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GEO ENGINEERING CONSULTANTS

(An ISO 9001:2015 Certified Company)

15, 2nd Floor, Murphy Das Street,
Dr. Seethapathy Nagar, Velachery,
Chennai – 600 042.

Ph.No. 9841036964 / 9841226220 / 9940176229.

[Email: info@gecindia.net/geoengineeringconsultant@gmail.com.](mailto:info@gecindia.net/geoengineeringconsultant@gmail.com)

PROJECT NAME

**PROPOSED CONSTRUCTION OF COMMERCIAL BUILDING
(S +10 FLOORS) AT 1 AVENUE, OLD S.NO 47 PT, 2/1A, 1B, 5, 6, 7 & 8 PT,
T.S.NO 37/1, BLOCK NO 5 OF PERIYAKUDALANNA NAGAR EAST,
CHINTHAMANI, CHENNAI, TAMIL NADU.**

CLIENT NAME

**THE EXECUTIVE ENGINEER,
ANNA NAGAR DIVISION, TAMILNADU HOUSING BOARD,
CHENNAI-600 040.**

TITLE

GEOTECHNICAL INVESTIGATION REPORT

PROJECT NO: GEC-JC-GT-1044/2019-2020

DATE: 16/03/2020

CONTENTS



	SEC. NO.	CONTENTS	PAGE NO.
			i-ii
CHAPTER-1		INTRODUCTION	
	1.0	Project Information Matrix	1
	1.1	Scope of Work	1
	1.1.1	Field Work	1
	1.1.2	Laboratory Work	1
	1.2	Structure of the Report	1
CHAPTER-2		INVESTIGATION METHODOLOGY & TEST RESULTS	
	2.0	Preamble	2
	2.1	Methodology of Field Work	2
	2.1.1	Equipment Used and Method of Drilling	2
	2.1.2	Standard Penetration Test	2
	2.1.3	Collection of Soil Samples	2
	2.1.4	Collection of Ground Water Samples	2-3
	2.2	Laboratory Testing	3
	2.2.1	On Coarse Grained Soil	3
	2.2.2	On Fine Grained Soil	3
	2.2.3	Chemical Analysis Tests	3
	2.3	Summary	3
FIGURES	2.0	Site Plan showing the Location of Field Investigation Points	4
	2.1 to 2.2	Soil Profile	5-10
	2.3 to 2.4	Graphical Representation of Grain Size Analyses Curve	11-12
	2.5 to 2.9	Graphical Representation of Hydrometer Analyses Curve	13-18
TABLES	2.1 to 2.2	Laboratory Test Results	19-20
	2.3	Results of Chemical analysis	21
CHAPTER-3		GEOLOGY & SUB-SURFACE STRATIFICATION	
	3.0	Preamble	22
	3.1	Geology of the study area	22
	3.2	Design Sub Soil Profile	23-24
CHAPTER-4		FOUNDATION SYSTEM	
	4.0	Preamble	25
	4.1	Proposed Structures	25
	4.2	Foundation System	25



TABLES	4.1	Recommended Safe Load Carrying Capacities of Bored Cast-in Situ Piles	26
CHAPTER-5		RECOMMENDATIONS	27
ANNEXURE		Estimation of safe load carrying capacity of vertical pile design	28
		Lateral Load Carrying Capacity of Bored Cast- Situ Piles	29
	A1	Relationship Between Angle of Internal Friction & N-Value	30
	A2	Relationship Between UCC & SPT -Value (N) of Saturated Clay	30

REPORT TEXT



INTRODUCTION

1.0 Project Information Matrix

Nature of project	: Commercial Building (Stilt+10 Upper Floors)
Project Client	: TAMIL NADU HOUSING BOARD,
Project Location	: 1 st Avenue, Anna Nagar East, Chennai.
Job Code	: JC-GT-1044

1.1 Scope Of Work

1.1.1 Field Work

- ❖ Conducting two soil investigation bore holes of 150 mm & NX diameter up to 29.0m 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 5.0m and thereafter at every 1.5m depth interval up to 20.0m depth and thereafter at every 2.0m depth interval up to termination depth.
- ❖ Collection of soil samples and undisturbed samples from the clayey strata with SPT-value greater than 2 to less than 15 if met within the investigation depth
- ❖ 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:

Two soil investigation boreholes were 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 2.2. The graphical representation of grain size distribution curve for the representative samples in each bore is presented in Fig. 2.3 to 2.4.

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 2.2. The graphical representation of hydrometer analyses curve for the representative samples in each bore is presented in Fig.2.5 to 2.9.

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.

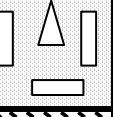
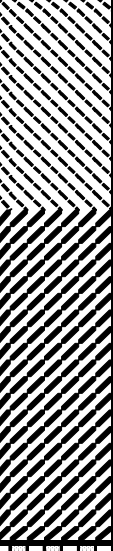
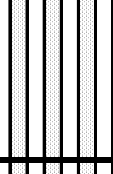
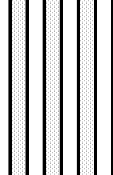
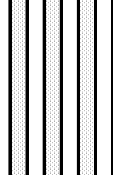
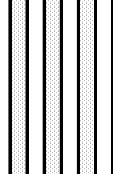
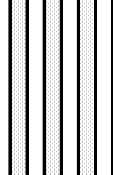
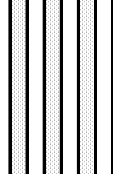
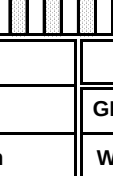
2.3 Summary:

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 2.2.

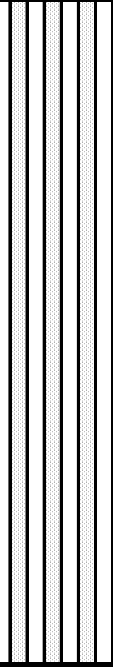
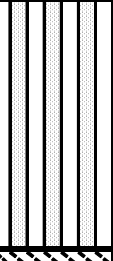
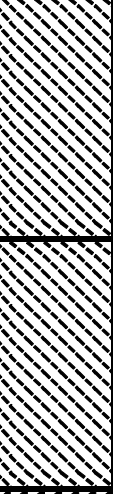
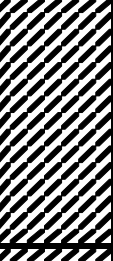
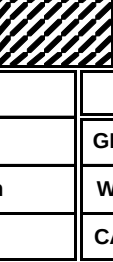
SITE PLAN

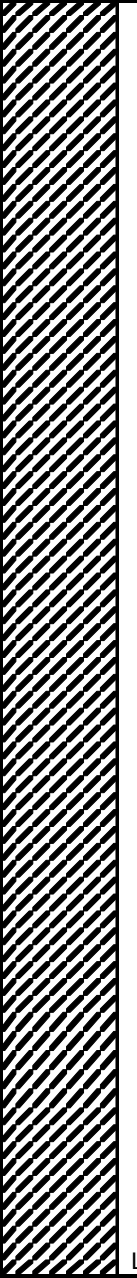
SOIL PROFILE

		SITE INVESTIGATION RECORD										BORE HOLE No.		BH-01			
												SHEET		1	OF	3	
PROJECT NAME		PROPOSED CONSTRUCTION OF COMMERCIAL BUILDING										DIA OF BORE HOLE		150mm	✓		
		NX															
LOCATION		Chinthamani ,Anna Nagar East, Chennai			MACHINE No.		CR-02		CHAINAGE (m)		-		BORE START DATE		22/02/2020		
STRUCTURE		Stilt+10 Upper Floors			DRILLING METHOD		Rotary		CO-ORDINATES		N	-		BORE END DATE		23/02/2020	
JOB CODE		JC-GT-1044			FLUSHING MEDIUM		Bentonite				E	-		TOTAL DRILL DAYS		2	

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	22/02/2020	09	19	SC	-	-	2	3	3	6	1.00	1	SS	-1.0		L1	0.6	Filled Up Soil (Old Building Materials)
		09	23															
2		09	43	SC	-	-	3	3	5	8	1.45	2	SS	-2.0		L2	4.0	Brownish Grey,Moist,Medium Stiff, SILTY CLAY(CI/CH) Silty Clays of Low to High plasticity
		09	50															
3		10	02	SC	-	-	4	3	4	7	2.00	3	SS	-3.0		L3	5.0	Brown,Moist,Loose,Poorly Graded, Silty Sand(SM) Sand-Silt mixtures
		10	08															
4		10	19	SC	-	-	4	3	5	8	3.00	4	SS	-4.0		L3	5.0	Brown,Moist,Loose,Poorly Graded, Silty Sand(SM) Sand-Silt mixtures
		10	23															
5		11	03	SC	-	-	11	14	15	29	3.45	5	SS	-5.0		L3	5.0	Brown,Moist,Loose,Poorly Graded, Silty Sand(SM) Sand-Silt mixtures
		11	08															
6	11	24	SC	-	-	12	14	11	25	5.00	6	SS	-6.5		L3	5.0	Brown,Moist,Loose,Poorly Graded, Silty Sand(SM) Sand-Silt mixtures	
	11	32																
7	11	54	SC	-	-	12	14	11	25	5.45	7	SS	-8.0		L3	5.0	Brown,Moist,Loose,Poorly Graded, Silty Sand(SM) Sand-Silt mixtures	
	11	59																
8	12	32	SC	-	-	11	11	9	20	6.50	8	SS	-9.5		L3	5.0	Brown,Moist,Loose,Poorly Graded, Silty Sand(SM) Sand-Silt mixtures	
	12	40																
9	12	32	SC	-	-	6	9	14	23	8.00	8	SS	-9.5		L3	5.0	Brown,Moist,Loose,Poorly Graded, Silty Sand(SM) Sand-Silt mixtures	
	12	40																
10																		

CS - Core Sample		DS - Disturbed Sample		LOGGED		M.Raguram		PROJECT SITE DETAILS		REMARKS	
SS - Split Spoon Sample		SC - Soil Cutter		DATE		22/02/2020		GROUND LEVEL (m)		0.00	
UDS- Undisturbed Sample		TCB - Tungsten Carbide Bit		CHECKED		K.Ramalingam		WATER TABLE (m)		2.80	
WS - Wash Sample		DB - Diamond Bit		DATE		12/03/2020		CASING DEPTH (m)		0.00	

		SITE INVESTIGATION RECORD										BORE HOLE No.		BH-01					
												SHEET		2	OF	3			
PROJECT NAME		PROPOSED CONSTRUCTION OF COMMERCIAL BUILDING										DIA OF BORE HOLE		150mm	✓				
				NX															
LOCATION		Chinthamani ,Anna Nagar East, Chennai			MACHINE No.		CR-02		CHAINAGE (m)		-		BORE START DATE		22/02/2020				
STRUCTURE		Stilt+10 Upper Floors			DRILLING METHOD		Rotary		CO-ORDINATES		N		-		BORE END DATE		23/02/2020		
JOB CODE		JC-GT-1044			FLUSHING MEDIUM		Bentonite				E		-		TOTAL DRILL DAYS		2		
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										
11	22/02/2020	12	58	SC	-	-	10	12	14	26	11.00	9	SS	-11.0		L4	11.0	Brownish Grey, Moist, Medium Dense to Dense, Poorly Graded, Silty Sand (SM) Sand-Silt mixtures	
12	13	To	13	09	SC	-	-	10	16	23	39	12.50	10	SS					-12.5
13	13	To	13	23	SC	-	-	10	16	23	39	12.95	10	SS					-12.5
14	22/02/2020	14	21	SC	-	-	38	12cm Penet. For 50 Blows			>100	14.00	11	SS	-14.0		L5	15.5	Grey, Moist, Very Dense, Poorly Graded, Silty Sand (SM) Sand-Silt mixtures
15	14	To	15	02	SC	-	-	24	37	32	69	15.50	12	SS	-15.5				
16	15	To	15	14	SC	-	-	24	37	32	69	15.95	12	SS	-15.5				
17	23/02/2020	15	48	SC	-	-	6	10	12	22	17.00	13	SS	-17.0		L6	17.0	Greyish Brown, Moist, Hard, Sandy Silty Clay (CI) Silty Clays of High plasticity	
18	15	To	15	57	SC	-	-	6	10	12	22	17.45	13	SS					-17.0
19	16	To	16	41	SC	-	-	6	10	12	22	17.85	13	SS					-17.0
20	23/02/2020	16	53	SC	-	-	6	6	10	16	18.50	14	SS	-18.5		L7	18.5	Greyish Green, Moist, Very Stiff, Silty Clay (CH) Silty Clays of High plasticity	
21	08	To	08	41	SC	-	-	6	6	10	16	18.95	14	SS					-18.5
22	08	To	08	49	SC	-	-	6	6	10	16	19.35	14	SS					-18.5
23	23/02/2020	08	41	SC	-	-	10	16	18	34	20.00	15	SS	-20.0		L8	20.0	Greyish Brown, Moist, Hard, Silty Clay (CH) Silty Clays of High plasticity	
24	08	To	08	49	SC	-	-	10	16	18	34	20.45	15	SS					-20.0
25	08	To	08	49	SC	-	-	10	16	18	34	20.85	15	SS					-20.0
CS - Core Sample		DS - Disturbed Sample			LOGGED		M.Raguram		PROJECT SITE DETAILS				REMARKS						
SS - Split Spoon Sample		SC - Soil Cutter			DATE		22/02/2020		GROUND LEVEL (m)				0.00						
UDS- Undisturbed Sample		TCB - Tungsten Carbide Bit			CHECKED		K.Ramalingam		WATER TABLE (m)				2.80						
WS - Wash Sample		DB - Diamond Bit			DATE		12/03/2020		CASING DEPTH (m)				0.00						

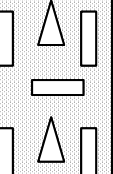
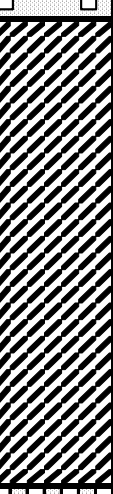
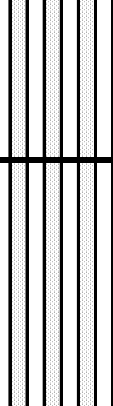
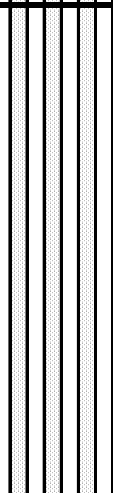
		SITE INVESTIGATION RECORD						BORE HOLE No.		BH-01												
								SHEET		3	OF	3										
PROJECT NAME		PROPOSED CONSTRUCTION OF COMMERCIAL BUILDING						DIA OF BORE HOLE		150mm	✓											
LOCATION		Chinthamani ,Anna Nagar East, Chennai		MACHINE No.		CR-02		CHAINAGE (m)		-		BORE START DATE		22/02/2020								
STRUCTURE		Stilt+10 Upper Floors		DRILLING METHOD		Rotary		CO-ORDINATES		N	-		BORE END DATE		23/02/2020							
JOB CODE		JC-GT-1044		FLUSHING MEDIUM		Bentonite				E	-		TOTAL DRILL DAYS		2							
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													
21		09	22	SC	-	-	10	16	15	31	21.50	16	SS	-21.5				Brownish Grey,Moist,Very Stiff to Hard,Compacted Clay (Shale) (Cl) Silty Clays of High plasticity				
		To																				
22		10	05	SC	-	-	7	11	13	24	23.00	17	SS	-23.0								
		To																				
23		11	23	SC	-	-	8	15	14	29	24.50	18	SS	-24.5								
		To																				
24		11	41	SC	-	-	10	13	17	30	26.00	19	SS	-26.0								
		To																				
25		12	20	SC	-	-	12cm Penet. For 50 Blows			>100	27.50	20	SS	-27.5								
		To																				
26		12	36	SC	-	-	5cm Penet. For 50 Blows			>100	29.00	21	SS	-29.0								
		To																				
27		13	47	SC	-	-				>100	27.62											
		To																				
28		15	02	SC	-	-				>100	29.05											
		To																				
29		15	40	SC	-	-				>100												
		To																				
30																						

CS - Core Sample	DS - Disturbed Sample	LOGGED	M.Raguram	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	22/02/2020	GROUND LEVEL (m)	0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	K.Ramalingam	WATER TABLE (m)	2.80	
WS - Wash Sample	DB - Diamond Bit	DATE	12/03/2020	CASING DEPTH (m)	0.00	

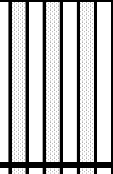
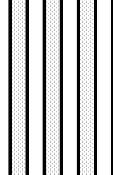
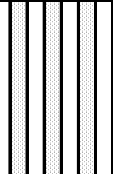
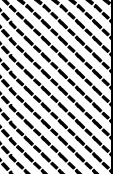
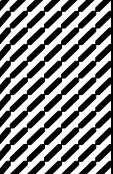
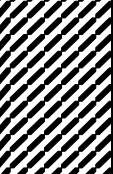
Borehole terminated at 29 m depth below E.G.L

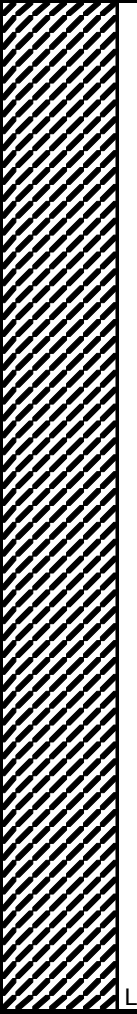
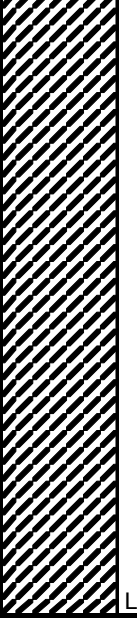
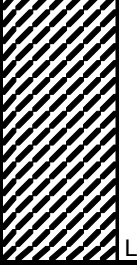
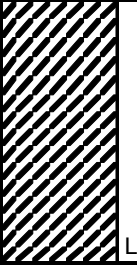
FIG.2.1 Sub Soil Profile at BH-01 Location

		SITE INVESTIGATION RECORD										BORE HOLE No.		BH-02				
												SHEET		1	OF	3		
PROJECT NAME		PROPOSED CONSTRUCTION OF COMMERCIAL BUILDING										DIA OF BORE HOLE		150mm	☒			
		NX																
LOCATION		Chinthamani ,Anna Nagar East, Chennai			MACHINE No.		CR-02		CHAINAGE (m)		-		BORE START DATE		24/02/2020			
STRUCTURE		Stilt+10 Upper Floors			DRILLING METHOD		Rotary		CO-ORDINATES		N		-		BORE END DATE		26/02/2020	
JOB CODE		JC-GT-1044			FLUSHING MEDIUM		Bentonite				E		-		TOTAL DRILL DAYS		3	

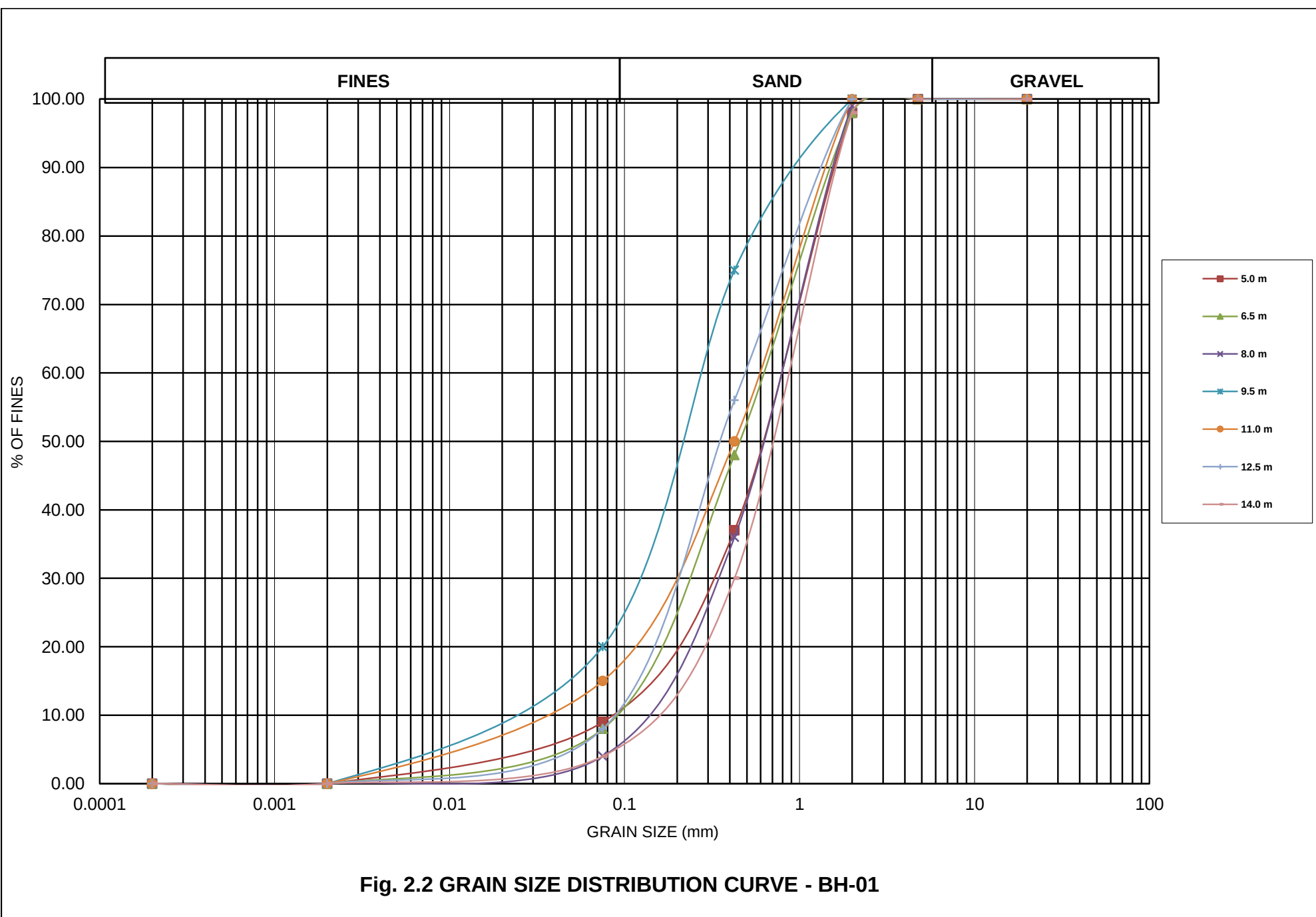
Depth below E.G.L. (m)	Drilling progress per metre		Type of Drill Bit (SC / TCB / DB)	Core Details		SPT Details				Sample Details				Layer Data								
	Date	Time		Total Core Recovery %	R.Q.D %	Blows/cm.			SPT 'N' Value	Depth	No.	Type	RL (m)	Legend	No	Depth	Geotechnical Description					
		Hr.				Min.	0-15	15-30										30-45				
1	24/02/2020	12	55	SC	-	-	-	-	-	1.00	1	SS	-1.0		L1	1.2	Filled Up Soil (Old Building Materials)					
2		To	13							02	2	2	3					5	2.00	2	SS	-2.0
		To	13							16	2.45	↓										
3		To	13							19	3	4	5					9	3.00	3	SS	-3.0
4	24/02/2020	13	34	SC	-	-	-	-	-	3.45	↓				L2	4.0	Brown,Moist,Medium Stiff to Stiff, SILTY CLAY(CH) Silty Clays of High plasticity					
		To	13							37	4	6	9					15	4.00	4	SS	-4.0
		To	14							30	4.45	↓										
5		To	14							33	17	37	8cm Penet. For 50 Blows					>100	5.00	5	SS	-5.0
6	24/02/2020	15	01	SC	-	-	-	-	-	5.45	↓				L3	5.0	Grey,Moist,Medium Dense,Poorly Graded, Silty Sand(SM) Sand-Silt mixtures					
		To	15							07	8	13	9					22	6.50	6	SS	-6.5
		To	15							19	6.95	↓										
7		To	15							24	3	5	7					12	8.00	7	SS	-8.0
8	25/02/2020	10	07	SC	-	-	-	-	-	8.45	↓				L4	6.5	Brown,Moist,Medium Dense,Poorly Graded, Silty Sand(SM) Sand-Silt mixtures					
		To	10							14	3	2	5					7	9.50	8	SS	-9.5
		To	10							14	9.95	↓										
9																						
10																		Brown,Moist,Loose,Poorly Graded, Silty Sand(SM) Sand-Silt mixtures				

CS - Core Sample		DS - Disturbed Sample		LOGGED		M.Raguram		PROJECT SITE DETAILS		REMARKS	
SS - Split Spoon Sample		SC - Soil Cutter		DATE		24/02/2020		GROUND LEVEL (m)		0.00	
UDS- Undisturbed Sample		TCB - Tungsten Carbide Bit		CHECKED		K.Ramalingam		WATER TABLE (m)		2.80	
WS - Wash Sample		DB - Diamond Bit		DATE		12/03/2020		CASING DEPTH (m)		0.00	

		SITE INVESTIGATION RECORD										BORE HOLE No.		BH-02								
												SHEET		2	OF	3						
PROJECT NAME		PROPOSED CONSTRUCTION OF COMMERCIAL BUILDING										DIA OF BORE HOLE		150mm	✓							
		NX																				
LOCATION		Chinthamani ,Anna Nagar East, Chennai		MACHINE No.		CR-02		CHAINAGE (m)		-		BORE START DATE		24/02/2020								
STRUCTURE		Stilt+10 Upper Floors		DRILLING METHOD		Rotary		CO-ORDINATES		N		-		BORE END DATE		26/02/2020						
JOB CODE		JC-GT-1044		FLUSHING MEDIUM		Bentonite				E		-		TOTAL DRILL DAYS		3						
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													
11	24/02/2020	10	30	SC	-	-	5	6	5	11	11.00	9	SS	-11.0		L6	11.0	Brown, Moist, Loose, Poorly Graded, Silty Sand(SM) Sand-Silt mixtures				
		To	10																37			
12		10	57																	To	11	07
13	24/02/2020	10	54	SC	-	-	8	8	8	16	12.50	10	SS	-12.5		L7	14.0	Grey, Moist, Medium Dense, Poorly Graded, Silty Sand(SM) Sand-Silt mixtures				
		To	11																02			
14		10	54																	To	11	02
15	24/02/2020	11	49	SC	-	-	17	22	18	40	14.00	11	SS	-14.0		L8	15.5	Grey, Moist, Dense, Poorly Graded, Silty Sand(SM) Sand-Silt mixtures				
		To	11																53			
16		11	49																	To	11	53
17	25/03/2020	12	14	SC	-	-	5	10	13	23	15.50	12	SS	-15.5		L9	17.0	Greyish Brown, Moist, Very Stiff, Silty Clay (CI) Silty Clays of High plasticity				
		To	12																20			
18		12	45																	To	13	03
19	25/03/2020	14	02	SC	-	-	7	8	10	18	18.50	14	SS	-18.5		L10	20.5	Greyish Brown, Moist, Very Stiff to Stiff, Silty Clay(CH) Silty Clays of High plasticity				
		To	14																17			
20		14	02																	To	14	17
20	25/03/2020	20	00	SC	-	-	5	6	8	14	20.00	15	SS	-20.0		L10	20.5	Greyish Brown, Moist, Very Stiff to Stiff, Silty Clay(CH) Silty Clays of High plasticity				
		To	20																00			
21		20	00																	To	20	00
CS - Core Sample				DS - Disturbed Sample				LOGGED		M.Raguram		PROJECT SITE DETAILS				REMARKS						
SS - Split Spoon Sample				SC - Soil Cutter				DATE		24/02/2020		GROUND LEVEL (m)		0.00								
UDS- Undisturbed Sample				TCB - Tungsten Carbide Bit				CHECKED		K.Ramalingam		WATER TABLE (m)		2.80								
WS - Wash Sample				DB - Diamond Bit				DATE		12/03/2020		CASING DEPTH (m)		0.00								

		SITE INVESTIGATION RECORD										BORE HOLE No.		BH-02				
												SHEET		3	OF	3		
PROJECT NAME		PROPOSED CONSTRUCTION OF COMMERCIAL BUILDING										DIA OF BORE HOLE		150mm	✓			
		NX																
LOCATION		Chinthamani ,Anna Nagar East, Chennai			MACHINE No.		CR-02		CHAINAGE (m)		-		BORE START DATE		24/02/2020			
STRUCTURE		Stilt+10 Upper Floors			DRILLING METHOD		Rotary		CO-ORDINATES		N	-		BORE END DATE		26/02/2020		
JOB CODE		JC-GT-1044			FLUSHING MEDIUM		Bentonite				E	-		TOTAL DRILL DAYS		3		
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									
21		14	53	SC	-	-	7	10	11	21	22.00	16	SS	-22.0				Brownish Grey,Moist,Very Stiff, Compacted Clay (Shale) (CH) Silty Clays of High plasticity
		To																
22	25/03/2020	15	07															
23		15	32	SC	-	-	6	12	15	27	22.45	17	SS	-24.0				
		To																
24		15	45															
25		09	28	SC	-	-					24.45	18	SS	-26.0				
		To																
26	26/03/2020	09	40															
27		10	12	SC	-	-	14	26	29	55	26.00	19	SS	-28.0				Brownish Grey,Moist,Hard, Compacted Clay (Shale) (CH) Silty Clays of High plasticity
		To																
28		10	32															
29																		
30																		
CS - Core Sample				DS - Disturbed Sample				LOGGED		M.Raguram		PROJECT SITE DETAILS				REMARKS		
SS - Split Spoon Sample				SC - Soil Cutter				DATE		24/02/2020		GROUND LEVEL (m)		0.00				
UDS- Undisturbed Sample				TCB - Tungsten Carbide Bit				CHECKED		K.Ramalingam		WATER TABLE (m)		2.80				
WS - Wash Sample				DB - Diamond Bit				DATE		12/03/2020		CASING DEPTH (m)		0.00				
Borehole terminated at 28 m depth below E.G.L																		
FIG.2.2 Sub Soil Profile at BH-02 Location																		

Grain Size Distribution Curves



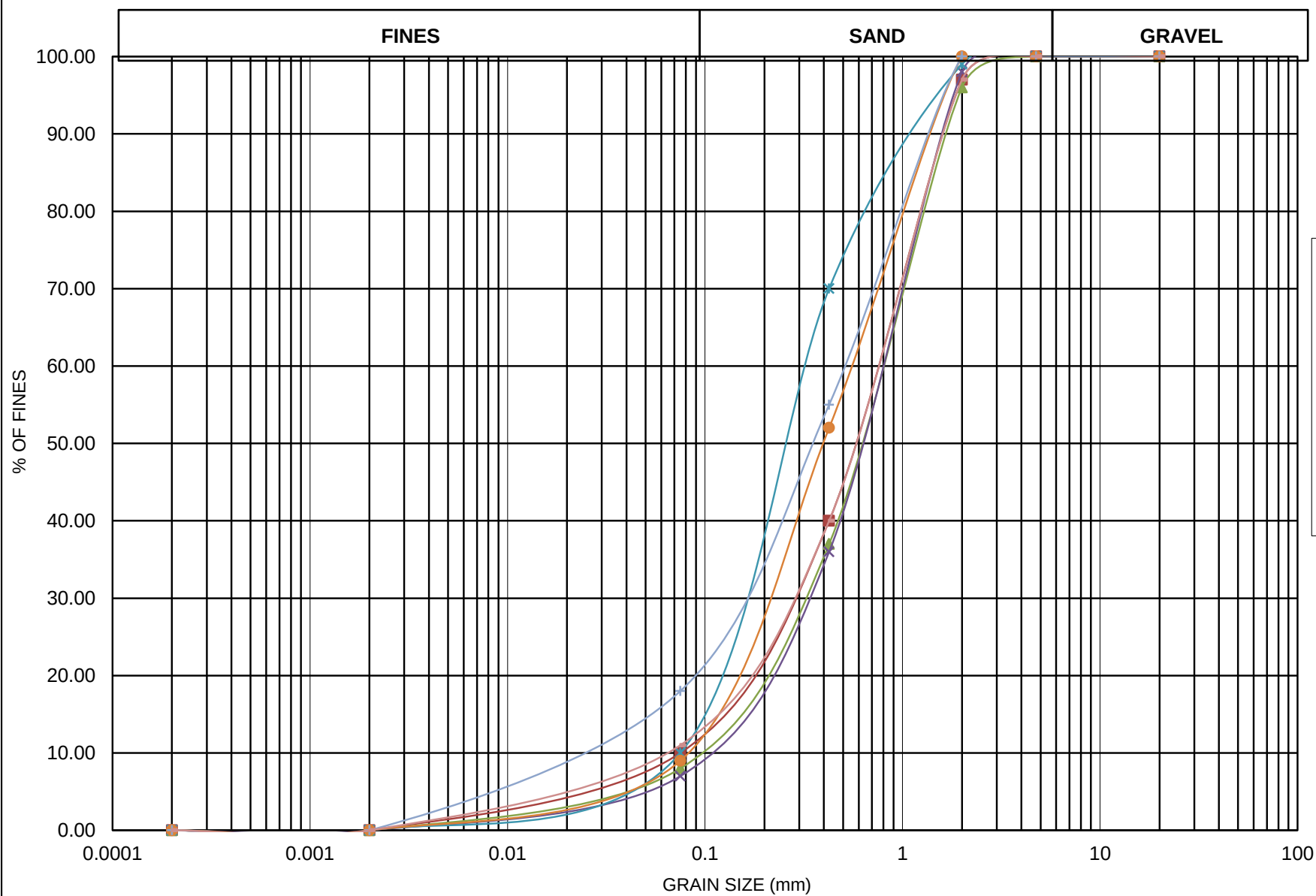


Fig. 2.3 GRAIN SIZE DISTRIBUTION CURVE - BH-02

HYDROMETER ANALYSIS CURVE

LABORATORY TEST RESULTS



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

Depth of Sample below E.G.L. (m)	SPT-Value	Type of Sample	Sub Soil Classification																														
			Fine Grained (FG)										Coarse Grained (CG)																				
			N.M.C(%)	L.L (%)	P.L (%)	I _p	I _c	Shrinkage (cm ³)	D.F.S (%)	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	6	SS	35	51	26	25	0.64	13	19	M.Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%							
2.0	8	SS	35	65	26	39	0.77	12	54	Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%							
3.0	7	SS	45	71	32	39	0.67	12	75	M.Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%							
4.0	8	SS	38	69	31	38	0.82	11	65	Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%							
5.0	29	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	2	61	28	9	0	-	-	-	-	-	M.Dense	<50%	SP-SM							
6.5	25	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	2	50	40	8	0	-	-	-	-	-	M.Dense	<50%	SP-SM							
8.0	20	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	1	63	32	4	0	-	-	-	-	-	M.Dense	<50%	SP							
9.5	23	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	25	55	20	0	-	-	-	-	-	M.Dense	<50%	SM							
11.0	26	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	50	35	15	0	-	-	-	-	-	M.Dense	<50%	SM							
12.5	39	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	44	48	8	0	-	-	-	-	-	Dense	<50%	SP-SM							
14.0	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	2	68	26	4	0	-	-	-	-	-	V.Dense	<50%	SP							
15.5	69	SS	21	49	25	24	1.17	14	60	Hard	Above	CI	5	7	7	15	66	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%							
17.0	22	SS	18	46	21	25	1.12	15	54	V.Stiff	Above	CI	2	6	9	18	65	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%							
18.5	16	SS	24	76	26	50	1.04	11	112	V.Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%							
20.0	32	SS	35	81	36	45	1.02	10	159	Hard	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%							
21.5	31	SS	27	85	28	57	1.02	10	45	Hard	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%							
23.0	24	SS	25	74	26	48	1.02	11	18	V.Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%							
24.5	29	SS	21	69	28	41	1.17	14	51	V.Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%							
26.0	30	SS	22	65	27	38	1.13	13	64	V.Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%							
27.5	>100	SS	18	41	21	20	1.15	14	21	Hard	Above	CI	7	2	6	8	77	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%							
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 Swell Index C _u = Uniformity Coefficient C _c = Coefficient of Curvature IP=LL-PL						LAB IN-CHARGE		M.PRAVEEN	
																														REVIEWED BY		K.RAMALINGAM	



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

Depth of Sample below E.G.L. (m)	SPT-Value	Type of Sample	Sub Soil Classification																												
			Fine Grained (FG)										Coarse Grained (CG)																		
			N.M.C(%)	L.L (%)	P.L (%)	I _p	I _c	Shrinkage (cm ³)	D.F.S (%)	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								
2.0	5	SS	35	52	26	26	0.65	13	54	M.Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%					
3.0	9	SS	36	66	32	34	0.88	12	75	Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%					
4.0	15	SS	38	67	31	36	0.81	14	65	Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%					
5.0	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	3	57	30	10	0	-	-	-	-	-	V.Dense	<50%	SP-SM					
6.5	22	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	4	59	29	8	0	-	-	-	-	-	M.Dense	<50%	SP-SM					
8.0	12	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	2	62	29	7	0	-	-	-	-	-	M.Dense	<50%	SP-SM					
9.5	7	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	1	29	60	10	0	-	-	-	-	-	Loose	<50%	SP-SM					
11.0	11	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	48	43	9	0	-	-	-	-	-	M.Dense	<50%	SP-SM					
12.5	16	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	45	37	18	0	-	-	-	-	-	M.Dense	<50%	SM					
14.0	40	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	3	57	29	11	0	-	-	-	-	-	Dense	<50%	SP-SM					
15.5	23	SS	21	45	23	22	1.09	14	65	V.Stiff	Above	CI	2	5	6	18	69	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%					
17.0	18	SS	18	65	23	42	1.12	13	72	V.Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%					
18.5	18	SS	24	72	27	45	1.07	12	92	V.Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%					
20.0	14	SS	45	85	32	53	0.75	11	112	Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%					
22.0	21	SS	24	88	35	53	1.21	11	120	V.Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%					
24.0	27	SS	23	71	29	42	1.14	10	57	V.Stiff	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%					
26.0	54	SS	21	65	26	39	1.13	14	45	Hard	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%					
28.0	>100	SS	22	68	25	43	1.07	13	23	Hard	Above	CH	-	-	-	-	100	0	-	-	-	-	-	FG>50%	FG>50%	FG>50%					
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 Swell Index C _U = Uniformity Coefficient C _C = Coefficient of Curvature IP=LL-PL					LAB IN-CHARGE		M.PRAVEEN		
																											REVIEWED BY		K.RAMALINGAM		

**GEOLOGY & SUB-SURFACE STRATIFICATION****3.0 Preamble:**

Geotechnical investigation carried out at a specific site provides location specific sub surface characteristics based on which the design of sub structures/foundations is generally carried out. However, the macro-level understanding of the sub surface is also needed for a comprehensive understanding of the sub structure/foundation response to naturally super imposed loads like earthquake forces etc., The macro level understanding of the sub surface is better provided through the knowledge of the Geology of the region. Since, it is beyond the scope of the present study to carry out geological investigation to establish the geology of the study region; published data are presented below along with the sub surface stratification observed through the direct borehole investigation carried out at the specified locations.

3.1 Geology of Study Area (based on the published data)

Geologically, the present site is located in a coastal region with sub surface consisting of sedimentary deposits. The top sedimentary deposit is under laid by upper Gondwana system, particularly lower stage of Sriperumpudur (Shale Formation). The formation mechanism of the sediments is chiefly due to transportation of surface water and marine deposition.

The above geological characteristics are also observed in the direct bore hole investigation, which confirms that the present site does not depict any surprising geological features that are different from that of the region.

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:				01	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	0.60	0.60	Filled Up Soil	-	-	-	-	-	-	-
2	0.60	4.00	3.40	Silty Clay	Brownish Grey	7	-	Medium Stiff	16	47	-
3	4.00	5.00	1.00	Silty Sand	Brown	8	Loose	-	14.5	-	29.6
4	5.00	11.00	6.00	Silty Sand	Brown	27	Medium Dense	-	19	-	35.1
5	11.00	15.50	4.50	Silty Sand	Grey	>100	Very Dense	-	20.5	-	42.5
6	15.50	17.00	1.50	Sandy Silty Clay	Greyish Brown	69	-	Hard	22	400	-
7	17.00	18.50	1.50	Silty Clay	Greyish Brown	22	-	Very Stiff	20.5	147	-
8	18.50	20.00	1.50	Silty Clay	Greyish Green	16	-	Very Stiff	20	107	-
9	20.00	27.50	7.50	Compacted Clay	Brownish Grey	30	-	Very Stiff	19	200	-
10	27.50	29.00	1.50	Compacted Clay (Shale)	Greenish Grey	>100	-	Hard	21	400	-



REFERENCE BORE HOLE-BH:				02	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	1.20	1.20	Filled Up Soil	-	-	-	-	-	-	-
2	1.20	4.00	2.80	Silty Clay	Brown	7	-	Medium Stiff	16	47	-
3	4.00	5.00	1.00	Silty Sand	Brown	15	Medium Dense	-	17.5	-	31.5
4	5.00	6.50	1.50	Silty Sand	Brown	>100	Very Dense	-	20.5	-	42.5
5	6.50	9.50	3.00	Silty Sand	Brown	17	Medium Dense	-	20.5	-	42.5
6	9.50	11.00	1.50	Silty Sand	Brown	7	Loose	-	14.5	-	29.4
7	11.00	14.00	3.00	Silty Sand	Grey	14	Medium Dense	-	17	-	31.2
8	14.00	15.50	1.50	Silty Sand	Grey	40	Dense	-	20	-	38.75
9	15.50	17.00	1.50	Sandy Silty Clay	Greyish Brown	23	-	Very Stiff	20.5	153	-
10	17.00	20.50	3.50	Silty Clay	Greyish Brown	17	-	Very Stiff	20	113	-
11	20.50	26.00	5.50	Silty Clay	Brownish Grey	24	-	Very Stiff	20.5	160	-
12	26.00	27.50	1.50	Compacted Clay	Brownish Grey	55	-	Hard	20.5	367	-
13	27.50	28.00	0.50	Compacted Clay (Shale)	Greenish Grey	>100	-	Hard	21	400	-

❖ Note:-Bulk density given in SPT correlation

FOUNDATION SYSTEM



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 Stilt and ten upper floors, and is meant for commercial building occupancy. For this kind of structure, the column loads could vary between 4,500kN to 5,000 kN. 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 Foundation System

For the kind of proposed structure and the sub soil conditions, it is not possible to adopt any kind of open foundation system from both shear and settlement considerations. Hence, it is advisable to adopt deep pile foundation system.

The piles can be installed by drilling with direct mud circulation technique (**Bored Cast In-situ Piles**) and the recommended safe load carrying capacity of bored cast in-situ piles in compression, tension and lateral for different depth and diameters is worked out as per IS 2911-Part-I-Section-2 and are presented in Table 4.1.

Typical computations are presented in Annexure



Table:- 4.1 Recommended Safe Load Carrying Capacities of Bored Cast-in Situ Piles								
Sl.No	Reference Bore hole No.	Length of Pile below E.G.L	Assumed Length of Cut-Off Below E.G.L	Length of Pile below Cut-off	Dia.of Pile in (mm)	SAFE LOAD CARRYING CAPACITY (kN)		
						Vertical Load Carrying Capacity	Pull Out Capacity	Lateral Load Carrying Capacity
1	BH-02	29.0	1.0	28.00	500	1000	700	43
2					550	1100	750	47
3					600	1300	800	52
4					650	1500	850	56
5					750	1700	950	65
6					800	1900	1100	69
7					800	2200	1200	78

RECOMMENDATIONS



RECOMMENDATIONS

5.0 Recommendation for Bored Cast In-situ Pile Foundation:

- ❖ For the kind of sub soil conditions **Deep Bored Cast in situ piles** are recommended as the suitable foundation system.
- ❖ The allowable safe load carrying capacities of different diameters of piles as given in Table-4.1 can be adopted as provisional design loads, as the load carrying capacity of piles not only depends upon the sub soil properties, but also depends on the care and experience of installation piles.
- ❖ The theoretical load carrying estimates of piles shall be confirmed by conducting pile loads tests as per the guide lines laid down in IS: 2911-Part-IV.
- ❖ The boring shall be carried out using direct mud circulation prepared out of sodium bentonite.
- ❖ After reaching the borehole termination depth, the borehole shall be cleaned using mud circulation for a minimum period of 30min or till the return mud is relatively clear of soil particles.
- ❖ After ensuring the borehole is clean, the tremie pipe shall be lowered and concrete can be done.

5.1 Construction method statement of pile foundation:

- ❖ For the bored cast in situ piles, a guide casing of 2.0 to 3.0m length can be adopted
- ❖ The mud used shall be made out of sodium bentonite with minimum free swell index of more than 300% and liquid limit more than 100%. The silt content in bentonite shall not more than 5%.
- ❖ The mud was prepared using sodium bentonite with a density of 1.10 to 1.15 g/cc.

5.2 General Recommendation:

- ❖ The chlorides and the sulphate levels are within the permissible limits as per the standards hence no special cement or reinforcement is required for the construction of sub structure.

5.3 Special Recommendations

- ❖ Since, the depth of piles is more and the number being high, in order to assure quality, it is ideal to carry out Pile Integrity Tests on all the piles (apart from load tests on selected piles).

FOR GEO ENGINEERING CONSULTANTS, CHENNAI

AUTHORIZED SIGNATURE

ANNEXURE



ESTIMATION OF SAFE LOAD CARRYING CAPACITY OF BORED CAST-INSITU PILES																		
Type of Pile				Bored		Diameter of Pile			Length of Pile below E.G.L.(m)			29	As Per IS:2911-(P-I,S-2)-2010					
Reference Bore Hole				BH-02					600	mm	Surcharge Pressure		0	kPa				
Layer No.	Layer Thk. (m)			Type of Strata	Ave. SPT	(γ) kN/m ³		Shear Parameters		Effective Overburden Pressure (kPa)			Adhesion Factor (α)	Earth Pressure Coefficient (k)	Skin Friction (Q _f) kN			
	Top. R.L.	Bot. R.L.	Thickness			of Layer	Ave. upto Layer	(C _u) kPa	(φ) Deg.	At top of Layer	At Bot. of Layer	At Mid. of Layer						
1	0	1	1	Cut-Off Level														
2	1	4	3.0	Clay	7	16.0	16.0	47	-	0.0	18.0	9.0	0.9	-	qf	2	239.2	
3	4	5	1.0	Sand	15	17.5	16.8	-	31.5	18.0	25.5	21.8	-	1.1	qf	3	27.0	
4	5	6.5	1.5	Sand	50	20.5	19.0	-	41.0	25.5	41.3	33.4	-	1.5	qf	4	123.1	
5	6.5	9.5	3.0	Sand	17	18.0	19.3	-	32.1	41.3	65.3	53.3	-	1.1	qf	5	209.0	
6	9.5	11	1.5	Sand	7	14.5	16.3	-	29.4	65.3	72.0	68.6	-	1.0	qf	6	109.3	
7	11	14	3.0	Sand	14	17.0	15.8	-	31.2	72.0	93.0	82.5	-	1.1	qf	7	299.7	
8	14	15.5	1.5	Sand	40	20.0	18.5	-	38.8	93.0	108.0	100.5	-	1.4	qf	8	329.1	
9	15.5	26	10.5	Clay	20	20.0	20.0	133	-	108.0	213.0	160.5	0.4	-	qf	9	921.3	
10	26	29	3.0	Clay	50	21.0	20.5	333	-	213.0	246.0	229.5	0.3	-	qf	10	489.6	
Summation of Positive Skin Resitance (kN) Q _f =																	2747.34	
Summation of Negative Skin Resistance (kN) -Q _f =																	0.00	
Computation of End Bearing Resistance																		
Bearing Stratum				Clay	SPT	φ	C _u	N _q	N _c	Eff.Ht.of Overburden			9	m				
					60	-	400	-	9	Effective Overburden Pressure		72.00	kN/m ²					
End Bearing Resistance (kN) Q _p =																	1017.88	
Ultimate Load Carrying Capacity (Q _{ult})													Q _u =Q _f +Q _p (kN)		3765.21			
Safe Load Carrying Capacity (Q _{safe})													Q _u /2.5 (kN)		1506.09			
Allowable Safe Load Carrying Capacity													Q _{A-safe} (kN)		1506.09			
Allowable Safe Pull out Capacity													Q _{A-pull} : Q _f /3 (kN)		915.78			
Skin Resistance in Clay Layer is π*d*T _f *C _u *α																		
Skin Resistance in Sand Layer is π*d*T _f *q _i *K*Tan(φ)																		
End Bearing Resistance in Clay Layer is π*d ² /4*C _u *N _c																		
End Bearing Resistance in Sand Layer is π*d ² /4*Q*N _q																		
Where																		
Cu=Undrained Shear Strength of Clay						K=Coef. Earth Pressure at Rest						d=Dia. Of Pile						
φ=Angle of Shearing Resistance						q _i =Effectivte Overburden Pressure at middle of Layer						α=Adhesion Factor						
N _c =Bearing Capacity Factor = 9						N _q =Bearing Capacity Factor, Ref. Fig.1 of IS: Code Referred above						T _f =Thickness of Layer						
Q (i.e) Effectivte Overburden Pressure at pile tip=Effective height of overburden X (γ-10)																		



LATERAL LOAD CARRYING CAPACITY OF BORED CAST- SITU PILES

Reference Bore Hole : BH-02

1.0 Geometrical Data

Type of Pile Head Considered	Fixed	
Diameter of Pile (d)	0.50	m
Free standing Length of Pile (e)	0	m
Length of Pile below E.G.L (Le)	29.0	m
Cut-Off Level From E.G.L	1.0	
Length of Pile below Cut-Off Level (Le)	28.0	m
Grade of Concrete (M)	25	MN/m ²
Young's Modulus of Concrete (E)	25000000	kN/m ²
Moment of Inertia (I)	0.003068	m ⁴

2.0 Determination of Depth of Fixity

Type of Soil Strata	Clay	
Ground Water Condition	Submerged	
Average Design SPT "N" Value	7	
$K = ((k1/1.5) * (0.3/B))$		
(n can be read as η in the above and below equation in case of Sand)		
K1=	18000	kN/m ³
K=	7200	kN/m ²
R=	2.15	
L1/R	0.00	
Lf/R	2.20	
Depth of Fixity below Cut off (z _f)	4.73	m

3.0 Determination of Lateral Load and Moment Carrying Capacity for

0.005 m Lateral Deflection:

Allowable Lateral Deflection (Y)	0.005	m
Lateral Load Carrying Capacity (H)= $Y * 12EI / (e + z_f)^3$	43.58	kN
Recommended Design Lateral Load carrying Capacity	43	kN
Fixed End Moment, $M_F = H(e + z_f) / 2$	103	
Reduction Factor (L_1/T)	0.67	m
Actual Moment (Fixed End Moment/Reduction Factor), M_F	69	kN-m

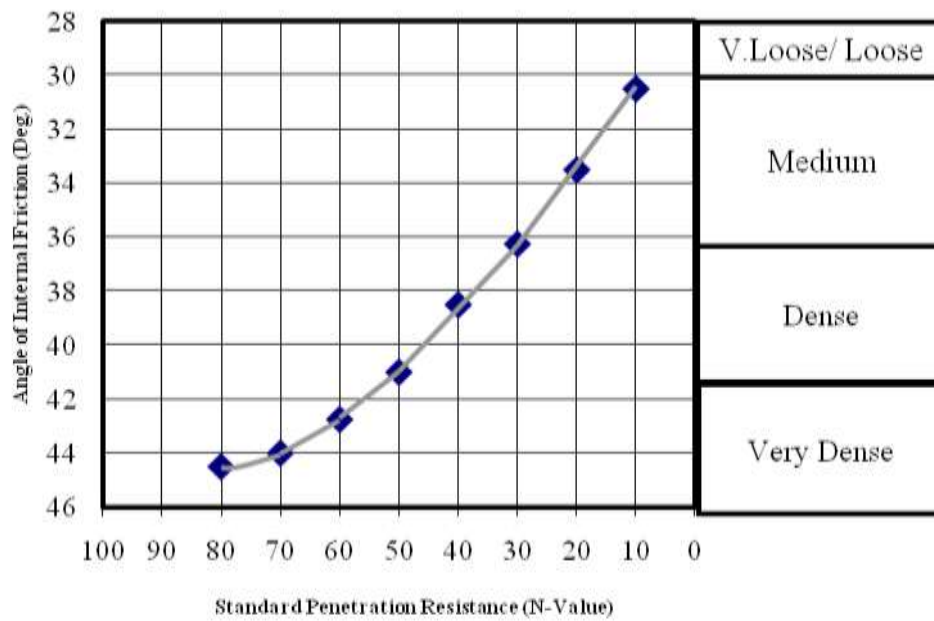


FIG. A1 Relation Ship between Angle of Internal Friction & N-value (Reproduced from IS:6403-1981)

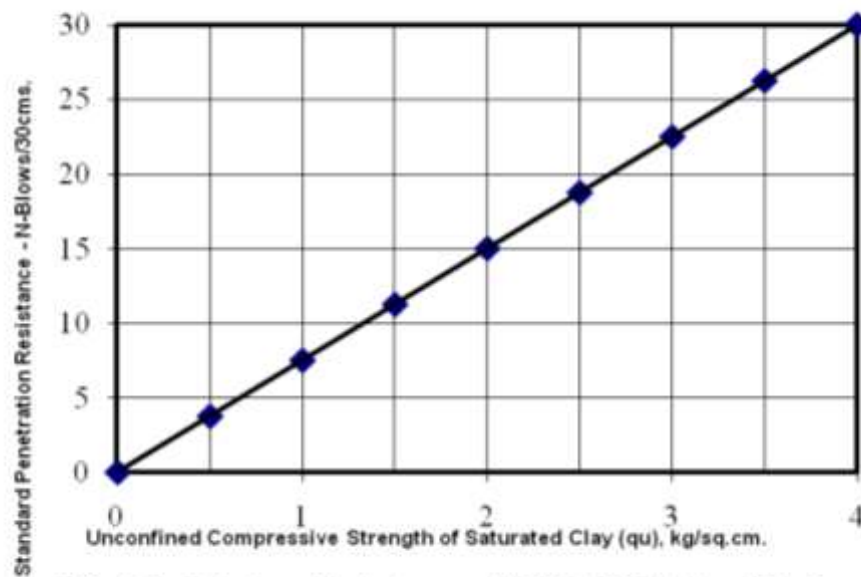
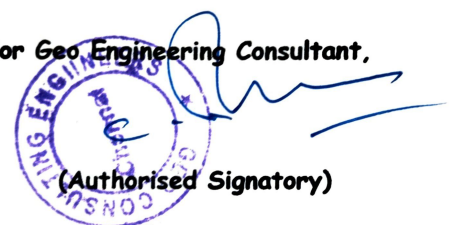
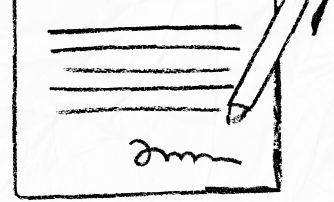


FIG. A2 : Relationship between UCC & SPT-Value (N) of Saturated Clay (After Terzaghi & Peck, 1948)

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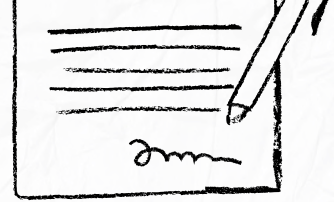
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