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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
NORTH GIRIAPPA ROAD OLD, 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 219 / Consultancy / 2022

DATE : 17th June 2022


Executive Engineer
Division - V / TNUHDB
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Chennai-600 004.


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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
NORTH GIRIAPPA ROAD OLD, ZONE IX, DIVISION V, GREATER CHENNAI
CORPORATION.**

Job. No. SM&FE 219 / Consultancy / 2022

Date: 17.06.2022

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 North Giriappa Road Old 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 North Giriappa Road Old 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 29th April to 12th 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.


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2. SITE CONDITION AND EXPERIMENTAL PROGRAMME

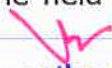


The proposed site is located at North Giriappa Road Old in Division V, TNUHDB, Chennai. The site is a plain terrain. The total number of borehole locations has been decided as '4', as agreed by the Officials of Executive Engineer of TNUHDB, Division – V, No. 5, Kamarajar Salai, Chennai – 600 005 and 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


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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 all four borehole locations.
2. Silty Clay was encountered from 5.0 m to 7.5 m depth in BH 1 location, 2.0 m to 4.0 m depth & from 7.5 m to 9.0 m depth in BH 2 location, 2.0 m to 6.0 m depth in BH 3 location and 6.0 m depth in BH 4 location with SPT 'N' value varying from 3 to 21.
3. Brown Silty Sand was observed from 10.5 m to 13.5 m depth in BH 2 location, 9.0 m to 19.5 m depth in BH 3 location with SPT 'N' value varying from 3 to >100.
4. Silty / Clayey Sand was found predominately in all borehole locations with SPT 'N' value varying from 4 to >100.
5. Brownish Grey Charnockite Rock was observed from 20.0 m to 23.0 m depth in BH 1 location, 19.5 m to 25.5 m depth in BH 2, 19.5 m to 25.5 m depth in BH 3 location, 21.0 to 25.5 m depth in BH 4 location with SPT 'N' values of >100.
6. The ground water table was observed from 1.5 m to 1.9 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).

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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.

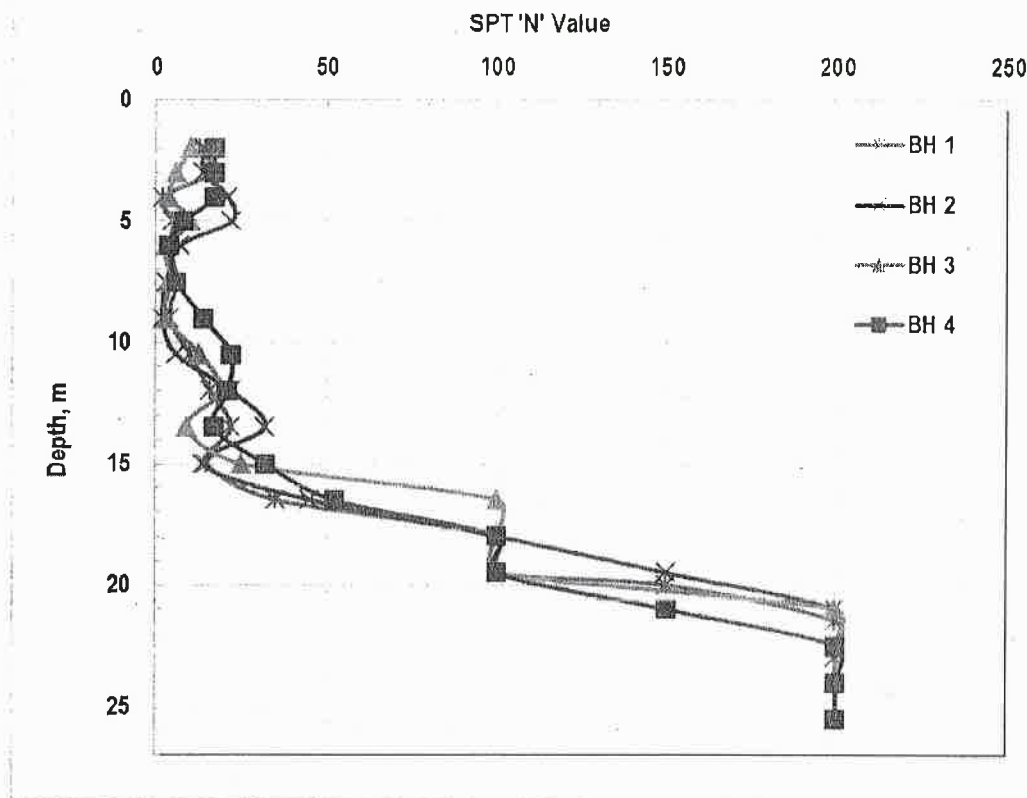


Figure (1) Variation of SPT 'N' value of different soil layers with respect to depth in Different Borehole Locations of the Site

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 22.0 m to 23.0 m. Safe pile carrying capacity computations were made for all four-borehole data. The Indian Standard IS 2911 (2010) specifies that the base resistance should not exceed 1000 to 1100 t/m² for bored cast-in-situ piles and 1500 t/m² for precast driven piles.

For calculating the skin friction along the pile length of 22.0 m to 24.0 m, 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 22.0 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	929	1118	1549	2049	3257	937	1128	1561	2063	3274
BH 2	963	1156	1595	2103	3325	1099	1308	1777	2315	3598
BH 3	1026	1227	1680	2201	3452	1062	1266	1727	2257	3523
BH 4	1106	1316	1786	2326	3612	1117	1327	1800	2342	3633

TABLE 2 Safe Uplift Capacity of 22.0 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	251	290	374	466	677
BH 2	371	423	533	652	917
BH 3	345	395	502	619	880
BH 4	416	474	595	726	1015

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The uplift capacity of a pile is given by sum of the frictional resistance and 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 North Giriappa Road Old 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 22.0 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 22.0 m to 24.0 m in Brownish Grey Charnockite Stratum.

TABLE 3 Safe Load carrying capacity and Lateral Load Capacity of Bored Cast-In-Situ Pile for varying diameter and for a length of 22.0 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	1000	48.30	4.09
500	1200	57.60	4.44
600	1650	77.00	5.14
700	2100	98.20	5.82
900	3400	147.20	7.11

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- 4) With regard to execution of bored cast-in-situ pile, procedure outlined in 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.

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LOCATION OF BOREHOLES

Legend

BH

BH01

BH02

ARULMIGU OMSAKTHI...

BH03

BH04

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IN-SITU GEOTECHNICAL BORE LOG

BORE-HOLE No.

BH 01

SHEET No.

(1/2)

Project: Geotechnical Investigation for the Reconstruction of Tenements at North Giriappa Road Old, Zone IX, Division V, Greater Chennai Corporation.

Co-ordinates: N - 1442172 ; E - 418337

Started: 29-04-2022

Location: North Giriappa Road

Completed: 30-04-2022

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: 23.0 m (19.5 m - Soil and 3.5 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 (%)	
1.0	1.0		Disturbed Sample	-	-	-	-			Very Loose
2.0	2.0		Brown Silty / Clayey Sand (SC)	12	6	7	13			Medium Dense
3.0	3.0		Brown Silty / Clayey Sand (CH)	5	10	6	16			Stiff
4.0	4.0		Greyish Silty / Clayey Sand (SC)	3	1	1	2			Loose
5.0	5.0		Greyish Silty Clay (CH)	4	2	3	5			Medium Stiff
6.0	6.0		Black Silty Clay (CH)	2	2	2	4			Soft
7.5	7.0		Black Silty / Clayey Sand (CH)	3	2	4	6			Medium Stiff
9.0	8.0		Greyish Silty / Clayey Sand (SC-SM)	2	2	2	4			Loose
10.5	9.0		Greyish Silty / Clayey Sand (SC)	3	4	6	10			Loose
12.0	11.0		Greyish Silty / Clayey Sand (SC-SM)	6	6	10	16			Medium Dense
13.5	12.0		Brownish Grey Silty / Clayey Sand (SC)	6	10	12	22			Medium Dense
15.0	13.0		Brownish Grey Silty / Clayey Sand (SC-SM)	6	7	8	15			Medium Dense
16.5	14.0		Greyish Brown Silty / Clayey Sand (SC)	16	15	20	35			Dense

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IN-SITU GEOTECHNICAL BORE LOG

BORE-HOLE No.	BH-01
SHEET No.	(2/2)

Project:		Geotechnical Investigation for the Reconstruction of Tenements at North Giriappa Road Old, Zone IX, Division V, Greater Chennai Corporation.									
Co-ordinates:		N - 1442172 ; E - 418337				Started:		29-04-2022			
Location:		North Giriappa Road				Completed:		30-04-2022			
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:		23.0 m (19.5 m - Soil and 3.5 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 90 120 150 180											
17.0											
18.0											
18.0											
19.5											
20.0											
20.0											
21.5											
21.5											
22.0											
22.0											
23.0											
23.0											

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IN-SITU GEOTECHNICAL BORE LOG

BORE-HOLE No.

BH-02

SHEET No.

(1/2)

Project:

Geotechnical Investigation for the Reconstruction of Tenements at North Giriappa Road Old, Zone IX, Division V, Greater Chennai Corporation.

Co-ordinates:

N - 1442165 ; E - 418342

Started:

08-05-2022

Location:

North Giriappa Road

Completed:

09-05-2022

Elevation (RL):

-

Ground Water Level:

1.8 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

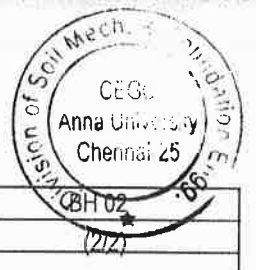
Total Drill Depth:

25.5 m (18.0 m - Soil and 7.5 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 90 120 150 180		
1.0	1.0		Disturbed Sample	-	-	-	-			Very Loose
2.0	2.0		Brown Silty Clay (CH)	5	6	8	14			Stiff
3.0	3.0		Greyish Silty Clay (CH)	4	6	8	14			Stiff
4.0	4.0		Greyish Silty Clay (CH)	9	11	10	21			Very Stiff
5.0	5.0		Greyish Silty Sand (SM-SP)	8	10	12	22			Medium Dense
6.0	6.0		Blackish Grey Silty / Clayey Sand (SC-SM)	2	3	4	7			Loose
7.5	7.0		Black Silty Clay (CH)	1	1	2	3			Soft
9.0	8.0		Black Silty Clay (CH)	1	1	1	2			Soft
10.5	9.0		Greyish Silty Sand (SM-SP)	2	3	3	6			Loose
12.0	11.0		Greyish Silty Sand (SM-SP)	8	9	13	22			Medium Dense
13.5	12.0		Greyish Silty Sand (SM-SP)	12	15	17	32			Dense
15.0	13.0		Brownish Grey Silty / Clayey Sand (SC)	5	6	8	14			Medium Dense
16.5	14.0		Brownish Grey Silty / Clayey Sand (CH)	15	17	28	45			Hard

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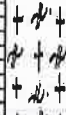
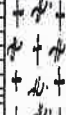
IN-SITU GEOTECHNICAL BORE LOG

BORE-HOLE No.

SHEET No.

BH 02

(2/2)

Project:		Geotechnical Investigation for the Reconstruction of Tenements at North Giriappa Road Old, Zone IX, Division V, Greater Chennai Corporation.									
Co-ordinates:		N - 1442165 ; E - 418342				Started:		08-05-2022			
Location:		North Giriappa Road				Completed:		09-05-2022			
Elevation (RL):		-				Ground Water Level:		1.8 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:		25.5 m (18.0 m - Soil and 7.5 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 90 120 150 180											
18.0	17.0		Brown Silty / Clayey Sand (SC-SM)	56 _(7 cm) Rebound			>100			Very Dense	
19.5	18.0		Brownish Grey, Charnockite, Completely Weathered (Grade V / VI)	51 _(0 cm) Rebound			>100			Hard / Very Weak	
21.0	20.0		Brownish, Charnockite, Completely Weathered (Grade V)					13.0	0.0	Hard / Weak	
	21.0										
22.5	22.0							26.0	0.0	Hard / Weak	
	23.0										
24.0	24.0							53.0	0.0	Hard / Weak	
25.5	25.0							39.0	0.0	Hard / Weak	

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26/5/22
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IN-SITU GEOTECHNICAL BORE LOG

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

Project:		Geotechnical Investigation for the Reconstruction of Tenements at North Giriappa Road Old, Zone IX, Division V, Greater Chennai Corporation.									
Co-ordinates:		N - 1442094 ; E - 418330				Started:		11-05-2022			
Location:		North Giriappa Road				Completed:		12-05-2022			
Elevation (RL):		-				Ground Water Level:		1.7 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:		25.5 m (19.5 m - Soil and 6.0 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 90 120 150 180											
1.0	1.0		Disturbed Sample	-	-	-	-			Very Loose	
2.0	2.0		Brown Silty / Clayey Sand (CH)	3	5	5	10			Stiff	
3.0	3.0		Brown Silty / Clayey Sand (CH)	2	2	4	6			Medium Stiff	
4.0	4.0		Greyish Silty Clay (CH)	2	2	2	4			Soft	
5.0	5.0		Brownish Grey Silty Sand (SM-SP)	3	4	6	10			Loose	
6.0	6.0		Greyish Silty Clay (CH)	1	1	2	3			Soft	
7.5	7.0		Greyish Silty / Clayey Sand (SC-SM)	1	2	2	4			Loose	
9.0	8.0		Greyish Silty Sand (SM-SP)	2	2	1	3			Loose	
10.5	10.0		Greyish Brown Silty / Clayey Sand (SC)	4	5	8	13			Medium Dense	
12.0	11.0		Greyish Silty / Clayey Sand (SC-SM)	8	10	9	19			Medium Dense	
13.5	13.0		Brownish Grey Silty Sand (SM-SP)	4	4	5	9			Loose	
15.0	14.0		Brown Silty / Clayey Sand (SC-SM)	9	11	14	25			Medium Dense	
16.5	16.0		Greyish Brown Silty Clay (CH)	12	25	65 (6 cm) Rebound	>100			Hard	

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IN-SITU GEOTECHNICAL BORE LOG

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

Project:		Geotechnical Investigation for the Reconstruction of Tenements at North Giriappa Road Old, Zone IX, Division V, Greater Chennai Corporation.									
Co-ordinates:		N - 1442094 ; E - 418330				Started:		11-05-2022			
Location:		North Giriappa Road				Completed:		12-05-2022			
Elevation (RL):		-				Ground Water Level:		1.7 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:		25.5 m (19.5 m - Soil and 6.0 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 90 120 150 180											
17.0											
18.0			Greyish Brown Silty / Clayey Sand (SC)	35	60 (4 cm) Rebound		>100			Very Dense	
19.0											
19.5			Greyish Silty Sand (SM-SP)	55 (7 cm) Rebound			>100			Very Dense	
20.0											
21.0								15.3	0.0	Hard / Weak	
22.0											
22.5			Brownish Grey, Charnockite, Completely Weathered (Grade V)					12.3	0.0	Hard / Weak	
23.0											
24.0								13.3	0.0	Hard / Weak	
25.0											
25.5								52.3	0.0	Hard / Weak	

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IN-SITU GEOTECHNICAL BORE LOG

BORE-HOLE No.

BH 04

SHEET No.

(1/2)

Project:

Geotechnical Investigation for the Reconstruction of Tenements at North Giriappa Road Old, Zone IX, Division V, Greater Chennai Corporation.

Co-ordinates:

N - 1442071 ; E - 418320

Started:

11-05-2022

Location:

North Giriappa Road

Completed:

12-05-2022

Elevation (RL):

-

Ground Water Level:

1.9 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:

25.5 m (19.5 m - Soil and 6.0 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 (%)	
1.0	1.0		Disturbed Sample	-	-	-	-			Very Loose
2.0	2.0		Brownish Grey Silty / Clayey Sand (SC)	10	11	6	17			Medium Dense
3.0	3.0		Brownish Grey Silty / Clayey Sand (SC-SM)	6	7	10	17			Medium Dense
4.0	4.0		Greyish Silty / Clayey Sand (SC)	7	9	8	17			Medium Dense
5.0	5.0		Black Silty / Clayey Sand (SC)	5	3	5	8			Loose
6.0	6.0		Black Silty Clay (CH)	2	2	2	4			Soft
7.5	7.0		Black Silty / Clayey Sand (SC)	2	3	3	6			Loose
9.0	8.0		Black Silty / Clayey Sand (SC)	4	6	8	14			Medium Dense
10.5	9.0		Brownish Grey Silty / Clayey Sand (SC)	8	10	12	22			Medium Dense
12.0	11.0		Greyish Silty / Clayey Sand (SC-SM)	7	9	12	21			Medium Dense
13.5	12.0		Brownish Grey Silty / Clayey Sand (SC-CI)	6	7	10	17			Medium Dense
15.0	13.0		Brownish Grey Silty / Clayey Sand (SC)	10	14	18	32			Dense
16.5	14.0		Brownish Silty / Clayey Sand (SC-SM)	17	24	28	52			Very Dense

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IN-SITU GEOTECHNICAL BORE LOG

BORE-HOLE No.

BNH/AS/14/10

SHEET No.

(2/2)

Project:

Geotechnical Investigation for the Reconstruction of Tenements at North Giriappa Road Old, Zone IX, Division V, Greater Chennai Corporation.

Co-ordinates: N - 1442071 ; E - 418320

Started: 11-05-2022

Location: North Giriappa Road

Completed: 12-05-2022

Elevation (RL): -

Ground Water Level: 1.9 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: 25.5 m (19.5 m - Soil and 6.0 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 90 120 150 180		
18.0	17.0		Brown Silty / Clayey Sand (SC)	28	55 (3 cm) Rebound		>100			Very Dense
19.5	19.0		Brown Silty / Clayey Sand (SC)		55 (2 cm) Rebound		>100			Very Dense
21.0	20.0		Brownish Grey, Charnockite, Completely Weathered (Grade V / VI)		54 (3 cm) Rebound		>100			Hard / Very Weak
22.5	22.0							18.7	0.0	Hard / Weak
24.0	23.0		Brownish Grey, Charnockite, Completely Weathered (Grade V)					34.3	0.0	Hard / Weak
25.5	25.0							28.3	0.0	Hard / Weak

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Annexure - A-2
Laboratory Test Results

Table A-1

Project : Geotechnical Investigation for the Reconstruction of Tenements at North Giriappa Road Old, 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/m³)	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %		Free Swell Index	Coarse Sand	Medium Sand	Fine Sand	Fines		Cohesion (c), kN/m²	Angle of Friction (φ) in Degrees
													Silt & Clay			
2.0	13	Brown Silty / Clayey Sand (SC)	22	15.9	32	17	15	2.65	0	11	4	54	31	20	25	
3.0	16	Brown Silty / Clayey Sand (CH)	23	16.6	59	23	36	2.62	0	0	4	35	61	100	0	
4.0	2	Greyish Silty / Clayey Sand (SC)	25	11.1	32	17	15	2.65	0	0	0	69	31	3	15	
5.0	5	Greyish Silty Clay (CH)	40	13.2	63	24	39	2.61	0	0	0	25	75	31	0	
6.0	4	Black Silty Clay (CH)	53	12.7	57	23	34	2.60	0	0	1	12	87	25	0	
7.5	6	Black Silty / Clayey Sand (CH)	39	13.7	52	22	30	2.63	0	0	3	28	69	38	0	
9.0	4	Greyish Silty / Clayey Sand (SC-SM)	21	12.7	23	16	7	2.66	0	3	15	60	22	4	18	
10.5	10	Greyish Silty / Clayey Sand (SC)	17	15.1	27	17	10	2.65	0	0	22	41	37	15	23	
12.0	16	Greyish Silty / Clayey Sand (SC-SM)	14	16.6	24	16	8	2.66	0	2	28	49	21	16	28	
13.5	22	Brownish Grey Silty / Clayey Sand (SC)	17	17.6	29	18	11	2.65	0	12	7	51	30	33	30	
15.0	15	Brownish Grey Silty / Clayey Sand (SC-SM)	14	16.4	27	16	11	2.66	0	12	19	42	27	23	26	
16.5	35	Greyish Brown Silty / Clayey Sand (SC)	14	19.3	31	21	10	2.65	0	9	15	44	32	53	35	
18.0	>100	Greyish Brown Silty Clay (CH)	24	22.0	77	30	47	2.67	0	1	5	13	81	625	0	
19.5	>100	Greyish Brown Silty / Clayey Sand (CH)	23	22.0	65	28	37	2.66	0	1	6	27	66	625	0	
					Porosity of Rock (%)					Soaked Strength of Rock						
										UCS, kN/m²		I _{sp} , kN/m²				
20.0	>100	Brownish Grey, Charnockite, Completely Weathered (Grade V / VI)	-	22.0		-		2.66	-	-	-	-	-	0	44	
21.5	-	Brownish, Charnockite, Completely Weathered (Grade V)	1.56	24.7		2.63		2.68	-	-	-	-	3560	0	45	
23.0	-	Brownish, Charnockite, Highly Weathered (Grade IV)	1.49	25.3		2.58		2.69	-	-	-	-	4270	0	45	



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Table A-2

Project : Geotechnical Investigation for the Reconstruction of Tenements at North Giriappa Road Old, Zone IX, Division V, Greater Chennai Corporation.

BH No: 2		LABORATORY TEST RESULTS										Ground Water Table Depth (m): 1.8					
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	Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines	Cohesion (c), kN/m²	Angle of Friction (φ) in Degrees	
2.0	14	Brown Silty Clay (CH)	25	16.2	67	24	43	80	2.61	0	0	1	19	80	88	0	
3.0	14	Greyish Silty Clay (CH)	28	16.2	61	22	39	75	2.62	0	1	1	22	76	88	0	
4.0	21	Greyish Silty Clay (CH)	29	17.5	59	22	37	70	2.60	0	0	0	1	28	71	131	
5.0	22	Greyish Silty Sand (SM-SP)	22	17.6	NP	NP	NP	NP	2.65	0	0	0	2	83	15	0	
6.0	7	Blackish Grey Silty / Clayey Sand (SC-SM)	37	14.1	27	16	11	10	2.66	0	1	2	68	29	7	22	
7.5	3	Black Silty Clay (CH)	48	12.0	65	24	41	60	2.60	0	0	0	13	87	19	0	
9.0	2	Black Silty Clay (CH)	48	11.1	55	23	32	30	2.60	0	2	4	11	83	13	0	
10.5	6	Greyish Silty Sand (SM-SP)	17	13.7	NP	NP	NP	NP	2.61	0	4	19	57	20	0	23	
12.0	22	Greyish Silty Sand (SM-SP)	14	17.6	NP	NP	NP	NP	2.63	0	3	38	38	21	0	33	
13.5	32	Greyish Silty Sand (SM-SP)	15	19.0	NP	NP	NP	NP	2.65	0	4	17	58	21	0	37	
15.0	14	Brownish Grey Silty / Clayey Sand (SC)	14	16.2	29	18	11	15	2.65	0	12	20	37	31	21	26	
16.5	45	Brownish Grey Silty / Clayey Sand (CH)	22	22.0	66	29	37	NP	2.66	0	6	7	19	68	281	0	
18.0	>100	Brown Silty / Clayey Sand (SC-SM)	15	22.0	29	18	11	10	2.66	0	13	21	38	28	80	41	
											Soaked Strength of Rock						
											UCS, kN/m²		I _s , kN/m²				
19.5	>100	Brownish Grey, Charnockite, Completely Weathered (Grade V / VI)	-	22.0		-			2.66		-			-	0	44	
21.0	-	Brownish, Charnockite, Completely Weathered (Grade V)	1.56	23.6		2.72			2.67					1280	0	45	
22.5	-	Brownish, Charnockite, Completely Weathered (Grade V)	1.59	24.9		2.68			2.68					4330	0	45	
24.0	-	Brownish, Charnockite, Completely Weathered (Grade V)	1.55	25.3		2.63			2.68					3560	0	45	
25.5	-	Brownish, Charnockite, Completely Weathered (Grade V)	1.49	25.8		2.54			2.68					2670	0	45	



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Table A-3

Project : Geotechnical Investigation for the Reconstruction of Tenements at North Giraappa Road Old, Zone IX, Division V, Greater Chennai Corporation.

BH No: 3		LABORATORY TEST RESULTS										Ground Water Table Depth (m):		1.7		
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	Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines	Cohesion (c), kN/m²	Angle of Friction (φ) in Degrees
2.0	10	Brown Silty / Clayey Sand (CH)	22	15.1	53	22	31	40	2.62	0	1	1	34	64	63	0
3.0	6	Brown Silty / Clayey Sand (CH)	29	13.7	55	21	34	40	2.60	0	0	2	38	60	38	0
4.0	4	Greyish Silty Clay (CH)	43	12.7	58	23	35	50	2.61	0	0	0	3	97	25	0
5.0	10	Brownish Grey Silty Sand (SM-SP)	26	15.1	NP	NP	NP	NP	2.64	0	0	15	67	18	0	26
6.0	3	Greyish Silty Clay (CH)	58	12.0	87	36	51	70	2.65	0	0	0	7	93	19	0
7.5	4	Greyish Silty / Clayey Sand (SC-SM)	25	12.7	26	16	10	10	2.66	0	3	12	62	23	4	19
9.0	3	Greyish Silty Sand (SM-SF)	18	12.0	NP	NP	NP	NP	2.64	0	5	21	53	21	0	20
10.5	13	Greyish Brown Silty / Clayey Sand (SC)	16	15.9	29	18	11	10	2.65	0	2	31	37	30	20	25
12.0	19	Greyish Silty / Clayey Sand (SC-SM)	14	17.1	29	14	15	65	2.66	0	1	26	45	28	19	29
13.5	9	Brownish Grey Silty Sand (SM-SP)	19	14.8	NP	NP	NP	NP	2.64	0	11	15	35	39	0	25
15.0	25	Brown Silty / Clayey Sand (SC-SM)	14	18.1	24	16	8	10	2.65	21	11	22	24	22	25	32
16.5	>100	Greyish Brown Silty Clay (CH)	23	22.0	58	23	35	45	2.62	0	5	8	17	70	625	0
18.0	>100	Greyish Brown Silty / Clayey Sand (SC)	20	22.0	39	19	20	40	2.65	0	10	20	39	31	90	40
19.5	>100	Greyish Silty Sand (SM-SP)	16	22.0	NP	NP	NP	NP	2.64	0	32	35	22	11	0	42
							Porosity of Rock (%)				Soaked Strength of Rock					
											UCS, kN/m²			I _p , kN/m²		
21.0	>100	Brownish Grey, Charnockite, Completely Weathered (Grade V)	1.64	23.4			2.72		2.67	-	-	-	-	1980	0	45
22.5	-	Brownish Grey, Charnockite, Completely Weathered (Grade V)	1.61	24.3			2.68		2.68	-	-	-	-	2530	0	45
24.0	-	Brownish Grey, Charnockite, Completely Weathered (Grade V)	1.54	24.6			2.65		2.68	-	-	-	-	3570	0	45
25.5	-	Brownish Grey, Charnockite, Completely Weathered (Grade V)	1.57	25.3			2.62		2.66	-	-	-	-	3560	0	45



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Table A-4

Project : Geotechnical Investigation for the Reconstruction of Tenements at North Giriappa Road Old, Zone IX, Division V, Greater Chennai Corporation.

BH No: 4		LABORATORY TEST RESULTS										Ground Water Table Depth (m):		1.9			
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		Coarse Sand			Fine Sand	Fines Silt & Clay		Cohesion (c), kN/m ²	Angle of Friction (Φ) in Degrees
										Gravel	Coarse Sand	Medium Sand					
2.0	17	Brownish Grey Silty / Clayey Sand (SC)	22	16.8	43	22	21	20	2.65	0	6	7	42	45	26	27	
3.0	17	Brownish Grey Silty / Clayey Sand (SC-SM)	23	16.8	27	16	11	10	2.66	0	0	3	70	27	17	28	
4.0	17	Greyish Silty / Clayey Sand (SC)	32	16.8	45	23	22	20	2.65	0	0	5	48	47	26	27	
5.0	8	Black Silty / Clayey Sand (SC)	26	14.5	30	19	11	15	2.65	0	0	2	65	33	12	22	
6.0	4	Black Silty Caly (CH)	59	12.7	58	21	37	30	2.62	0	0	0	6	94	25	0	
7.5	6	Black Silty / Clayey Sand (SC)	33	13.7	40	22	18	20	2.65	0	1	12	46	41	9	20	
9.0	14	Black Silty / Clayey Sand (SC)	25	16.2	33	20	13	15	2.66	0	2	16	47	35	21	26	
10.5	22	Brownish Grey Silty / Clayey Sand (SC)	14	17.6	35	12	23	25	2.65	0	0	21	42	37	33	30	
12.0	21	Greyish Silty / Clayey Sand (SC-SM)	15	17.5	26	16	10	10	2.66	0	4	27	41	28	21	30	
13.5	17	Brownish Grey Silty / Clayey Sand (SC-CI)	19	16.8	29	21	8	20	2.65	0	2	7	43	48	26	27	
15.0	32	Brownish Grey Silty / Clayey Sand (SC)	18	19.0	39	22	17	20	2.65	0	7	14	37	42	48	34	
16.5	52	Brownish Silty / Clayey Sand (SC-SM)	13	22.0	24	16	8	10	2.66	20	11	23	24	22	52	41	
18.0	>100	Brown Silty / Clayey Sand (SC)	21	22.0	54	27	27	30	2.65	0	13	27	27	33	90	40	
19.5	>100	Brown Silty / Clayey Sand (SC)	14	22.0	46	25	21	44	2.66	16	10	29	24	21	90	40	
						Porosity of Rock (%)				Soaked Strength of Rock							
											UCS, kN/m ²		I _s , kN/m ²				
21.0	>100	Brownish Grey, Charnockite, Completely Weathered (Grade V / VI)	-	22.0		-			2.67	-	-	-	-	-	0	44	
22.5	-	Brownish Grey, Charnockite, Completely Weathered (Grade V)	0.65	24.3		0.71			2.68	-	-	-	710		0	45	
24.0	-	Brownish Grey, Charnockite, Completely Weathered (Grade V)	0.57	25.6		0.68			2.68	-	-	-	360		0	45	
25.5	-	Brownish Grey, Charnockite, Completely Weathered (Grade V)	0.55	26.3		0.62			2.68	-	-	-	1350		0	45	



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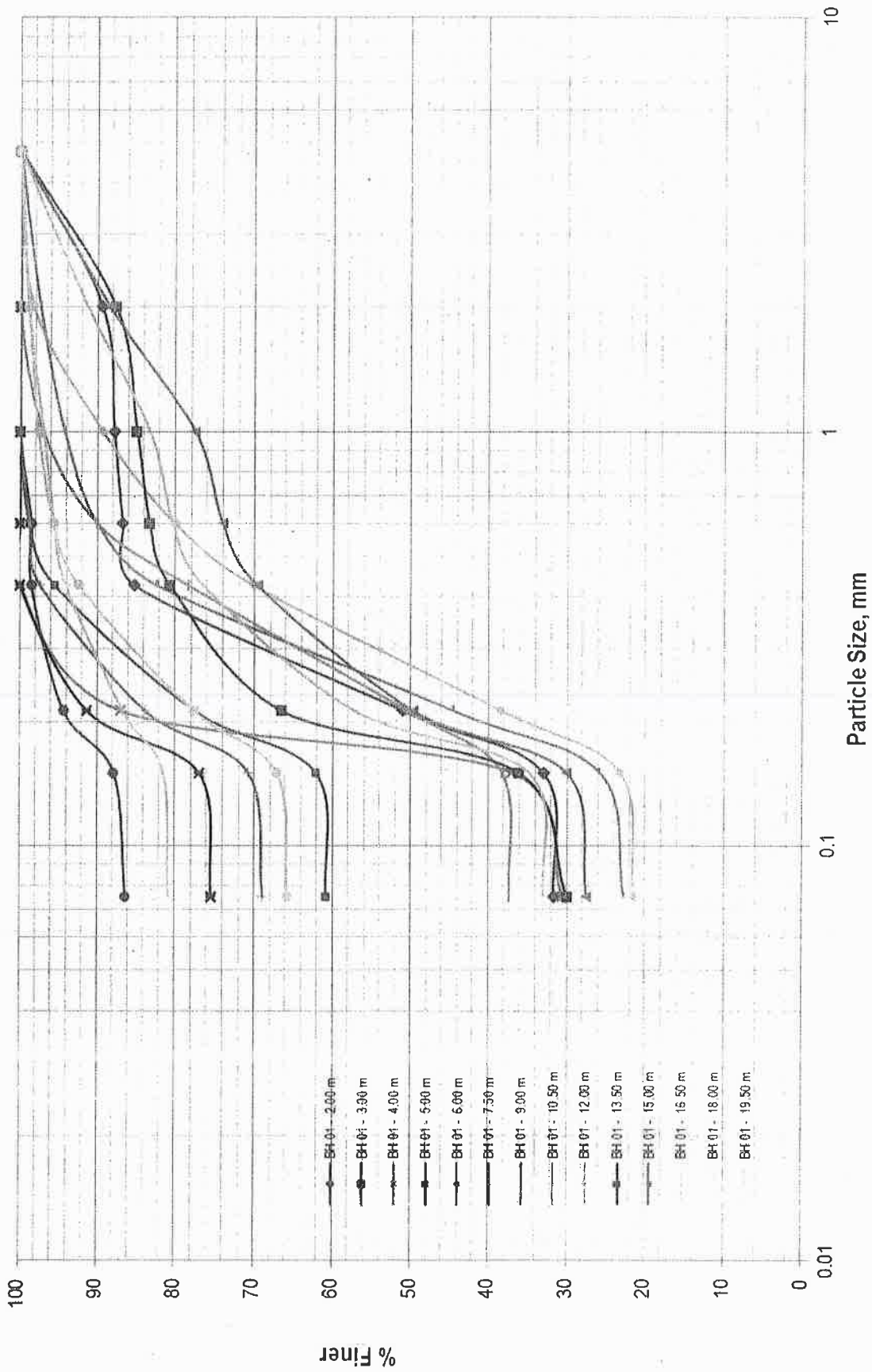


Figure B-1 Grain Size Distribution Curves of Soil Samples encountered in BH-1 Locations

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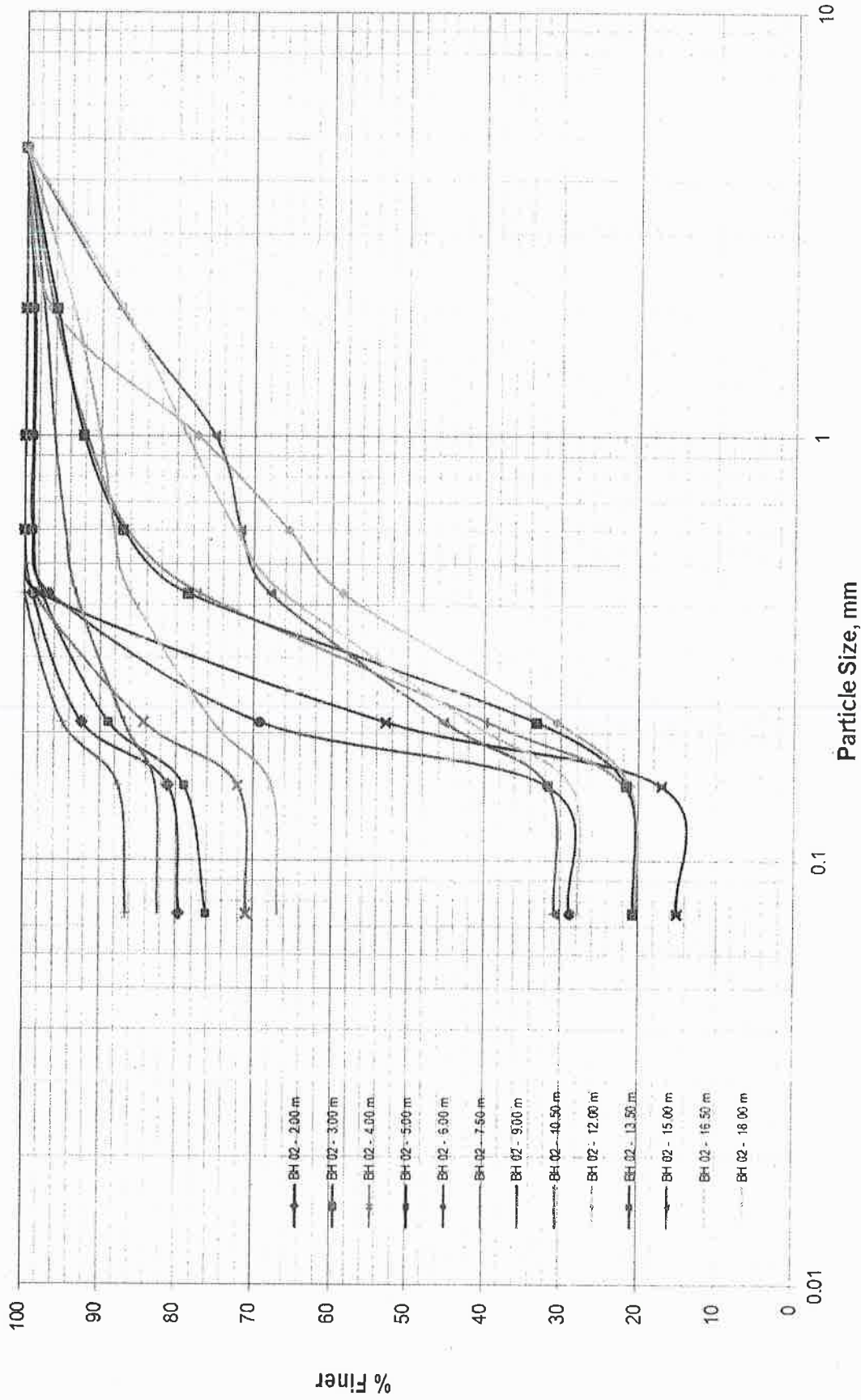


Figure B-2 Grain Size Distribution Curves of Soil Samples encountered in BH-2 Location

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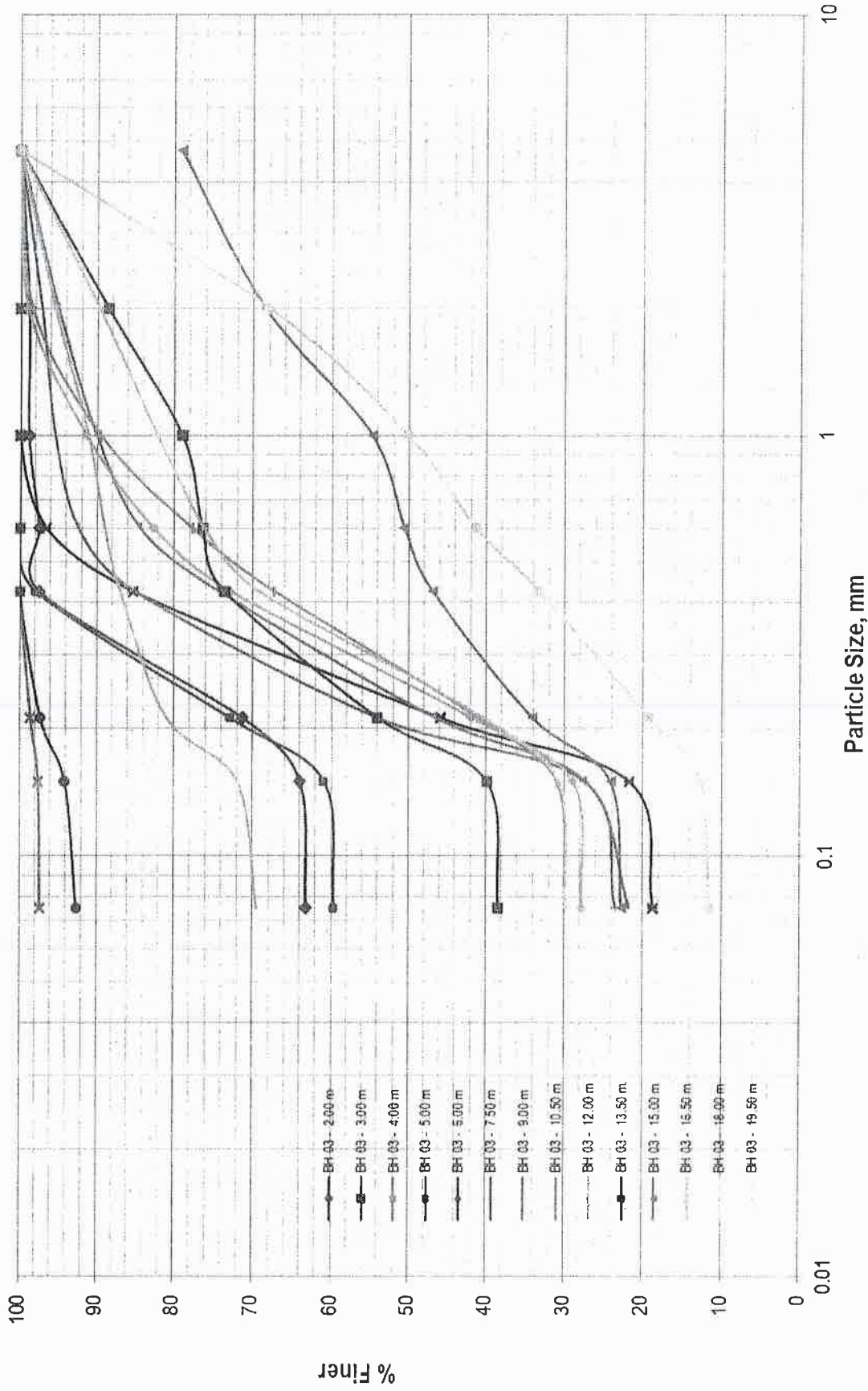


Figure B-3 Grain Size Distribution Curves of Soil Samples encountered in BH-3 Location

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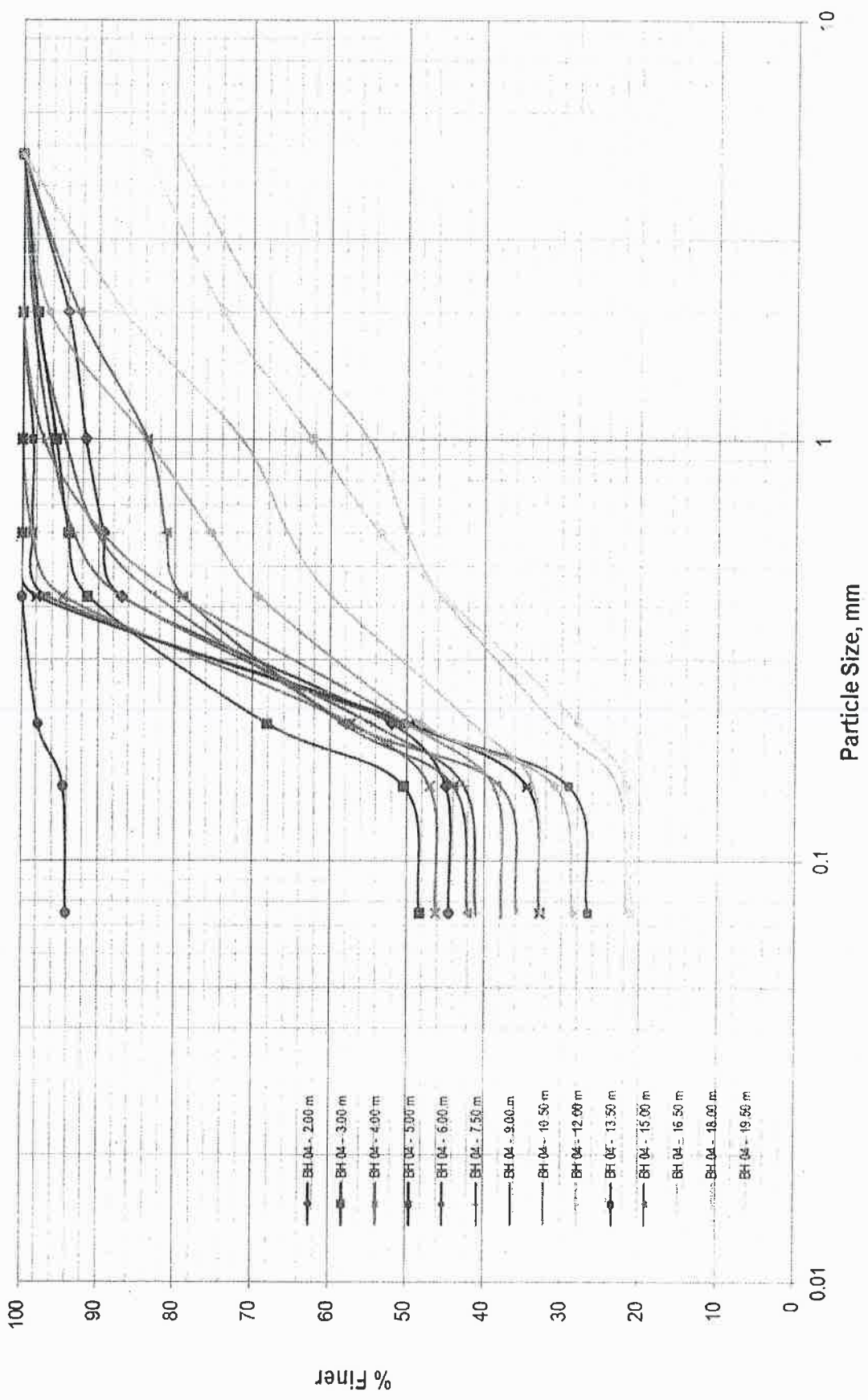


Figure B-4 Grain Size Distribution Curves of Soil Samples encountered in BH-4 Location



Appendix - A

GEOTECHNICAL DESIGN PARAMETERS

GEOTECHNICAL DESIGN PARAMETERS OF DIFFERENT LAYERS BELOW GROUND LEVEL

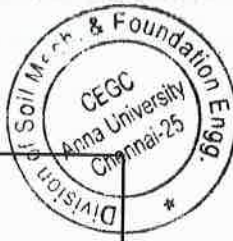
PROJECT: Geotechnical Investigation for the Reconstruction of Tenements at North Giriappa Road Old, Zone IX, Division V, Greater Chennai Corporation.

BH No:	1	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	Angle of Friction (ϕ) in Degrees	SPT 'N' Value	
						Shear Strength (c_u), kN/m^2			
2.00	13	Brown Silty / Clayey Sand (SC)	13	15.9	8960	20	25.0		
3.00	16	Brown Silty / Clayey Sand (CH)	16	16.6	9920	100	0.0		
4.00	2	Greyish Silty / Clayey Sand (SC)	2	11.1	5440	3	15.0		
5.00	5	Greyish Silty Clay (CH)	5	13.2	6400	31	0.0		
6.00	4	Black Silty Clay (CH)	4	12.7	6080	25	0.0		
7.50	6	Black Silty / Clayey Sand (CH)	6	13.7	6720	38	0.0		
9.00	4	Greyish Silty / Clayey Sand (SC-SM)	4	12.7	6080	4	18.0		
10.50	10	Greyish Silty / Clayey Sand (SC)	10	15.1	8000	15	23.0		
12.00	16	Greyish Silty / Clayey Sand (SC-SM)	16	16.6	9920	16	28.0		
13.50	22	Brownish Grey Silty / Clayey Sand (SC)	22	17.6	11840	33	30.0		
15.00	15	Brownish Grey Silty / Clayey Sand (SC-SM)	15	16.4	9600	23	26.0		
16.50	35	Greyish Brown Silty / Clayey Sand (SC)	35	19.3	16000	53	35.0		
18.00	>100	Greyish Brown Silty Clay (CH)	100	22.0	36800	625	0.0		
19.50	>100	Greyish Brown Silty / Clayey Sand (CH)	100	22.0	36800	625	0.0		
20.00	>100	Brownish Grey, Charnockite, Completely Weathered (Grade V / VI)	150	22.0	197500	0	44.0		
21.50	-	Brownish, Charnockite, Completely Weathered (Grade V)	200	24.7	250000	0	45.0		
23.00	-	Brownish, Charnockite, Highly Weathered (Grade IV)	200	25.3	250000	0	45.0		

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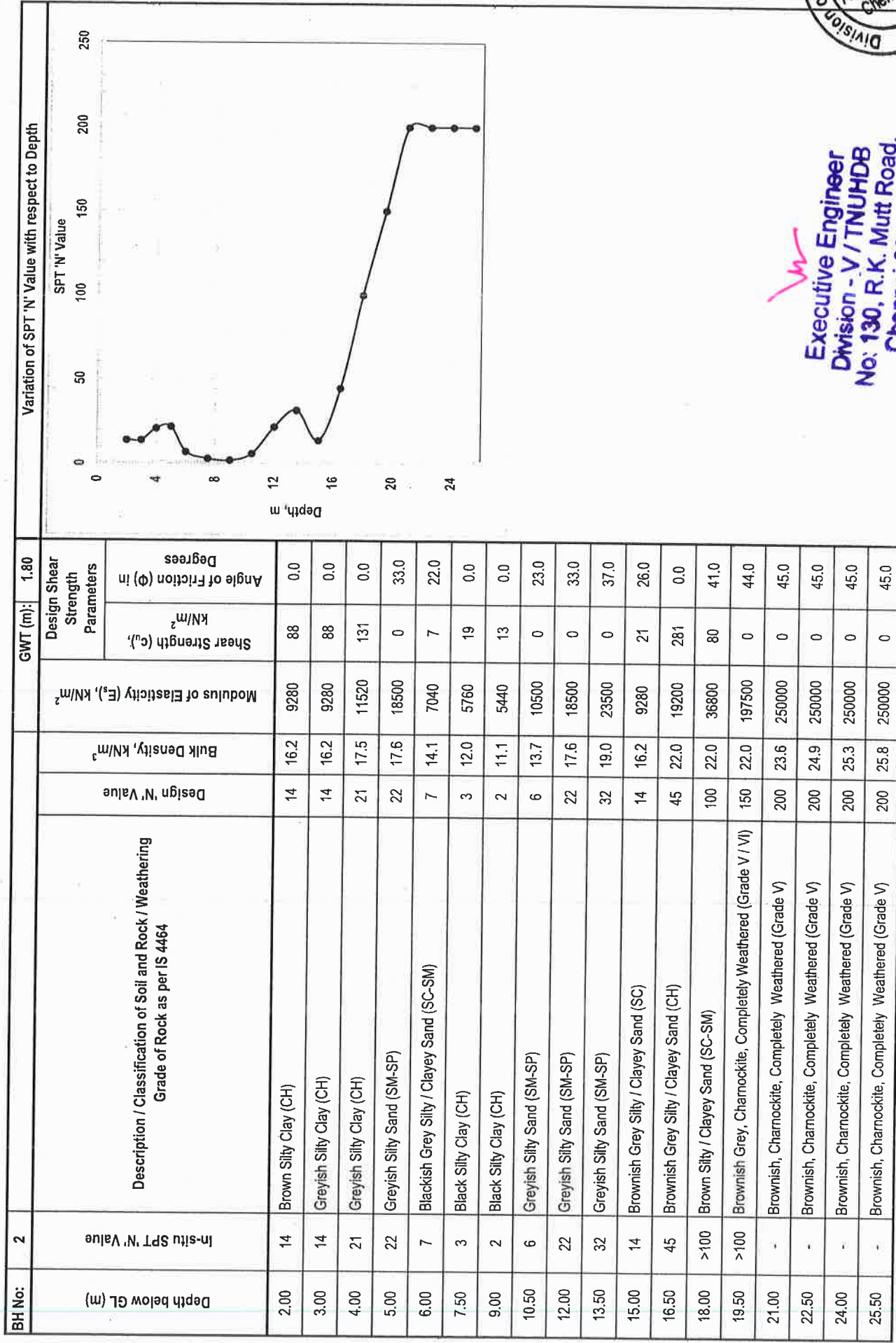
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GEOTECHNICAL DESIGN PARAMETERS OF DIFFERENT LAYERS BELOW GROUND LEVEL

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GEOTECHNICAL DESIGN PARAMETERS OF DIFFERENT LAYERS BELOW GROUND LEVEL

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BH No:	3	GWT (m): 1.70		Design Shear Strength Parameters		Design 'N' Value		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	Shear Strength (c_u), KN/m^2	Angle of Friction (ϕ) in Degrees	SPT 'N' Value	Depth, m
2.00	10	Brown Silty / Clayey Sand (CH)	10	15.1	8000	63	0.0		
3.00	6	Brown Silty / Clayey Sand (CH)	6	13.7	6720	38	0.0		
4.00	4	Greyish Silty Clay (CH)	4	12.7	6080	25	0.0		
5.00	10	Brownish Grey Silty Sand (SM-SP)	10	15.1	12500	0	26.0		
6.00	3	Greyish Silty Clay (CH)	3	12.0	5730	19	0.0		
7.50	4	Greyish Silty / Clayey Sand (SC-SM)	4	12.7	6030	4	19.0		
9.00	3	Greyish Silty Sand (SM-SP)	3	12.0	9000	0	20.0		
10.50	13	Greyish Brown Silty / Clayey Sand (SC)	13	15.9	8950	20	25.0		
12.00	19	Greyish Silty / Clayey Sand (SC-SM)	19	17.1	10880	19	29.0		
13.50	9	Brownish Grey Silty Sand (SM-SF)	9	14.8	12000	0	25.0		
15.00	25	Brown Silty / Clayey Sand (SC-SM)	25	18.1	12800	25	32.0		
16.50	>100	Greyish Brown Silty Clay (CH)	100	22.0	36800	625	0.0		
18.00	>100	Greyish Brown Silty / Clayey Sand (SC)	100	22.0	36800	90	40.0		
19.50	>100	Greyish Silty Sand (SM-SP)	100	22.0	57500	0	42.0		
21.00	>100	Brownish Grey, Charnockite, Completely Weathered (Grade V)	200	23.4	107500	0	45.0		
22.50	-	Brownish Grey, Charnockite, Completely Weathered (Grade V)	200	24.3	107500	0	45.0		
24.00	-	Brownish Grey, Charnockite, Completely Weathered (Grade V)	200	24.6	107500	0	45.0		
25.50	-	Brownish Grey, Charnockite, Completely Weathered (Grade V)	200	25.3	250000	0	45.0		

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GEOTECHNICAL DESIGN PARAMETERS OF DIFFERENT LAYERS BELOW GROUND LEVEL

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BH No:	4	GWT (m): 1.90				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	Angle of Friction (ϕ) in Degrees	SPT 'N' Value	
						Shear Strength (c_u), kN/m^2			
2.00	17	Brownish Grey Silty / Clayey Sand (SC)	17	16.8	10240	26	27.0		
3.00	17	Brownish Grey Silty / Clayey Sand (SC-SM)	17	16.8	10240	17	28.0		
4.00	17	Greyish Silty / Clayey Sand (SC)	17	16.8	10240	26	27.0		
5.00	8	Black Silty / Clayey Sand (SC)	8	14.5	7360	12	22.0		
6.00	4	Black Silty Caly (CH)	4	12.7	6080	25	0.0		
7.50	6	Black Silty / Clayey Sand (SC)	6	13.7	6720	9	20.0		
9.00	14	Black Silty / Clayey Sand (SC)	14	16.2	9280	21	26.0		
10.50	22	Brownish Grey Silty / Clayey Sand (SC)	22	17.6	11840	33	30.0		
12.00	21	Greyish Silty / Clayey Sand (SC-SM)	21	17.5	11520	21	30.0		
13.50	17	Brownish Grey Silty / Clayey Sand (SC-CI)	17	16.8	10240	26	27.0		
15.00	32	Brownish Grey Silty / Clayey Sand (SC)	32	19.0	15040	48	34.0		
16.50	52	Brownish Silty / Clayey Sand (SC-SM)	52	22.0	21440	52	41.0		
18.00	>100	Brown Silty / Clayey Sand (SC)	100	22.0	36800	90	40.0		
19.50	>100	Brown Silty / Clayey Sand (SC)	100	22.0	36800	90	40.0		
21.00	>100	Brownish Grey, Charnockite, Completely Weathered (Grade V / VI)	150	22.0	197500	0	44.0		
22.50	-	Brownish Grey, Charnockite, Completely Weathered (Grade V)	200	24.3	250000	0	45.0		
24.00	-	Brownish Grey, Charnockite, Completely Weathered (Grade V)	200	25.6	250000	0	45.0		
25.50	-	Brownish Grey, Charnockite, Completely Weathered (Grade V)	200	26.3	250000	0	45.0		

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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; and N_q

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.



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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 m²;
- N_c = bearing capacity factor, may be taken as 9;
- c_p = average cohesion at pile tip, in kN/m²;
- $\sum_{i=1}^n$ = 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/m²; and
- A_{si} = surface area of pile shaft in the i th layer, in m².

B-3.3 Ultimate skin friction resistance can be approximated to local side friction (f_s), in kN/m², 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/m², 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/m²;
- q_{c1} = minimum static cone resistance over the same $2D$ below the pile tip, in kN/m²;
- 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/m²; 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

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

$$Q_u = A_p (cN_c + P_0 N_q + 0.5\gamma DN_y) + \sum A_{si}(\alpha_i c_i + K P_{Di} \tan \phi)$$

Where,

Q_u	-	Ultimate Pile Capacity, kN	A_{si}	-	Surface Area of Pile at respective soil layers, m ²
A_p	-	Cross Sectional Area of Pile, m ²	α_i	-	Adhesion factor
c_i	-	Cohesion value of soil at pile base, kN/m ²	c	-	Cohesion value of soil at respective soil layers, kN/m ²
P_0	-	Effective overburden pressure at pile base, kN/m ²	K_i	-	Co-efficient of earth pressure at respective soil layers
γ	-	Unit weight of soil, kN/m ³	P_{Di}	-	Effective overburden pressure at respective soil layers, kN/m ²
D	-	Diameter of pile, m	ϕ	-	Friction angle, degrees
			N_c, N_q	-	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):

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

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.

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

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DETERMINATION OF PILE CARRYING CAPACITY AS PER IS 2911 : 2010

Borehole Location

BH 1

Length of Pile (L), m	22.00 m	From Existing Borehole Level
Angle of Internal Friction (ϕ) in Degrees	45.00	
Undrained cohesion value at Pile Tip (c_p), kN/m ²	0.00 kN/m ²	
Submerged Unit Weight at Pile Tip (γ_p), kN/m ³	14.70 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)	350.00	Taken from Figure 1 of IS 2911:2010 Part 1 Sec.2
Bearing Capacity Factor (N_{ϕ})	271.75	
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	32.98	38.83
End Bearing Resistance of Pile (q_p), kN/m ² using 'c' and 'φ'	12440.06	14587.42
End Bearing Resistance of Pile (q_p), kN/m ² using 'N' values	80000.00	80000.00
Limiting End Bearing Resistance of Pile ($q_{p,ult}$), kN/m ²	11000.00	11000.00
Ultimate End Bearing Capacity of Pile ($Q_{p,ult}$), kN using 'c' and 'φ' values	1749.47	2159.84
Ultimate End Bearing Capacity of Pile ($Q_{p,ult}$), kN using 'N' values	1749.47	2159.84
Safe End Bearing Capacity of Pile ($Q_{p,SAFE}$), kN using 'c' and 'φ' values	699.79	863.94
Safe End Bearing Capacity of Pile ($Q_{p,SAFE}$), kN using 'N' values	699.79	863.94
Ultimate Frictional Capacity of Pile ($Q_{f,ult}$), kN using 'c' and 'φ' values	975.58	1083.98
Ultimate Frictional Capacity of Pile ($Q_{f,ult}$), kN using 'N' values	958.97	1065.52
Negative Skin Friction of Pile (Q_{nf}), kN using 'c' and 'φ' values	161.52	179.46
Negative Skin Friction of Pile (Q_{nf}), kN using 'N' values	146.08	162.32
Safe Frictional Capacity of Pile ($Q_{f,SAFE}$), kN using 'c' and 'φ' values	228.72	254.13
Safe Frictional Capacity of Pile ($Q_{f,SAFE}$), kN using 'N' values	237.50	263.89
Self Weight of Pile (W), kN	87.47	107.99
Safe Pile Carrying Capacity of Pile (Q_{SAFE}), kN ('c' and 'φ')	929	1118
Safe Pile Carrying Capacity of Pile (Q_{SAFE}), kN ('N' values)	937	1128
Recommended Safe Pile Carrying Capacity of Pile (Q_{SAFE}), kN	933	1123
Safe Uplift Capacity of Pile (Q_{up}), kN using 'c' and 'φ' values	251	290
		374
		466
		677



A-2-BH 1

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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 _{0i} (kN/m ²)	'α _i '	'K _i '	N' Value
2.00	Brown Silty / Clayey Sand (SC)	2.00	20	25	15.90	5.90	5.90	0.30	1.00	13
3.00	Brown Silty / Clayey Sand (CH)	1.00	100	0	16.60	6.60	15.10	0.50	1.00	16
4.00	Greyish Silty / Clayey Sand (SC)	1.00	3	15	11.10	1.10	18.95	0.30	1.00	2
5.00	Greyish Silty Clay (CH)	1.00	31	0	13.20	3.20	21.10	0.80	1.00	5
6.00	Black Silty Clay (CH)	1.00	25	0	12.70	2.70	24.05	0.80	1.00	4
7.50	Black Silty / Clayey Sand (CH)	1.50	38	0	13.70	3.70	28.18	0.80	1.00	6
9.00	Greyish Silty / Clayey Sand (SC-SM)	1.50	4	18	12.70	2.70	32.98	0.30	1.00	4
10.50	Greyish Silty / Clayey Sand (SC)	1.50	15	23	15.10	5.10	38.83	0.30	1.00	10
12.00	Greyish Silty / Clayey Sand (SC-SM)	1.50	16	28	16.60	6.60	47.60	0.30	1.00	16
13.50	Brownish Grey Silty / Clayey Sand (SC)	1.50	33	30	17.60	7.60	58.25	0.30	1.00	22
15.00	Brownish Grey Silty / Clayey Sand (SC-SM)	1.50	23	26	16.40	6.40	68.75	0.30	1.00	15
16.50	Greyish Brown Silty / Clayey Sand (SC)	1.50	53	35	19.30	9.30	80.53	0.30	1.00	35
18.00	Greyish Brown Silty Clay (CH)	1.50	625	0	22.00	12.00	96.50	0.25	1.00	100
19.50	Greyish Brown Silty / Clayey Sand (CH)	1.50	625	0	22.00	12.00	114.50	0.25	1.00	100
20.00	Brownish Grey, Charnockite, Completely Weathered (Grade V / VI)	0.50	0	44	22.00	12.00	126.50	0.00	1.00	150
21.50	Brownish, Charnockite, Completely Weathered (Grade V)	2.00	0	45	24.70	14.70	144.20	0.00	1.00	200
23.00	Brownish, Charnockite, Highly Weathered (Grade IV)	1.50	0	45	25.30	15.30	170.38	0.00	1.00	200



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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	Brown Silty / Clayey Sand (SC)	8.75	24.74	27.49	32.99	38.49	49.49	21.67	61.26	68.07	81.68	95.29	122.52
3.00	Brown Silty / Clayey Sand (CH)	50.00	70.69	78.54	94.25	109.96	141.37	80.00	84.82	94.25	113.10	131.95	169.65
4.00	Greyish Silty / Clayey Sand (SC)	5.98	8.45	9.39	11.27	13.15	16.90	3.33	4.71	5.24	6.28	7.33	9.42
5.00	Greyish Silty Clay (CH)	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 (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
7.50	Black Silty / Clayey Sand (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
9.00	Greyish Silty / Clayey Sand (SC-SM)	11.91	25.27	28.07	33.69	39.30	50.53	6.67	14.14	15.71	18.85	21.99	28.27
10.50	Greyish Silty / Clayey Sand (SC)	20.98	44.49	49.43	59.32	69.21	88.98	16.67	35.34	39.27	47.12	54.98	70.69
12.00	Greyish Silty / Clayey Sand (SC-SM)	30.11	63.85	70.94	85.13	99.32	127.70	26.67	56.55	62.83	75.40	87.96	113.10
13.50	Brownish Grey Silty / Clayey Sand (SC)	43.53	92.31	102.57	123.08	143.59	184.62	36.67	77.75	86.39	103.67	120.95	155.51
15.00	Brownish Grey Silty / Clayey Sand (SC-SM)	40.43	85.74	95.26	114.32	133.37	171.48	25.00	53.01	58.90	70.69	82.47	106.03
16.50	Greyish Brown Silty / Clayey Sand (SC)	72.28	127.23	141.37	169.65	197.92	254.47	58.33	123.70	137.44	164.93	192.42	247.40
18.00	Greyish Brown Silty Clay (CH)	156.25	127.23	141.37	169.65	197.92	254.47	500.00	127.23	141.37	169.65	197.92	254.47
19.50	Greyish Brown Silty / Clayey Sand (CH)	156.25	127.23	141.37	169.65	197.92	254.47	500.00	127.23	141.37	169.65	197.92	254.47
20.00	Brownish Grey, Charnockite, Completely Weathered (Grade V / VI)	122.16	42.41	47.12	56.55	65.97	84.82	250.00	42.41	47.12	56.55	65.97	84.82
21.50	Brownish, Charnockite, Completely Wsathered (Grade V)	144.20	169.65	188.50	226.19	263.89	339.29	333.33	169.65	188.50	226.19	263.89	339.29
23.00	Brownish, Charnockite, Highly Weathered (Grade IV)	170.38	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47

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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 2

Length of Pile (L), m	22.00 m	From Existing Borehole Level
Angle of Internal Friction (ϕ) in Degrees	45.00	
Undrained cohesion value at Pile Tip (c_p), kN/m ²	0.00 kN/m ²	
Submerged Unit Weight at Pile Tip (γ_p), kN/m ³	14.90 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)	350.00	
Bearing Capacity Factor (N_{ϕ})	271.75	
Factor of Safety (FS)	2.50	
Diameter of Pile (D), mm	450	500
Critical Depth of Pile ($20 \times D$), m	9	10
Effective overburden pressure at Pile Tip (P_0), kN/m ²	41.63	45.23
End Bearing Resistance of Pile (q_p), kN/m ² using 'c' and 'φ'	15479.78	16841.01
End Bearing Resistance of Pile (q_p), kN/m ² using 'N' values	80000.00	80000.00
Limiting End Bearing Resistance of Pile (q_{pL}), kN/m ²	11000.00	11000.00
Ultimate End Bearing Capacity of Pile (Q_{pult}), kN using 'c' and 'φ' values	1749.47	2159.84
Ultimate End Bearing Capacity of Pile (Q_{pult}), kN using 'N' values	1749.47	2159.84
Safe End Bearing Capacity of Pile (Q_{p-safe}), kN using 'c' and 'φ' values	699.79	863.94
Safe End Bearing Capacity of Pile (Q_{p-safe}), kN using 'N' values	699.79	863.94
Ultimate Frictional Capacity of Pile (Q_{fult}), kN using 'c' and 'φ' values	1221.85	1357.61
Ultimate Frictional Capacity of Pile (Q_{fult}), kN using 'N' values	1225.22	1361.36
Negative Skin Friction of Pile (Q_{nf}), kN using 'c' and 'φ' values	123.90	137.66
Negative Skin Friction of Pile (Q_{nf}), kN using 'N' values	90.71	100.79
Safe Frictional Capacity of Pile (Q_{f-safe}), kN using 'c' and 'φ' values	364.84	405.38
Safe Frictional Capacity of Pile (Q_{f-safe}), kN using 'N' values	399.37	443.75
Self Weight of Pile (W), kN	87.47	107.99
Safe Pile Carrying Capacity of Pile (Q_{safe}), kN ('c' and 'φ')	1065	1269
Safe Pile Carrying Capacity of Pile (Q_{safe}), kN ('N' values)	1099	1308
Recommended Safe Pile Carrying Capacity of Pile (Q_{safe}), kN	1082	1289
Safe Uplift Capacity of Pile (Q_{up}), kN using 'c' and 'φ' values	371	423
		533
		652
		917

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



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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	Brown Silty Clay (CH)	2.00	88	0	16.20	6.20	6.20	0.65	1.00	14
3.00	Greyish Silty Clay (CH)	1.00	88	0	16.20	6.20	15.50	0.65	1.00	14
4.00	Greyish Silty Clay (CH)	1.00	131	0	17.50	7.50	22.35	0.50	1.00	21
5.00	Greyish Silty Sand (SM-SP)	1.00	0	33	17.60	7.60	29.90	0.00	1.00	22
6.00	Blackish Grey Silty / Clayey Sand (SC-SM)	1.00	7	22	14.10	4.10	35.75	0.30	1.00	7
7.50	Black Silty Clay (CH)	1.50	19	0	12.00	2.00	39.30	0.80	1.00	3
9.00	Black Silty Clay (CH)	1.50	13	0	11.10	1.10	41.63	1.00	1.00	2
10.50	Greyish Silty Sand (SM-SP)	1.50	0	23	13.70	3.70	45.23	0.00	1.00	6
12.00	Greyish Silty Sand (SM-SP)	1.50	0	33	17.60	7.60	53.70	0.00	1.00	22
13.50	Greyish Silty Sand (SM-SP)	1.50	0	37	19.00	9.00	66.15	0.00	1.00	32
15.00	Brownish Grey Silty / Clayey Sand (SC)	1.50	21	26	16.20	6.20	77.55	0.30	1.00	14
16.50	Brownish Grey Silty / Clayey Sand (CH)	1.50	281	0	22.00	12.00	91.20	0.25	1.00	45
18.00	Brown Silty / Clayey Sand (SC-SM)	1.50	80	41	22.00	12.00	109.20	0.30	1.00	100
19.50	Brownish Grey, Charnockite, Completely Weathered (Grade V / VI)	1.50	0	44	22.00	12.00	127.20	0.00	1.00	150
21.00	Brownish, Charnockite, Completely Weathered (Grade V)	1.50	0	45	23.60	13.60	146.40	0.00	1.00	200
22.50	Brownish, Charnockite, Completely Weathered (Grade V)	1.00	0	45	24.90	14.90	125.65	0.00	1.00	200
24.00	Brownish, Charnockite, Completely Weathered (Grade V)	1.50	0	45	25.30	15.30	144.58	0.00	1.00	200
25.50	Brownish, Charnockite, Completely Weathered (Grade V)	1.50	0	45	25.80	15.80	168.45	0.00	1.00	200



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2/10/20

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	Brown Silty Clay (CH)	57.20	161.73	179.70	215.64	251.58	323.46	70.00	169.65	188.50	226.19	263.89	339.29
3.00	Greyish Silty Clay (CH)	57.20	80.86	89.85	107.82	125.79	161.73	70.00	84.82	94.25	113.10	131.95	169.65
4.00	Greyish Silty Clay (CH)	65.50	84.82	94.25	113.10	131.95	169.65	105.00	84.82	94.25	113.10	131.95	169.65
5.00	Greyish Silty Sand (SM-SP)	19.42	27.45	30.50	36.60	42.70	54.90	36.67	51.84	57.60	69.12	80.63	103.67
6.00	Blackish Grey Silty / Clayey Sand (SC-SM)	16.54	23.39	25.99	31.18	36.38	46.78	11.67	16.49	18.33	21.99	25.66	32.99
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 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
10.50	Greyish Silty Sand (SM-SP)	19.20	40.71	45.23	54.28	63.32	81.42	10.00	21.21	23.56	28.27	32.99	42.41
12.00	Grayish Silty Sand (SM-SP)	34.87	73.95	82.17	98.60	115.04	147.90	36.67	77.75	86.39	103.67	120.95	155.51
13.50	Grayish Silty Sand (SM-SP)	49.85	105.71	117.45	140.94	164.43	211.41	53.33	113.10	125.66	150.80	175.93	226.19
15.00	Brownish Grey Silty / Clayey Sand (SC)	44.12	93.57	103.96	124.76	145.55	187.14	23.33	49.48	54.98	65.97	76.97	98.96
16.50	Brownish Grey Silty / Clayey Sand (C-H)	70.25	127.23	141.37	169.65	197.92	254.47	225.00	127.23	141.37	169.65	197.92	254.47
18.00	Brown Silty / Clayey Sand (SC-SM)	118.93	127.23	141.37	169.65	197.92	254.47	166.67	127.23	141.37	169.65	197.92	254.47
19.50	Brown silty Grey, Charnockite, Completely Weathered (Grade V)	122.84	127.23	141.37	169.65	197.92	254.47	250.00	127.23	141.37	169.65	197.92	254.47
21.00	Brown silty, Charnockite, Completely Weathered (Grade V)	146.40	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47
22.50	Brown silty, Charnockite, Completely Weathered (Grade V)	125.65	84.82	94.25	113.10	131.95	169.65	333.33	84.82	94.25	113.10	131.95	169.65
24.00	Brown silty, Charnockite, Completely Weathered (Grade V)	144.58	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47
25.50	Brown silty, Charnockite, Completely Weathered (Grade V)	168.45	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47



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26/01/2020
 JE

DETERMINATION OF PILE CARRYING CAPACITY AS PER IS 2911 : 2010

Borehole Location

BH 3

Length of Pile (L), m	24.00 m	From Existing Borehole Level
Angle of Internal Friction (ϕ) in Degrees	45.00	
Undrained cohesion value at Pile Tip (c_p), kN/m ²	0.00 kN/m ²	
Submerged Unit Weight at Pile Tip (γ_p), kN/m ³	14.30 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)	350.00	Taken from Figure 1 of IS 2911:2010 Part 1 Sec.2
Bearing Capacity Factor (N_{ϕ})	271.75	
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	29.25	35.18
End Bearing Resistance of Pile (q_p), kN/m ² using 'c' and ' ϕ '	11111.85	13282.75
End Bearing Resistance of Pile (q_p), kN/m ² using 'N' values	80000.00	80000.00
Limiting End Bearing Resistance of Pile (q_{pL}), kN/m ²	11000.00	11000.00
Ultimate End Bearing Capacity of Pile (Q_{pult}), kN using 'c' and ' ϕ ' values	1749.47	2159.84
Ultimate End Bearing Capacity of Pile (Q_{pult}), kN using 'N' values	1749.47	2159.84
Safe End Bearing Capacity of Pile (Q_{p-safe}), kN using 'c' and ' ϕ ' values	699.79	863.94
Safe End Bearing Capacity of Pile (Q_{p-safe}), kN using 'N' values	699.79	863.94
Ultimate Frictional Capacity of Pile (Q_{fult}), kN using 'c' and ' ϕ ' values	1158.12	1286.80
Ultimate Frictional Capacity of Pile (Q_{fult}), kN using 'N' values	1161.60	1290.67
Negative Skin Friction of Pile (Q_{nf}), kN using 'c' and ' ϕ ' values	136.64	151.83
Negative Skin Friction of Pile (Q_{nf}), kN using 'N' values	102.49	113.88
Safe Frictional Capacity of Pile (Q_{f-safe}), kN using 'c' and ' ϕ ' values	326.61	362.90
Safe Frictional Capacity of Pile (Q_{f-safe}), kN using 'N' values	362.15	402.39
Self Weight of Pile (W), kN	95.43	117.81
Safe Pile Carrying Capacity of Pile (Q_{safe}), kN ('c' and ' ϕ ')	1026	1227
Safe Pile Carrying Capacity of Pile (Q_{safe}), kN ('N' values)	1062	1266
Recommended Safe Pile Carrying Capacity of Pile (Q_{safe}), kN	1044	1247
Safe Uplift Capacity of Pile (Q_{up}), kN using 'c' and ' ϕ ' values	345	395
	502	619
	880	

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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 _{0i} (kN/m ²)	'α _i '	'K _i '	N' Value
2.00	Brown Silty / Clayey Sand (CH)	2.00	63	0	15.10	5.10	5.10	0.65	1.00	10
3.00	Brown Silty / Clayey Sand (CH)	1.00	38	0	13.70	3.70	12.05	0.80	1.00	6
4.00	Greyish Silty Clay (CH)	1.00	25	0	12.70	2.70	15.25	0.80	1.00	4
5.00	Brownish Grey Silty Sand (SM-SP)	1.00	0	26	15.10	5.10	19.15	0.00	1.00	10
6.00	Greyish Silty Clay (CH)	1.00	19	0	12.00	2.00	22.70	0.80	1.00	3
7.50	Greyish Silty / Clayey Sand (SC-SM)	1.50	4	19	12.70	2.70	25.73	0.30	1.00	4
9.00	Greyish Silty Sand (SM-SP)	1.50	0	20	12.00	2.00	29.25	0.00	1.00	3
10.50	Greyish Brown Silty / Clayey Sand (SC)	1.50	20	25	15.90	5.90	35.18	0.30	1.00	13
12.00	Greyish Silty / Clayey Sand (SC-SM)	1.50	19	29	17.10	7.10	44.93	0.30	1.00	19
13.50	Brownish Grey Silty Sand (SM-SP)	1.50	0	25	14.80	4.80	53.85	0.00	1.00	9
15.00	Brown Silty / Clayey Sand (SC-SM)	1.50	25	32	18.10	8.10	63.53	0.30	1.00	25
16.50	Greyish Brown Silty Clay (CH)	1.50	625	0	22.00	12.00	78.60	0.25	1.00	100
18.00	Greyish Brown Silty / Clayey Sand (SC)	1.50	90	40	22.00	12.00	96.60	0.30	1.00	100
19.50	Greyish Silty Sand (SM-SP)	1.50	0	42	22.00	12.00	114.60	0.00	1.00	100
21.00	Brownish Grey, Charnockite, Completely Weathered (Grade V)	1.50	0	45	23.40	13.40	133.65	0.00	1.00	200
22.50	Brownish Grey, Charnockite, Completely Weathered (Grade V)	1.50	0	45	24.30	14.30	154.43	0.00	1.00	200
24.00	Brownish Grey, Charnockite, Completely Weathered (Grade V)	1.50	0	45	24.60	14.60	176.10	0.00	1.00	200
25.50	Brownish Grey, Charnockite, Completely Weathered (Grade V)	1.50	0	45	25.30	15.30	198.53	0.00	1.00	200

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28/09
JE

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		Brown Silty / Clayey Sand (CH)	40.95	115.78	128.65	154.38	180.11	231.57	50.00	141.37	157.08	188.50	219.91	282.74
3.00		Brown Silty / Clayey Sand (CH)	30.40	42.98	47.75	57.30	66.85	85.95	30.00	42.41	47.12	56.55	65.97	84.82
4.00		Greyish 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
5.00		Brownish Grey Silty Sand (SM-SP)	9.34	13.20	14.67	17.61	20.54	26.41	16.67	23.56	26.18	31.42	36.65	47.12
6.00		Greyish Silty Clay (CH)	15.20	21.49	23.88	28.65	33.43	42.98	5.00	7.07	7.85	9.42	11.00	14.14
7.50		Greyish Silty / Clayey Sand (SC-SM)	10.06	21.33	23.70	28.44	33.18	42.66	6.67	14.14	15.71	18.85	21.99	28.27
9.00		Greyish Silty Sand (SM-SP)	10.65	22.58	25.08	30.10	35.12	45.15	5.00	10.60	11.78	14.14	16.49	21.21
10.50		Greyish Brown Silty / Clayey Sand (SC)	22.40	47.51	52.78	63.34	73.90	95.01	21.67	45.95	51.05	61.26	71.47	91.89
12.00		Greyish Silty / Clayey Sand (SC-SM)	30.60	64.89	72.11	86.53	100.95	129.79	31.67	67.15	74.61	89.54	104.46	134.30
13.50		Brownish Grey Silty Sand (SM-SP)	25.11	53.25	59.17	71.00	82.83	106.50	15.00	31.81	35.34	42.41	49.48	63.62
15.00		Brown Silty / Clayey Sand (SC-SM)	47.19	100.08	111.20	133.44	155.68	200.16	41.67	88.36	98.17	117.81	137.44	176.71
16.50		Greyish Brown Silty Clay (CH)	156.25	127.23	141.37	169.65	197.92	254.47	166.67	127.23	141.37	169.65	197.92	254.47
18.00		Greyish Brown Silty / Clayey Sand (SC)	108.06	127.23	141.37	169.65	197.92	254.47	500.00	127.23	141.37	169.65	197.92	254.47
19.50		Greyish Silty Sand (SM-SP)	103.19	127.23	141.37	169.65	197.92	254.47	166.67	127.23	141.37	169.65	197.92	254.47
21.00		Brownish Grey, Charnockite, Completely Weathered (Grade V)	133.65	127.23	141.37	169.65	197.92	254.47	1000.00	127.23	141.37	169.65	197.92	254.47
22.50		Brownish Grey, Charnockite, Completely Weathered (Grade V)	154.43	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47
24.00		Brownish Grey, Charnockite, Completely Weathered (Grade V)	176.10	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47
25.50		Brownish Grey, Charnockite, Completely Weathered (Grade V)	198.53	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47



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21/09/25
JF

DETERMINATION OF PILE CARRYING CAPACITY AS PER IS 2911 : 2010

Borehole Location

BH 4

Length of Pile (L), m	=	23.00 m	From Existing Borehole Level
Angle of Internal Friction (ϕ) in Degrees	=	45.00	
Undrained cohesion value at Pile Tip (c_p), kN/m ²	=	0.00 kN/m ²	
Submerged Unit Weight at Pile Tip (γ_p), kN/m ³	=	14.30 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)	=	350.00	
Bearing Capacity Factor (N_{ϕ})	=	271.75	
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_D), kN/m ²	=	44.60	54.95
End Bearing Resistance of Pile (q_p), kN/m ² using 'c' and ' ϕ '	=	16484.35	20204.00
End Bearing Resistance of Pile (q_p), kN/m ² using 'N' values	=	80000.00	80000.00
Limiting End Bearing Resistance of Pile (q_{pL}), kN/m ²	=	11000.00	11000.00
Ultimate End Bearing Capacity of Pile (Q_{p-ult}), kN using 'c' and ' ϕ ' values	=	1749.47	2159.84
Ultimate End Bearing Capacity of Pile (Q_{p-ult}), kN using 'N' values	=	1749.47	2159.84
Safe End Bearing Capacity of Pile (Q_{p-safe}), kN using 'c' and ' ϕ ' values	=	699.79	863.94
Safe End Bearing Capacity of Pile (Q_{p-safe}), kN using 'N' values	=	699.79	863.94
Ultimate Frictional Capacity of Pile (Q_{f-ult}), kN using 'c' and ' ϕ ' values	=	1227.83	1364.25
Ultimate Frictional Capacity of Pile (Q_{f-ult}), kN using 'N' values	=	1213.44	1348.27
Negative Skin Friction of Pile (Q_{nf}), kN using 'c' and ' ϕ ' values	=	84.60	94.00
Negative Skin Friction of Pile (Q_{nf}), kN using 'N' values	=	68.33	75.92
Safe Frictional Capacity of Pile (Q_{f-safe}), kN using 'c' and ' ϕ ' values	=	406.53	451.70
Safe Frictional Capacity of Pile (Q_{f-safe}), kN using 'N' values	=	417.05	463.38
Self Weight of Pile (W), kN	=	91.45	112.90
Safe Pile Carrying Capacity of Pile (Q_{safe}), kN ('c' and ' ϕ ')	=	1106	1316
Safe Pile Carrying Capacity of Pile (Q_{safe}), kN ('N' values)	=	1117	1327
Recommended Safe Pile Carrying Capacity of Pile (Q_{safe}), kN	=	1112	1321
Safe Uplift Capacity of Pile (Q_{up}), kN using 'c' and ' ϕ ' values	=	416	474
		595	726
			1015

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



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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 _{bt} (kN/m ²)	'α _i '	'K _i '	N' Value
2.00	Brownish Grey Silty / Clayey Sand (SC)	2.00	26	27	16.80	6.80	6.80	0.30	1.00	17
3.00	Brownish Grey Silty / Clayey Sand (SC-SM)	1.00	17	28	16.80	6.80	17.00	0.30	1.00	17
4.00	Greyish Silty / Clayey Sand (SC)	1.00	26	27	16.80	6.80	23.80	0.30	1.00	17
5.00	Black Silty / Clayey Sand (SC)	1.00	12	22	14.50	4.50	29.45	0.30	1.00	8
6.00	Black Silty Caly (CH)	1.00	25	0	12.70	2.70	33.05	0.80	1.00	4
7.50	Black Silty / Clayey Sand (SC)	1.50	9	20	13.70	3.70	37.18	0.30	1.00	6
9.00	Black Silty / Clayey Sand (SC)	1.50	21	26	16.20	6.20	44.60	0.30	1.00	14
10.50	Brownish Grey Silty / Clayey Sand (SC)	1.50	33	30	17.60	7.60	54.95	0.30	1.00	22
12.00	Greyish Silty / Clayey Sand (SC-SM)	1.50	21	30	17.50	7.50	66.28	0.30	1.00	21
13.50	Brownish Grey Silty / Clayey Sand (SC-CI)	1.50	26	27	16.80	6.80	77.00	0.30	1.00	17
15.00	Brownish Grey Silty / Clayey Sand (SC)	1.50	48	34	19.00	9.00	88.85	0.30	1.00	32
16.50	Brownish Silty / Clayey Sand (SC-SM)	1.50	52	41	22.00	12.00	104.60	0.30	1.00	52
18.00	Brown Silty / Clayey Sand (SC)	1.50	90	40	22.00	12.00	122.60	0.30	1.00	100
19.50	Brown Silty / Clayey Sand (SC)	1.50	90	40	22.00	12.00	140.60	0.30	1.00	100
21.00	Brownish Grey, Charnockite, Completely Weathered (Grade V / VI)	1.50	0	44	22.00	12.00	158.60	0.00	1.00	150
22.50	Brownish Grey, Charnockite, Completely Weathered (Grade V)	2.00	0	45	24.30	14.30	181.90	0.00	1.00	200
24.00	Brownish Grey, Charnockite, Completely Weathered (Grade V)	1.50	0	45	25.60	15.60	207.90	0.00	1.00	200
25.50	Brownish Grey, Charnockite, Completely Weathered (Grade V)	1.50	0	45	26.30	16.30	231.83	0.00	1.00	200



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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 / Clayey Sand (SC)	11.26	31.85	35.39	42.47	49.55	63.70	28.33	80.11	89.01	106.81	124.62	160.22
3.00	Brownish Grey Silty / Clayey Sand (SC-SM)	14.14	19.99	22.21	26.65	31.09	39.98	28.33	40.06	44.51	53.41	62.31	80.11
4.00	Greyish Silty / Clayey Sand (SC)	19.93	28.17	31.30	37.56	43.82	56.34	28.33	40.06	44.51	53.41	62.31	80.11
5.00	Black Silty / Clayey Sand (SC)	15.50	21.91	24.35	29.21	34.08	43.82	13.33	18.85	20.94	25.13	29.32	37.70
6.00	Black Silty Caly (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
7.50	Black Silty / Clayey Sand (SC)	16.23	34.42	38.24	45.89	53.54	68.84	10.00	21.21	23.56	28.27	32.99	42.41
9.00	Black Silty / Clayey Sand (SC)	28.05	59.49	66.10	79.32	92.54	118.98	23.33	49.48	54.98	65.97	76.97	98.96
10.50	Brownish Grey Silty / Clayey Sand (SC)	41.63	88.27	98.08	117.69	137.31	176.54	36.67	77.75	86.39	103.67	120.95	155.51
12.00	Greyish Silty / Clayey Sand (SC-SM)	44.56	94.50	105.00	126.00	147.00	189.00	35.00	74.22	82.47	98.96	115.45	148.44
13.50	Brownish Grey Silty / Clayey Sand (SC-CI)	47.03	99.74	110.82	132.98	155.15	199.48	28.33	60.08	66.76	80.11	93.46	120.17
15.00	Brownish Grey Silty / Clayey Sand (SC)	74.33	127.23	141.37	169.65	197.92	254.47	53.33	113.10	125.66	150.80	175.93	226.19
16.50	Brownish Silty / Clayey Sand (SC-SM)	106.53	127.23	141.37	169.65	197.92	254.47	86.67	127.23	141.37	169.65	197.92	254.47
18.00	Brown Silty / Clayey Sand (SC)	129.87	127.23	141.37	169.65	197.92	254.47	166.67	127.23	141.37	169.65	197.92	254.47
19.50	Brown Silty / Clayey Sand (SC)	144.98	127.23	141.37	169.65	197.92	254.47	166.67	127.23	141.37	169.65	197.92	254.47
21.00	Brownish Grey, Charnockite, Completely Weathered (Grade V / VI)	153.16	127.23	141.37	169.65	197.92	254.47	250.00	127.23	141.37	169.65	197.92	254.47
22.50	Brownish Grey, Charnockite, Completely Weathered (Grade V)	181.90	169.65	188.50	226.19	263.89	339.29	333.33	169.65	188.50	226.19	263.89	339.29
24.00	Brownish Grey, Charnockite, Completely Weathered (Grade V)	207.90	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47
25.50	Brownish Grey, Charnockite, Completely Weathered (Grade V)	231.83	127.23	141.37	169.65	197.92	254.47	333.33	127.23	141.37	169.65	197.92	254.47



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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_n)	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
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 I Sec. 2	Long Pile	Long Pile
(e/R)	0.00	0.00
(Z_p/T) from Fig.4 of IS 2911 Part 1 Sec.2	1.90	1.90
Depth of Fixity (Z_f), m	4.09	5.14
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	57.60
		77.00
		98.20
		147.20

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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.


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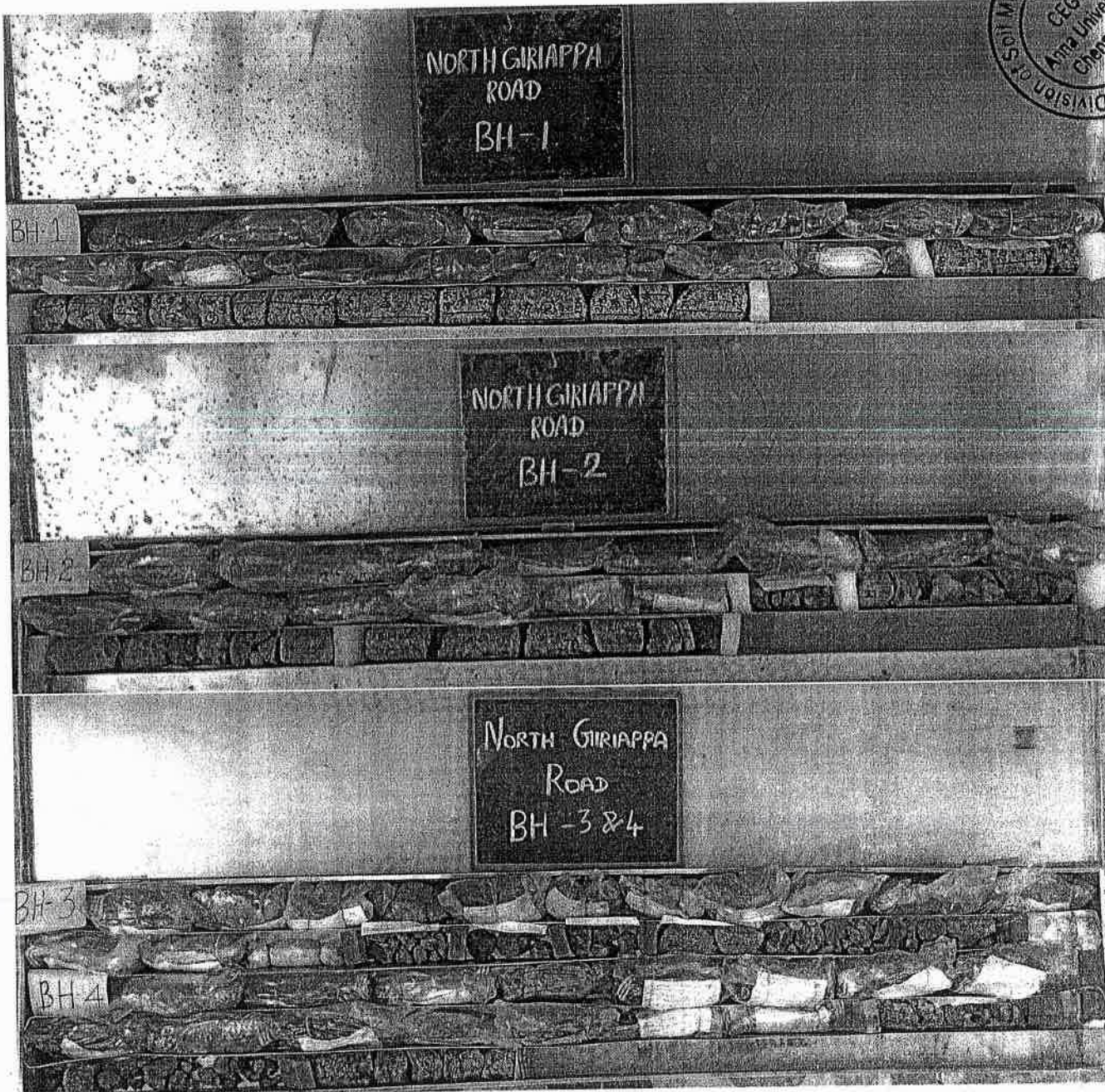


Figure 2 View of Soil and Rock Samples collected at the Proposed Site

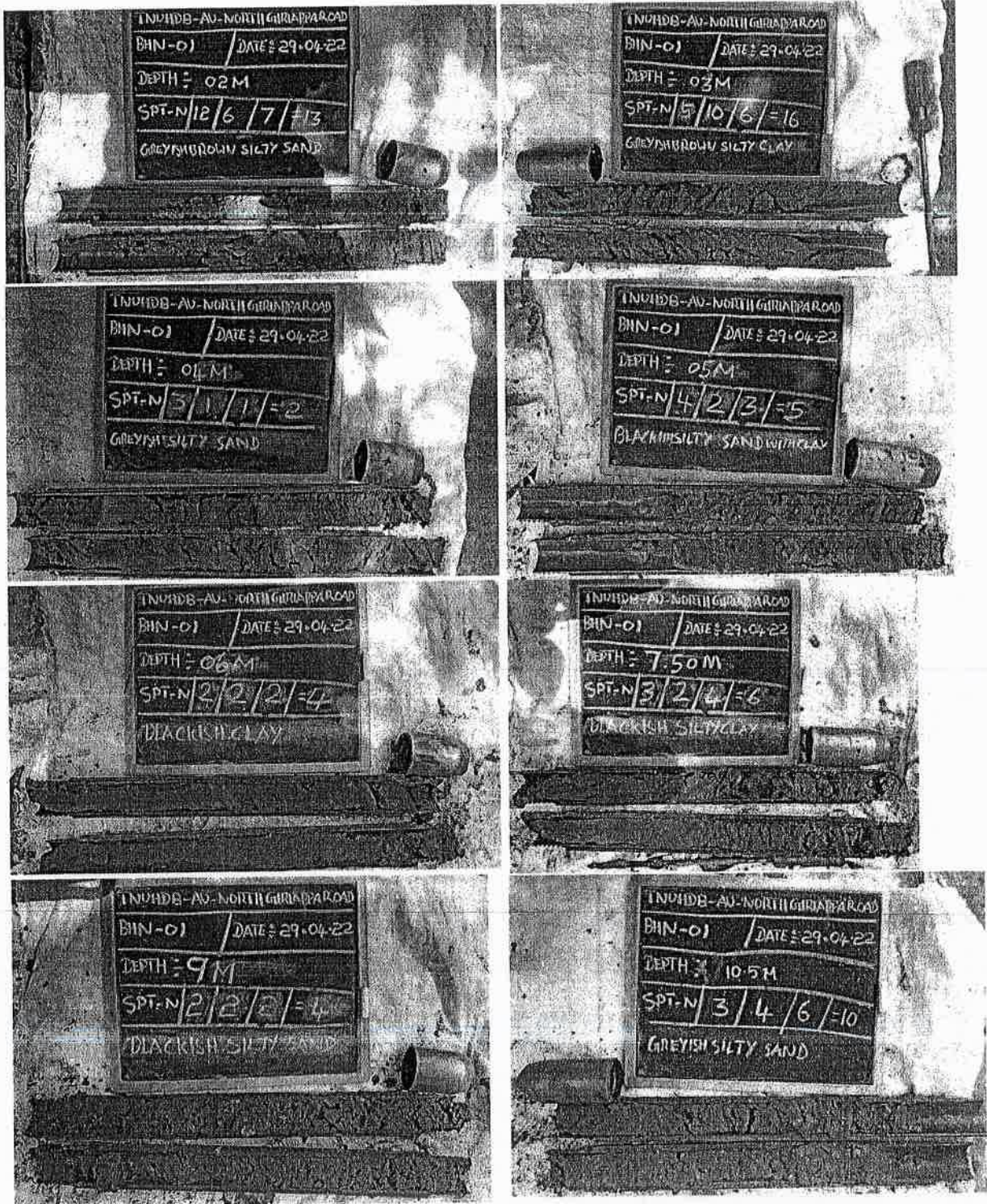

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View of Soil and Rock Samples collected in BH 1 to BH 4 Locations of the Reconstruction
Tenements at North Giriappa Road Old in Zone IX, Division V, Greater Chennai
Corporation.

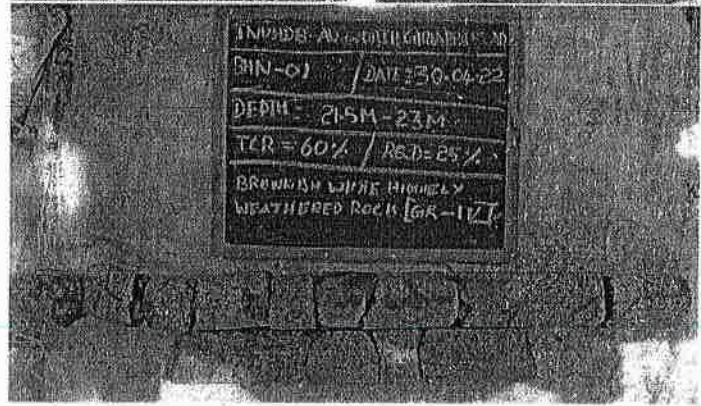
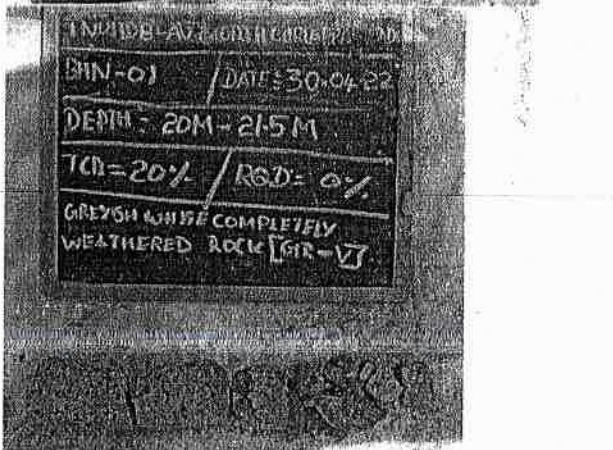
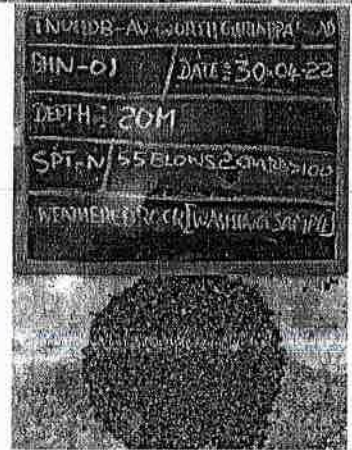
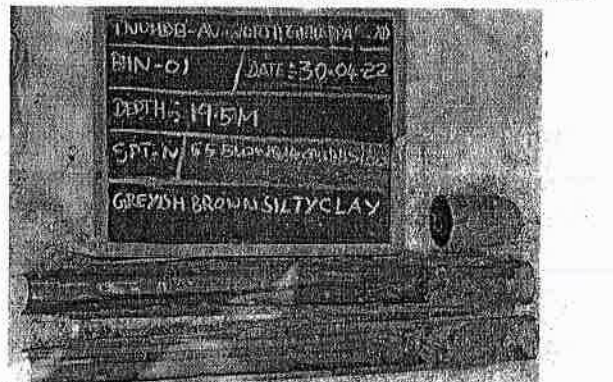
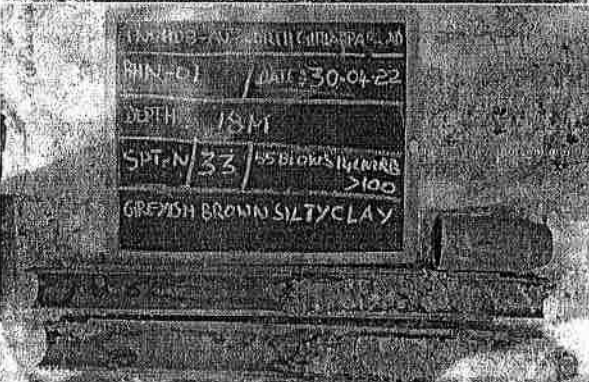
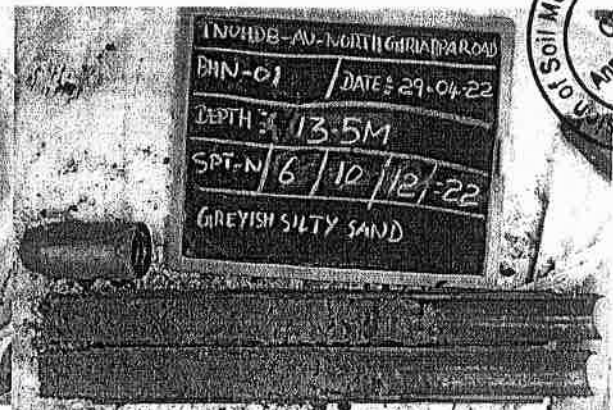
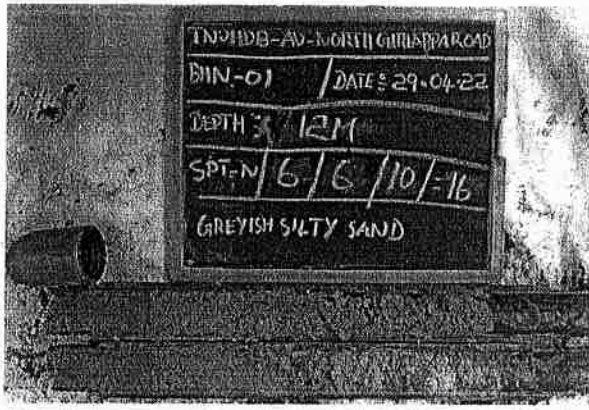


Plate – 1 Soil / Rock Samples Collected in BH-01 Location



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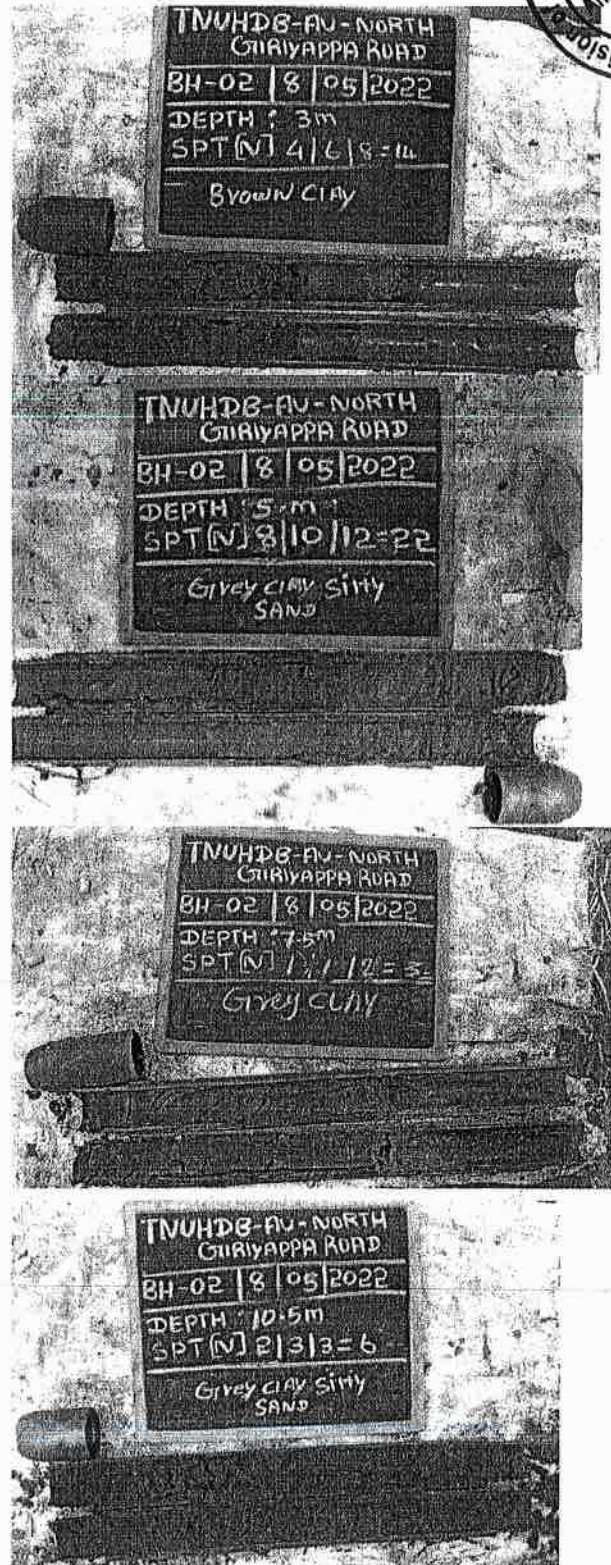
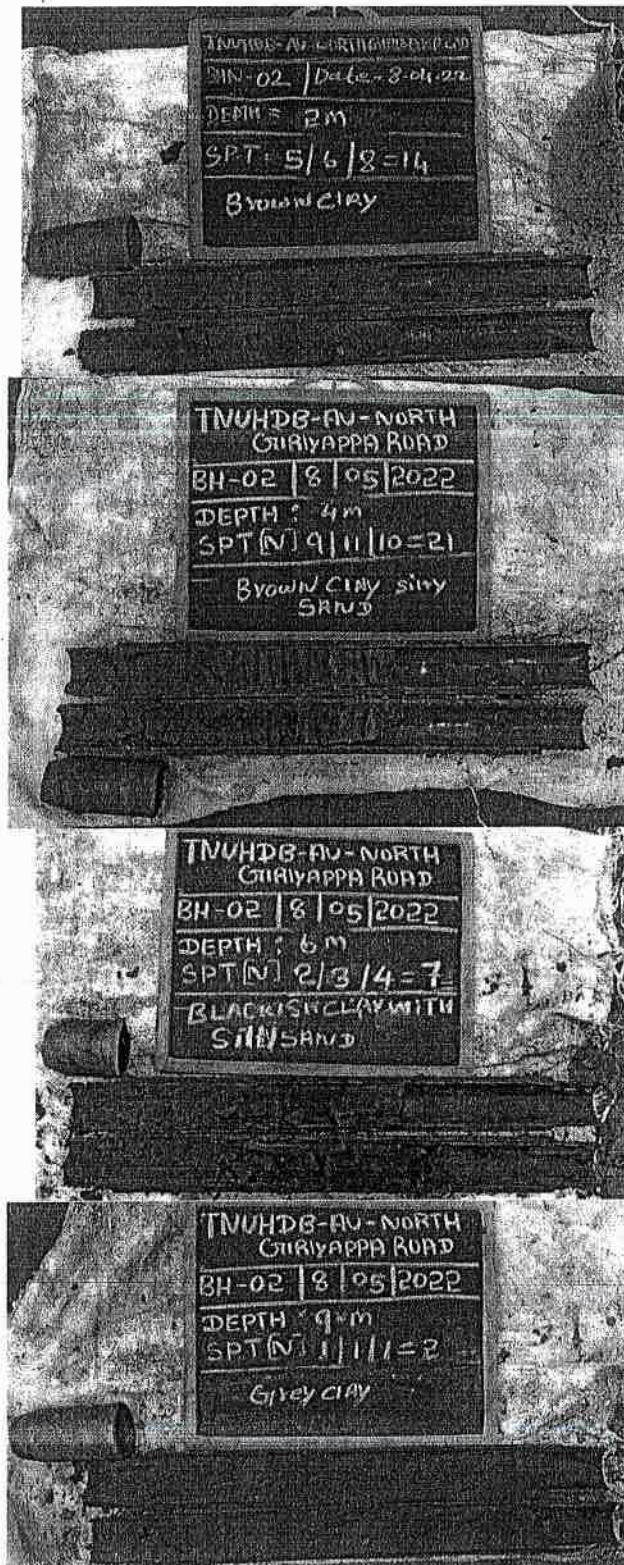
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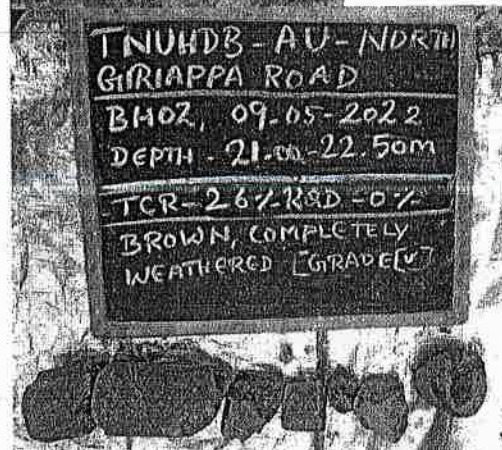
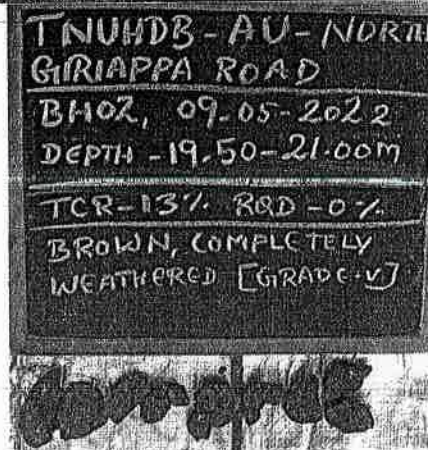
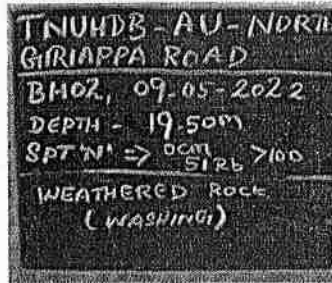
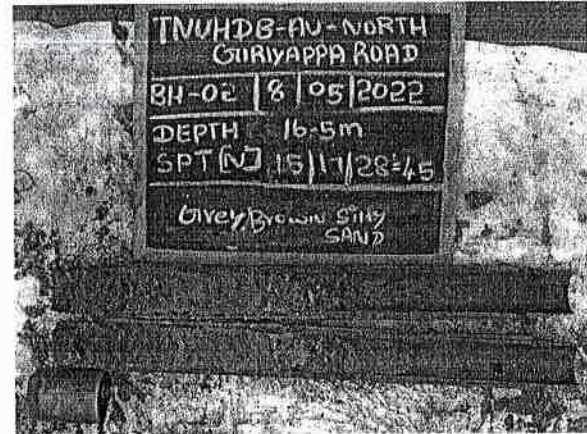
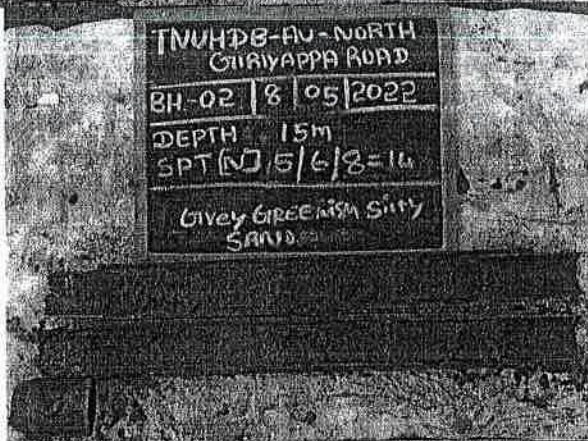
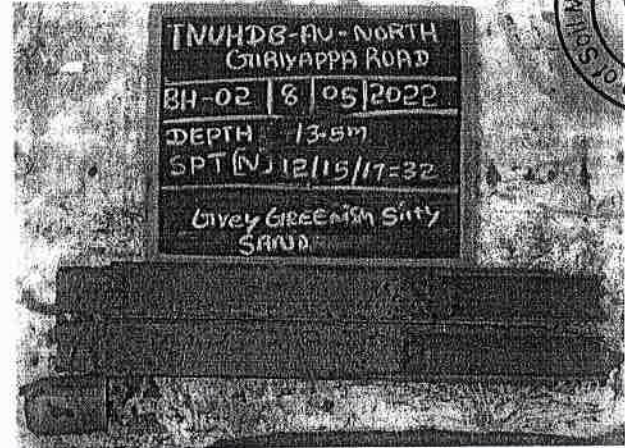
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Plate – 2 Soil / Rock Samples Collected in BH-02 Location



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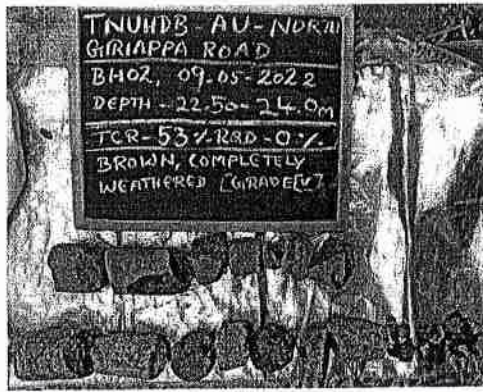
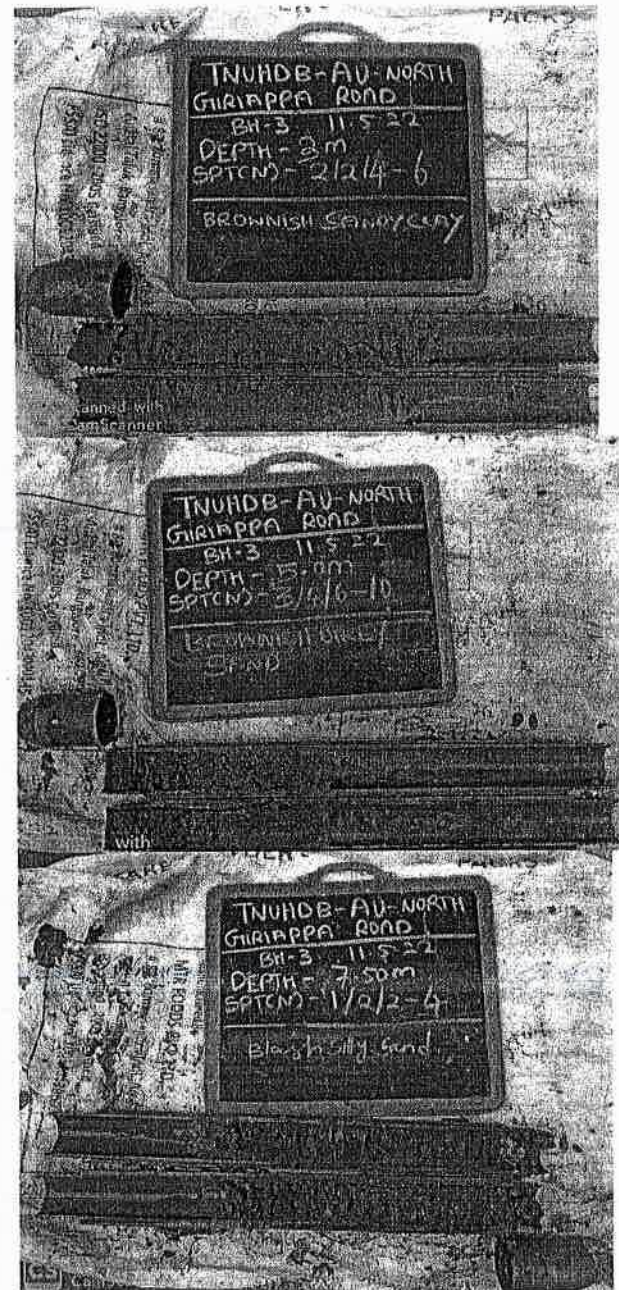
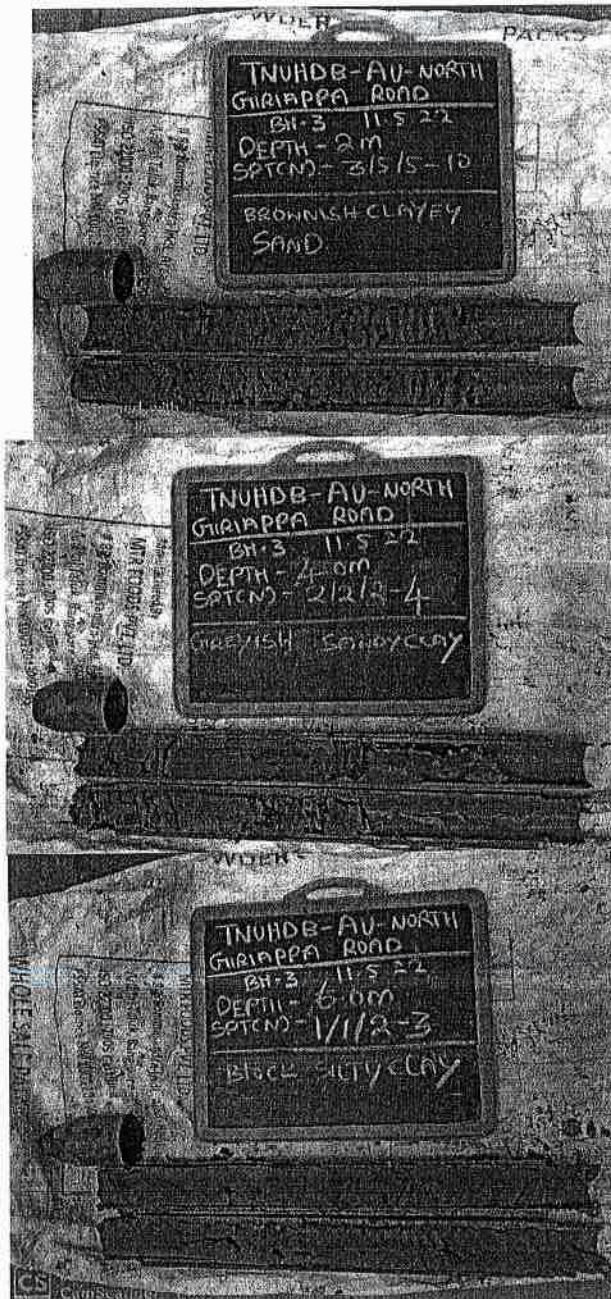
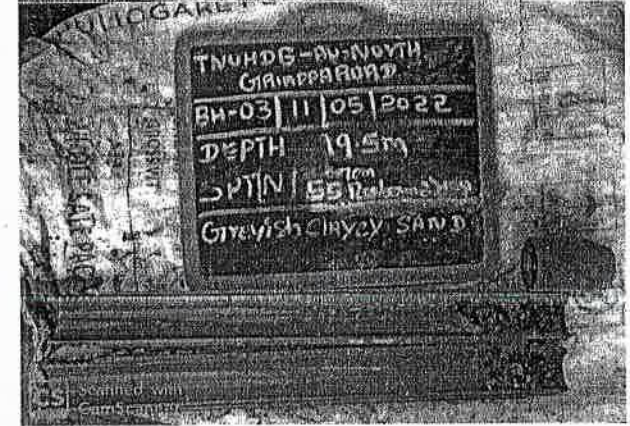
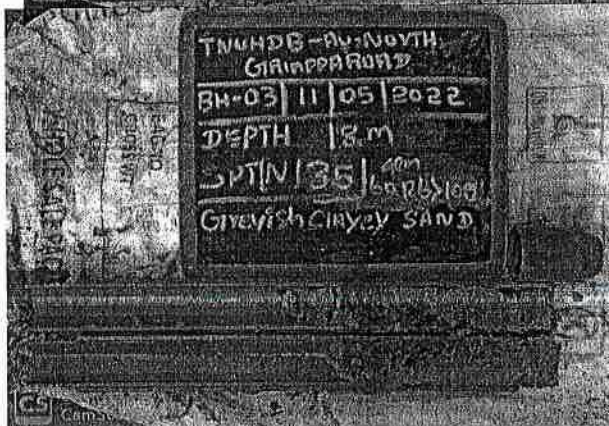
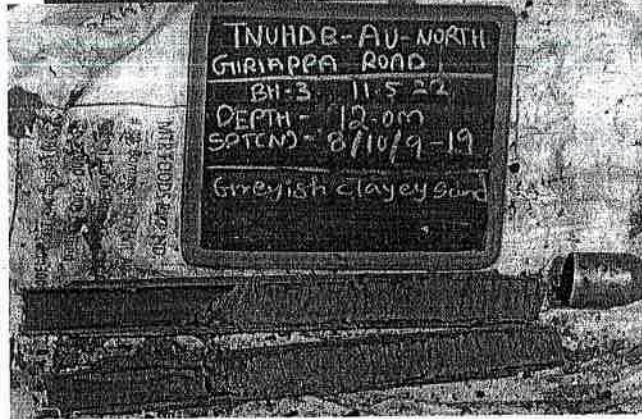
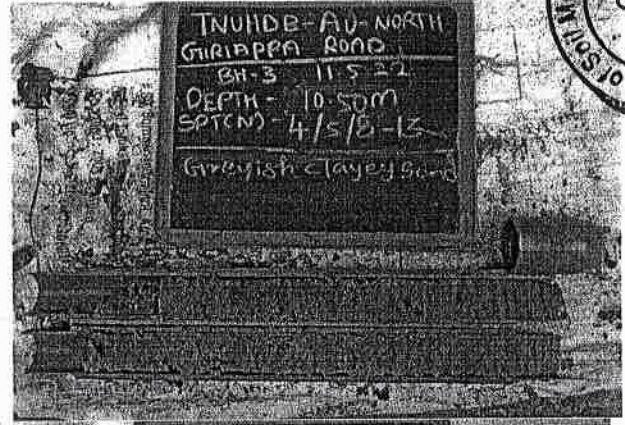


Plate – 3 Soil / Rock Samples Collected in BH-03 Location



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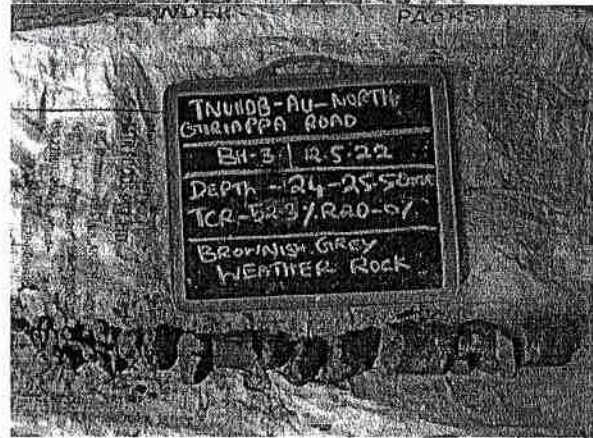
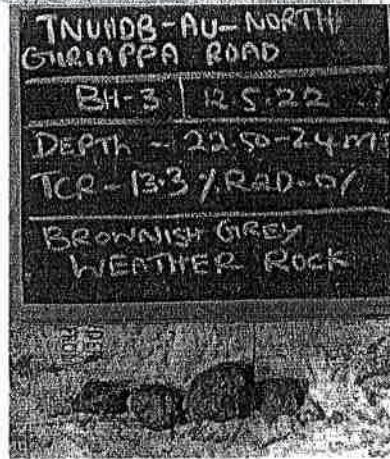
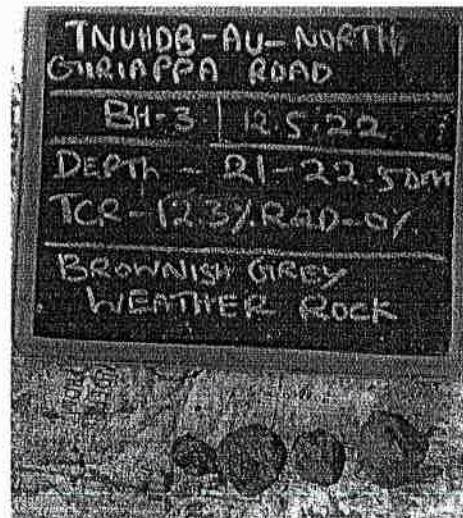
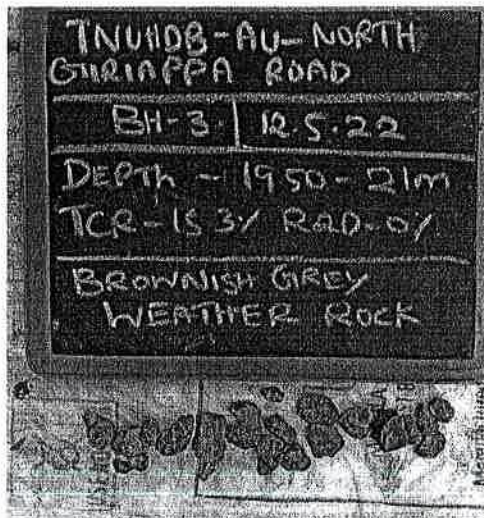
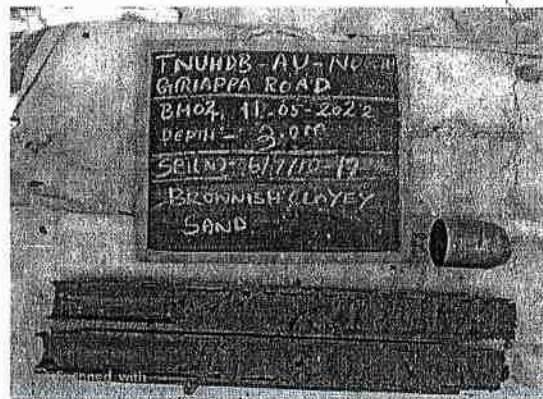
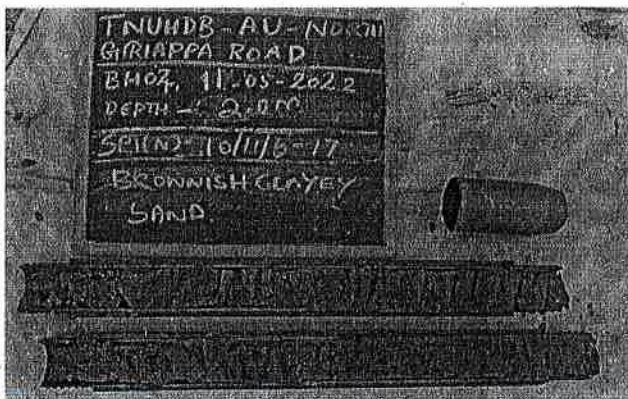
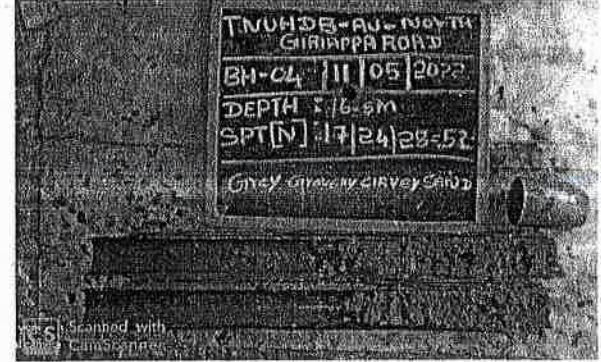
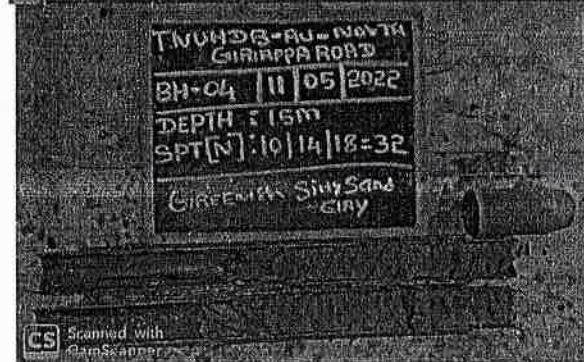
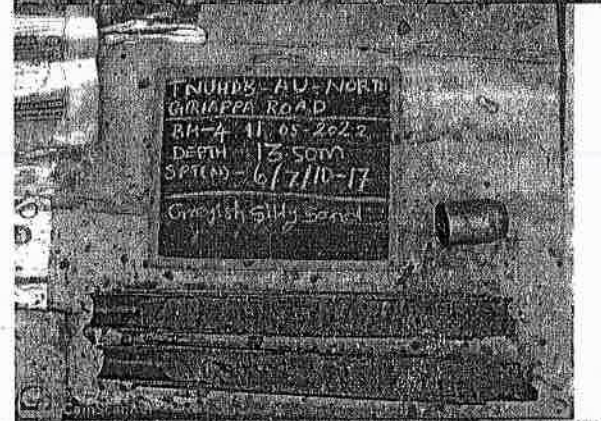
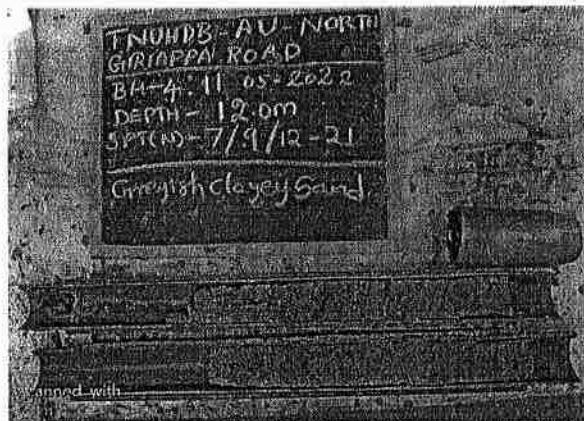
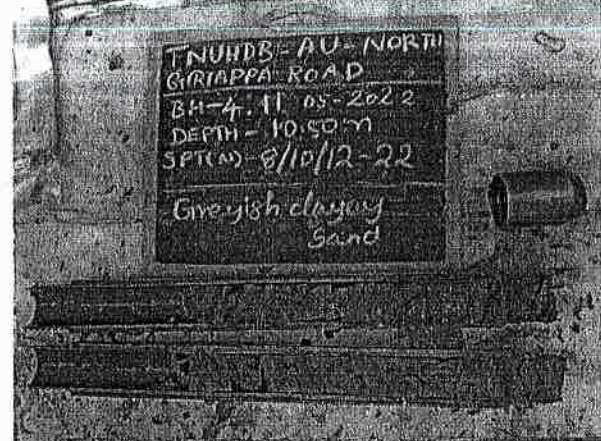
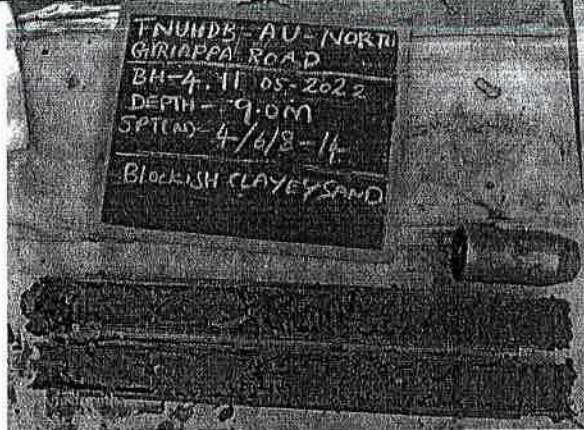
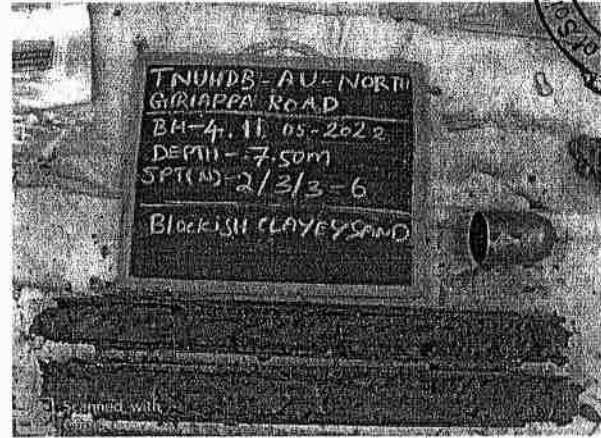
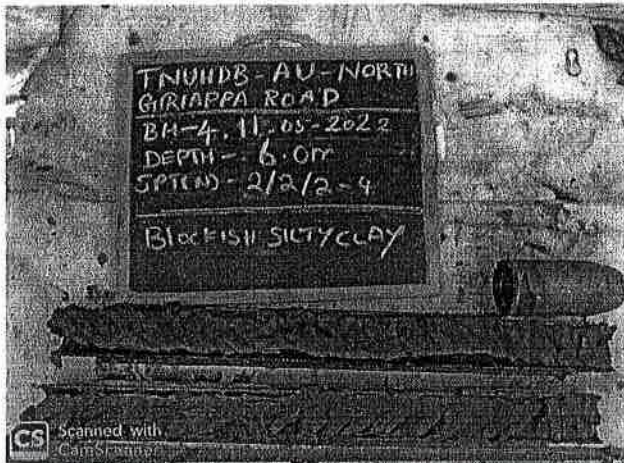


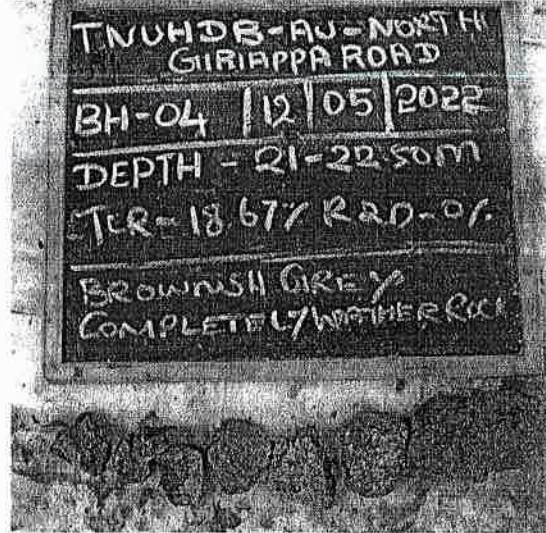
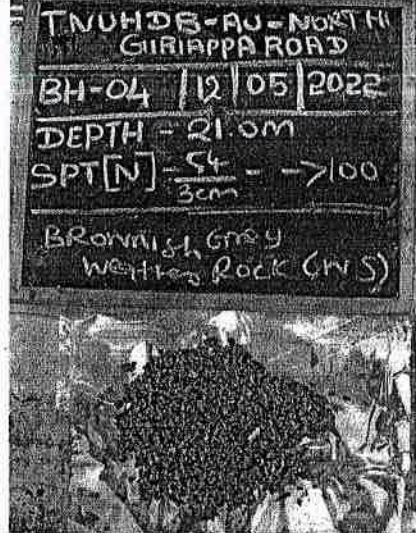
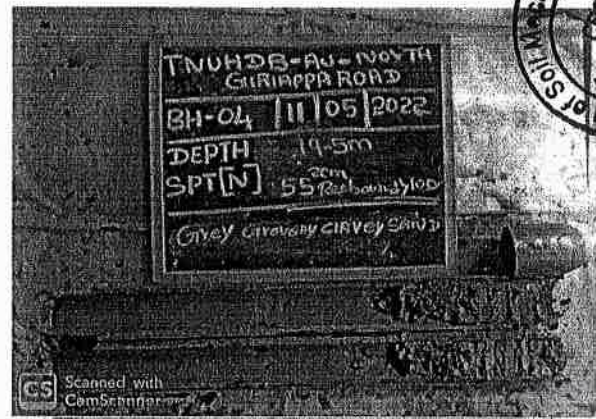
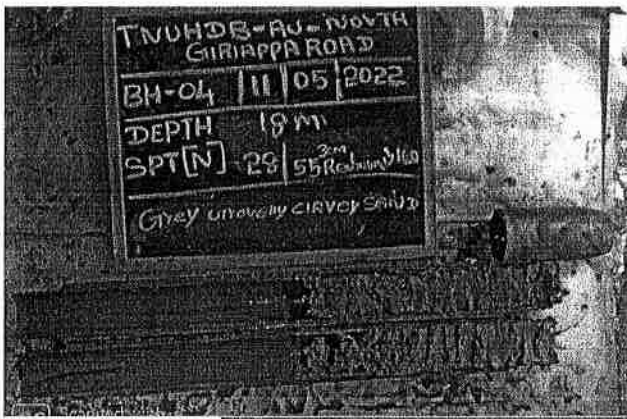
Plate - 4 Soil / Rock Samples Collected in BH-04 Location





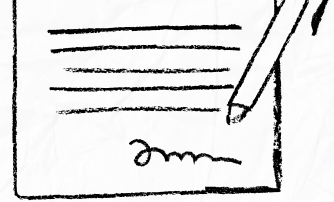
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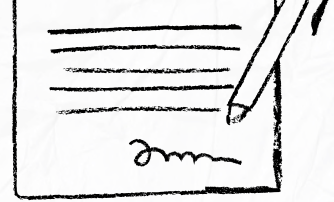
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