SITU GEOTECHNICAL BORE LOG

BORE-HOLE No.

BH 01

SHEET No.

(1/2)



Project: Geotechnical Investigation for the Reconstruction of Tenements at Baruva Nagar in Zone IX, Division V, Greater Chennai Corporation.

Co-ordinates: N - 1441087; E - 418649

Started: 30-04-2022

Location: Barva Nagar

Completed: 03-05-2022

Elevation (RL): -

Ground Water Level: 1.5 m

Dia of Boring: Px Size in Soil & Nx Size in Rock

Type of Core Barrel: Nx Size Core Barrel

Casing Depth: -

Water Loss Depths : -

Type of Boring: Rotary – Auto Trip SPT

Total Drill Depth: 24.0 m (21.0 m - Soil and 3.0 m - Rock)

Depth from EGL (m)	Log	Lithology	Description / Classification of Soil and Rock / Weathering Grade of Rock as per IS 4464 / Special Observations and Interpretations	Standard Penetration Test (SPT) / UDS / Core Drilling						Relative Density / Consistency of Soil / Strength of Rock
				0-15 cm	15-30 cm	30-45 cm	SPT-N	TCR (%)	RQD (%)	
								0 30 60 90 120 150		
1.0	1.0		Black Gravelly Sand (GP)	0	0	1	1			Loose
2.0	2.0		Black Silty / Clayey Sand (CL)	0	0	1	1			Very Soft
3.0	3.0		Brownish Grey Silty / Clayey Sand (CL)	4	7	10	17			Very Stiff
4.0	4.0		Brownish Grey Silty / Clayey Sand (CL)	5	7	7	14			Stiff
5.0	5.0		Black Silty / Clayey Sand (CI)	2	2	2	4			Soft
6.0	6.0		Black Silty / Clayey Sand (CI)	2	2	3	5			Medium Stiff
7.5	7.0		Black Silty / Clayey Sand (CH)	1	1	2	3			Soft
9.0	8.0		Black Silty / Clayey Sand (SC)	2	3	5	8			Loose
10.5	9.0		Greyish Sand (SP)	11	8	6	14			Medium Dense
12.0	11.0		Black Silty Sand (SM-SP)	3	3	4	7			Loose
13.5	12.0		Blackish Grey Silty / Clayey Sand (SC)	2	2	3	5			Loose
15.0	13.0		Black Silty Clay (CH)	1	1	1	2			Very Soft
16.5	14.0		Brownish Grey Silty / Clayey Sand (SC)	8	8	6	14			Medium Dense



IN-SITU GEOTECHNICAL BORE LOG

BORE-HOLE No.

BH 01

SHEET No.

(2/2)

Project: Geotechnical Investigation for the Reconstruction of Tenements at Baruva Nagar in Zone IX, Division V, Greater Chennai Corporation.

Co-ordinates: N - 1441087; E - 418649

Started: 30-04-2022

Location: Barva Nagar

Completed: 03-05-2022

Elevation (RL): -

Ground Water Level: 1.5 m

Dia of Boring: Px Size in Soil & Nx Size in Rock

Type of Core Barrel: Nx Size Core Barrel

Casing Depth: -

Water Loss Depths : -

Type of Boring: Rotary – Auto Trip SPT

Total Drill Depth: 24.0 m (21.0 m - Soil and 3.0 m - Rock)

Depth from EGL (m)	Log	Lithology	Description / Classification of Soil and Rock / Weathering Grade of Rock as per IS 4464 / Special Observations and Interpretations	Standard Penetration Test (SPT) / UDS / Core Drilling						Relative Density / Consistency of Soil / Strength of Rock
				0-15 cm	15-30 cm	30-45 cm	SPT-N	TCR (%)	RQD (%)	
0 30 60 90 120 150										
17.0										
18.0			Brownish Grey Silty / Clayey Sand (SC)	5	4	6	10			Loose
19.5			Greyish Brown Silty / Clayey Sand (SC)	35	55 (12 cm) Rebound		>100			Very Dense
21.0			Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V / VI)	55 (1 cm) Rebound			>100			Hard / Very Weak
22.5			Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)					43.3	0.0	Hard / Weak
24.0			Yellowish Brown, Shale with Sandstone, Moderately Weathered (Grade IV)					67.3	15.0	Moderately Weak



IN-SITU GEOTECHNICAL BORE LOG

BORE-HOLE No.

BH 02

SHEET No.

(1/2)

Project: Geotechnical Investigation for the Reconstruction of Tenements at Baruva Nagar in Zone IX, Division V, Greater Chennai Corporation.

Co-ordinates: N - 1441146; E - 418653

Started: 03-05-2022

Location: Barva Nagar

Completed: 08-05-2022

Elevation (RL): -

Ground Water Level: 2.0 m

Dia of Boring: Px Size in Soil & Nx Size in Rock

Type of Core Barrel: Nx Size Core Barrel

Casing Depth: -

Water Loss Depths : -

Type of Boring: Rotary – Auto Trip SPT

Total Drill Depth: 22.5 m (19.5 m - Soil and 3.0 m - Rock)

Depth from EGL (m)	Log	Lithology	Description / Classification of Soil and Rock / Weathering Grade of Rock as per IS 4464 / Special Observations and Interpretations	Standard Penetration Test (SPT) / UDS / Core Drilling						Relative Density / Consistency of Soil / Strength of Rock
				0-15 cm	15-30 cm	30-45 cm	SPT-N	TCR (%)	RQD (%)	
								0 30 60 90 120 150		
1.0	1.0		Disturbed Sample	-	-	-	-			Very Loose
2.0	2.0		Greyish Silty / Clayey Sand (CL)	2	2	3	5			Medium Stiff
3.0	3.0		Greyish Silty / Clayey Sand (CL)	4	4	5	9			Stiff
4.0	4.0		Greyish Black Silty Clay (CL)	5	6	8	14			Stiff
5.0	5.0		Black Silty Clay (CH)	3	2	2	4			Soft
6.0	6.0		Black Silty Clay (CH)	2	2	1	3			Soft
7.5	7.0		Black Silty Clay (CH)	2	1	2	3			Soft
9.0	8.0		Black Silty / Clayey Sand (SC-SM)	1	1	2	3			Loose
10.5	9.0		Greyish Silty Sand (SM-SP)	10	5	5	10			Loose
12.0	10.0		Greyish Silty Sand (SM-SP)	5	2	2	4			Loose
13.5	11.0		Black Silty Clay (CH)	2	3	3	6			Medium Stiff
15.0	12.0		Black Silty Clay (CH)	2	2	5	7			Medium Stiff
16.5	13.0		Black Silty / Clayey Sand (SC)	6	5	5	10			Loose



IN-SITU GEOTECHNICAL BORE LOG

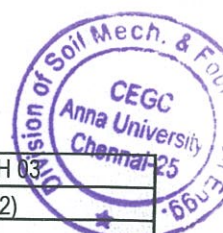
BORE-HOLE No. BH 02
SHEET No. (2/2)

Project:		Geotechnical Investigation for the Reconstruction of Tenements at Baruva Nagar in Zone IX, Division V, Greater Chennai Corporation.									
Co-ordinates:		N - 1441146; E - 418653				Started:		03-05-2022			
Location:		Barva Nagar				Completed:		08-05-2022			
Elevation (RL):		-				Ground Water Level:		2.0 m			
Dia of Boring:		Px Size in Soil & Nx Size in Rock				Type of Core Barrel:		Nx Size Core Barrel			
Casing Depth:		-				Water Loss Depths :		-			
Type of Boring:		Rotary – Auto Trip SPT				Total Drill Depth:		22.5 m (19.5 m - Soil and 3.0 m - Rock)			
Depth from EGL (m)	Log	Lithology	Description / Classification of Soil and Rock / Weathering Grade of Rock as per IS 4464 / Special Observations and Interpretations	Standard Penetration Test (SPT) / UDS / Core Drilling						Relative Density / Consistency of Soil / Strength of Rock	
				0-15 cm	15-30 cm	30-45 cm	SPT-N	TCR (%)	RQD (%)		
0 30 60 90 120 150											
17.0											
18.0			Brownish Grey Silty / Clayey Sand (SC)	8	11	19	30			Medium Dense	
19.5			Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V / VI)	55 (1 cm) Rebound			>100			Very Dense	
20.0											
21.0			Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)					13.0	0.0	Hard / Weak	
22.5								50.0	0.0	Hard / Weak	



IN-SITU GEOTECHNICAL BORE LOG

BORE-HOLE No.	BH 03
SHEET No.	(1/2)



Project: Geotechnical Investigation for the Reconstruction of Tenements at Baruva Nagar in Zone IX, Division V, Greater Chennai Corporation.

Co-ordinates: N - 1441098; E - 418654

Started: 05-05-2022

Location: Barva Nagar

Completed: 07-05-2022

Elevation (RL): -

Ground Water Level: 1.5 m

Dia of Boring: Px Size in Soil & Nx Size in Rock

Type of Core Barrel: Nx Size Core Barrel

Casing Depth: -

Water Loss Depths : -

Type of Boring: Rotary – Auto Trip SPT

Total Drill Depth: 22.5 m (19.5 m - Soil and 3.0 m - Rock)

Depth from EGL (m)	Log	Lithology	Description / Classification of Soil and Rock / Weathering Grade of Rock as per IS 4464 / Special Observations and Interpretations	Standard Penetration Test (SPT) / UDS / Core Drilling						Relative Density / Consistency of Soil / Strength of Rock
				0-15 cm	15-30 cm	30-45 cm	SPT-N	TCR (%)	RQD (%)	
								0 30 60 90 120 150		
1.0	1.0		Disturbed Sample	-	-	-	-			Very Loose
2.0	2.0		Brownish Grey Silty Clay (CL)	1	4	5	9			Stiff
3.0	3.0		Brownish Grey Silty Sand (SM-SP)	4	6	6	12			Medium Dense
4.0	4.0		Black Silty Clay (CI)	2	2	2	4			Soft
5.0	5.0		Black Silty / Clayey Sand (CL)	2	2	3	5			Medium Stiff
6.0	6.0		Black Silty Clay (CI)	1	2	2	4			Soft
7.5	7.0		Greyish Silty Clay (CI)	1	1	1	2			Very Soft
9.0	8.0		Greyish Silty Sand (SM-SP)	4	5	7	12			Medium Dense
10.5	9.0		Greyish Silty Sand (SM-SP)	5	5	7	12			Medium Dense
12.0	11.0		Greyish Silty Sand (SM-SP)	1	2	2	4			Loose
13.5	12.0		Greyish Silty / Clayey Sand (CH)	3	3	4	7			Medium Stiff
15.0	13.0		Greyish Silty Clay (CH)	2	2	3	5			Medium Stiff
16.5	14.0		Greyish Silty / Clayey Sand (SC)	4	4	6	10			Loose



IN-SITU GEOTECHNICAL BORE LOG

BORE-HOLE No.

BH 03

SHEET No.

(2/2)



Project: Geotechnical Investigation for the Reconstruction of Tenements at Baruva Nagar in Zone IX, Division V, Greater Chennai Corporation.

Co-ordinates: N - 1441098; E - 418654

Started: 05-05-2022

Location: Barva Nagar

Completed: 07-05-2022

Elevation (RL): -

Ground Water Level: 1.5 m

Dia of Boring: Px Size in Soil & Nx Size in Rock

Type of Core Barrel: Nx Size Core Barrel

Casing Depth: -

Water Loss Depths : -

Type of Boring: Rotary – Auto Trip SPT

Total Drill Depth: 22.5 m (19.5 m - Soil and 3.0 m - Rock)

Depth from EGL (m)	Log	Lithology	Description / Classification of Soil and Rock / Weathering Grade of Rock as per IS 4464 / Special Observations and Interpretations	Standard Penetration Test (SPT) / UDS / Core Drilling						Relative Density / Consistency of Soil / Strength of Rock
				0-15 cm	15-30 cm	30-45 cm	SPT-N	TCR (%)	RQD (%)	
								0 30 60 90 120 150		
17.0										
18.0			Greyish Silty / Clayey Sand (SC)	1	2	2	4			Loose
19.5			Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V / VI)	55 (2 cm) Rebound			>100			Hard / Very Weak
21.0			Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)					14.0	0.0	Hard / Weak
22.5								34.0	0.0	Hard / Weak



IN-SITU GEOTECHNICAL BORE LOG

BORE-HOLE No.

BH-04

SHEET No.

(1/2)



Project: Geotechnical Investigation for the Reconstruction of Tenements at Baruva Nagar in Zone IX, Division V, Greater Chennai Corporation.

Co-ordinates: N - 1441119; E - 418660

Started: 08-05-2022

Location: Barva Nagar

Completed: 09-05-2022

Elevation (RL): -

Ground Water Level: 1.5 m

Dia of Boring: Px Size in Soil & Nx Size in Rock

Type of Core Barrel: Nx Size Core Barrel

Casing Depth: -

Water Loss Depths : -

Type of Boring: Rotary – Auto Trip SPT

Total Drill Depth: 24.0 m (19.5 m - Soil and 4.5 m - Rock)

Depth from EGL (m)	Log	Lithology	Description / Classification of Soil and Rock / Weathering Grade of Rock as per IS 4464 / Special Observations and Interpretations	Standard Penetration Test (SPT) / UDS / Core Drilling						Relative Density / Consistency of Soil / Strength of Rock
				0-15 cm	15-30 cm	30-45 cm	SPT-N	TCR (%)	RQD (%)	
								0 30 60 90 120 150		
1.0	1.0		Disturbed Sample	-	-	-	-			Very Loose
2.0	2.0		Greyish Silty / Clayey Sand (SC)	3	3	3	6			Loose
3.0	3.0		Greyish Silty / Clayey Sand (CI)	4	6	7	13			Stiff
4.0	4.0		Brown Silty / Clayey Sand (SC-SM)	4	4	6	10			Medium Dense
5.0	5.0		Black Silty Clay (CH)	2	2	2	4			Soft
6.0	6.0		Black Silty / Clayey Sand (CI)	2	2	2	4			Soft
7.5	7.0		Greyish Black Silty / Clayey Sand (CH)	2	2	1	3			Soft
9.0	9.0		Greyish Black Silty / Clayey Sand (SC)	3	4	7	11			Medium Dense
10.5	10.0		Greyish Black Silty Sand (SM-SP)	4	6	8	14			Medium Dense
12.0	12.0		Greyish Silty Sand (SM-SP)	3	4	6	10			Loose
13.5	13.0		Black Silty / Clayey Sand (SC)	4	3	2	5			Loose
15.0	15.0		Black Silty Clay (CH)	4	3	4	7			Medium Stiff
16.5	16.0		Black Silty / Clayey Sand (SC-SM)	6	8	10	18			Medium Dense

IN-SITU GEOTECHNICAL BORE LOG



Annexure - A-2
Laboratory Test Results

Table A-1

Project : Geotechnical Investigation for the Reconstruction of Tenements at Baruva Nagar in Zone IX, Division V, Greater Chennai Corporation.

BH No: 1		LABORATORY TEST RESULTS										Ground Water Table Depth (m): 1.5				
Depth (m)	SPT 'N' Value	Soil Description / Classification	Index Properties						Specific Gravity	Grain Size Analysis (%)					Direct Shear / Terzaghi and Peck (1974) - Shear Strength Parameters	
			Natural Moisture Content / Water Absorption %	Bulk Density (kN/m ³)	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Free Swell Index		Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines Silt & Clay	Cohesion (c), kN/m ²	Angle of Friction (Φ) in Degrees
1.0	1	Black Gravelly Sand (GP)	46	12.2	NP	NP	NP	NP	2.64	50	7	11	12	20	0	17
2.0	1	Black Silty / Clayey Sand (CL)	69	12.2	24	18	6	20	2.62	0	14	14	13	59	6	0
3.0	17	Brownish Grey Silty / Clayey Sand (CL)	31	16.8	34	19	15	20	2.63	0	0	3	22	75	106	0
4.0	14	Brownish Grey Silty / Clayey Sand (CL)	28	16.2	27	18	9	20	2.62	0	0	0	37	63	88	0
5.0	4	Black Silty / Clayey Sand (CI)	34	12.7	40	20	20	25	2.61	0	0	9	26	65	25	0
6.0	5	Black Silty / Clayey Sand (CI)	42	13.2	41	20	21	25	2.62	0	0	8	27	65	31	0
7.5	3	Black Silty / Clayey Sand (CH)	54	12.6	45	22	23	25	2.63	0	1	8	21	70	19	0
9.0	8	Black Silty / Clayey Sand (SC)	34	14.5	31	19	12	15	2.64	0	0	14	47	39	12	22
10.5	14	Greyish Sand (SP)	16	16.2	NP	NP	NP	NP	2.63	0	0	33	58	9	0	30
12.0	7	Black Silty Sand (SM-SP)	23	14.1	NP	NP	NP	NP	2.64	0	10	19	52	19	0	24
13.5	5	Blackish Grey Silty / Clayey Sand (SC)	27	13.2	37	19	18	50	2.65	0	1	14	49	36	8	19
15.0	2	Black Silty Clay (CH)	51	12.4	59	31	28	60	2.60	0	0	1	3	96	13	0
16.5	14	Brownish Grey Silty / Clayey Sand (SC)	20	16.2	39	21	18	20	2.65	0	7	34	24	35	21	26
18.0	10	Brownish Grey Silty / Clayey Sand (SC)	18	15.1	37	21	16	20	2.65	0	18	36	21	25	15	23
19.5	>100	Greyish Brown Silty / Clayey Sand (SC)	17	22.0	38	21	17	20	2.66	15	10	32	17	26	90	40
								</								

Table A-2

Project : Geotechnical Investigation for the Reconstruction of Tenements at Baruva Nagar in Zone IX, Division V, Greater Chennai Corporation.

BH No: 2		LABORATORY TEST RESULTS										Ground Water Table Depth (m): 2.0				
Depth (m)	SPT 'N' Value	Soil Description / Classification	Index Properties						Specific Gravity	Grain Size Analysis (%)					Direct Shear / Terzaghi and Peck (1974) - Shear Strength Parameters	
			Natural Moisture Content / Water Absorption %	Bulk Density (kN/m ³)	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Free Swell Index		Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines Silt & Clay	Cohesion (c), kN/m ²	Angle of Friction (Φ) in Degrees
2.0	5	Greyish Silty / Clayey Sand (CL)	25	12.2	29	18	11	15	2.60	0	0	1	44	55	31	0
3.0	9	Greyish Silty / Clayey Sand (CL)	32	14.8	33	19	14	20	2.61	0	0	0	30	70	56	0
4.0	14	Greyish Black Silty Clay (CL)	40	16.2	34	20	14	20	2.61	0	0	2	25	73	88	0
5.0	4	Black Silty Clay (CH)	52	12.7	56	30	26	15	2.60	0	0	1	6	93	25	0
6.0	3	Black Silty Clay (CH)	47	12.6	55	27	28	25	2.62	0	0	5	15	80	19	0
7.5	3	Black Silty Clay (CH)	51	12.6	53	25	28	70	2.60	0	4	5	14	77	19	0
9.0	3	Black Silty / Clayey Sand (SC-SM)	31	12.6	26	16	10	10	2.66	0	0	20	57	23	3	18
10.5	10	Greyish Silty Sand (SM-SP)	17	15.1	NP	NP	NP	NP	2.64	0	1	34	54	11	0	26
12.0	4	Greyish Silty Sand (SM-SP)	18	12.7	NP	NP	NP	NP	2.65	0	1	24	64	11	0	21
13.5	6	Black Silty Clay (CH)	43	13.7	53	25	28	55	2.60	0	1	6	22	71	38	0
15.0	7	Black Silty Clay (CH)	39	14.1	56	27	29	60	2.61	0	1	7	18	74	44	0
16.5	10	Black Silty / Clayey Sand (SC)	36	15.1	38	19	19	25	2.65	0	4	22	37	37	15	23
18.0	30	Brownish Grey Silty / Clayey Sand (SC)	17	18.7	31	20	11	15	2.66	16	9	27	19	29	45	33

Table A-3

Project : Geotechnical Investigation for the Reconstruction of Tenements at Baruva Nagar in Zone IX, Division V, Greater Chennai Corporation.

BH No: 3		LABORATORY TEST RESULTS										Ground Water Table Depth (m): 1.5				
Depth (m)	SPT 'N' Value	Soil Description / Classification	Index Properties						Specific Gravity	Grain Size Analysis (%)					Direct Shear / Terzaghi and Peck (1974) - Shear Strength Parameters	
			Natural Moisture Content / Water Absorption %	Bulk Density (kN/m³)	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Free Swell Index		Coarse Sand		Medium Sand	Fine Sand	Fines		
										Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt & Clay		
2.0	9	Brownish Grey Silty Clay (CL)	30	14.8	32	20	12	15	2.62	0	2	1	24	73	56	0
3.0	12	Brownish Grey Silty Sand (SM-SP)	25	15.7	NP	NP	NP	NP	2.64	0	0	4	80	16	0	27
4.0	4	Black Silty Clay (CI)	41	12.7	48	31	17	40	2.65	0	3	2	10	85	25	0
5.0	5	Black Silty / Clayey Sand (CL)	38	13.2	34	21	13	15	2.62	0	0	10	25	65	31	0
6.0	4	Black Silty Clay (CI)	48	12.7	45	22	23	25	2.65	0	0	8	19	73	25	0
7.5	2	Greyish Silty Clay (CI)	56	12.4	47	23	24	25	2.66	0	1	6	19	74	13	0
9.0	12	Greyish Silty Sand (SM-SP)	25	15.7	NP	NP	NP	NP	2.63	0	4	23	52	21	0	27
10.5	12	Greyish Silty Sand (SM-SP)	22	15.7	NP	NP	NP	NP	2.63	0	0	31	55	14	0	27
12.0	4	Greyish Silty Sand (SM-SP)	17	12.7	NP	NP	NP	NP	2.64	0	2	25	62	11	0	21
13.5	7	Greyish Silty / Clayey Sand (CH)	42	14.1	53	26	27	30	2.62	0	3	9	26	62	44	0
15.0	5	Greyish Silty Clay (CH)	57	13.2	67	34	33	70	2.60	0	0	1	4	95	31	0
16.5	10	Greyish Silty / Clayey Sand (SC)	22	15.1	38	20	18	20	2.65	0	3	28	37	32	15	23
18.0	4	Greyish Silty / Clayey Sand (SC)	33	12.7	40	21	19	43	2.65	0	15	17	26	42	6	18
												Soaked Strength of Rock				
												UCS, kN/m²		I _s , kN/m²		
19.5	>100	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V / VI)	-	22.0		-			2.66		-			-	1000	0
21.0	-	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	2.98	22.3		6.41			2.67		-			140	1250	
22.5	-	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	2.74	22.6		6.24			2.67		-			220	1250	

Table A-4

Project : Geotechnical Investigation for the Reconstruction of Tenements at Baruva Nagar in Zone IX, Division V, Greater Chennai Corporation.



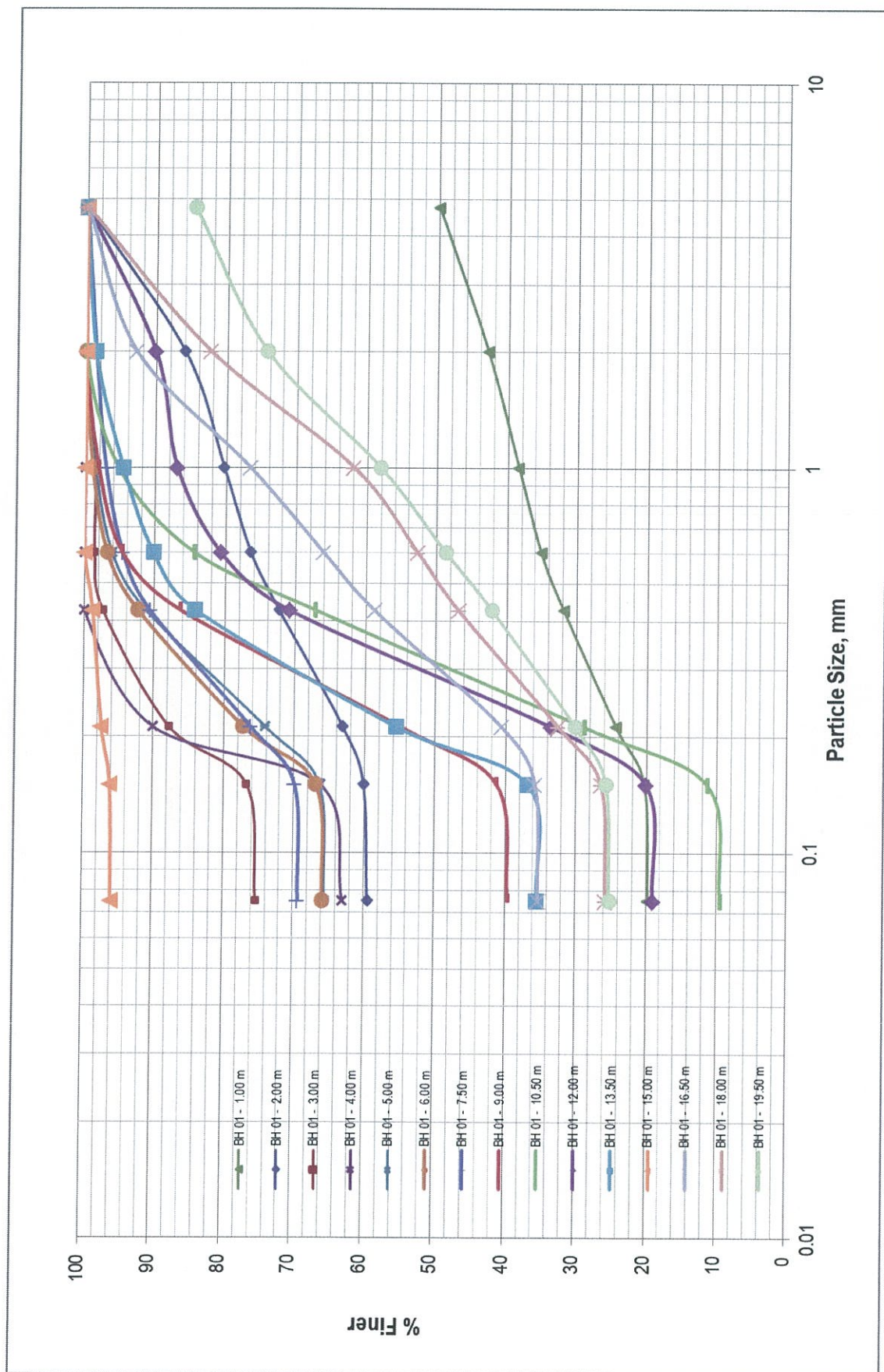


Figure B-1 Grain Size Distribution Curves of Soil Samples encountered in BH-1 Locations

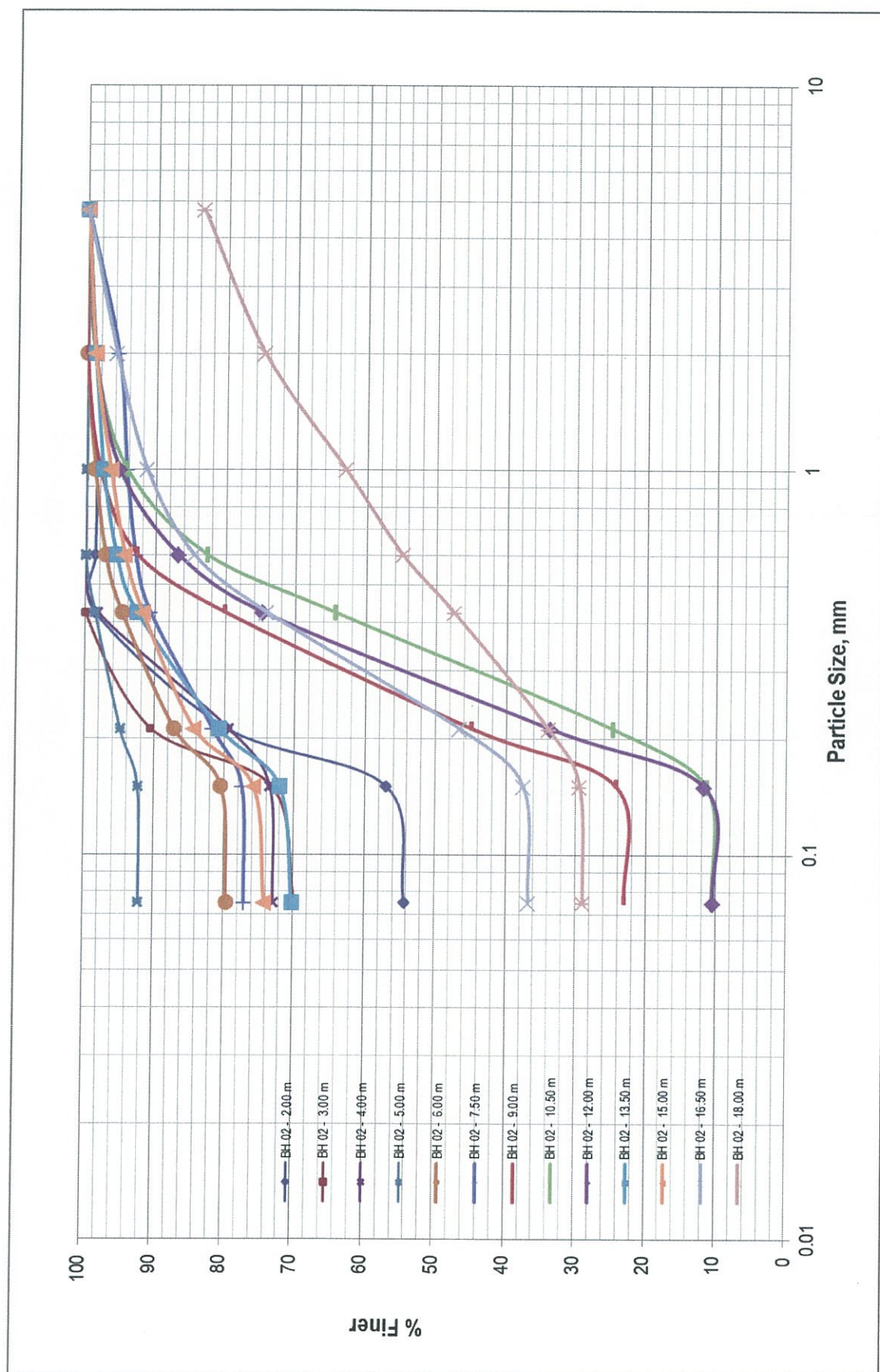


Figure B-2 Grain Size Distribution Curves of Soil Samples encountered in BH-2 Location

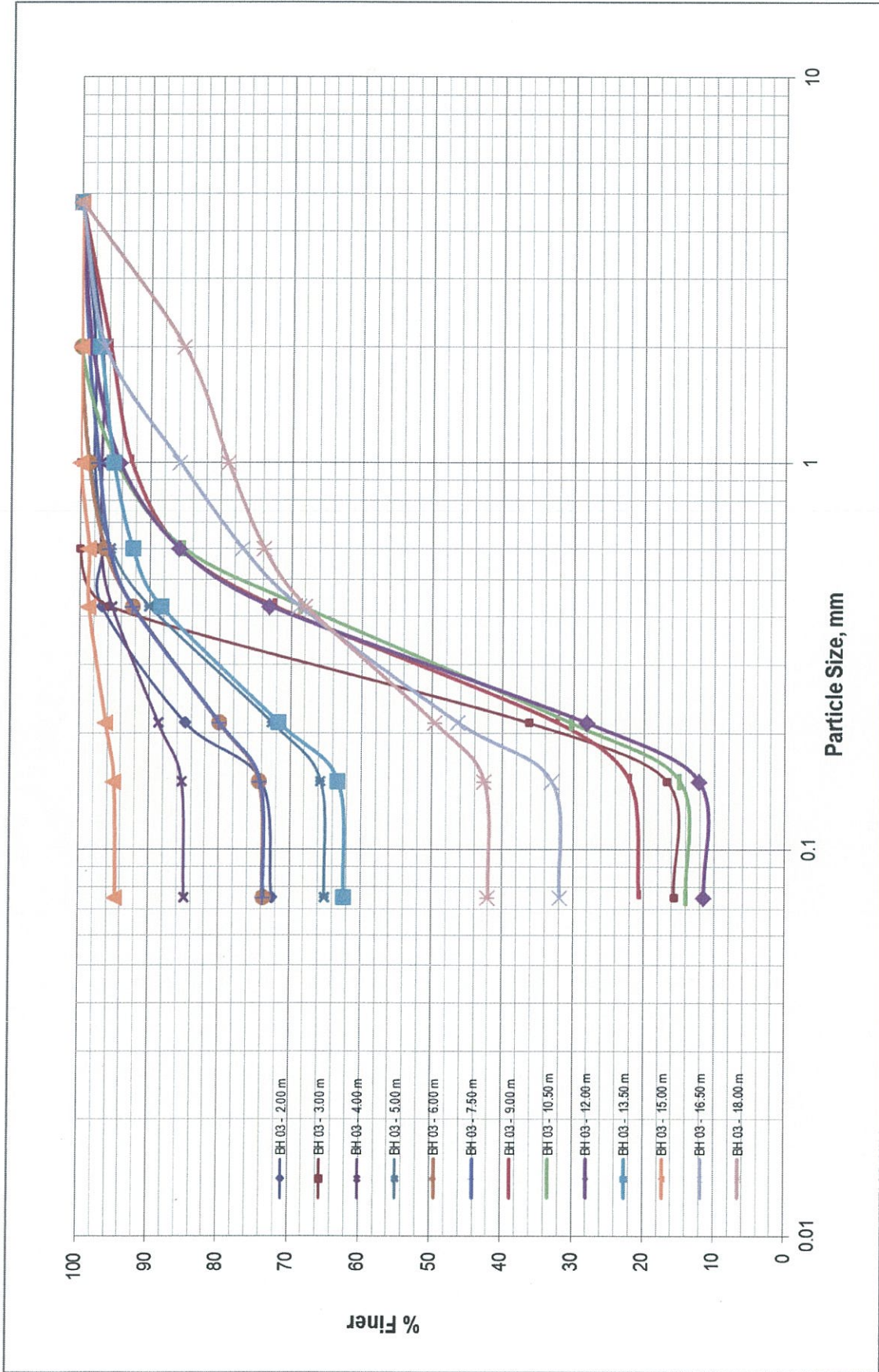


Figure B-3 Grain Size Distribution Curves of Soil Samples encountered in BH-3 Location

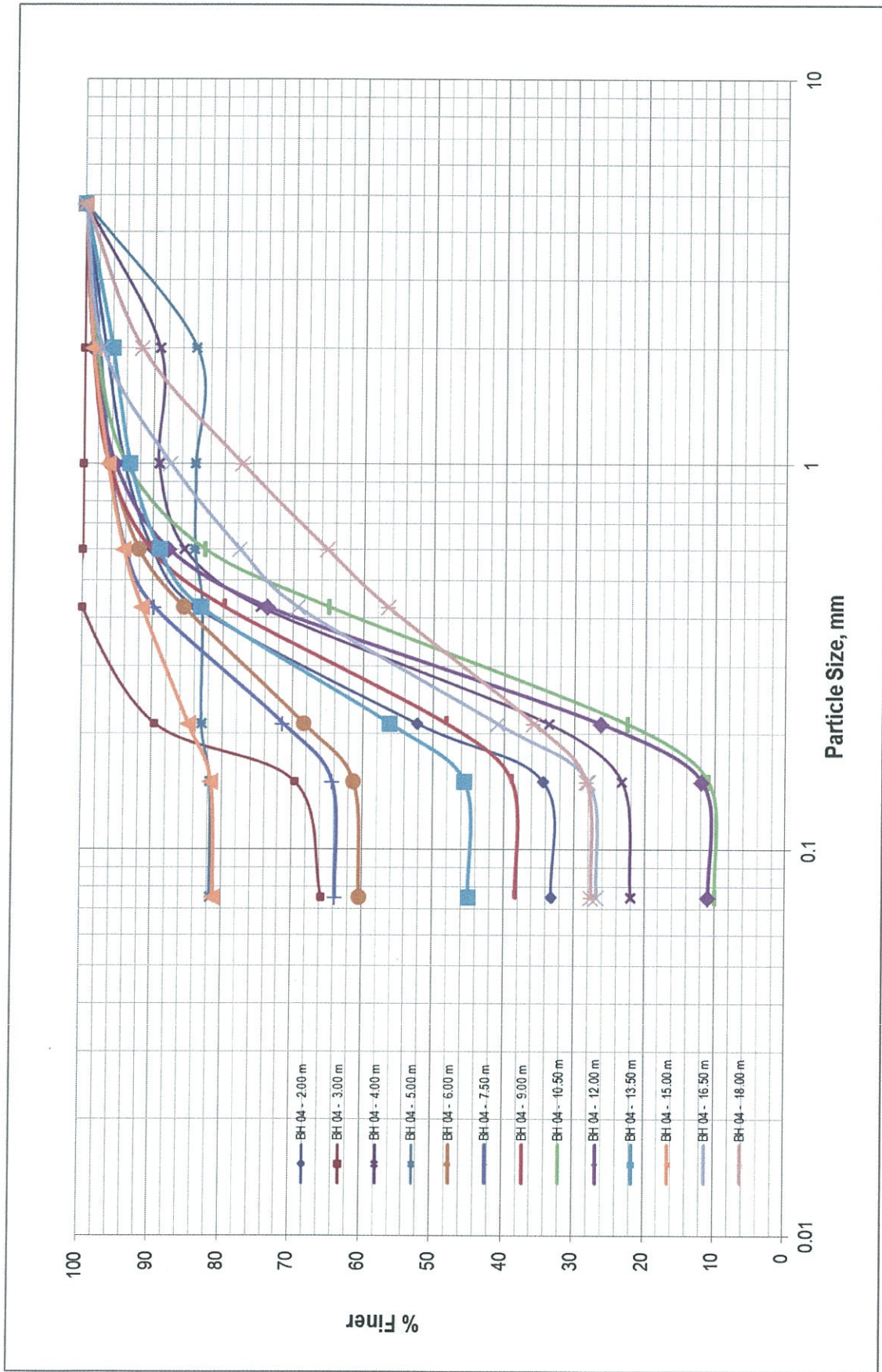


Figure B-4 Grain Size Distribution Curves of Soil Samples encountered in BH-4 Location

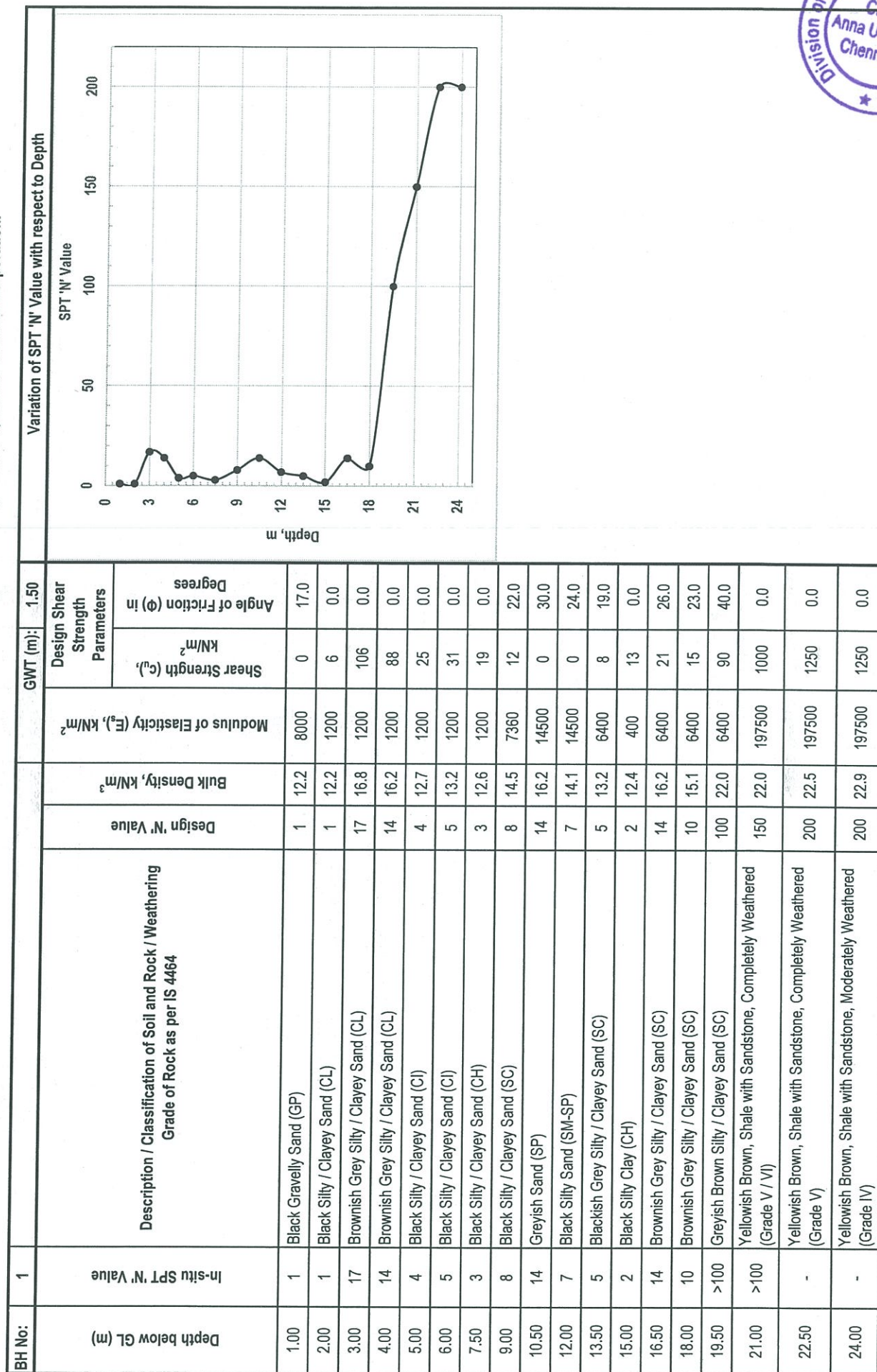


Appendix - A

GEOTECHNICAL DESIGN PARAMETERS

GEOTECHNICAL DESIGN PARAMETERS OF DIFFERENT LAYERS BELOW GROUND LEVEL

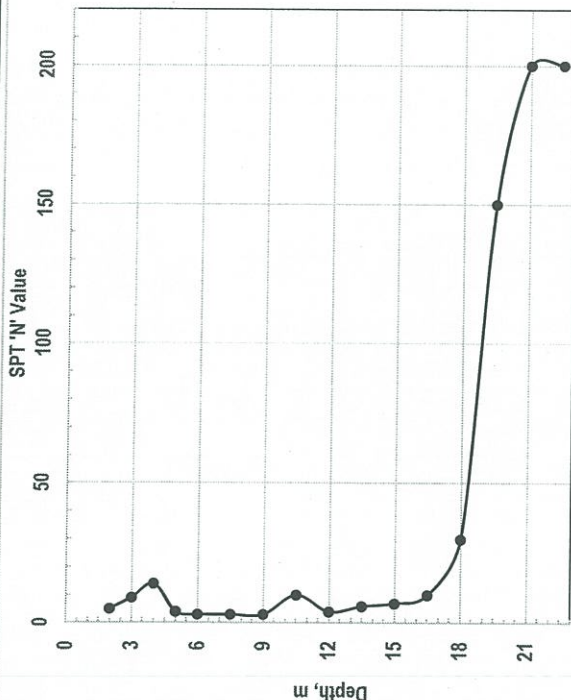
PROJECT: Geotechnical Investigation for the Reconstruction of Tenements at Baruva Nagar in Zone IX, Division V, Greater Chennai Corporation.



GEOTECHNICAL DESIGN PARAMETERS OF DIFFERENT LAYERS BELOW GROUND LEVEL

PROJECT: Geotechnical Investigation for the Reconstruction of Tenements at Baruvu Nagar in Zone IX, Division V, Greater Chennai Corporation.

BH No:	2	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		GWT (m):	2.00		
						Shear Strength (c_u), KN/m^2	Angle of Friction (ϕ) in Degrees				
2.00	5	Greyish Silty / Clayey Sand (CL)	5	12.2	6200	31	0.0				
3.00	9	Greyish Silty / Clayey Sand (CL)	9	14.8	11200	56	0.0				
4.00	14	Greyish Black Silty Clay (CL)	14	16.2	17600	88	0.0				
5.00	4	Black Silty Clay (CH)	4	12.7	5000	25	0.0				
6.00	3	Black Silty Clay (CH)	3	12.6	3800	19	0.0				
7.50	3	Black Silty Clay (CH)	3	12.6	3800	19	0.0				
9.00	3	Black Silty / Clayey Sand (SC-SM)	3	12.6	5760	3	18.0				
10.50	10	Greyish Silty Sand (SM-SP)	10	15.1	12500	0	26.0				
12.00	4	Greyish Silty Sand (SM-SP)	4	12.7	12500	0	21.0				
13.50	6	Black Silty Clay (CH)	6	13.7	3800	38	0.0				
15.00	7	Black Silty Clay (CH)	7	14.1	3800	44	0.0				
16.50	10	Black Silty / Clayey Sand (SC)	10	15.1	5760	15	23.0				
18.00	30	Brownish Grey Silty / Clayey Sand (SC)	30	18.7	5760	45	33.0				
19.50	>100	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V / VI)	150	22.0	197500	1000	0.0				
21.00	-	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	200	22.4	197500	1250	0.0				
22.50	-	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	200	22.7	197500	1250	0.0				



GEOTECHNICAL DESIGN PARAMETERS OF DIFFERENT LAYERS BELOW GROUND LEVEL

PROJECT: Geotechnical Investigation for the Reconstruction of Tenements at Baruva Nagar in Zone IX, Division V, Greater Chennai Corporation.

BH No:	3	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	GWT (m): 1.50	Variation of SPT 'N' Value with respect to Depth
Depth below GL (m)							Shear Strength (c_u), KN/m^2 Angle of Friction (ϕ) in Degrees		
2.00	9		Brownish Grey Silty Clay (CL)	9	14.8	3800	56 0.0		
3.00	12		Brownish Grey Silty Sand (SM-SP)	12	15.7	13500	0 27.0		
4.00	4		Black Silty Clay (CI)	4	12.7	5000	25 0.0		
5.00	5		Black Silty / Clayey Sand (CL)	5	13.2	3800	31 0.0		
6.00	4		Black Silty Clay (CI)	4	12.7	3800	25 0.0		
7.50	2		Greyish Silty Clay (CI)	2	12.4	3800	13 0.0		
9.00	12		Greyish Silty Sand (SM-SP)	12	15.7	13500	0 27.0		
10.50	12		Greyish Silty Sand (SM-SP)	12	15.7	13500	0 27.0		
12.00	4		Greyish Silty Sand (SM-SP)	4	12.7	13500	0 21.0		
13.50	7		Greyish Silty / Clayey Sand (CH)	7	14.1	8800	44 0.0		
15.00	5		Greyish Silty Clay (CH)	5	13.2	10000	31 0.0		
16.50	10		Greyish Silty / Clayey Sand (SC)	10	15.1	5760	15 23.0		
18.00	4		Greyish Silty / Clayey Sand (SC)	4	12.7	5760	6 18.0		
19.50	>100		Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V / VI)	150	22.0	197500	1000 0.0		
21.00	-		Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	200	22.3	197500	1250 0.0		
22.50	-		Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	200	22.6	197500	1250 0.0		



GEOTECHNICAL DESIGN PARAMETERS OF DIFFERENT LAYERS BELOW GROUND LEVEL

PROJECT: Geotechnical Investigation for the Reconstruction of Tenements at Baruva Nagar in Zone IX, Division V, Greater Chennai Corporation.

BH No:	4	GWT (m): 1.50					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	SPT 'N' Value	Depth, m
						Shear Strength (c_u), KN/m^2 Angle of Friction (ϕ) in Degrees		
2.00	6	Greyish Silty / Clayey Sand (SC)	6	13.7	6720	9 20.0		
3.00	13	Greyish Silty / Clayey Sand (CI)	13	15.9	16200	81 0.0		
4.00	10	Brown Silty / Clayey Sand (SC-SM)	10	15.1	6720	15 23.0		
5.00	4	Black Silty Clay (CH)	4	12.7	16200	25 0.0		
6.00	4	Black Silty / Clayey Sand (CI)	4	12.7	16200	25 0.0		
7.50	3	Greyish Black Silty / Clayey Sand (CH)	3	12.0	16200	19 0.0		
9.00	11	Greyish Black Silty / Clayey Sand (SC)	11	15.4	6720	17 24.0		
10.50	14	Greyish Black Silty Sand (SM-SP)	14	16.2	14500	0 29.0		
12.00	10	Greyish Silty Sand (SM-SP)	10	15.1	14500	0 26.0		
13.50	5	Black Silty / Clayey Sand (SC)	5	13.2	6400	8 19.0		
15.00	7	Black Silty Clay (CH)	7	14.1	8800	44 0.0		
16.50	18	Black Silty / Clayey Sand (SC-SM)	18	17.0	6400	18 29.0		
18.00	43	Greyish Brown Silty / Clayey Sand (SC-SM)	43	20.1	18560	43 39.0		
19.50	>100	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V / VI)	150	22.0	250000	1000 0.0		
21.00	-	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	200	22.6	250000	1250 0.0		
22.50	-	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	200	23.2	250000	1250 0.0		
24.00	-	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	200	23.5	250000	1250 0.0		

Appendix - B (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 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.



Appendix - B (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:

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

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



Appendix - B (DETERMINATION OF PILE CARRYING CAPACITY AS PER IS 2911:2010)

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

$Q_u = A_p (c N_c + P_D N_q + 0.5 \gamma D N_\gamma) + \Sigma A_{si} (\alpha_i c_i + K P_{Di} \tan \phi)$	
Where,	
Q_u -	Ultimate Pile Capacity, kN
A_p -	Cross Sectional Area of Pile, m ²
c_i -	Cohesion value of soil at pile base, kN/m ²
P_D -	Effective overburden pressure at pile base, kN/m ²
γ -	Unit weight of soil, kN/m ³
D -	Diameter of pile, m
A_{si} -	Surface Area of Pile at respective soil layers, m ²
α_i -	Adhesion factor
c -	Cohesion value of soil at respective soil layers, kN/m ²
K_i -	Co-efficient of earth pressure at respective soil layers
P_{Di} -	Effective overburden pressure at respective soil layers, kN/m ²
ϕ -	Friction angle, degrees
N_c -	Bearing capacity factors based on IS 2911: 2010 and
N_q, N_γ	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



DETERMINATION OF PILE CARRYING CAPACITY AS PER IS 2911 : 2010

BH 1

Appendix - B (Determination of Pile Carrying Capacity as Per IS 2911:2010)

Depth (m)	Soil Description	H _i (m)	'c' kN/m ²	'φ'	'Y' kN/m ³	'Y' _{sub} ' kN/m ³	P _{oi} (kN/m ²)	'α _i '	'K _i '	N' Value
1.00	Black Gravelly Sand (GP)	1.00	0	17	12.20	2.20	1.10	0.00	1.00	1
2.00	Black Silty / Clayey Sand (CL)	1.00	6	0	12.20	2.20	3.30	1.00	1.00	1
3.00	Brownish Grey Silty / Clayey Sand (CL)	1.00	106	0	16.80	6.80	7.80	0.50	1.00	17
4.00	Brownish Grey Silty / Clayey Sand (CL)	1.00	88	0	16.20	6.20	14.30	0.65	1.00	14
5.00	Black Silty / Clayey Sand (CI)	1.00	25	0	12.70	2.70	18.75	0.80	1.00	4
6.00	Black Silty / Clayey Sand (CI)	1.00	31	0	13.20	3.20	21.70	0.80	1.00	5
7.50	Black Silty / Clayey Sand (CH)	1.50	19	0	12.60	2.60	25.25	0.80	1.00	3
9.00	Black Silty / Clayey Sand (SC)	1.50	12	22	14.50	4.50	30.58	0.30	1.00	8
10.50	Greyish Sand (SP)	1.50	0	30	16.20	6.20	38.60	0.00	1.00	14
12.00	Black Silty Sand (SM-SP)	1.50	0	24	14.10	4.10	46.33	0.00	1.00	7
13.50	Blackish Grey Silty / Clayey Sand (SC)	1.50	8	19	13.20	3.20	51.80	0.30	1.00	5
15.00	Black Silty Clay (CH)	1.50	13	0	12.40	2.40	56.00	1.00	1.00	2
16.50	Brownish Grey Silty / Clayey Sand (SC)	1.50	21	26	16.20	6.20	62.45	0.30	1.00	14
18.00	Brownish Grey Silty / Clayey Sand (SC)	1.50	15	23	15.10	5.10	70.93	0.30	1.00	10
19.50	Greyish Brown Silty / Clayey Sand (SC)	1.50	90	40	22.00	12.00	83.75	0.30	1.00	100
21.00	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V / VI)	1.50	1000	0	22.00	12.00	101.75	0.25	1.00	150
22.50	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	2.00	1250	0	22.50	12.50	123.25	0.25	1.00	200
24.00	Yellowish Brown, Shale with Sandstone, Moderately Weathered (Grade IV)	1.50	1250	0	22.90	12.90	145.43	0.25	1.00	200

Appendix - B (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	Black Gravelly Sand (GP)	0.34	0.48	0.53	0.63	0.74	0.95	1.67	2.36	2.62	3.14	3.67	4.71
2.00	Black Silty / Clayey Sand (CL)	6.00	8.48	9.42	11.31	13.19	16.96	5.00	7.07	7.85	9.42	11.00	14.14
3.00	Brownish Grey Silty / Clayey Sand (CL)	53.00	74.93	83.25	99.90	116.55	149.85	85.00	84.82	94.25	113.10	131.95	169.65
4.00	Brownish Grey Silty / Clayey Sand (CL)	57.20	80.86	89.85	107.82	125.79	161.73	70.00	84.82	94.25	113.10	131.95	169.65
5.00	Black Silty / Clayey Sand (CI)	20.00	28.27	31.42	37.70	43.98	56.55	20.00	28.27	31.42	37.70	43.98	56.55
6.00	Black Silty / Clayey Sand (CI)	24.80	35.06	38.96	46.75	54.54	70.12	25.00	35.34	39.27	47.12	54.98	70.69
7.50	Black Silty / Clayey Sand (CH)	15.20	32.23	35.81	42.98	50.14	64.47	15.00	31.81	35.34	42.41	49.48	63.62
9.00	Black Silty / Clayey Sand (SC)	15.95	33.83	37.59	45.11	52.62	67.66	13.33	28.27	31.42	37.70	43.98	56.55
10.50	Greyish Sand (SP)	22.29	47.26	52.51	63.01	73.51	94.52	23.33	49.48	54.98	65.97	76.97	98.96
12.00	Black Silty Sand (SM-SP)	20.63	43.74	48.60	58.32	68.04	87.47	11.67	24.74	27.49	32.99	38.48	49.48
13.50	Blackish Grey Silty / Clayey Sand (SC)	20.24	42.91	47.68	57.22	66.75	85.82	8.33	17.67	19.63	23.56	27.49	35.34
15.00	Black Silty Clay (CH)	13.00	27.57	30.63	36.76	42.88	55.13	10.00	21.21	23.56	28.27	32.99	42.41
16.50	Brownish Grey Silty / Clayey Sand (SC)	36.76	77.95	86.61	103.93	121.26	155.90	23.33	49.48	54.98	65.97	76.97	98.96
18.00	Brownish Grey Silty / Clayey Sand (SC)	34.61	73.38	81.54	97.85	114.15	146.77	16.67	35.34	39.27	47.12	54.98	70.69
19.50	Greyish Brown Silty / Clayey Sand (SC)	97.27	127.23	141.37	169.65	197.92	254.47	166.67	127.23	141.37	169.65	197.92	254.47
21.00	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V / VI)	250.00	127.23	141.37	169.65	197.92	254.47	250.00	127.23	141.37	169.65	197.92	254.47
22.50	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	312.50	169.65	188.50	226.19	263.89	339.29	333.33	169.65	188.50	226.19	263.89	339.29
24.00	Yellowish Brown, Shale with Sandstone, Moderately Weathered (Grade IV)	312.50	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47



DETERMINATION OF PILE CARRYING CAPACITY AS PER IS 2911 : 2010

BH 2



Appendix - B (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 _{oi} (kN/m ²)	'α _i '	'K _i '	N' Value
2.00	Greyish Silty / Clayey Sand (CL)	2.00	31	0	12.20	2.20	2.20	0.80	1.00	5
3.00	Greyish Silty / Clayey Sand (CL)	1.00	56	0	14.80	4.80	6.80	0.65	1.00	9
4.00	Greyish Black Silty Clay (CL)	1.00	88	0	16.20	6.20	12.30	0.65	1.00	14
5.00	Black Silty Clay (CH)	1.00	25	0	12.70	2.70	16.75	0.80	1.00	4
6.00	Black Silty Clay (CH)	1.00	19	0	12.60	2.60	19.40	0.80	1.00	3
7.50	Black Silty Clay (CH)	1.50	19	0	12.60	2.60	22.65	0.80	1.00	3
9.00	Black Silty / Clayey Sand (SC-SM)	1.50	3	18	12.60	2.60	26.55	0.30	1.00	3
10.50	Greyish Silty Sand (SM-SP)	1.50	0	26	15.10	5.10	32.33	0.00	1.00	10
12.00	Greyish Silty Sand (SM-SP)	1.50	0	21	12.70	2.70	38.18	0.00	1.00	4
13.50	Black Silty Clay (CH)	1.50	38	0	13.70	3.70	42.98	0.80	1.00	6
15.00	Black Silty Clay (CH)	1.50	44	0	14.10	4.10	48.83	0.80	1.00	7
16.50	Black Silty / Clayey Sand (SC)	1.50	15	23	15.10	5.10	55.73	0.30	1.00	10
18.00	Brownish Grey Silty / Clayey Sand (SC)	1.50	45	33	18.70	8.70	66.08	0.30	1.00	30
19.50	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V / VI)	1.50	1000	0	22.00	12.00	81.60	0.25	1.00	150
21.00	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	1.50	1250	0	22.40	12.40	99.90	0.25	1.00	200
22.50	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	2.00	1250	0	22.70	12.70	121.90	0.25	1.00	200



Appendix - B (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
2.00	Greyish Silty / Clayey Sand (CL)	24.80	70.12	77.91	93.49	109.08	140.24	25.00	70.69	78.54	94.25	109.96	141.37
3.00	Greyish Silty / Clayey Sand (CL)	36.40	51.46	57.18	68.61	80.05	102.92	45.00	63.62	70.69	84.82	98.96	127.23
4.00	Greyish Black Silty Clay (CL)	57.20	80.86	89.85	107.82	125.79	161.73	70.00	84.82	94.25	113.10	131.95	169.65
5.00	Black Silty Clay (CH)	20.00	28.27	31.42	37.70	43.98	56.55	20.00	28.27	31.42	37.70	43.98	56.55
6.00	Black Silty Clay (CH)	15.20	21.49	23.88	28.65	33.43	42.98	15.00	21.21	23.56	28.27	32.99	42.41
7.50	Black Silty Clay (CH)	15.20	32.23	35.81	42.98	50.14	64.47	15.00	31.81	35.34	42.41	49.48	63.62
9.00	Black Silty / Clayey Sand (SC-SM)	9.53	20.20	22.45	26.94	31.43	40.40	5.00	10.60	11.78	14.14	16.49	21.21
10.50	Greyish Silty Sand (SM-SP)	15.77	33.43	37.15	44.58	52.01	66.87	16.67	35.34	39.27	47.12	54.98	70.69
12.00	Greyish Silty Sand (SM-SP)	14.65	31.07	34.53	41.43	48.34	62.15	6.67	14.14	15.71	18.85	21.99	28.27
13.50	Black Silty Clay (CH)	30.40	64.47	71.63	85.95	100.28	128.93	30.00	63.62	70.69	84.82	98.96	127.23
15.00	Black Silty Clay (CH)	35.20	74.64	82.94	99.53	116.11	149.29	35.00	74.22	82.47	98.96	115.45	148.44
16.50	Black Silty / Clayey Sand (SC)	28.15	59.70	66.34	79.60	92.87	119.40	16.67	35.34	39.27	47.12	54.98	70.69
18.00	Brownish Grey Silty / Clayey Sand (SC)	56.41	119.62	132.91	159.49	186.08	239.24	50.00	106.03	117.81	141.37	164.93	212.06
19.50	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V / VI)	250.00	127.23	141.37	169.65	197.92	254.47	250.00	127.23	141.37	169.65	197.92	254.47
21.00	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	312.50	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47
22.50	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	312.50	169.65	188.50	226.19	263.89	339.29	333.33	169.65	188.50	226.19	263.89	339.29



Appendix - B (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	=	0.00	
Undrained cohesion value at Pile Tip (c_p), kN/m ²	=	1250.00 kN/m ²	
Submerged Unit Weight at Pile Tip (γ_p), kN/m ³	=	12.60 kN/m ³	
Ground Water Table Depth (GWT), m	=	0.00 m	Submerged Condition
Bearing Capacity Factor (N_c)	=	9.00	
Bearing Capacity Factor (N_q)	=	0.00	
Bearing Capacity Factor (N_{ϕ})	=	0.00	
Factor of Safety (FS)	=	2.50	
Diameter of Pile (D), mm	=	450	500
Critical Depth of Pile (20 x D), m	=	9	10
Effective overburden pressure at Pile Tip (P_0), kN/m ²	=	31.78	40.33
End Bearing Resistence of Pile (q_p), kN/m ² using 'c' and ' ϕ '	=	11250.00	11250.00
End Bearing Resistence of Pile (q_p), kN/m ² using 'N' values	=	80000.00	80000.00
Limiting End Bearing Resistence of Pile (q_{pL}), kN/m ²	=	10000.00	10000.00
Ultimate End Bearing Capacity of Pile (Q_{p-ult}), kN using 'c' and ' ϕ ' values	=	1590.43	1963.50
Ultimate End Bearing Capacity of Pile (Q_{p-ult}), kN using 'N' values	=	1590.43	1963.50
Safe End Bearing Capacity of Pile (Q_{p-safe}), kN using 'c' and ' ϕ ' values	=	636.17	785.40
Safe End Bearing Capacity of Pile (Q_{p-safe}), kN using 'N' values	=	636.17	785.40
Ultimate Frictional Capacity of Pile (Q_{f-ult}), kN using 'c' and ' ϕ ' values	=	842.83	936.48
Ultimate Frictional Capacity of Pile (Q_{f-ult}), kN using 'N' values	=	862.37	958.19
Negative Skin Friction of Pile (Q_{nf}), kN using 'c' and ' ϕ ' values	=	173.62	192.91
Negative Skin Friction of Pile (Q_{nf}), kN using 'N' values	=	106.03	117.81
Safe Frictional Capacity of Pile (Q_{f-safe}), kN using 'c' and ' ϕ ' values	=	163.51	181.68
Safe Frictional Capacity of Pile (Q_{f-safe}), kN using 'N' values	=	238.92	265.46
Self Weight of Pile (W), kN	=	91.45	112.90
Safe Pile Carrying Capacity of Pile (Q_{safe}), kN ('c' and ' ϕ ')	=	800	967
Safe Pile Carrying Capacity of Pile (Q_{safe}), kN ('N' values)	=	875	1051
Recommended Safe Pile Carrying Capacity of Pile (Q_{safe}), kN	=	837	1009
Safe Uplift Capacity of Pile (Q_{up}), kN using 'c' and ' ϕ ' values	=	199	232
			306
			388
			580

Taken from Figure 1 of IS 2911:2010 Part 1 Sec.2



Appendix - B (Determination of Pile Carrying Capacity as Per IS 2911:2010)

Depth (m)	Soil Description	H _i (m)	'c' kN/m ²	'φ'	'Y' kN/m ³	'Y' _{sub} ' kN/m ³	P _{oi} (kN/m ²)	'α' _i	'K' _i	N' Value
2.00	Brownish Grey Silty Clay (CL)	2.00	56	0	14.80	4.80	4.80	0.65	1.00	9
3.00	Brownish Grey Silty Sand (SM-SP)	1.00	0	27	15.70	5.70	12.45	0.00	1.00	12
4.00	Black Silty Clay (CI)	1.00	25	0	12.70	2.70	16.65	0.80	1.00	4
5.00	Black Silty / Clayey Sand (CL)	1.00	31	0	13.20	3.20	19.60	0.80	1.00	5
6.00	Black Silty Clay (CI)	1.00	25	0	12.70	2.70	22.55	0.80	1.00	4
7.50	Greyish Silty Clay (CI)	1.50	13	0	12.40	2.40	25.70	1.00	1.00	2
9.00	Greyish Silty Sand (SM-SP)	1.50	0	27	15.70	5.70	31.78	0.00	1.00	12
10.50	Greyish Silty Sand (SM-SP)	1.50	0	27	15.70	5.70	40.33	0.00	1.00	12
12.00	Greyish Silty Sand (SM-SP)	1.50	0	21	12.70	2.70	46.63	0.00	1.00	4
13.50	Greyish Silty / Clayey Sand (CH)	1.50	44	0	14.10	4.10	51.73	0.80	1.00	7
15.00	Greyish Silty Clay (CH)	1.50	31	0	13.20	3.20	57.20	0.80	1.00	5
16.50	Greyish Silty / Clayey Sand (SC)	1.50	15	23	15.10	5.10	63.43	0.30	1.00	10
18.00	Greyish Silty / Clayey Sand (SC)	1.50	6	18	12.70	2.70	69.28	0.30	1.00	4
19.50	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V / VI)	1.50	1000	0	22.00	12.00	80.30	0.25	1.00	150
21.00	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	1.50	1250	0	22.30	12.30	98.53	0.25	1.00	200
22.50	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	2.00	1250	0	22.60	12.60	120.35	0.25	1.00	200



Appendix - B (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
2.00	Brownish Grey Silty Clay (CL)	36.40	102.92	114.35	137.22	160.10	205.84	45.00	127.23	141.37	169.65	197.92	254.47
3.00	Brownish Grey Silty Sand (SM-SP)	6.34	8.97	9.96	11.96	13.95	17.94	20.00	28.27	31.42	37.70	43.98	56.55
4.00	Black Silty Clay (CI)	20.00	28.27	31.42	37.70	43.98	56.55	20.00	28.27	31.42	37.70	43.98	56.55
5.00	Black Silty / Clayey Sand (CL)	24.80	35.06	38.96	46.75	54.54	70.12	25.00	35.34	39.27	47.12	54.98	70.69
6.00	Black Silty Clay (CI)	20.00	28.27	31.42	37.70	43.98	56.55	20.00	28.27	31.42	37.70	43.98	56.55
7.50	Greyish Silty Clay (CI)	13.00	27.57	30.63	36.76	42.88	55.13	10.00	21.21	23.56	28.27	32.99	42.41
9.00	Greyish Silty Sand (SM-SP)	16.19	34.33	38.15	45.78	53.41	68.66	20.00	42.41	47.12	56.55	65.97	84.82
10.50	Greyish Silty Sand (SM-SP)	20.55	43.57	48.41	58.09	67.78	87.14	20.00	42.41	47.12	56.55	65.97	84.82
12.00	Greyish Silty Sand (SM-SP)	17.90	37.95	42.17	50.60	59.04	75.91	6.67	14.14	15.71	18.85	21.99	28.27
13.50	Greyish Silty / Clayey Sand (CH)	35.20	74.64	82.94	99.53	116.11	149.29	35.00	74.22	82.47	98.96	115.45	148.44
15.00	Greyish Silty Clay (CH)	24.80	52.59	58.43	70.12	81.81	105.18	25.00	53.01	58.90	70.69	82.47	106.03
16.50	Greyish Silty / Clayey Sand (SC)	31.42	66.63	74.04	88.84	103.65	133.27	16.67	35.34	39.27	47.12	54.98	70.69
18.00	Greyish Silty / Clayey Sand (SC)	24.31	51.55	57.28	68.73	80.19	103.10	6.67	14.14	15.71	18.85	21.99	28.27
19.50	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V / VI)	250.00	127.23	141.37	169.65	197.92	254.47	250.00	127.23	141.37	169.65	197.92	254.47
21.00	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	312.50	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47
22.50	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	312.50	169.65	188.50	226.19	263.89	339.29	333.33	169.65	188.50	226.19	263.89	339.29



DETERMINATION OF PILE CARRYING CAPACITY AS PER IS 2911 : 2010

BH 4



Appendix - B (Determination of Pile Carrying Capacity as Per IS 2911:2010)

Depth (m)	Soil Description	H _i (m)	'c' kN/m ²	'φ'	'Y' kN/m ³	'Y' _{sub} ' kN/m ³	P _{Di} (kN/m ²)	'α _i '	'K _i '	N' Value
2.00	Greyish Silty / Clayey Sand (SC)	2.00	9	20	13.70	3.70	3.70	0.30	1.00	6
3.00	Greyish Silty / Clayey Sand (CI)	1.00	81	0	15.90	5.90	10.35	0.65	1.00	13
4.00	Brown Silty / Clayey Sand (SC-SM)	1.00	15	23	15.10	5.10	15.85	0.30	1.00	10
5.00	Black Silty Clay (CH)	1.00	25	0	12.70	2.70	19.75	0.80	1.00	4
6.00	Black Silty / Clayey Sand (CI)	1.00	25	0	12.70	2.70	22.45	0.80	1.00	4
7.50	Greyish Black Silty / Clayey Sand (CH)	1.50	19	0	12.00	2.00	25.30	0.80	1.00	3
9.00	Greyish Black Silty / Clayey Sand (SC)	1.50	17	24	15.40	5.40	30.85	0.30	1.00	11
10.50	Greyish Black Silty Sand (SM-SP)	1.50	0	29	16.20	6.20	39.55	0.00	1.00	14
12.00	Greyish Silty Sand (SM-SP)	1.50	0	26	15.10	5.10	48.03	0.00	1.00	10
13.50	Black Silty / Clayey Sand (SC)	1.50	8	19	13.20	3.20	54.25	0.30	1.00	5
15.00	Black Silty Clay (CH)	1.50	44	0	14.10	4.10	59.73	0.80	1.00	7
16.50	Black Silty / Clayey Sand (SC-SM)	1.50	18	29	17.00	7.00	68.05	0.30	1.00	18
18.00	Greyish Brown Silty / Clayey Sand (SC-SM)	1.50	43	39	20.10	10.10	80.88	0.30	1.00	43
19.50	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V / VI)	1.50	1000	0	22.00	12.00	97.45	0.25	1.00	150
21.00	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	1.50	1250	0	22.60	12.60	115.90	0.25	1.00	200
22.50	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	2.00	1250	0	23.20	13.20	138.55	0.25	1.00	200
24.00	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	1.50	1250	0	23.50	13.50	161.88	0.25	1.00	200

Appendix - B (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
2.00	Greyish Silty / Clayey Sand (SC)	4.05	11.44	12.71	15.26	17.80	22.88	10.00	28.27	31.42	37.70	43.98	56.55
3.00	Greyish Silty / Clayey Sand (CI)	52.65	74.43	82.70	99.24	115.78	148.86	65.00	84.82	94.25	113.10	131.95	169.65
4.00	Brown Silty / Clayey Sand (SC-SM)	11.23	15.87	17.64	21.16	24.69	31.75	16.67	23.56	26.18	31.42	36.65	47.12
5.00	Black Silty Clay (CH)	20.00	28.27	31.42	37.70	43.98	56.55	20.00	28.27	31.42	37.70	43.98	56.55
6.00	Black Silty / Clayey Sand (CI)	20.00	28.27	31.42	37.70	43.98	56.55	20.00	28.27	31.42	37.70	43.98	56.55
7.50	Greyish Black Silty / Clayey Sand (CH)	15.20	32.23	35.81	42.98	50.14	64.47	15.00	31.81	35.34	42.41	49.48	63.62
9.00	Greyish Black Silty / Clayey Sand (SC)	18.84	39.94	44.38	53.26	62.13	79.88	18.33	38.88	43.20	51.84	60.48	77.75
10.50	Greyish Black Silty Sand (SM-SP)	21.92	46.49	51.65	61.99	72.32	92.98	23.33	49.48	54.98	65.97	76.97	98.96
12.00	Greyish Silty Sand (SM-SP)	23.42	49.67	55.19	66.23	77.27	99.34	16.67	35.34	39.27	47.12	54.98	70.69
13.50	Black Silty / Clayey Sand (SC)	21.08	44.70	49.67	59.60	69.54	89.40	8.33	17.67	19.63	23.56	27.49	35.34
15.00	Black Silty Clay (CH)	35.20	74.64	82.94	99.53	116.11	149.29	35.00	74.22	82.47	98.96	115.45	148.44
16.50	Black Silty / Clayey Sand (SC-SM)	43.12	91.44	101.60	121.92	142.24	182.88	30.00	63.62	70.69	84.82	98.96	127.23
18.00	Greyish Brown Silty / Clayey Sand (SC-SM)	78.39	127.23	141.37	169.65	197.92	254.47	71.67	127.23	141.37	169.65	197.92	254.47
19.50	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V / VI)	250.00	127.23	141.37	169.65	197.92	254.47	250.00	127.23	141.37	169.65	197.92	254.47
21.00	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	312.50	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47
22.50	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	312.50	169.65	188.50	226.19	263.89	339.29	333.33	169.65	188.50	226.19	263.89	339.29
24.00	Yellowish Brown, Shale with Sandstone, Completely Weathered (Grade V)	312.50	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47



Appendix - B (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	=	23.00 m	From Existing Borehole Level
Type of Fixity	=	Fixed Head by Pile Cap	
Cantilever Length above Ground Level (e), m	=	0.00 m	
Allowable Deflection as per IS 2911 Part 4 : 1985, Page No. 10 in mm	=	5.00 mm	Point of application of Lateral Load (Assumed)
Modulus of Subgrade Reaction of Soil (η_h)	=	1200.00 kN/m ³	
Grade of Concrete	=	30.00 N/mm ²	From Table 3 of IS 2911 Part 1 Sec. 2
Young's Modulus of Pile Material (E), kN/m ²	=	27386127.88 kN/m ²	M 30
Diameter of Pile (D), mm	=	450	500
Moment of Inertia of Pile Section (I), m ⁴	=	0.00201	0.00307
Stiffness Factor, (T)	=	2.15	2.34
Criteria for Behaviour of Pile as per Table 5 of IS 2911 Part 1 Sec. 2	=	Long Pile	Long Pile
(e/R)	=	0.00	0.00
(Z _f /T) from Fig.4 of IS 2911 Part 1 Sec.2	=	1.90	1.90
Depth of Fixity (Z _f), m	=	4.09	5.82
Allowable Deflection as per IS 2911 Part 4 : 1985, Page No. 10 in mm	=	5.00	5.00
Lateral Load Capacity of Pile (H), kN	=	48.30	77.00
			98.20
			147.20



Appendix – C
SITE PHOTOGRAPHS





Figure 1 Geo-technical Investigation is in progress at Reconstruction of Tenements at North Giriappa Road Old in Zone IX, Division V, Greater Chennai Corporation.

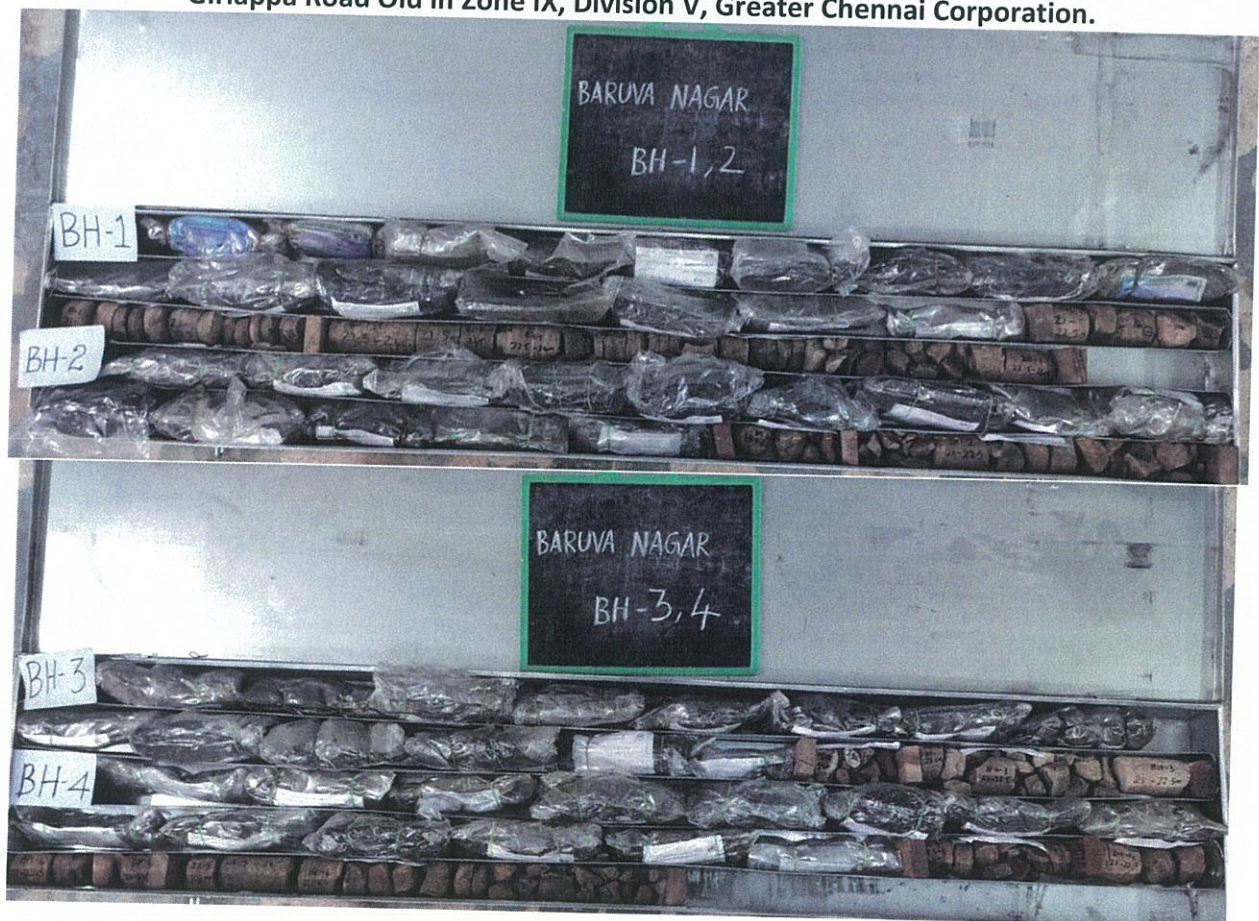


Figure 2 View of Soil and Rock Samples collected at the Proposed Site

View of Soil and Rock Samples collected in BH 1 to BH 4 Locations of the Reconstruction of Tenements at Baruva Nagar in Zone IX, Division V, Greater Chennai Corporation.

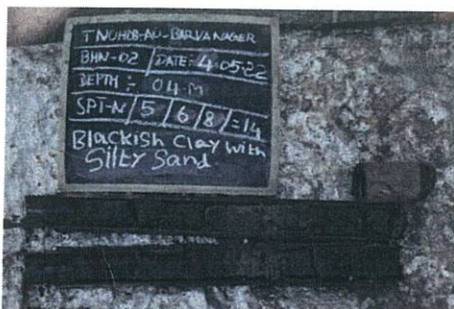
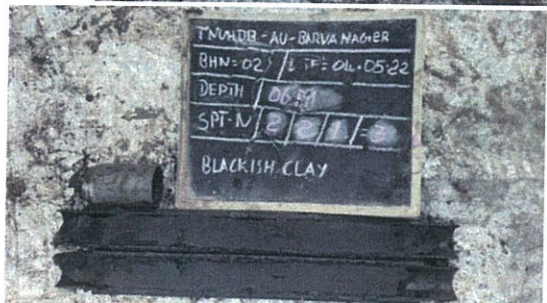
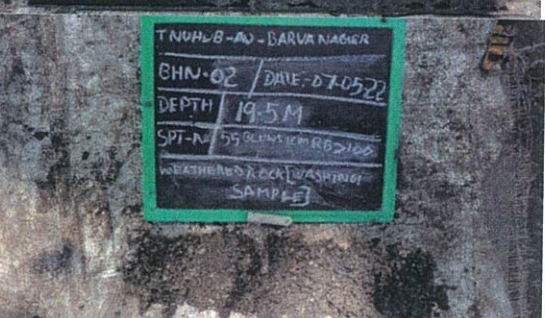
Plate – 1 Soil / Rock Samples Collected in BH-01 Location





Plate – 2 Soil / Rock Samples Collected in BH-02 Location





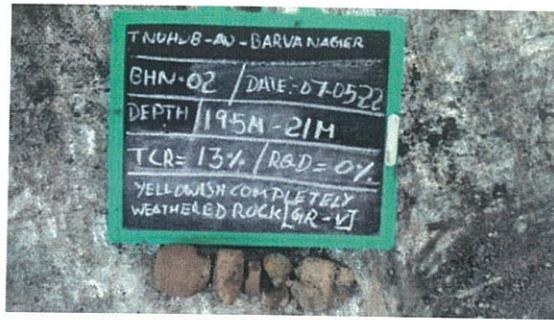


Plate – 3 Soil / Rock Samples Collected in BH-03 Location

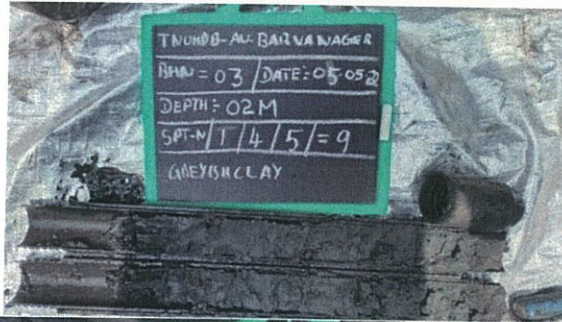
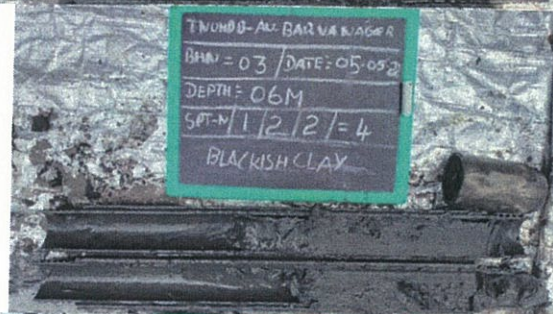
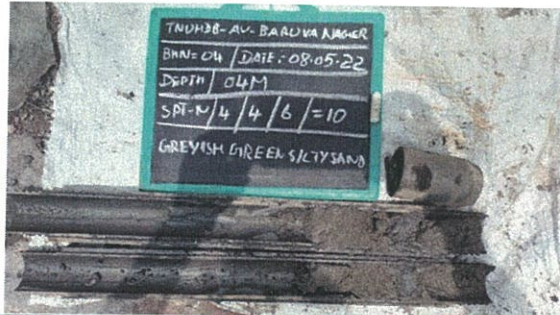
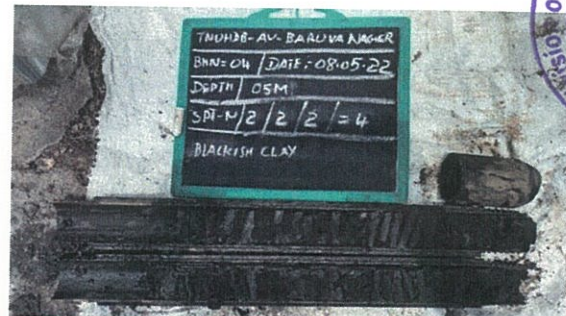
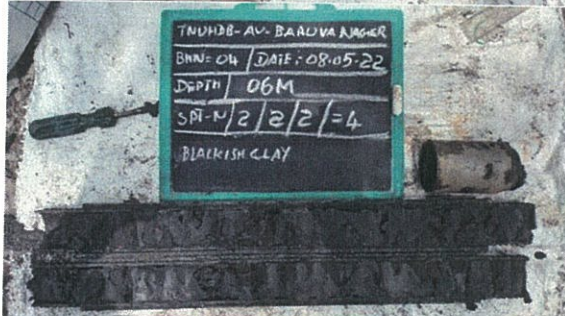
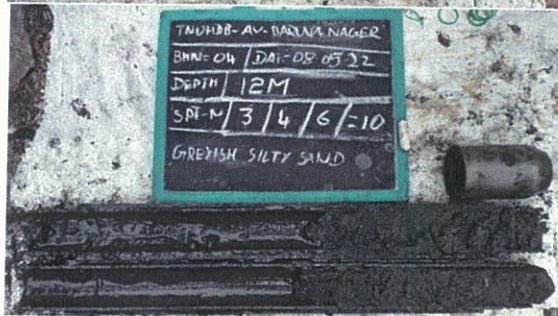
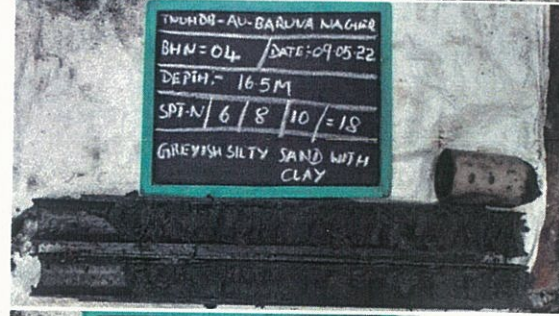
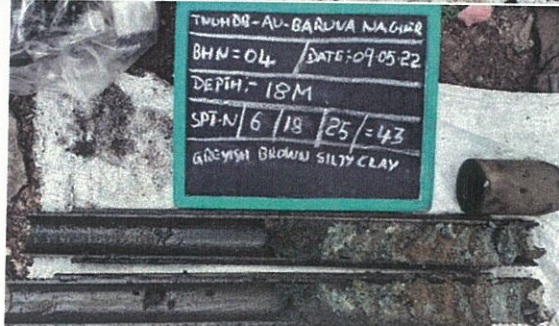
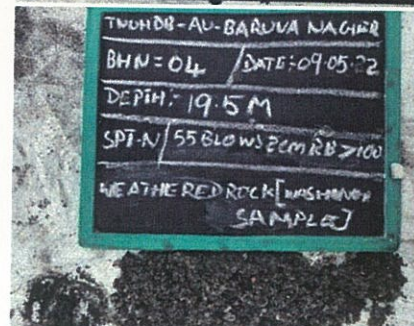
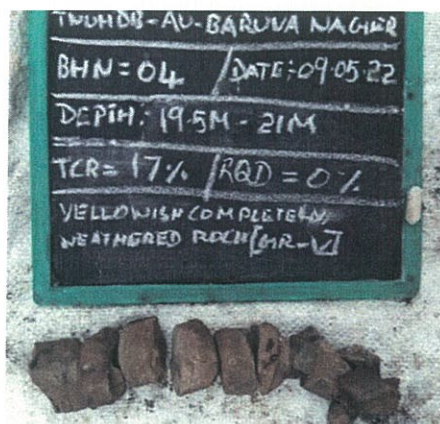
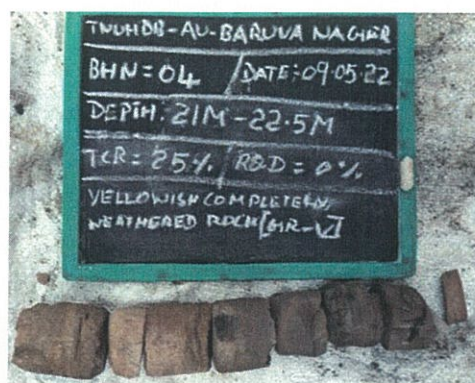
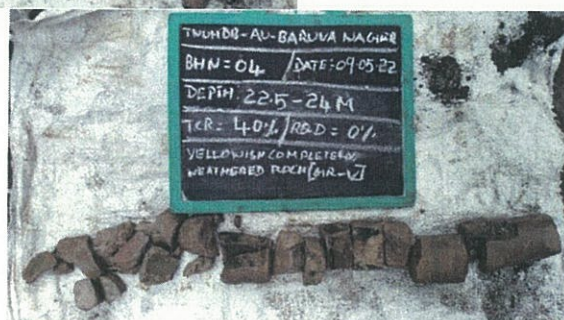


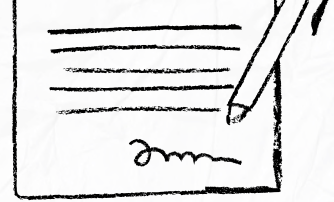


Plate – 4 Soil / Rock Samples Collected in BH-04 Location









our services doesn't just end there



Buying & Selling Services

Property Buying Assistance, Property Selling Support, Market Price Analysis, Owner Outreach and Negotiation.



Legal & Documentation Services

Certified EC, Patta, legal opinions, property verification, due diligence, litigation solutions, and legal heir certificates.



Property Development & Approvals

Building plan approvals, construction, layout and sub-division approvals, zone conversion, and occupancy certification.



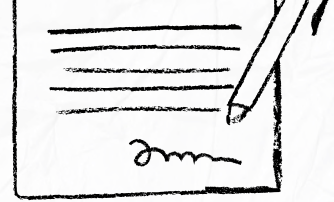
NRI & Investment Services

Escrow Services, Rentals, Litigation Solutions, Property Valuation and Property Management



Compliance & Special Services

Demolition, Vaasthu checks, regularization of unauthorized buildings, and office space solutions.



 **empowering your real estate decisions**
with smart tools



Property Valuation & Cost Estimation

Guideline Value, Apartment Composite Value, Stamp Duty & Registration Fees Calculator, Building Value Calculator, Capital Gains Calculator, Area Unit Converter, Length Unit Converter



Ownership, Compliance & Legal Verification

Encumbrance Certificate (EC) Search, Find Your SRO, Temple Property Check, WAQF Property Check, View Patta/Chitta, View FMB, Patta Analyzer, EC Analyzer



Zoning & Land Use Analysis

Land Use Zone Finder, CRZ Zone Check, Aquifer Zone Check, CBA Check, EWS Check, Road Width Check, Proposed Road Widening Check, FSI Calculator



Property Documentation & Workflow Tools

Forms & Templates, Document Generator, Document Translation, Dictionary



Vastu & Property Management Tools

Home Vastu Shastra, Plot Vastu Shastra, Property Management



We're honored to be part of your
real estate journey

3/350/2 Mettukuppam,
OMR Thoraipakkam,
Chennai, India

hello@verified.realestate
[+91 9996 12 9996](tel:+919996129996)
www.verified.realestate