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GEO ENGINEERING CONSULTANTS & SERVICES

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12B, 2nd Floor, Anbu Nagar, 3rd Street,
Alwarthirunagar, Chennai-600 087.

Ph.No. 9841226220/9444901825/9094853994.

Email: info@geoenggservices.com/geoengineeringconsultantindia@gmail.com

Web: www.geoenggservices.com

PROJECT NAME

THE PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING
(1BASEMENT+GROUND+11 UPPER FLOORS) AT PLOT NO-1 &2,
CLASSICE FARMS AVENUE, SHOLINGANALLUR, (OMR),
CHENNAI-600 119.

CLIENT NAME

M/S LANCOR HOLDING LTD.,
NO. 58, 2ND FLOOR, VTN SQUARE,
GOPATHI NARAYANASWAMI CHETTY ROAD,
G.N CHETTY ROAD, SATYAMURTHY NAGAR,
T. NAGAR, CHENNAI-600 017.

TITLE

GEOTECHNICAL INVESTIGATION REPORT

PROJECT NO: GECS-JC-GT-1331-2023-2024

REPORT SUBMISSION DATE: 25/03/2024



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REPORT TEXT

INTRODUCTION

1.0 PROJECT INFORMATION MATRIX

Nature of project	: Proposed Construction of Residential Building
Type of Structures	: 1Basement+Ground+ 11 Upper Floors
Project Client	: M/S LANCOR HOLDING LTD.,
Project Location	: Plot No-1 &2, Classice Farms Avenue, Sholinganallur, (OMR), Chennai.
Job Code	: GECS-JC-GT-1331.

1.1 SCOPE OF WORK

1.1.1 Field Work

- ❖ Conducting Three soil investigation bore holes of 150 mm diameter up to 10.0m depth or up to the refusal strata with SPT>100
- ❖ Conducting Standard Penetration Test (SPT) within the borehole at every 1.0m depth interval up to 4.0m and thereafter at every 1.5m depth interval up termination depth.
- ❖ Collection of Soil Samples and undisturbed samples from the clayey strata with SPT-value less than 15.
- ❖ Collection of water samples if groundwater table met within the investigation depth

1.1.2 Laboratory Work

- ❖ Natural Moisture Content
- ❖ Atterberg's limits
- ❖ Grain Size Analysis
- ❖ Chemical Analysis test on soil and water samples to give pH, Chlorides and Sulphates

1.2 Structure of the Report

- ❖ Contents
- ❖ Introduction
- ❖ Investigation Methodology & Test Results
- ❖ Geology &Sub-Surface Stratification
- ❖ Foundation System
- ❖ Recommendation
- ❖ Annexure



INVESTIGATION METHODOLOGY & TEST RESULTS

2.0 Preamble:

Three soil investigation borehole was put as per the planning of the engineer in-charge and these locations are shown in Fig.2.0. The equipment used and the methodology adopted to carry out the fieldwork is described below.

2.1 Methodology of Field Work:

2.1.1 Equipment Used and Method of Drilling:

All the boreholes were sunk by conventional rotary drilling rigs. For borehole Methodology followed for boring conformed to IS: 1892 -2000. Boring was progressed by the cutting action of rotating bit with water circulation and stabilizing the side of the boreholes by using casing pipes/bentonite slurry up to required depth to prevent collapse of sidewall. Boring was continued by normal boring process using MS soil cutter in soil. However, Tungsten Carbide (TC) bit drilling was resorted to drill in highly weathered rock stratum where the normal boring process became slow. Diamond Core (DC) bit drilling was adopted in moderately weathered rock formations where penetration using TC bit was became slow.

2.1.2 Standard Penetration Tests:

This is a field test to determine "Penetration Resistance of Stratum at the Test Depth". This has been conducted in the boreholes generally up to refusal depth using procedures described in IS: 2131- 2002. In this test, split spoon sampler (50.8 mm OD and 35 mm ID) has replaced driving bit. Sampler is then driven by dropping 63.5 kg hammer on top of driving collar with free fall of 75 cm. The length of sampler is 60 cm.

The tests were conducted at the depth intervals indicated in Chapter-1 (Sec.1.1.1).

2.1.3 Collection of Soil Samples:

2.1.3.1 Disturbed Samples:

The SPT-samples collected were used as disturbed soil samples. These samples were used for visual and physical identification and for conducting laboratory classification tests as per I.S.1498-1970.

2.1.4 Collection of Ground Water Samples:

One representative water sample from each borehole was collected after 24 hours of completing the borehole if water table met within the investigated depth.

Note on Groundwater Table Record:

- ❖ Groundwater table observation in geotechnical report is predominantly to arrive at foundation design criteria and shall not be construed as design guidelines for the design of dewatering systems



- ❖ The groundwater level indicated in the bore logs is specific to the duration of investigation and intensity of the monsoon rains during the time of investigation. Hence, the level shall be taken as guidelines only to plan the investigation for the dewatering system
- ❖ No foundation excavation or basement excavations if anticipated within the groundwater table zone shall be carried out without implementing groundwater lowering schemes

2.2 Laboratory testing:

2.2.1 On Coarse Grained Soil

On the representative samples, sieve analysis tests were conducted to arrive at grain size distribution. These tests were conducted as per I.S.2720 (part 4)-1985 and the results are presented in Tables-2.1 to 2.3. The graphical representation of grain size distribution curve for the representative samples in each bore is presented in Fig. 2.4 to 2.6.

2.2.2 On Fine Grained Soil

On the SPT sample index property tests were conducted to estimate consistency. These test results are presented in Tables-2.1 to 2.3. The graphical representation of hydrometer analyses curve for the representative samples in each bore is presented in Fig.2.7 to 2.8.

2.2.3 Chemical Analysis Tests

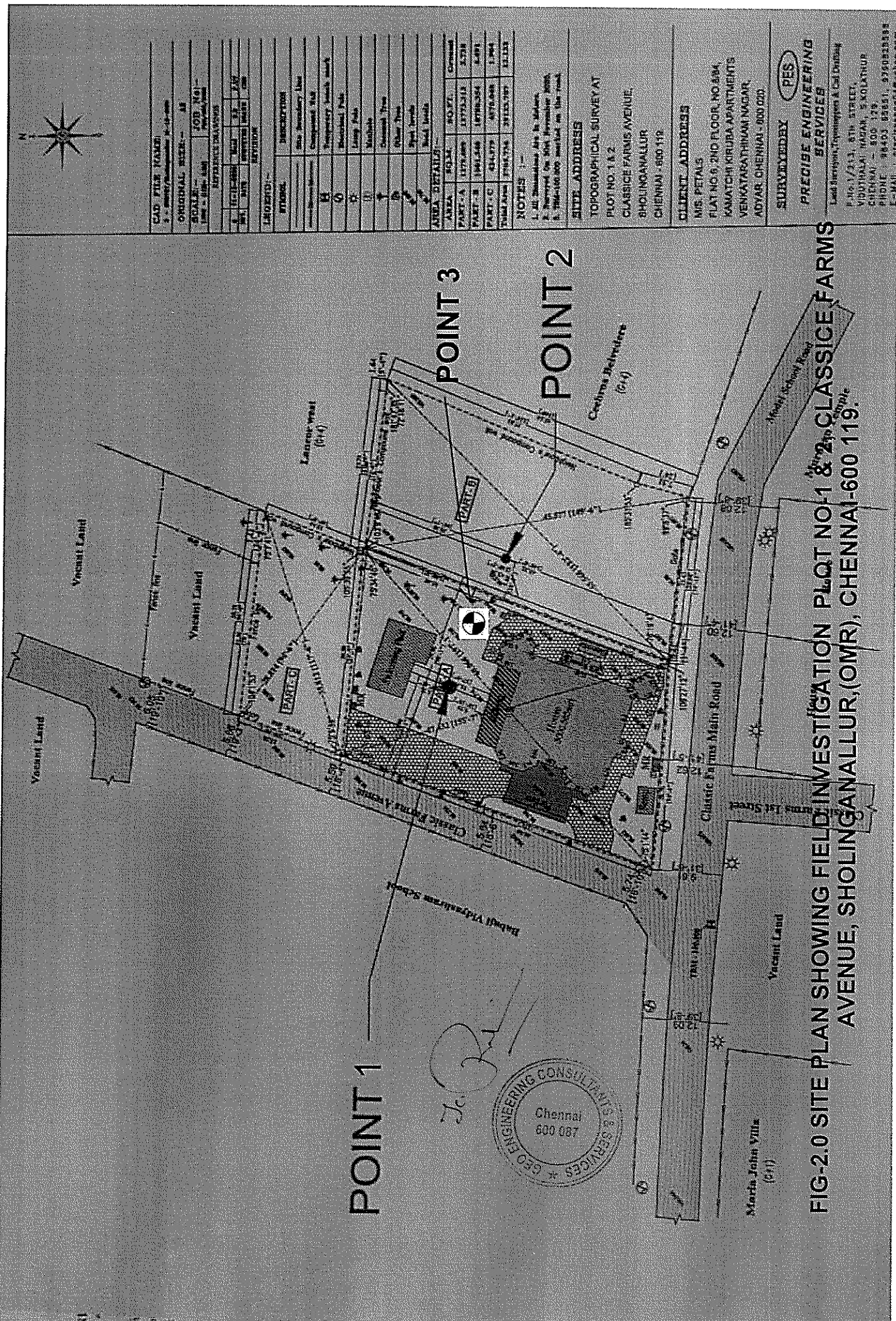
On representative soil and water samples chemical analysis tests were conducted to estimate pH, Chloride and Sulphates and these results are presented in Table – 2.3.

2.3 Summary:

The locations of the field investigation boreholes are shown in site plan given in Fig.2.0. The average sub soil profiles encountered at each location along with their classification and engineering properties are presented in Figs.2.1 to 2.3.



SITE PLAN



SOIL PROFILES

G E S Specialty Of Expertise		SITE INVESTIGATION RECORD						BORE HOLE No. BH-01										
PROJECT NAME		THE PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING						SHEET 1 OF 1										
LOCATION		MACHINE No.		CR-01		CHAINAGE (m)		DIA OF BORE HOLE 150mm ✓ NX										
STRUCTURE		DRILLING METHOD		Rotary		CO-ORDINATES		BORE START DATE 16/09/2023										
JOB CODE		FLUSHING MEDIUM		Bentonite				BORE END DATE 16/09/2023										
GECS-JC-GT-1138								TOTAL DRILL DAYS 1										
Depth below E.G.L. (m)	Drilling progress per metre		Type of Drill Bit (SC / TCB / DB)	Core Details		SPT Details			Sample Details			Layer Data						
	Date	Time		Total Core Recovery %	R.Q.D %	Blows/cm.			SPT 'N' Value	Depth	No.	Type	RL (m)	Legend	No	Depth	Geotechnical Description	
	Hr.	Min.				0-15	15-30	30-45										
	16/09/2023	11:23 To 11:27	SC	-	-	3	3	4	7	1.00	1	SS	-1.0		L1	2.0	Brown, Moist, Loose, Poorly Graded, Fine to Medium Grains, Silty Sand (SM) Sand-Silt mixtures	
		11:34 To 11:37	SC	-	-	7	9	13	22	2.00	2	SS	-2.0					
		11:45 To 11:48	SC	-	-	27	13CM Penet. For 50 Blows			>100	3.00	3	SS	-3.0		L2	3.0	Brownish Grey, Moist, Medium Dense, Poorly Graded, Clayey Silty Sand (SC) Sand-Clay mixtures
		12:02 To 12:05	SC	-	-	9CM Penet. For 50 Blows			>100	4.00	4	SS	-4.0					
		12:18 To 12:22	SC	-	-	SPT Hammer Rebounded			>100	5.50	5	WS	-5.5		L3	5.5	Brownish Grey, Yellow, Very Dene, Medium to Coarse Grains, Completely to Highly Weathered Rock (Descent from Charnockite)	

CS - Core Sample	DS - Disturbed Sample	LOGGED	VINOTH	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	16/09/2023	GROUND LEVEL (m)	0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	R.Bhuvana	WATER TABLE (m)	0.90	
WS - Wash Sample	DB - Diamond Bit	DATE	21/09/2023	CASING DEPTH (m)	0.00	

Borehole terminated at 5.5 m depth below E.G.L.

FIG.2.1 Sub Soil Profile at BH-01 Location

G E C S Geotechnical Engineering Consultants		SITE INVESTIGATION RECORD										BORE HOLE No. BH-02						
PROJECT NAME		THE PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING										SHEET 1 OF 1						
LOCATION		Plot No-1 & 2, Classic Farms Avenue, Sholinganallur, (OMR)		MACHINE No.		CR-01		CHAINAGE (m)		-		DIA OF BORE HOLE 150mm ✓ NX						
STRUCTURE		Ground+7 Upper Floors		DRILLING METHOD		Rotary		CO-ORDINATES		N - E -		BORE START DATE 18/09/2023 BORE END DATE 18/09/2023						
JOB CODE		GECS-JC-GT-1138		FLUSHING MEDIUM		Bentonite						TOTAL DRILL DAYS 1						
Depth below E.G.L. (m)	Drilling progress per metre			Core Details			SPT Details			Sample Details			Layer Data					
	Date	Time		Type of Drill Bit (SC / TCB / DB)	Total Core Recovery %	R.Q.D %	Blows/cm.			SPT 'N' Value	Depth	No.	Type	RL (m)	Legend	No	Depth	Geotechnical Description
		Hr.	Min.				0-15	15-30	30-45									
1	18/09/2023	11:23 To 11:27		SC	-	-	3	4	4	8	1.00	1	SS	-1.0		L1	2.0	Brown, Moist, Loose, Poorly Graded, Fine to Medium Grains, Silty Sand (SM) Sand-Silt mixtures
2		11:34 To 11:37		SC	-	-	18	29	12CM Penet. For 50 Blows	>100	2.00	2	SS	-2.0				
3		11:45 To 11:48		SC	-	-	30		11CM Penet. For 50 Blows	>100	2.42	3	SS	-3.0		L2	3.0	Yellowish Brown, Moist, Poorly Graded, Very Dense, Residual Soil (Descent from Charnockite)
4		12:02 To 12:05		SC	-	-			7CM Penet. For 50 Blows	>100	3.00	4	SS	-4.0				Brownish Grey, Yellow, Very Dense, Medium to Coarse Grains, Completely to Highly Weathered Rock (Descent from Charnockite)
5		12:02 To 12:05							SPT Hammer Rebounded	>100	3.26	5	WS	-4.5		L3	4.5	
6																		
7																		
8																		
9																		
10																		



CS - Core Sample	DS - Disturbed Sample	LOGGED	VINOTH	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	18/09/2023	GROUND LEVEL (m)	0.00	
UDS - Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	R.Bhuvana	WATER TABLE (m)	0.90	
WS - Wash Sample	DB - Diamond Bit	DATE	21/09/2023	CASING DEPTH (m)	0.00	

Borehole terminated at 4.5 m depth below E.G.L

FIG.2.2 Sub Soil Profile at BH-02 Location

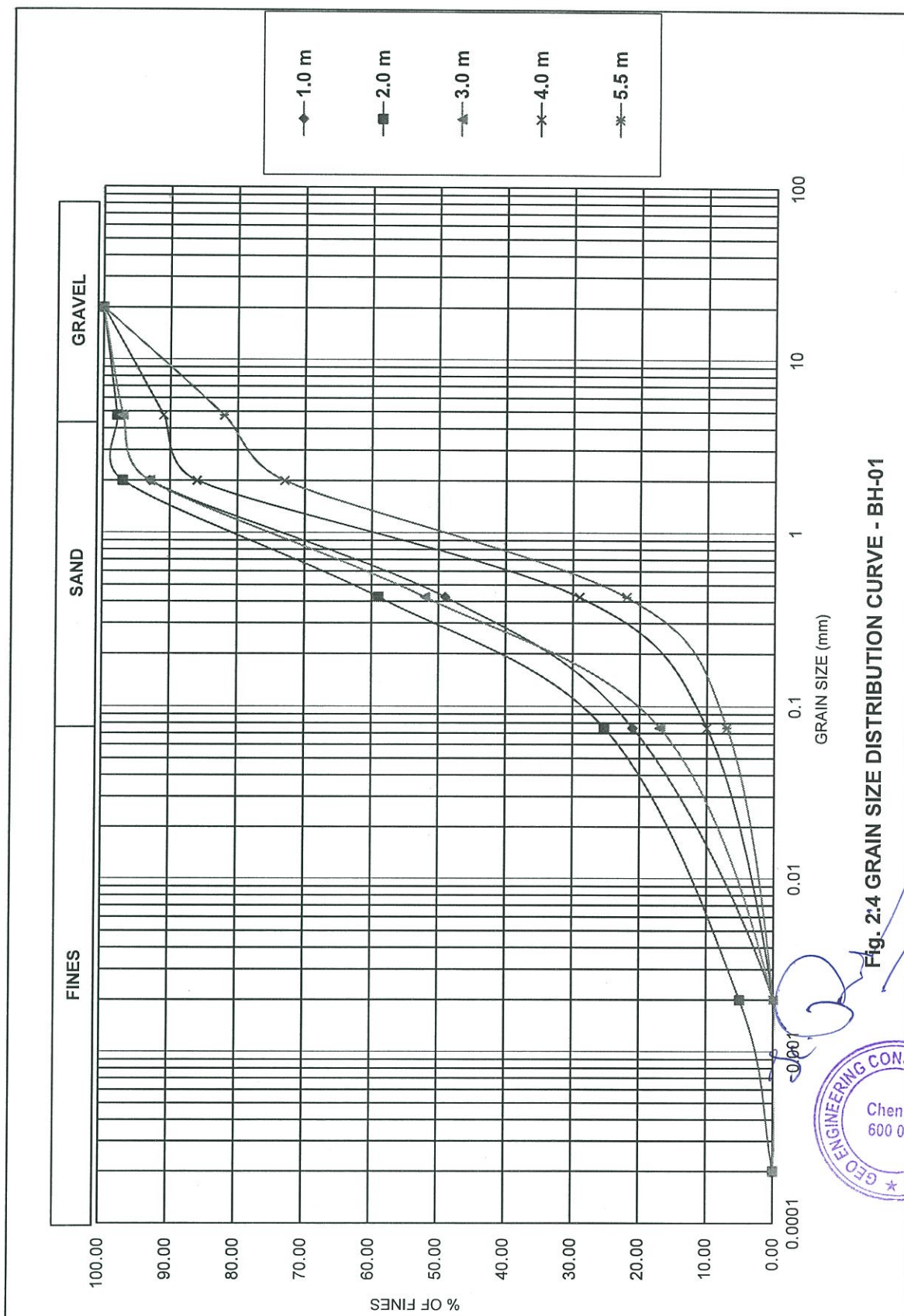
G E C S Spirit Of Experience		SITE INVESTIGATION RECORD										BORE HOLE No. BH-03						
PROJECT NAME		THE PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING										SHEET 1 OF 1						
LOCATION		Plot No-1 &2, Classice Farms Avenue, Sholinganallur, (OMR)		MACHINE No.		CR-01		CHAINAGE (m)		-		DIA OF BORE HOLE 150mm NX						
STRUCTURE		1B+Ground+11 Upper Floors		DRILLING METHOD		Rotary		CO-ORDINATES		N -		BORE START DATE 18/03/2024						
JOB CODE		GECS-JC-GT-1331		FLUSHING MEDIUM		Bentonite				E -		BORE END DATE 18/03/2024						
TOTAL DRILL DAYS		1																
Depth below E.G.L. (m)	Drilling progress per metre			Type of Drill Bit (SC / TCB / DB)	Core Details			SPT Details			Sample Details			Layer Data				
	Date	Time			Total Core Recovery %	R.Q.D %	Blows/cm.			SPT 'N' Value	Depth	No.	Type	RL (m)	Legend	No	Depth	Geotechnical Description
		Hr.	Min.				0-15	15-30	30-45									
1	11	15	To	SC	-	-	2	3	5	8	1.00	1	SS	-1.0				Brownish Grey, Yellow, Moist, Loose to Medium Dense, Poorly Graded, Fine to Medium Grains, Silty Sand (SM) with clay binder Sand-Silt mixtures
2	11	29	To	SC	-	-	6	6	6	12	1.45	2	SS	-2.0				
3	11	32	To	SC	-	-	2	2	5	7	2.00	3	SS	-3.0		L1	3.0	Greyish Brown, Yellow, Moist, Loose, Poorly Graded, Clayey Silty Sand (SC) Sand-Clay mixtures
4	11	41	To	SC	-	-	14	18	25	43	2.45	4	SS	-4.0		L2	4.0	
5	12	03	To	SC	-	-	17	29	35	64	3.00	5	SS	-5.5				Brownish Grey, Yellow, Moist, Poorly Graded, Dense to Very Dense, Residual Soil to Completely Weathered Rock (Grade-VI-V) (Descent from Charnockite)
6	12	13	To	SC	-	-	24	35			3.45	6	SS	-7.0		L3	7.0	
7	12	19	To	SC	-	-					4.00	7	SS	-8.5				Brownish Grey, Yellow, Very Dense, Medium to Coarse Grains, Completely to Highly Weathered Rock (Grade-V-IV) (Descent from Charnockite)
8	12	36	To	SC	-	-					4.45	8	WS	-9.0		L4	9.0	
9	13	18	To	SC	-	-					5.50	9	CS	-10.0		L5	10.0	Brownish Grey, Medium to Coarse Grains, Fresh Hard Rock (Grade-I) (Descent from Charnockite)
10	13	25	To	DB	50	19					5.95							
	14	02	To								7.00							
	14	40	To								7.42							
											8.50							
											8.59							
											9.00							
											10.00							

CS - Core Sample	DS - Disturbed Sample	LOGGED	VINOTH	PROJECT SITE DETAILS		REMARKS sennai 080 087 GEO ENGINEERING CONSULTANTS & SERVICES
SS - Split Spoon Sample	SC - Soil Cutter	DATE	18/03/2024	GROUND LEVEL (m)	0.00	
UDS - Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	R.Bhuvana	WATER TABLE (m)	2.30	
WS - Wash Sample	DB - Diamond Bit	DATE	23/03/2023	CASING DEPTH (m)	0.00	

Borehole terminated at 10 m depth below E.G.L

FIG.2.3 Sub Soil Profile at BH-03 Location

GRAIN SIZE DISTRIBUTION CURVE



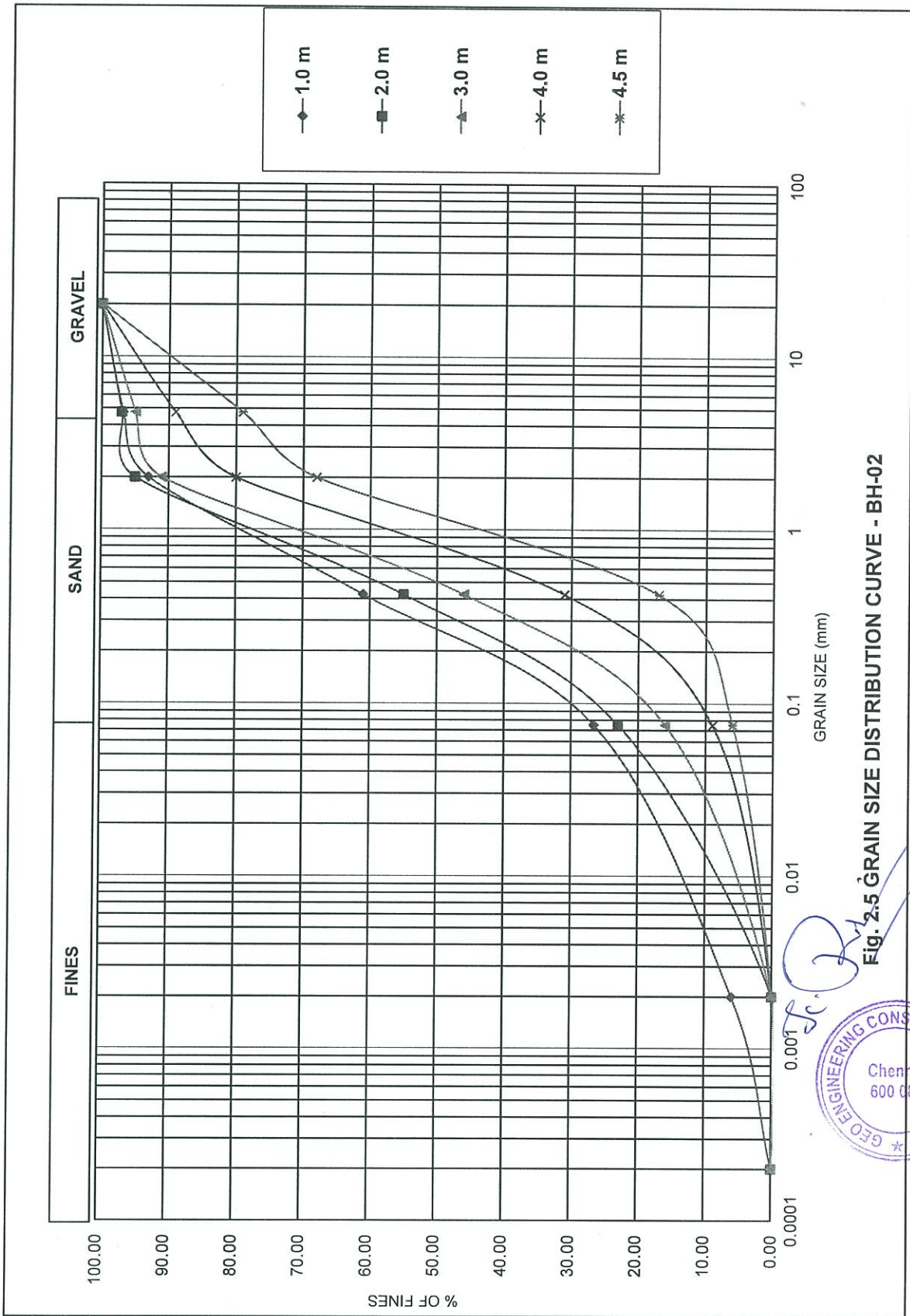


Fig. 2.5 GRAIN SIZE DISTRIBUTION CURVE - BH-02



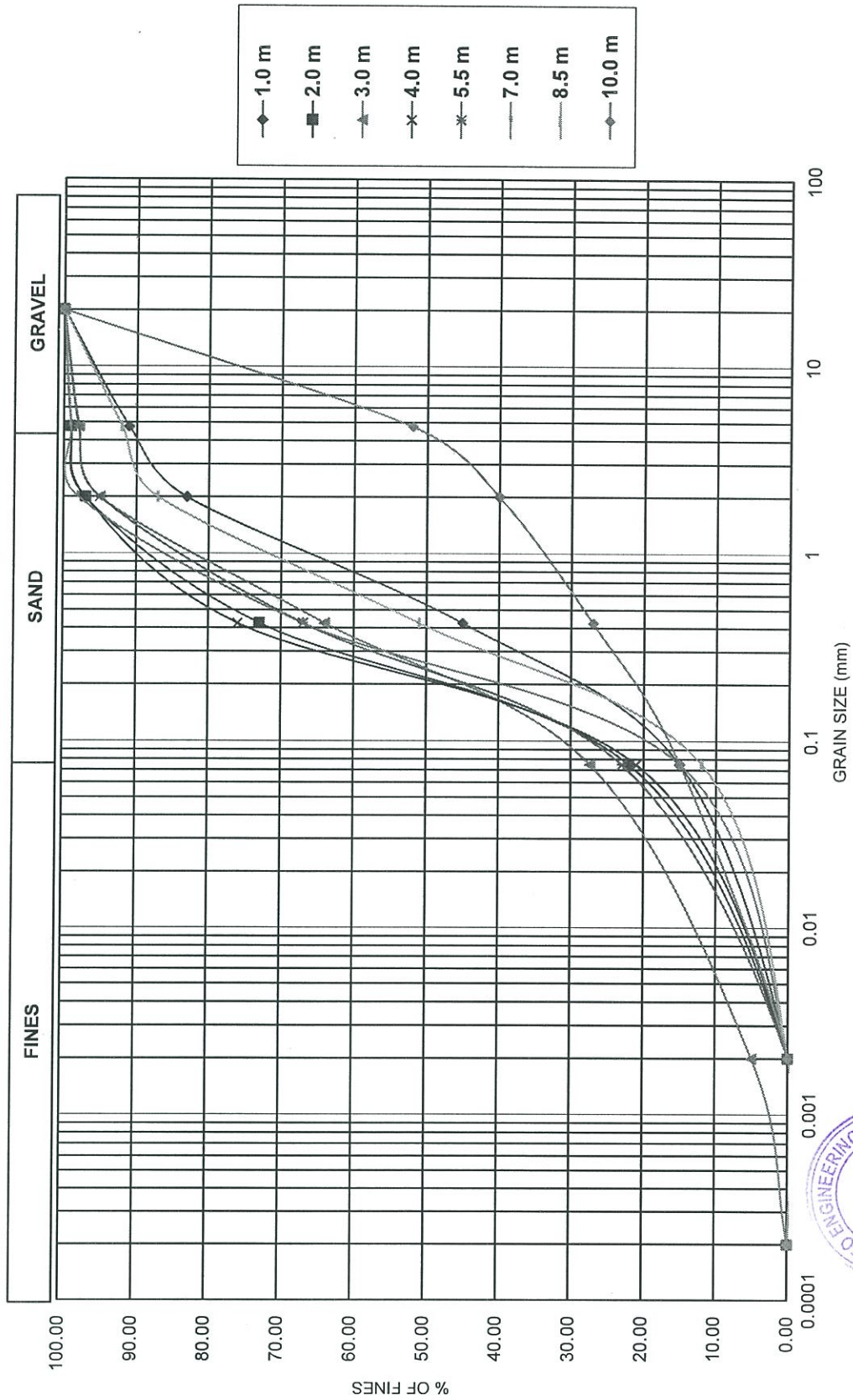


Fig. 2.6 GRAIN SIZE DISTRIBUTION CURVE - BH-03



HYDROMETER ANALYSIS CURVE

—◆— Bore Hole No: 1 Depth: 2.0m

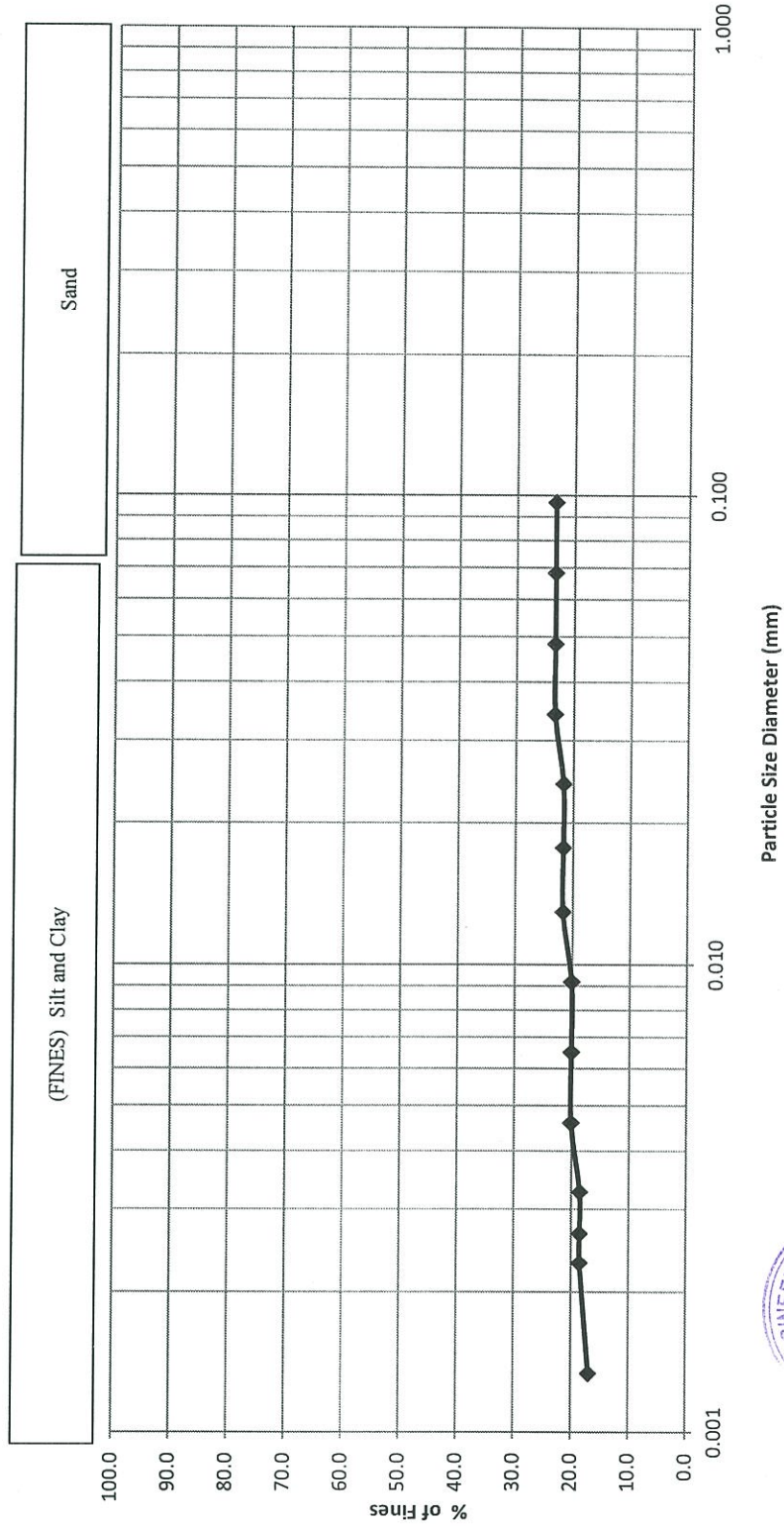


Fig 2.7 Hydrometer Analysis Master Curve



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◆ Bore Hole No: 2 Depth: 1.0m

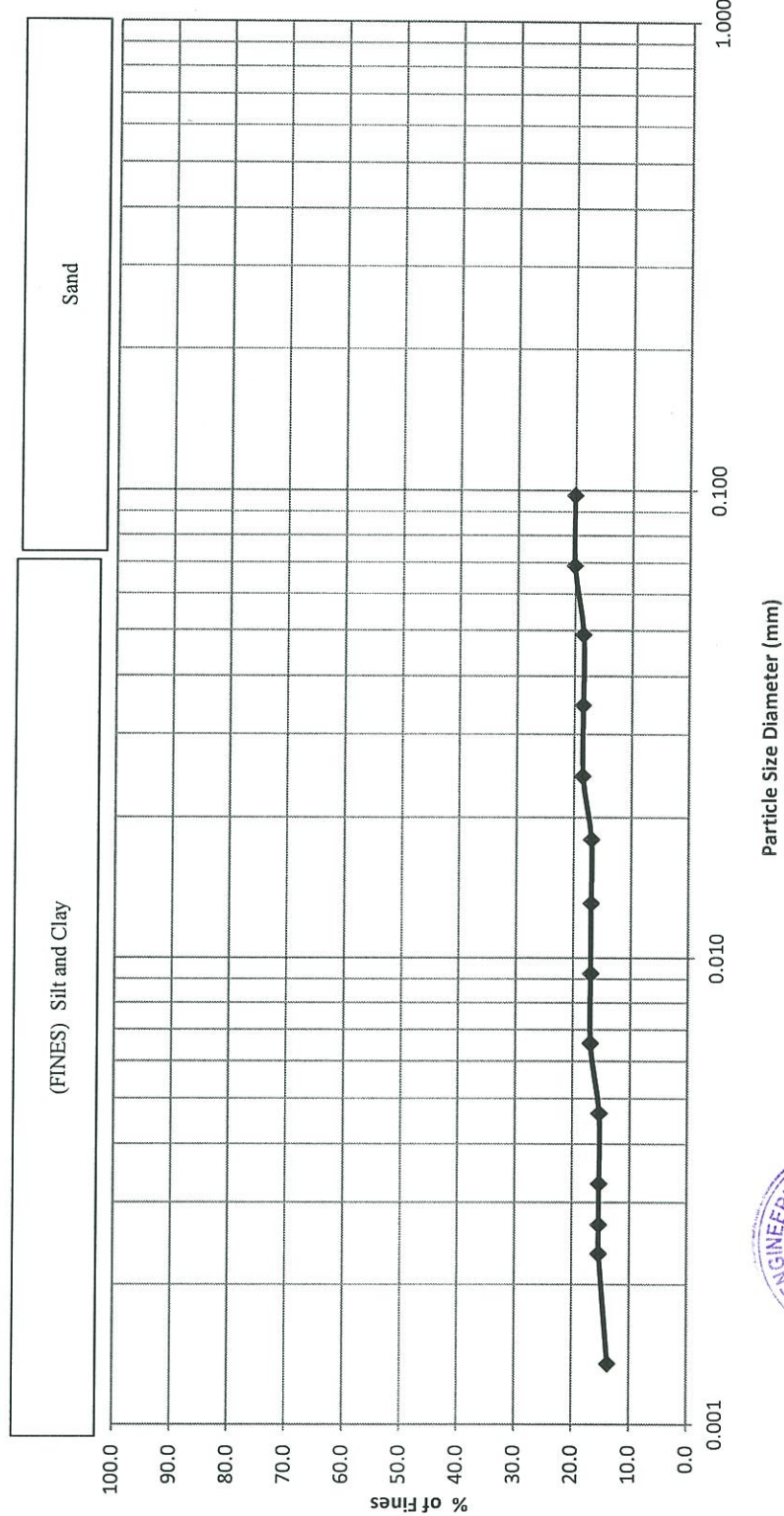


Fig 2.8 Hydrometer Analysis Master Curve



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LABORATORY TEST RESULTS

Table-2.1 Laboratory Classification of Soil Samples from BH-01

Sub Soil Classification																														
Fine Grained (FG)																														
Depth of Sample below E.G.L. (m)	SPT-Value	Type of Sample	NMC(%)	LL (%)	PL (%)	Ip	Ic	SL (%)	FS (%)	Consistency	Position With Respect to A-Alline	IS:Notation	Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	D ₁₀ (mm)	D ₃₀ (mm)	D ₆₀ (mm)	C _u =D ₆₀ /D ₁₀	C _c =D ₃₀ ² /(D ₁₀ x D ₆₀)	Relative Density	IS-Notation					
																									Gravel	Sand				
1.0	7	SS	-	-	-	-	-	-	-	CG>50%	-	-	3	4	44	28	21	0	-	-	-	-	-	-	Loose	<50%	SM			
2.0	22	SS	17	29	18	11	1.09	16	34	CG>50%	Above	-	2	1	38	30	24	5	-	-	-	-	-	-	M.Dense	<50%	SC			
3.0	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	3	4	41	35	17	0	-	-	-	-	-	-	V.Dense	<50%	SM			
4.0	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	9	5	57	19	10	0	-	-	-	-	-	-	V.Dense	<50%	SM			
5.5	>100	WS	-	-	-	-	-	-	-	CG>50%	-	-	18	9	51	15	7	0	-	-	-	-	-	-	V.Dense	<50%	SM			
FG = Fine Grained CG = Coarse Grained NMC= Nature Moisture Content LL = Liquid Limit			PL = Plastic Limit Ip = Plasticity Index Ic = (LL-NMC)/Ip SL = Shrinkage Limit														FS = Differential Free Well Index C _u = Uniformity Coefficient C _c = Coefficient of Curvature IP=LL-PL				LAB IN-CHARGE		R.BHUVANA							
																											REVIEWED BY		GEOTECH TEAM	



Table-2.2 Laboratory Classification of Soil Samples from BH-02

Sub Soil Classification																												
Fine Grained (FG)																												
Depth of Sample below E.G.L. (m)	SPT-Value	Type of Sample	NMC(%)	LL (%)	PL (%)	Ip	Ic	SL (%)	FS (%)	Consistency	Position With Respect to A-Aline	IS:Notation	Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	D ₁₀ (mm)	D ₃₀ (mm)	D ₆₀ (mm)	C _u =D ₆₀ /D ₁₀	C _c =D ₃₀ ² /(D ₁₀ x D ₆₀)	Relative Density	Gravel	Sand	IS-Notation	
1.0	8	SS	21	31	19	12	0.83	15	42	CG>50%	Above	-	3	4	32	30	25	6	-	-	-	-	-	-	Loose	<50%	SC	
2.0	>100	SS								CG>50%	Above	-	3	2	40	32	23	0	-	-	-	-	-	-	V.Dense	<50%	SC	
3.0	>100	SS								CG>50%	-	-	5	4	45	30	16	0	-	-	-	-	-	-	V.Dense	<50%	SM	
4.0	>100	SS								CG>50%	-	-	11	9	49	22	9	0	-	-	-	-	-	-	V.Dense	<50%	SM	
4.5	>100	WS								CG>50%	-	-	21	11	51	11	6	0	-	-	-	-	-	-	V.Dense	<50%	SM	
FG = Fine Grained						PL = Plastic Limit			FS = Differential Free Well Index																	R.BHUVANA		
CG = Coarse Grained			Ip = Plasticity Index			Cu = Uniformity Coefficient																	LAB IN-CHARGE					
NMC= Nature Moisture Content			Ic = (LL-NMC)/Ip			Cc = Coefficient of Curvature																	REVIEWED BY			GEOTECH TEAM		
LL = Liquid Limit			SL = Shrinkage Limit			IP=LL-PL																						



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Table-2.3 Laboratory Classification of Soil Samples from BH-03

Sub Soil Classification																														
Fine Grained (FG)													IS:Notation																	
Depth of Sample below E.G.L. (m)	SPT-Value	Type of Sample	NMC(%)	LL (%)	PL (%)	Ip	Ic	SL (%)	FS (%)	Consistency	Position With Respect to A-Aline	IS:Notation	Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	D ₁₀ (mm)	D ₃₀ (mm)	D ₆₀ (mm)	C _u =D ₆₀ /D ₁₀	C _c =D ₃₀ ² /(D ₁₀ x D ₆₀)	Relative Density	IS-Notation					
																									Gravel	Sand				
1.0	8	SS	-	-	-	-	-	-	-	CG>50%	Above	-	9	8	38	30	15	0	-	-	-	-	-	Loose	<50%	SC				
2.0	12	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	2	24	51	22	0	-	-	-	-	-	M.Dense	<50%	SM				
3.0	7	SS	21	28	18	10	0.70	20	24	CG>50%	Above	-	2	3	31	33	26	5	-	-	-	-	-	Loose	<50%	SC				
4.0	43	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	2	21	55	21	0	-	-	-	-	-	Dense	<50%	SM				
5.5	64	SS	-	-	-	-	-	-	-	CG>50%	-	-	2	3	28	44	23	0	-	-	-	-	-	V.Dense	<50%	SM				
7.0	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	1	31	52	15	0	-	-	-	-	-	V.Dense	<50%	SM				
8.5	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	8	5	36	39	12	0	-	-	-	-	-	V.Dense	<50%	SM				
9.0	>100	WS	-	-	-	-	-	-	-	CG>50%	-	-	48	12	13	12	15	0	-	-	-	-	-	V.Dense	GM	SM				
FG = Fine Grained CG = Coarse Grained NMC= Nature Moisture Content LL = Liquid Limit													FS = Differential Free Well Index C _u = Uniformity Coefficient C _c = Coefficient of Curvature IP=LL-PL														LAB IN-CHARGE		R.BHUVANA	
																											REVIEWED BY		GEOTECH TEAM	

[Handwritten Signature]





Table-2.4 Results of Chemical Analysis									
SL No.	Bore HoleNo.	Water				Soil (2:1)			
		Depth of Sample (m)	pH	Chlorides (ppm)	Sulphates (ppm)	Depth of Sample (m)	pH	Chlorides (ppm)	Sulphates (ppm)
1	BH-03	2.30	7.16	326	385	3.0	7.05	318	343




GEOLOGY & SUB-SURFACE STRATIFICATION

3.0 Preamble:

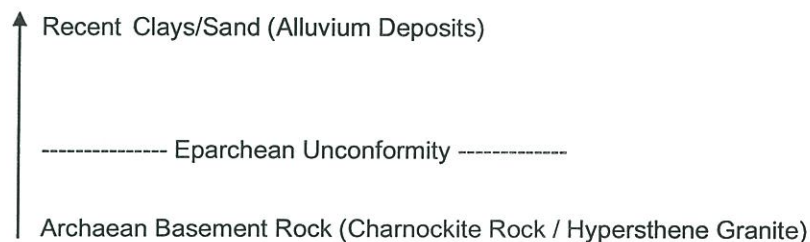
Geotechnical investigation carried out at a specific site provides location specific sub surface engineering characteristics. However, in major project sites, where the construction activities spread over a very large area, location specific sub surface strata characteristics are studied together with the geological mapping data. This is required to incorporate the impact of any documented macro-level geological characteristics of the region on the foundation design, irrespective of the location specific sub surface strata characteristics.

In view on the above, though it is beyond the scope of the present study to carry out macro-level geological investigation, the regional geology based on the published data is presented and discussed with respect to the foundation design.

3.1 Geology of the Region (based on the published data)

Formation Characteristics:

The present location falls under Chennai District, geologically it is classified as recent alluvium deposits consisting of marine clay and silty sand, which is underlain with basement rock.



3.2 DESIGN SUB SOIL PROFILE:(WRT Foundation Engineering Application)

The sub soil characteristics obtained at the test location are further processed to arrive at the design soil parameters required for the design of sub structure using the following shear strength correlations with respect to the Standard Penetration Test Values of different layers.

- ❖ For Coarse Grained Material, Ref. IS: 6403 to estimate Angle of Shearing Resistance (Reproduced and shown in Fig.A1)
- ❖ For Fine Grained Material, Ref. Terzaghi & Peck, 1948, to estimate Unconfined Compressive Strength (Reproduced and shown in Fig.A2)

Based on the above, the average design soil characteristics are given below:





REFERENCE BORE HOLE-BH:					1.0	Ref R.L. of G.L. (m):			0.00		
Layer No.	Layer Thk. (m)			Type of Strata	Colour	Ave. Design SPT	Relative Density	Consistency	* (γ) kN/m ³	Shear Parameters	
	Top. R.L.	Bot. R.L.	Thickness							* (C _u) kPa	* (ϕ) Deg.
1	0.00	2.00	2.00	Silty Sand	Brown	7	Loose	-	14.5	-	29.4
2	2.00	3.00	1.00	Clayey Silty Sand	Brownish Grey	22	Medium Dense	-	18.5	-	33.6
3	3.00	5.50	2.50	Completely to Highly Weathered Rock	Brownish Grey, Yellow	>100	Very Dense	-	21	-	42.5

❖ Note: -Bulk density, & "C", " ϕ " values are given in SPT correlation

REFERENCE BORE HOLE-BH:					2.0	Ref R.L. of G.L. (m):			0.00		
Layer No.	Layer Thk. (m)			Type of Strata	Colour	Ave. Design SPT	Relative Density	Consistency	* (γ) kN/m ³	Shear Parameters	
	Top. R.L.	Bot. R.L.	Thickness							* (C _u) kPa	* (ϕ) Deg.
1	0.00	2.00	2.00	Clayey Silty Sand	Grey	8	Loose	-	14.5	-	29.6
2	2.00	3.00	1.00	Residual Soil	Yellowish Brown	>100	Very Dense	-	21	-	42.5
3	3.00	4.50	1.50	Completely to Highly Weathered Rock	Brownish Grey, Yellow	>100	Very Dense	-	21	-	42.5

❖ Note: -Bulk density, & "C", " ϕ " values are given in SPT correlation





REFERENCE BORE HOLE-BH:				3.0	Ref R.L. of G.L. (m):			0.00			
Layer No.	Layer Thk. (m)			Type of Strata	Colour	Ave. Design SPT	Relative Density	Consistency	(γ) kN/m ³	Shear Parameters	
	Top. R.L.	Bot. R.L.	Thickness							(C _u) kPa	(φ) Deg.
1	0.00	4.00	4.00	Silty Sand with Clay Binder	Brownish Grey, Yellow	9	Loose	-	14.5	-	29.8
2	4.00	7.00	3.00	Residual soil to Completely Weathered Rock	Brownish Grey, Yellow	54	Very Dense	-	20.5	-	41.6
3	7.00	9.00	2.00	Completely to Highly Weathered Rock	Brownish Grey, Yellow	>100	Very Dense	-	21	-	42.5
4	9.00	10.00	1.00	Fresh Hard Rock	Brownish Grey	CRR-50%, RQD-19%					

❖ Note: -Bulk density, & "C", " ϕ " values are given in SPT correlation



FOUNDATION SYSTEM



CHAPTER-4

FOUNDATION SYSTEM

4.0 Preamble:

In the design of foundation system, the stress-strain compatibility of the super structure, sub structure and the bearing strata should be satisfied both individually and as a combined system. In view of this, the following data are needed for the design of foundation system, defined in terms of the type of sub structure and the bearing strata characteristics.

- The super structure characteristics along with the loading pattern on the sub structure
- The sub soil characteristics that define the required substructure configuration for a safe transfer of super-structural loads to the bearing strata

Considering the above aspects of the foundation design, the suitable type of foundation system is presented below.

4.1 Proposed Structures

An understanding of the proposed construction and the order of loads on the foundations is needed for choosing the appropriate foundation system. In the present case, the proposed structure is configured with one basement+ground floor+11upper floors, and is meant for residential use. For this kind of structure, the column loads could vary between 6000kN to 7500kN. The above-mentioned loads have no bearing on the design of either sub or super structures and are mentioned just to provide an insight to choose an appropriate foundation system with respect to subsoil conditions.

4.2 Sub Soil Stratification:

In the present location the sub soil strata consist of the following:

0.0m to 3.0m	: Loose Silty Sand/Clayey Silty Sand
3.0m to 7.0M	: Dense Residual Soil to Completely weathered Rock
7.0m to 9.0m	: Very Dense Completely to Highly Weathered Rock
9.0m to 10.0m	: Hard Fresh Rock

During the time of investigation (3rd Week of March-2024) the ground water table observed at 2.3m below existing ground level.

4.3 Sub Surface formation & Bearing Strata:

The sub surface formation is predominantly weathered rock deposit and extends up to the top of underlying hard rock formation, Hence, for the kind of proposed structure, it is ideal to consider the underlying weathered fracture rock as the bearing strata.





4.4 Foundation System

4.4.1 Isolated Column Footings or Raft:

In the present case the proposed construction consists of basement floor height informed to be 3.0m from the existing ground level excluding the depth of foundation during the time of report preparation. In the present case, for the kind of sub soil conditions either Isolated column footings or raft foundation system can be adopted based on the structural load requirements.

The recommended allowable safe bearing pressure with embedment of 1.0m depth below the top of the basement slab is worked out is 350kPa.

In case, the coverage of the area of the footing is more than the 50% of the plan area of the basement, foundation system shall be designed as a raft foundation.

Since the sub soil stratum below the founding level is rock with varying grade of weathering only immediate elastic settlement will takes place.

4.5 Excavation Design Philosophy

Basement excavation can be carried out using excavator or proclain up to 3.0m depth. beyond 3.0m soil is weathered rock in case proclain excavation is difficult rock breaker shall be use. The strata comprise predominantly of residual soil silt size particle, machine excavation shall be stopped at least 300mm above the required dredge line (bottom of excavation) and in this zone, it is ideal to adopt manual excavation, such the bearing strata is not loosened. However, machine excavation is resorted, the bearing strata shall be well compacted by using minimum 3 Ton roller.

Option:-I

However, as a precaution, it is ideal to adopt a mild slope of 1Horizontal to 2Vertical. can be adopted. Considering the possible monsoon rains during construction, it is recommended to cover the surface of the slope with 1mm thick HDPE sheet suitably anchored at top and toe with either sand bags or 100mm thick P.C.C. of M10 grade with minimum 1.0m width.

Option: II

Alternatively, the exposed surface shall be protected with soil nails of 3.0m length with 4.0mm welded mesh duly covered and shotcrete concrete.

4.6 Dewatering Technique:

In the present case, the anticipated excavation being 4.0m depth for effective lowering of ground water it is ideal to provide ground water lowering bore wells in a grid pattern with grid spacing not exceeding 20m centre to centre outside the excavation line for a minimum depth of 9m below the existing ground level.

Further the borehole can be connected to a common header and the pumped water shall be conveyed to the source away from the excavation preferably to a storm drainage network or any unobjectionable location by ensuring that the pumped water will not recharge the same aquifer.





4.7 Design of Basement slab for Uplift

In the present case, the basement slab shall be designed for the uplift pressure corresponding to assumed ground water table at ground level.

Note:

Before excavation is started a workshop shall be conducted including the Owner, Architect, Structural Engineer, Geotechnical Engineer and Execution agency to ensure the proposal given by the contractor is workable and safe.



RECOMMENDATIONS

RECOMMENDATIONS

5.0 Recommendations for Foundation Design

- ❖ For the kind of proposed structure and the sub soil conditions, either isolated footing or raft foundation system with shear block can be adopted.
- ❖ In the present case, the depth of excavation including the foundation embedment is about 4.0m below the existing ground level.
- ❖ The footings shall be designed for an recommended allowable safe bearing pressure with embedment of 1.0m depth below the top of the basement slab is worked out is 350kPa.
- ❖ In case the foundation area is more than 50% of the plan area it is ideal to adopt raft with shear block.
- ❖ In case of raft foundation system adopted, the raft can be designed for an recommended allowable safe bearing pressure of 350kPa.
- ❖ **The basement floor slab shall be designed for the uplift pressure corresponding to the ground water table assumed at the existing ground level.**
- ❖ All foundation shall rest on 100mm thick M10 Grade levelling coarse bed.
- ❖ Since the formation beyond the bearing stratum is disintegrated, very dense rock formation followed by hard rock formation only immediate elastic settlement will takes place.
- ❖ During the course of foundation excavation if the subsurface seepage water is encountered the bearing strata under wet condition may exhibit a slushy nature, hence in such conditions the slush shall be removed and sand or quarry dust of minimum 200mm shall be laid and compacted to ensure confinement of bearing strata without being subjected to swelling under wet conditions

5.1 Recommendations for Excavation

- ❖ As discussed in chapter-4, Section 4.4 it is recommended to adopt open excavation with a mild slope of 2 Vertical:1 Horizontal
- ❖ The ground water shall be lowered by adopting system discussed in section 4.5, chapter-4.
- ❖ Considering the possible monsoon rains during construction, it is recommended to cover the surface of the slope with 1mm thick HDPE sheet suitably anchored at top and toe with either sand bags or 100mm thick P.C.C. of M10 grade with minimum 1.0m width





5.2 General Recommendation

- ❖ Since, chlorides and sulphates are well within the permissible limits, no special steel or cement is required for the construction.
- ❖ Excavated soil shall be use for foundation back filling purpose.

5.3 Special Recommendations

- ❖ Before construction activities are initiated, a scientific due-diligence of the condition of the neighbouring structures shall be carried out and authenticated. This is required to ensure that no undue claims or interpretations are made by the neighbourhood that the construction activities cause damages to their structures

FOR GEO ENGINEERING CONSULTANTS & SERVICES., CHENNAI.

K. RAMALINGAM (M.Sc., M. Phil (Geologist) BE (CIVIL))

Geotechnical Engineers

K. RAMALINGAM
M.Sc., M.Phil (Geologist), BE (Civil),
Sr. Geotechnical Engineer
Geo Engineering Consultants & Services
No.12B, Anbu Nagar, 3rd Street, Alwarthuru Nagar, Chennai-600087.
info@geocengservices.com
Ph: 9841226220 / 9444901825.



ANNEXURE



TYPICAL BEARING CAPACITY COMPUTATIONS FOR SHALLOW FOUNDATIONS

1.0 COMPUTATION OF BEARING CAPACITY AS PER IS:6403

	Reference Borehole No.	BH-03
1.1 Geometrical Data		
Shape of the Foundation		Sqaure
Depth of Basement floor Height Below R.L (m)		3.00
Assumed Thickness of Foundation or Depth of Embedment (m)		1.00
Though the overall foundation depth(m)		4.00
Breadth of Footing "B" (m)		1.00
Length of Footing "L" (m)		1.00
B/L		1.00
Inclination of Vertical Load with the Vertical (a)		0.00

1.2 Soil Data

Type of Effective Bearing Strata :	Completely Weathered Rock
Design SPT-value of the Bearing Strata :	30.00
Type of Shear Failure:	General
Angle of Shearing Resistance	36.00

1.3 Design Parameters

Bulk Density of Soil above the foundation depth (γ_{bulk})	18.00
Effective Overburden pressure at foundation level (q)	32.00
Water Table Correction Factor (w')	0.50
Bearing Capacity Factors:	
$N_c =$	N/A
$N_q =$	39.48
$N_g =$	60.31

Shape Factors:

$S_c =$	-
$S_q =$	1.20
$S_g =$	0.60

Depth Factors :

$D_c =$	-
$D_q =$	1.05
$D_g =$	1.05

Inclination Factor:

$I_c =$	1.00
$I_q =$	1.00
$I_g =$	1.00

1.4 Ultimate Bearing Capacity (Qu)

$$Q_u = q \cdot (N_q - 1) \cdot S_q \cdot D_q \cdot I_q + 0.5 \cdot B \cdot \gamma \cdot N_g \cdot S_g \cdot D_g \cdot I_g \cdot w'$$

(g should be read as gama)

1718.41 kPa

1.5 Safe Bearing Capacity (Qsafe) :

Factor of Safety (FOS) :	2.50
Qsafe :	687.36 kPa
However limit Q_{safe}	350 kPa

2.0 Computation of Settlement for Maximum Pressure and Size of Footing: (as per IS:8009-Part-I-Ref. Eq.11) (Elastic Analysis)

Type of compressible strata	Completely Weathered Rock
Immediate Settlement (S_i)= $qB(1-\mu^2)/E_s$	
Bearing Capacity (q)	350.00
Poisson's Ratio (μ)	0.20
Modulus of Elasticity (E_s)(Ref. Joseph E Bowels,1996,page316,Table5.6, Japanese design standards)	
Modulus of Elasticity (E_s)	78000
Size of footing considered for maximum settlement(m)	1.00
Influence factor	1.00
Rigidity Factor	1.00
Elastic Settlement (DH_i)	4.31 mm
	<50 mm



TYPICAL BEARING CAPACITY COMPUTATIONS FOR SHALLOW FOUNDATIONS

1.0 COMPUTATION OF BEARING CAPACITY AS PER IS:6403

Reference Borehole No.	BH-03
1.1 Geometrical Data	
Shape of the Foundation	Raft
Depth of Basement floor Height Below R.L (m)	3.00
Assumed Thickness of Foundation or Depth of Embedment (m)	1.00
Though the overall foundation depth(m)	4.00
Breadth of Footing "B" (m)	10.00
Length of Footing "L" (m)	10.00
B/L	1.00
Inclination of Vertical Load with the Vertical (a)	0.00

1.2 Soil Data

Type of Effective Bearing Strata :	Completely Weathered Rock
Design SPT-value of the Bearing Strata :	30.00
Type of Shear Failure:	General
Angle of Shearing Resistance	36.00

1.3 Design Parameters

Bulk Density of Soil above the foundation depth (γ_{bulk})	18.00
Effective Overburden pressure at foundation level (q)	32.00
Water Table Correction Factor (w')	0.50
Bearing Capacity Factors:	
$N_c =$	N/A
$N_q =$	39.48
$N_g =$	60.31
Shape Factors:	
$S_c =$	-
$S_q =$	1.20
$S_g =$	0.60
Depth Factors :	
$D_c =$	-
$D_q =$	1.00
$D_g =$	1.00
Inclination Factor:	
$I_c =$	1.00
$I_q =$	1.00
$I_g =$	1.00

1.4 Ultimate Bearing Capacity (Q_u)

$$Q_u = q \cdot (N_q - 1) \cdot S_q \cdot D_q \cdot I_q + 0.5 \cdot B \cdot \gamma \cdot N_g \cdot S_g \cdot D_g \cdot I_g \cdot w' \quad 3120.65 \text{ kPa}$$

(g should be read as gamma)

1.5 Safe Bearing Capacity (Q_{safe}) :

Factor of Safety (FOS) :	2.50
$Q_{safe} :$	1248.26 kPa
However limit Q_{safe}	350 kPa

2.0 Computation of Settlement for Maximum Pressure and Size of Footing: (as per IS:8009-Part-I-Ref. Eq.11) (Elastic Analysis)

Type of compressible strata	Completely Weathered Rock
Immediate Settlement (S_i)= $qB(1-m^2)/E_s$	
Bearing Capacity (q)	350.00
Poisson's Ratio (μ)	0.20
Modulus of Elasticity (E_s)(Ref. Joseph E Bowels,1996,page316,Table5.6, Japanese design standards)	
Modulus of Elasticity (E_s)	78000
Size of Raft considered for maximum settlement(m)	10.00
Influence factor	1.00
Rigidity Factor	1.00
Elastic Settlement (DH_i)	43.08 mm
	<50 mm



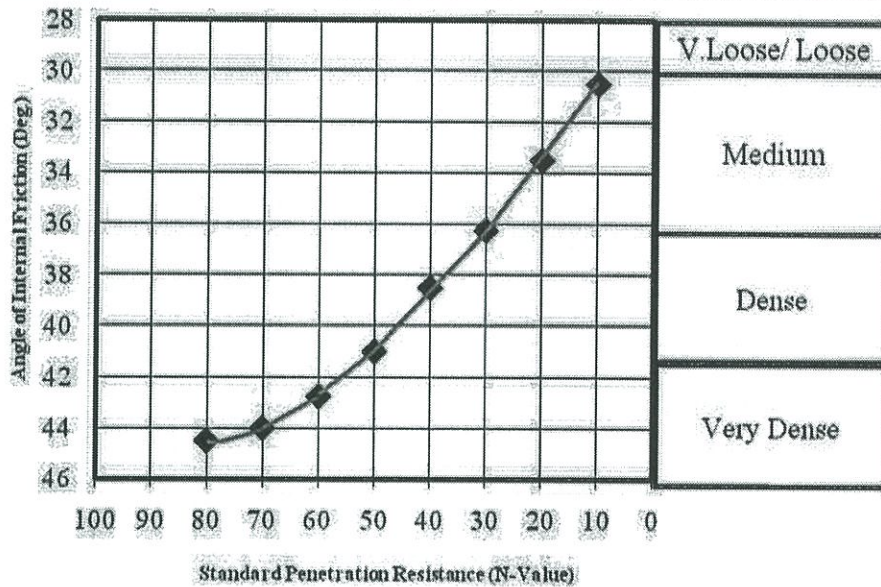


FIG. A1 Relation Ship between Angle of Internal Friction & N-value (Reproduced from IS:6403-1981)

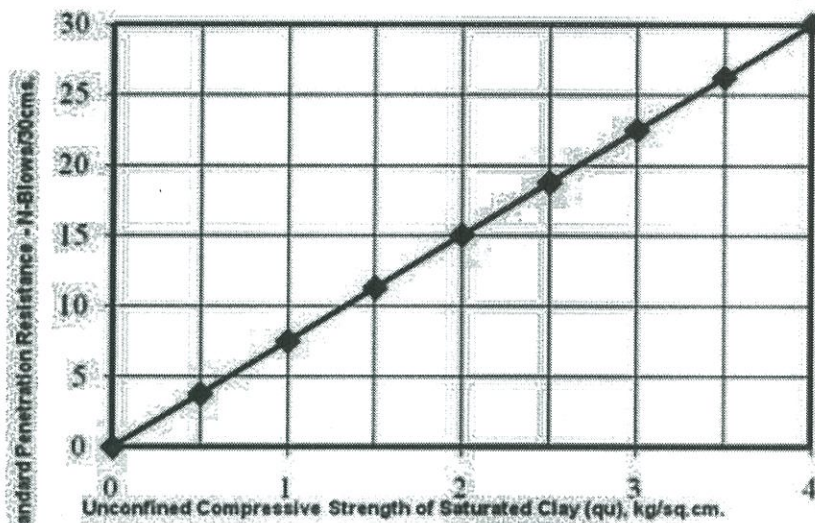
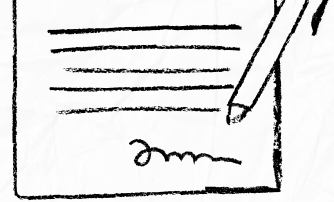


FIG. A2 : Relationship between UCC & SPT-Value (N) of Saturated Clay (After Terzaghi & Peck, 1948)





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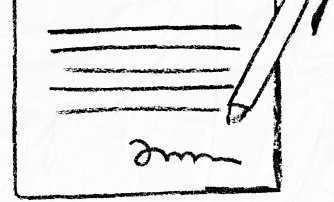
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hello@verified.realestate
[+91 9996 12 9996](tel:+919996129996)
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