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GEO ENGINEERING CONSULTANTS & SERVICES

(An ISO 9001:2015 Certified Company)

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PROJECT NAME

THE PROPOSED CONSTRUCTION OF GROUP DEVELOPMENT RESIDENTIAL BUILDING CONSISTS OF BLOCK-01,STILT FLOOR + 5 FLOORS RESIDENTIAL BUILDING WITH 10 DWELLING UNITS (WITH HEIGHT 18.30M) AND BLOCK-02 STILT FLOOR + 5 FLOORS RESIDENTIAL BUILDING WITH 20 DWELLING UNITS (WITH HEIGHT 18.30M) (TOTALLY 30 DWELLING UNITS) AVAILING PREMIUM FSI AT DOOR NO-03,1ST CROSS STREET, RAJAJI STREET, RAMAKRISHNA NAGAR, VALASARAVAKKAM, CHENNAI-600095 AND COMPRISED IN S.NOS 116/756, 116/757, 116/758, 116/672 & 116/673 OF VALASARAVAKKAM VILLAGE, MADURAVOYAL TALUK AND WITHIN THE LIMITS OF GREATER CHENNAI CORPORATION ZONE- XI, DIVISION-149.

CLIENT NAME

MR. IVANS,

CHENNAI.

Er. M. Ammaiappan, B.E., M.E(Geo Tech)., (Ph.D)
Registered Geo Technical Engineer
CMDA - Reg. No. STE/2020/08/046
Thirumullaivoyal, Chennai - 600 062.

TITLE

GEOTECHNICAL INVESTIGATION REPORT

GEO ENGINEERING CONSULTANTS & SERVICES Chennai 600 087

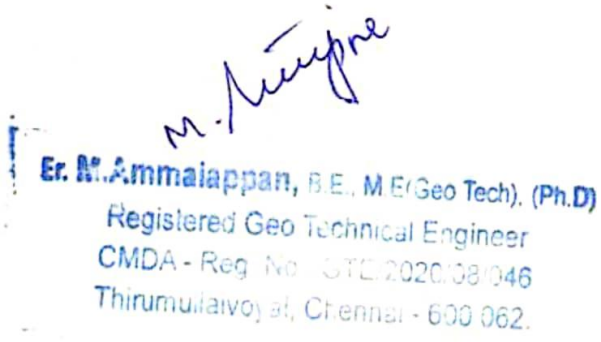
PROJECT NO: GECS-JC-GT-1112-2023-2024

REPORT SUBMISSION DATE:26/08/2023

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REPORT TEXT

CHAPTER-1

INTRODUCTION

1.0 Project Information Matrix

Nature of project	: The Proposed Construction Residential Building
Type Structures	: Stilt+5Upper Floors
Project Client	: **MR. IVANS,**
Project Location	: 1st Cross Street, Rajaji Street, Ramakrishna Nagar, Rajaji Street, Valasaravakkam, Chennai.
Job Code	: GECS-JC-GT-1112

1.1 Scope of Work

1.1.1 Field Work

- Conducting Two soil investigation bore holes of 150 mm& NX diameter up to 31.0m 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 to 19.0m 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
- Rock Core photos

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CHAPTER-2

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 bor
  investigation and intensity of the monsoon r

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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.

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SITE PLAN

SOIL PROFILES

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SITE INVESTIGATION RECORD

BORE HOLE No.	BH-01		
SHEET	1	OF	4
DIA OF BORE HOLE	150mm ✓		
	NX		

PROJECT NAME	THE PROPOSED CONSTRUCTION OF GROUP DEVELOPMENT RESIDENTIAL BUILDING CONSISTS OF BLOCK-01 & BLOCK-02					BORE START DATE	18/08/2023
LOCATION	Rajaji Street, Valasaravakkam, Chennai.	MACHINE No.	CR-02	CHAINAGE (m)	-	BORE END DATE	20/08/2023
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	TOTAL DRILL DAYS	3
JOB CODE	GEC-JC-GT-1112	FLUSHING MEDIUM	Bentonite		E -		

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Sample Details: RL (m)	Layer Data: Legend	Layer Data: No	Layer Data: Depth	Geotechnical Description
1	18/08/2023	12	40 To 12	SC	-	-	-	-	-	-	1.00	1	DS	-1.0		L1	1.5	**Filled Up Soil** (Old Building Materials)
2		12	44	SC	-	-	2	2	3	**5**	2.00	2	SS	-2.0				Brown,Moist,Medium Stiff,**Sandy Silty CLAY(CI)** Lean Clay of Medium plasticity
		13	40 To 13								2.45							
3		13	44	SC	-	-	4	6	7	**13**	3.00	3	SS	-3.0		L2	3.0	
		14	10 To 14								3.45							Brown,Moist,Medium Dense,Poorly Graded,**Silty Sand(SM)** Sand-Silt mixtures with Clay Binder
4		14	14	SC	-	-	1	1	3	**4**	4.00	4	SS	-4.0		L3	4.0	
		14	35 To 14								4.45							Greyish Black,Moist,Medium Stiff to Soft
5		14	38	SC	-	-	5	6	5	**11**	5.50	5	SS					
6		14	48 To 14								5.95							
		14	52 To 15															
7		15	20	SC	-	-	5	6	7	**13**	7.00	6	SS					
		15	25 To 16								7.45							
8		16	01 To 16															Grey,Moist,Medium Dense,Poorly Graded,**Silty Sand(SM)** Sand-Silt mixtures with Clay Binder
		16	04	SC	-	-	9	10	9	**19**	8.50	7	SS	-8.5				
9		14	40 To 14								8.95							
10		14	45	SC	-	-	7	6	8	**14**	10.00	8	SS	-10.0			10.5	
											10.45							

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CS - Core Sample	DS - Disturbed Sample	LOGGED	K.RAMALINGAM	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	18/08/2023	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	25/08/2023	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-01		
SHEET	2	OF	4
DIA OF BORE HOLE	150mm ✓		
	NX		

PROJECT NAME	THE PROPOSED CONSTRUCTION OF GROUP DEVELOPMENT RESIDENTIAL BUILDING CONSISTS OF BLOCK-01 & BLOCK-02					BORE START DATE	18/08/2023
LOCATION	Rajaji Street, Valasaravakkam, Chennai.	MACHINE No.	CR-02	CHAINAGE (m)	-	BORE END DATE	20/08/2023
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	TOTAL DRILL DAYS	3
JOB CODE	GEC-JC-GT-1112	FLUSHING MEDIUM	Bentonite		E -		

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	15-30	30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
11	18/08/2023	16	40															
		To																
		16	44	SC	-	-	6	6	7	13	11.50	9	SS	-11.5				Grey,Moist,Medium Dense,Poorly Graded,Silty Sand(SM) Sand-Silt mixtures with Clay Binder
12		17	17								1.95							
		To																
		17	19															
13				SC	-	-	1	2	6	8	13.00	10	SS	-13.0		L5	13.0	
											13.45							Greyish Black,Moist,Stiff,**SILTY CLAY(CH)** Silty Clays of High plasticity
		17	45															
14		To																
		17	48	SC	-	-	2	1	2	3	14.50	11	SS	-14.5				
											14.95							
15		07	40															
		To																
		07	44															
16				SC	-	-	1	1	2	3	16.00	12	SS	-16.0				
											16.45							
		08	28															
17		To																
		08	32															
	19/08/2023			SC	-	-	1	1	1	2	17.50	13	SS	-17.5				Greyish Black,Moist,Very Soft to Soft, **SILTY CLAY(CH)** Silty Clays of High plasticity
											17.95							
18		09	15															
		To																
		09	18															
19				SC	-	-	1	2	2	4	19.00	14	SS	-19.0				
											19.45							
		11	03															
20		To																
		11	06													L7	20.5	

M. Ammaiappan

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CS - Core Sample	DS - Disturbed Sample	LOGGED	K.RAMALINGAM	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	19/08/2023	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	25/08/2023	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-01		
SHEET	3	OF	4
DIA OF BORE HOLE	150mm ✓		
	NX		

PROJECT NAME	THE PROPOSED CONSTRUCTION OF GROUP DEVELOPMENT RESIDENTIAL BUILDING CONSISTS OF BLOCK-01 & BLOCK-02					BORE START DATE	18/08/2023
LOCATION	Rajaji Street, Valasaravakkam,Chennai.	MACHINE No.	CR-02	CHAINAGE (m)	-	BORE END DATE	20/08/2023
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	TOTAL DRILL DAYS	3
JOB CODE	GEC-JC-GT-1112	FLUSHING MEDIUM	Bentonite		E -		

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Sample Details: RL (m)	Layer Data: Legend	Layer Data: No	Layer Data: Depth	Layer Data: Geotechnical Description
21				SC	-	-	1	2	3	5	21.00 / 21.45	15	SS	-21.0				
		12	31															
		To																
22		12	34															
23				SC	-	-	1	2	4	6	23.00 / 23.45	16	SS	-23.0				
24		14	42															
		To																
		14	45															
25	19/08/2023			SC	-	-	2	2	3	5	25.00 / 25.45	17	SS	-25.0				
26		15	47															
		To																
		15	51															
27				SC	-	-	12	17	21	38	27.00 / 27.45	18	SS	-27.0		L8	27.0	Greyish Black,Moist,Very Soft to Soft, **SILTY CLAY(CH)** Silty Clays of High plasticity
28		16	48															Brownish Grey, Yellow,Moist, Very Dense,Poorly Graded,**Clayey Silty Sand(SC)** Sand-Clay mixtures
		To																
		16	52															
29				SC	-	-	7	15	35	50	29.00 / 29.45	19	SS	-29.0		L9	29.0	
	20/08/2023	07	45															Brownish Grey,Moist, Fine Grains, Hard,Feebly,Fissile Structure **(SHALE)** (Sedimentary Origin)
30		To															30.0	
		07	50															

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CS - Core Sample	DS - Disturbed Sample	LOGGED	K.RAMALINGAM	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	19/08/2023	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	25/08/2023	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-01		
SHEET	4	OF	4
DIA OF BORE HOLE	150mm ✓		
	NX ✓		

PROJECT NAME	THE PROPOSED CONSTRUCTION OF GROUP DEVELOPMENT RESIDENTIAL BUILDING CONSISTS OF BLOCK-01 & BLOCK-02							BORE START DATE	18/08/2023
LOCATION	Rajaji Street, Valasaravakkam,Chennai.	MACHINE No.	CR-02	CHAINAGE (m)	-			BORE END DATE	20/08/2023
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N	-		TOTAL DRILL DAYS	3
JOB CODE	GEC-JC-GT-1112	FLUSHING MEDIUM	Bentonite		E	-			

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Sample Details: RL (m)	Layer Data: Legend	Layer Data: No	Layer Data: Depth	Geotechnical Description
31	20/08/2023			-	-	-	-	-	-	-	31.00	20	SS	-31.0		L10	31.0	Brownish Grey,Moist, Fine Grains, Hard,Feebly,Fissile Structure **(SHALE)** (Sedimentary Origin)
32																		
33																		
34																		
35																		
36																		
37																		
38																		
39																		
40																		

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CS - Core Sample	DS - Disturbed Sample	LOGGED	K.RAMALINGAM	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	20/08/2023	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	25/08/2023	CASING DEPTH (m) 0.00	

Borehole terminated at 31 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	4
DIA OF BORE HOLE	150mm ✓	NX	

PROJECT NAME	THE PROPOSED CONSTRUCTION OF GROUP DEVELOPMENT RESIDENTIAL BUILDING CONSISTS OF BLOCK-01 & BLOCK-02						
LOCATION	Rajaji Street, Valasaravakkam,Chennai.	MACHINE No.	CR-02	CHAINAGE (m)	-	BORE START DATE	20/08/2023
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	22/08/2023
JOB CODE	GEC-JC-GT-1112	FLUSHING MEDIUM	Bentonite		E -	TOTAL DRILL DAYS	3

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	15-30	30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
1	20/08/2023	14	03	SC	-	-	1	3	3	6	1.00	1	SS	-1.0				Brown,Moist,Medium Stiff,**Sandy Silty CLAY(CI)** Lean Clay of Medium plasticity
		To									1.45							
		14	06															
		14	13															
		To																
2		14	18	SC	-	-	2	8	10	18	2.00	2	SS	-2.0		L1	2.0	
		14	40								2.45							Brown,Moist,Medium Dense,Poorly Graded,**Clayey Silty Sand(SC)** Sand-Clay mixtures
		To																
3		14	45	SC	-	-	5	8	5	13	3.00	3	SS	-3.0		L2	3.0	
		14	54								3.45							Brown,Moist,Medium Dense,Poorly Graded,**Silty Sand(SM)** Sand-Silt mixtures with Clay Binder
		To																
4		14	58	SC	-	-	1	1	2	3	4.00	4	SS	-4.0		L3	4.0	
		15	14								4.45							
		To																
5		15	18															
				SC	-	-	1	2	4	6	5.50	5	SS	-5.5				Greyish Brown,Moist,Soft to Medium Stiff,**SILTY CLAY(CH)** Silty Clays of High plasticity
6		15	46								5.95							
		To																
		15	51															
7				SC	-	-	6	11	12	23	7.00	6	SS	-7.0		L4	7.0	
		16	09								7.45							
		To																
8		16	12															
				SC	-	-	7	10	9	19	8.50	7	SS	-8.5				Grey,Moist,Medium Dense to Dense,Poorly Graded,Fine to Medium Coarse Grains,**Silty Sand(SM)** Sand-Silt mixtures
9		16	46								8.95							
		To																
		16	52															
10				SC	-	-	10	16	23	39	10.00	8	SS	-10.0				
											10.45						10.5	

CS - Core Sample	DS - Disturbed Sample	LOGGED	K.RAMALINGAM	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	20/08/2023	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	25/08/2023	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-02		
SHEET	2	OF	4
PROJECT NAME	THE PROPOSED CONSTRUCTION OF GROUP DEVELOPMENT RESIDENTIAL BUILDING CONSISTS OF BLOCK-01 & BLOCK-02	DIA OF BORE HOLE	150mm ✓ / NX
LOCATION	Rajaji Street, Valasaravakkam,Chennai.	MACHINE No.	CR-02
CHAINAGE (m)	-	BORE START DATE	20/08/2023
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary
CO-ORDINATES	N -	BORE END DATE	22/08/2023
JOB CODE	GEC-JC-GT-1112	FLUSHING MEDIUM	Bentonite
CO-ORDINATES	E -	TOTAL DRILL DAYS	3

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	15-30	30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
11	20/08/2023	17	17															
		To																
		17	20															
				SC	-	-	8	13	11	**24**	11.50	9	SS	-11.5				Grey,Moist,Medium Dense to Dense,Poorly Graded,Fine to Medium Coarse Grains,**Silty Sand(SM)** Sand-Silt mixtures
12											1.95 ↓							
		17	48															
		To																
		17	52															
13				SC	-	-	1	2	4	**6**	13.00	10	SS	-13.0		L5	13.0	
											13.45 ↓							
		07	30															Greyish Black,Moist,Medium Stiff, **SILTY CLAY(CH)** Silty Clays of High plasticity
		To																
14		07	34															
				SC	-	-	1	1	1	**2**	14.50	11	SS	-14.5		L6	14.5	
											14.95 ↓							
15		08	32															
		To																
		08	36															
16				SC	-	-	1	1	2	**3**	16.00	12	SS	-16.0				
											16.45 ↓							
	21/08/2023	09	40															
		To																
17		09	45															
				SC	-	-	1	1	3	**4**	17.50	13	SS	-17.5				Greyish Black,Moist,Very Soft to Soft, **SILTY CLAY(CH)** Silty Clays of High plasticity
											17.95 ↓							
18		10	40															
		To																
		10	45															
19				SC	-	-	1	2	2	**4**	19.00	14	SS	-19.0				
											19.45 ↓							
		11	42															
		To																
20		11	45													L7	20.5	

CS - Core Sample	DS - Disturbed Sample	LOGGED	K.RAMALINGAM	PROJECT SITE DETAILS		REMARKS	
SS - Split Spoon Sample	SC - Soil Cutter	DATE	21/08/2023	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	25/08/2023	CASING DEPTH (m)	0.00		

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-02		
SHEET	3	OF	4
DIA OF BORE HOLE	150mm ✓		
	NX		

PROJECT NAME	THE PROPOSED CONSTRUCTION OF GROUP DEVELOPMENT RESIDENTIAL BUILDING CONSISTS OF BLOCK-01 & BLOCK-02					BORE START DATE	20/08/2023
LOCATION	Rajaji Street, Valasaravakkam,Chennai.	MACHINE No.	CR-02	CHAINAGE (m)	-	BORE END DATE	22/08/2023
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	TOTAL DRILL DAYS	3
JOB CODE	GEC-JC-GT-1112	FLUSHING MEDIUM	Bentonite		E -		

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Sample Details: RL (m)	Layer Data: Legend	Layer Data: No	Layer Data: Depth	Geotechnical Description
21	21/08/2023	13	02	SC	-	-	2	3	4	7	21.00	15	SS	-21.0				
											21.45							
		To																
22		13	05															Greyish Black,Moist,Medium Stiff, **SILTY CLAY(CH)** Silty Clays of High plasticity
23				SC	-	-	1	3	3	6	23.00	16	SS	-23.0				
											23.45							
24		15	41															
		To																
		15	43															
25				SC	-	-	5	9	13	22	25.00	17	SS	-25.0		L8	25.0	
											25.45							
26																		Grey,Moist,Very Stiff,**Clayey Silt** (ML) with Non to low Plsticity
		17	10															
		To																
		17	15															
27				SC	-	-	16	21	22	43	27.00	18	SS	-27.0		L9	27.0	
											27.45							
28		07	12															Grey,Moist,Dense,Poorly Graded,Fine to Medium Coarse Grains,**Silty Sand(SM)** Sand-Silt mixtures
		To																
		07	18															
29				SC	-	-	31	42	22	64	29.00	19	SS	-29.0		L10	29.0	
											29.45							
		08	45															Brownish Grey, Yellow,Moist, Very Dense,Poorly Graded,**Clayey Silty Sand(SC)** Sand-Clay mixtures
30		To																
		08	48													L11	30.0	

CS - Core Sample	DS - Disturbed Sample	LOGGED	K.RAMALINGAM	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	21/08/2023	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	25/08/2023	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-02		
SHEET	4	OF	4
DIA OF BORE HOLE	150mm ✓		
	NX ✓		

PROJECT NAME	THE PROPOSED CONSTRUCTION OF GROUP DEVELOPMENT RESIDENTIAL BUILDING CONSISTS OF BLOCK-01 & BLOCK-02						
LOCATION	Rajaji Street, Valasaravakkam,Chennai.	MACHINE No.	CR-02	CHAINAGE (m)	-	BORE START DATE	20/08/2023
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	22/08/2023
JOB CODE	GEC-JC-GT-1112	FLUSHING MEDIUM	Bentonite		E -	TOTAL DRILL DAYS	3

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Sample Details: RL (m)	Layer Data: Legend	Layer Data: No	Layer Data: Depth	Geotechnical Description
31	20/08/2023			SC	-	-	-	-	-	-	31.00	20	SS	-31.0		L12	31.0	Brownish Grey,Moist, Fine Grains, Hard,Feebly,Fissile Structure **(SHALE)** (Sedimentary Origin)
32																		
33																		
34																		
35																		
36																		
37																		
38																		
39																		
40																		

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CS - Core Sample	DS - Disturbed Sample	LOGGED	K.RAMALINGAM	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	20/08/2023	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	25/08/2023	CASING DEPTH (m) 0.00	

Borehole terminated at 31 m depth below E.G.L

FIG.2.2 Sub Soil Profile at BH-02 Location

GRAIN SIZE DISTRIBUTION CURVE

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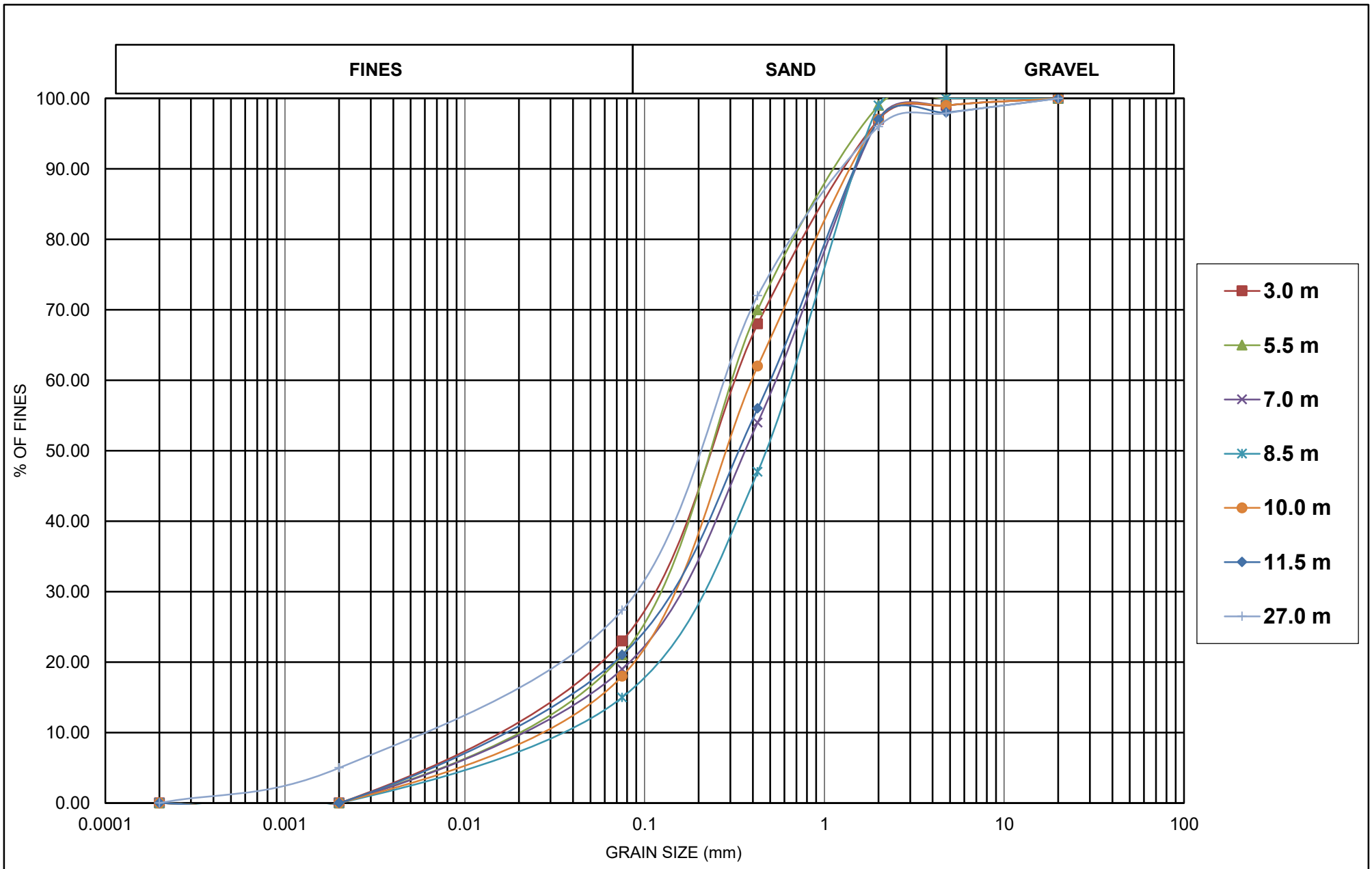


Fig. 2.3 GRAIN SIZE DISTRIBUTION CURVE - BH-01

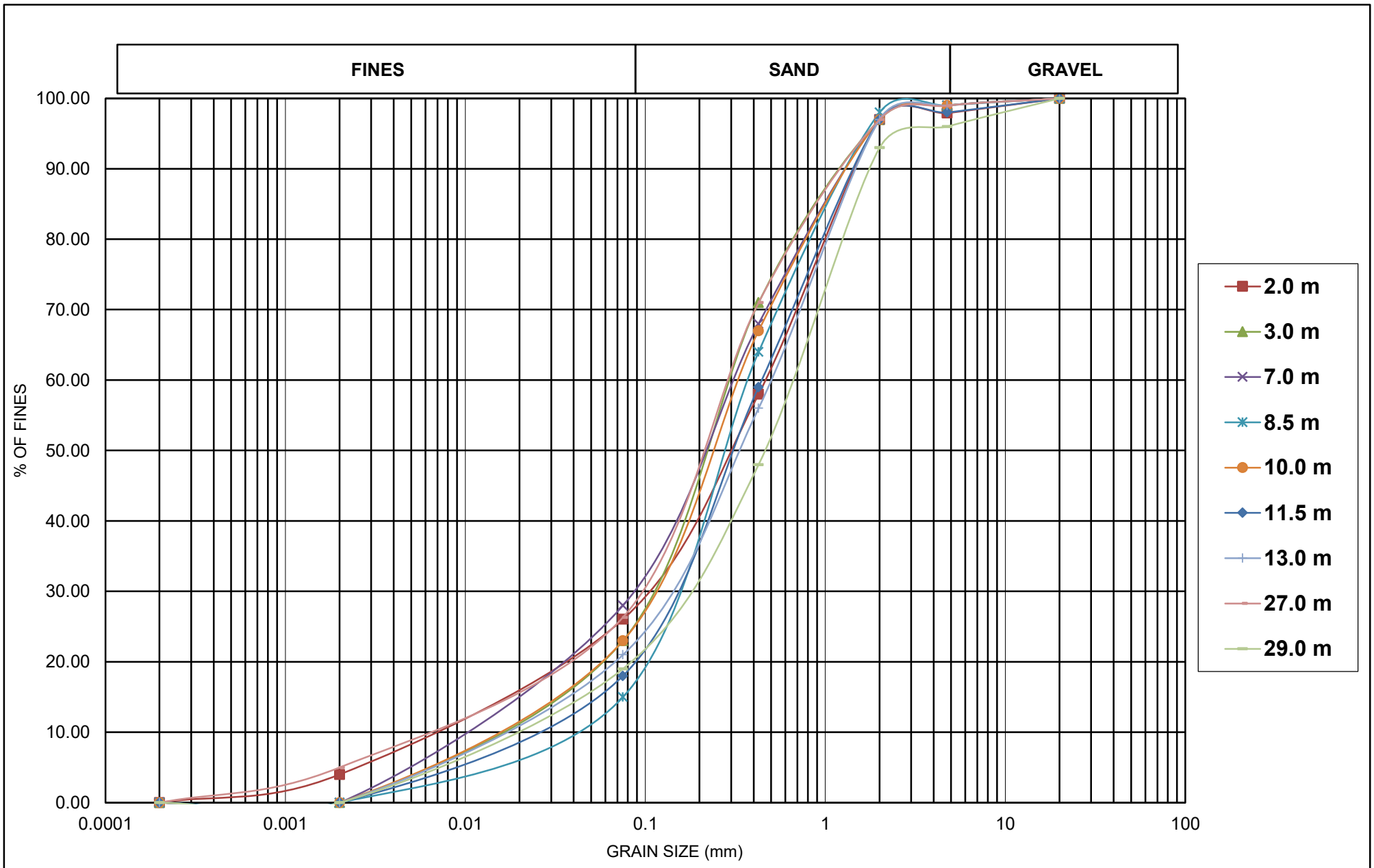


Fig. 2.4 GRAIN SIZE DISTRIBUTION CURVE - BH-02

HYDROMETER ANALYSIS CURVE

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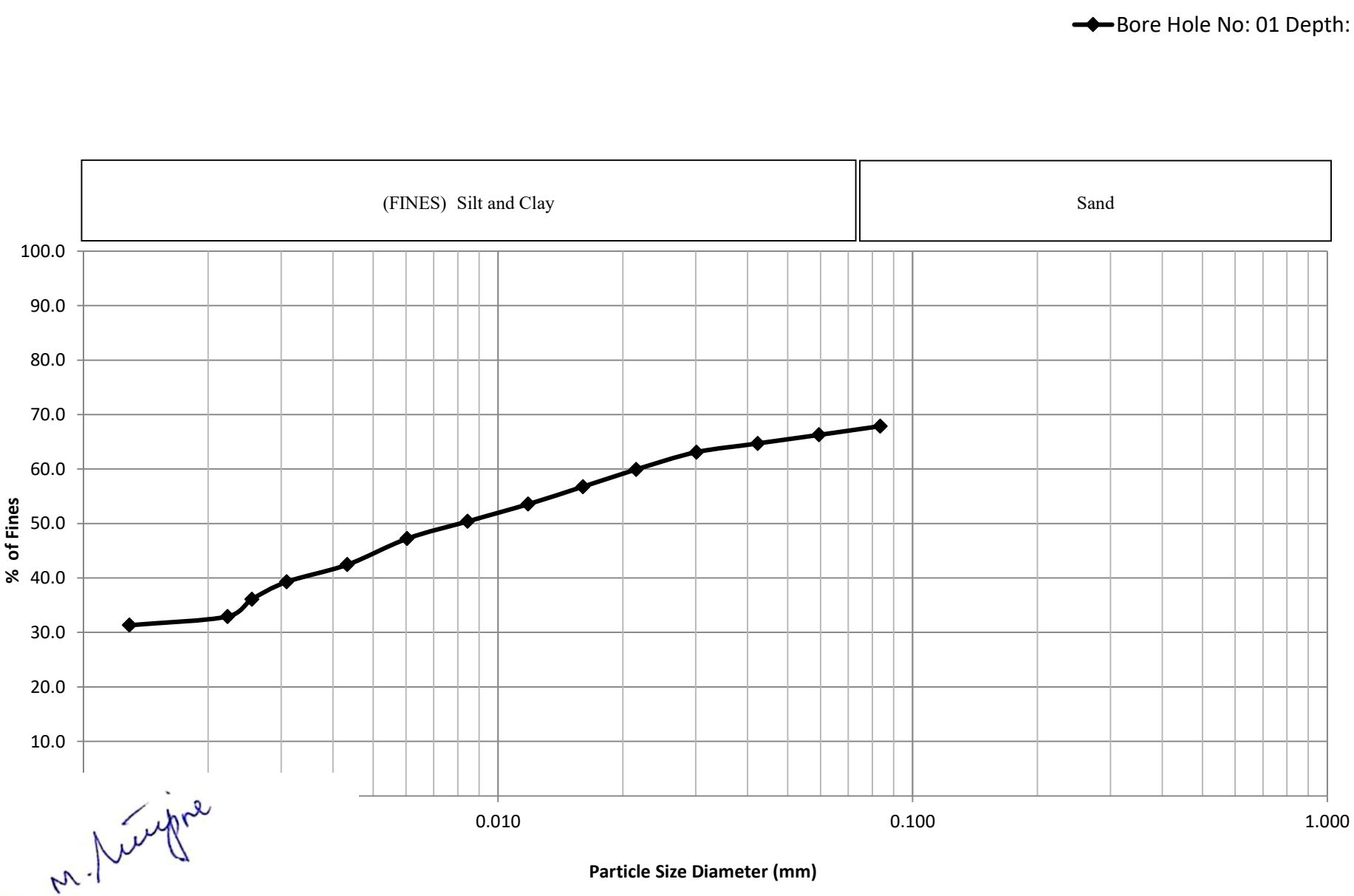


Fig 2.5 Hydrometer Analysis Master Curve

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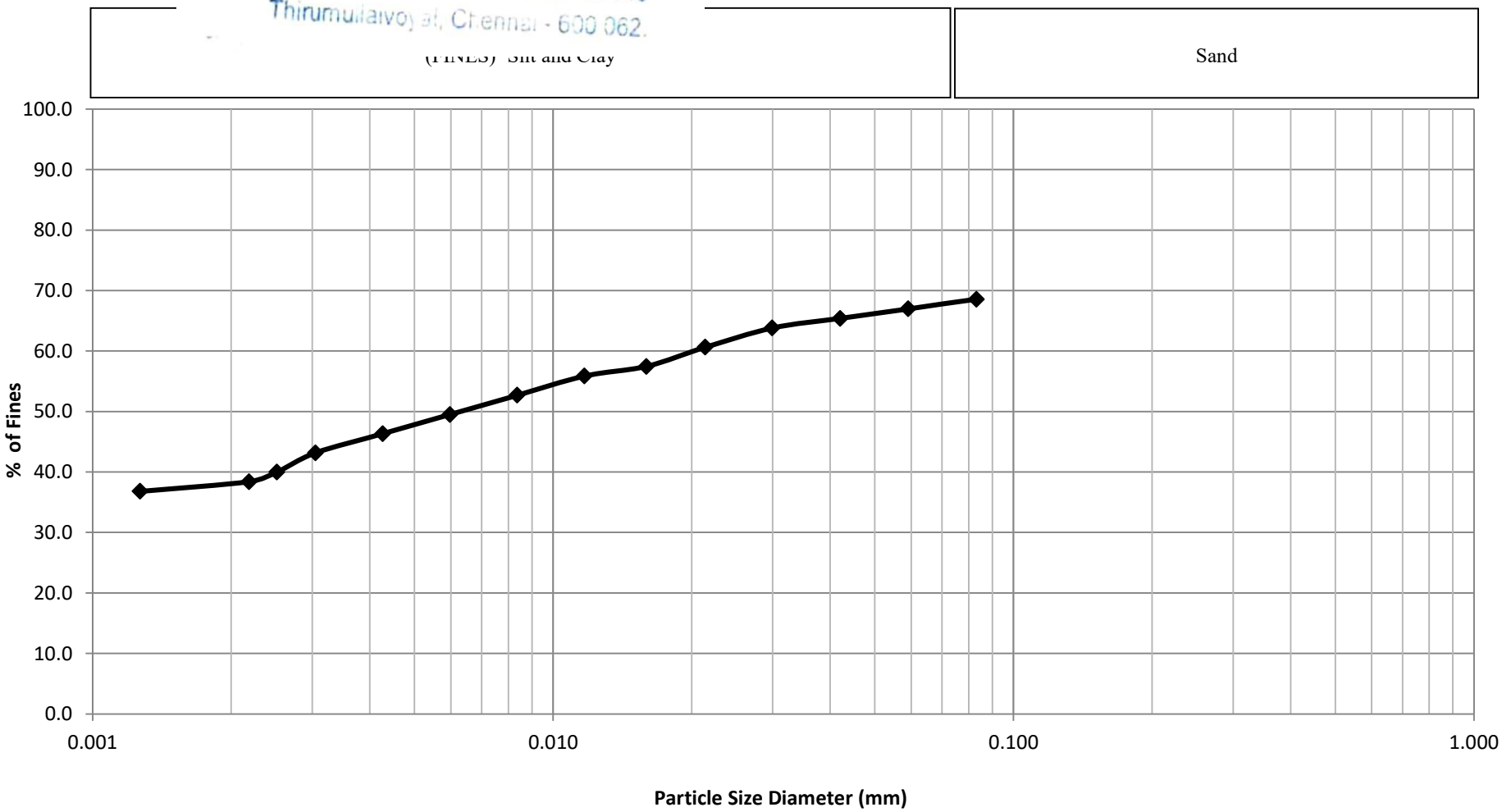


Fig 2.6 Hydrometer Analysis Master Curve

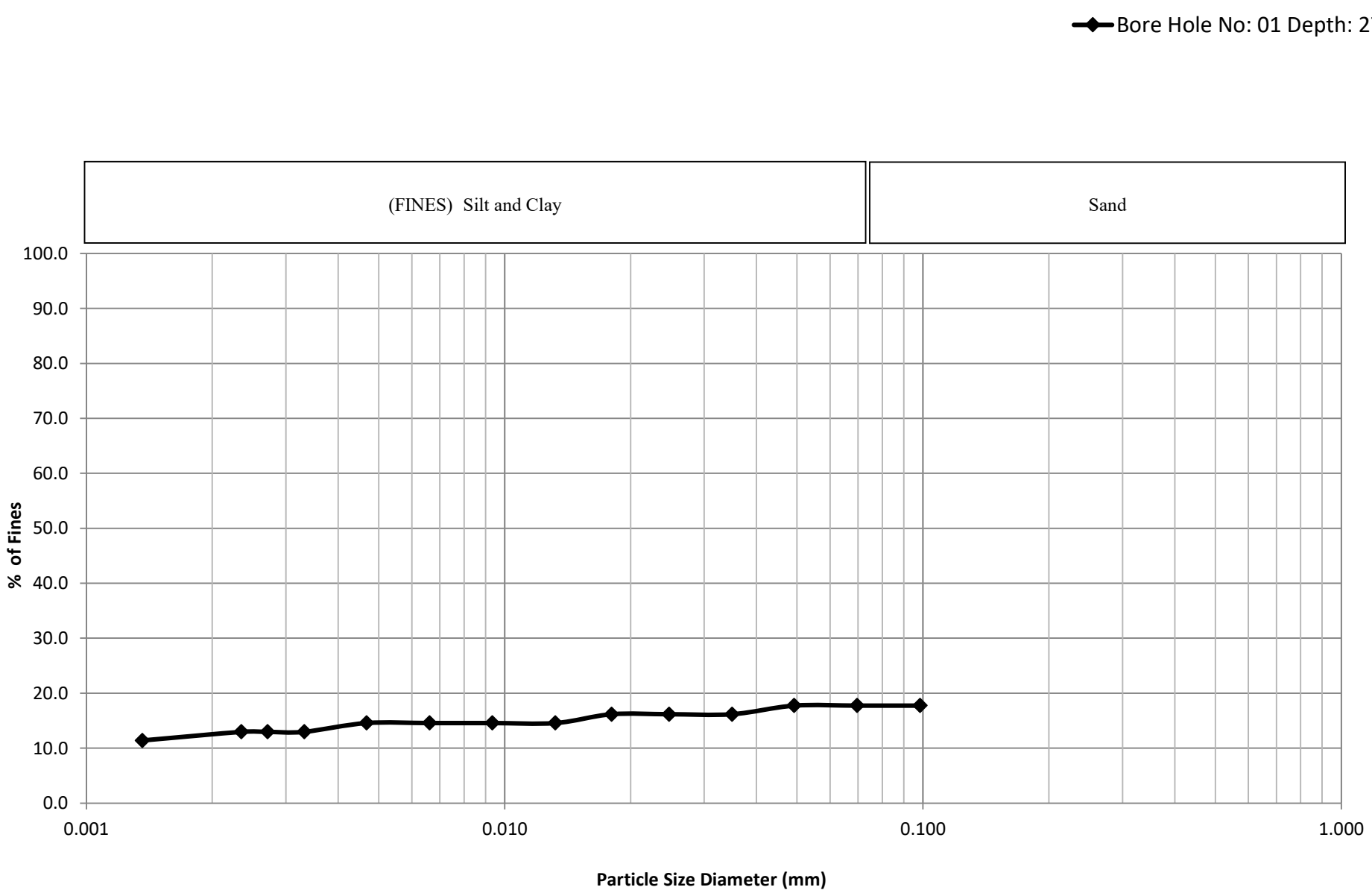


Fig 2.7 Hydrometer Analysis Master Curve

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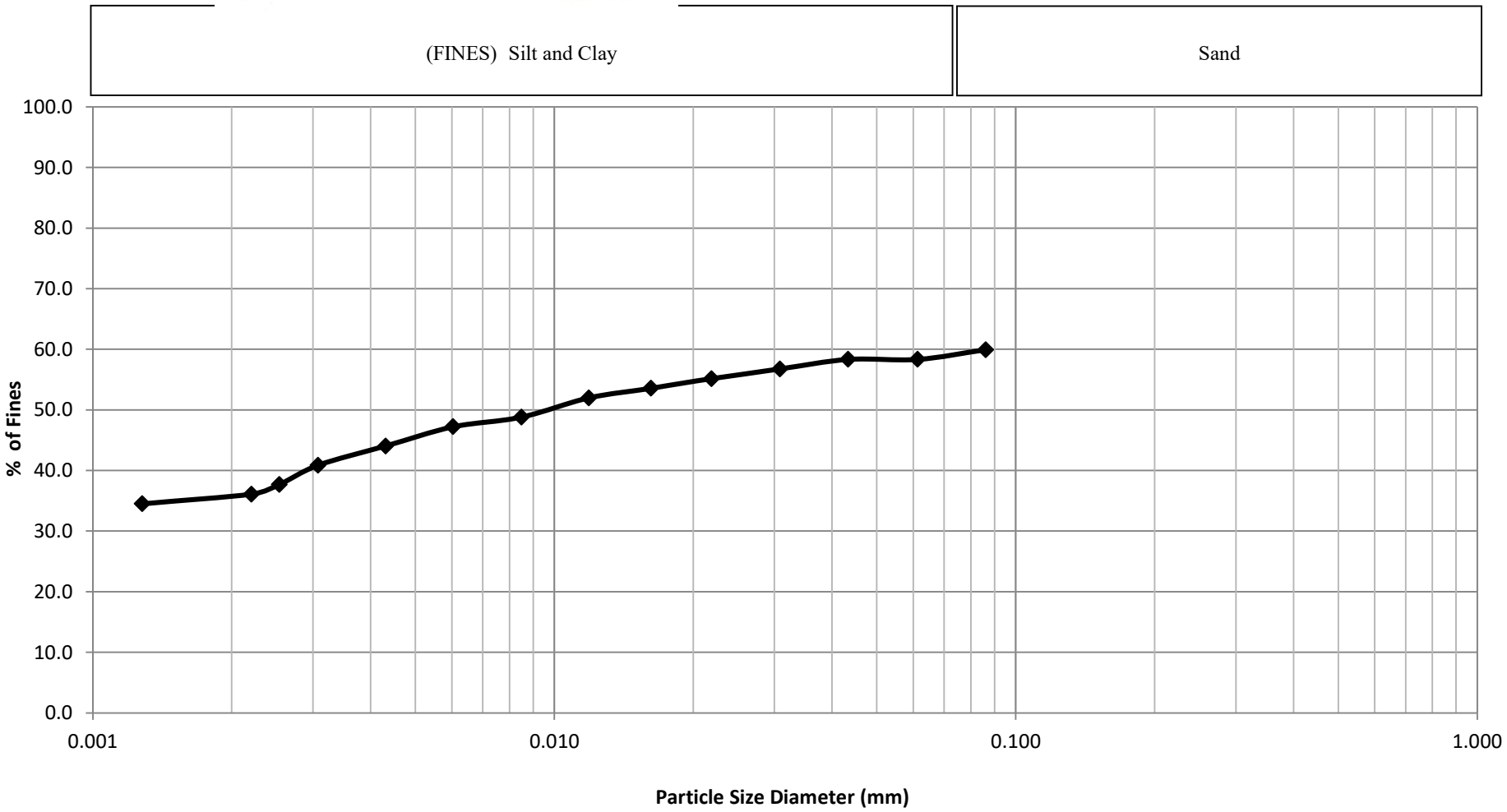


Fig 2.8 Hydrometer Analysis Master Curve

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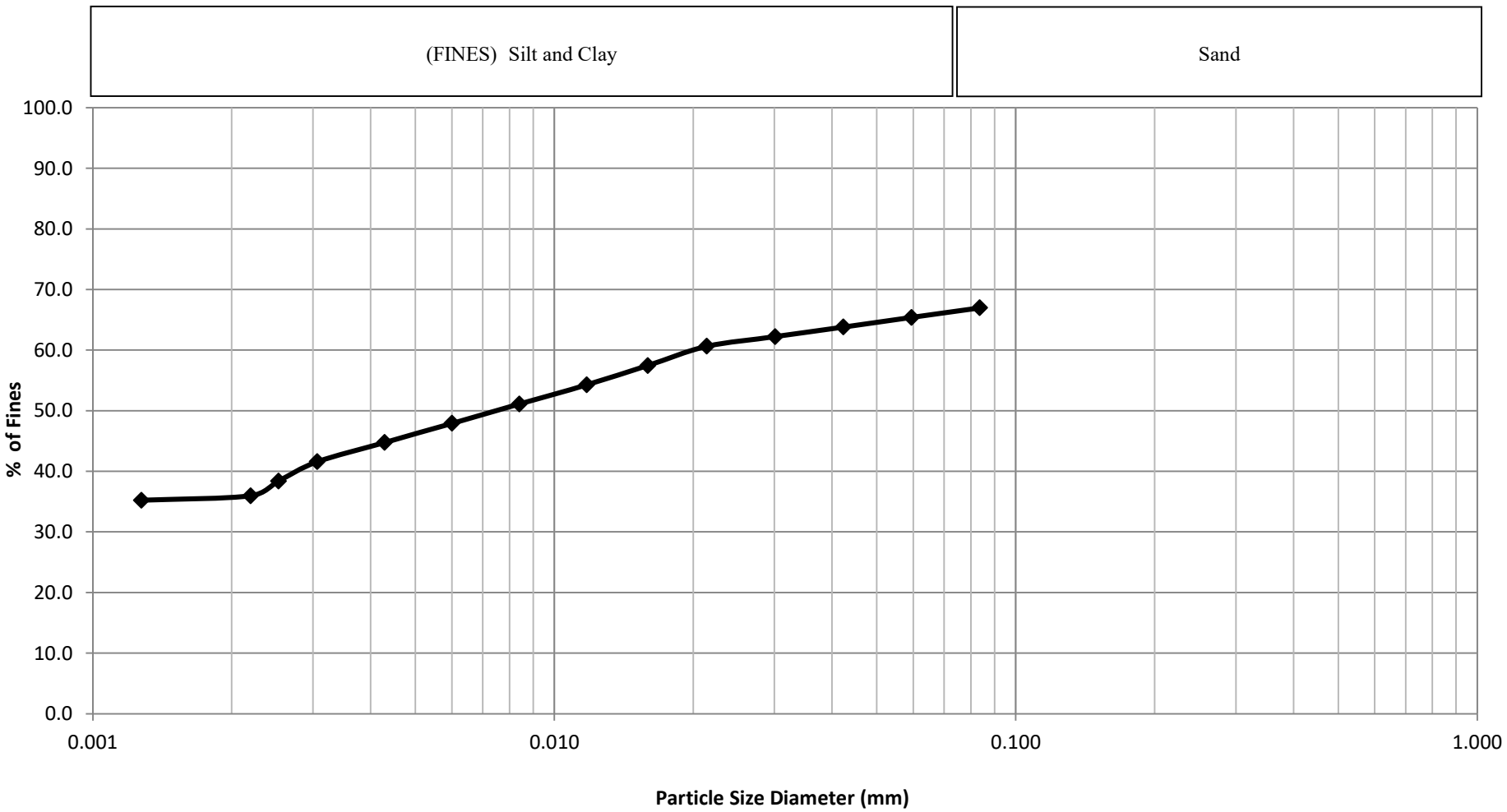


Fig 2.9 Hydrometer Analysis Master Curve

LABORATORY TEST RESULTS

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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)												IS-Notation	
			N.M.C(%)	L.L (%)	P.L (%)	I_P	Ic	Shrinkage(cm^3)	D.F.S (%)	Consistancy	Position With Respect to A-Aline	IS:Notation	Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	D_{10} (mm)	D_{30}(mm)	D_{60} (mm)	$C_U=D_{60}/D_{10}$	$C_c=D_{30}^2/(D_{10}xD_{60})$	Relative Density	Gravel	Sand
2.0	5	SS	32	46	21	25	0.56	14	48	M.Stiff	Above	CI	-	-	-	-	70	30	-	-	-	-	-	FG>50%	FG>50%	FG>50%
3.0	13	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	2	29	45	23	0	-	-	-	-	-	M.Dense	<50%	SM
4.0	4	SS	38	51	23	28	0.46	13	54	Soft	Above	CH	-	-	-	-	67	33	-	-	-	-	-	FG>50%	FG>50%	FG>50%
5.5	11	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	1	29	49	21	0	-	-	-	-	-	M.Dense	<50%	SM
7.0	13	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	2	43	35	19	0	-	-	-	-	-	M.Dense	<50%	SM
8.5	19	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	1	52	32	15	0	-	-	-	-	-	M.Dense	<50%	SM
10.0	14	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	2	35	44	18	0	-	-	-	-	-	M.Dense	<50%	SM
11.5	13	SS	-	-	-	-	-	-	-	CG>50%	-	-	2	1	41	35	21	0	-	-	-	-	-	M.Dense	<50%	SM
13.0	8	SS	32	68	31	37	0.97	13	65	Stiff	Above	CH	-	-	-	-	68	32	-	-	-	-	-	FG>50%	FG>50%	FG>50%
14.5	3	SS	57	85	25	60	0.47	11	90	Soft	Above	CH	-	-	-	-	67	33	-	-	-	-	-	FG>50%	FG>50%	FG>50%
16.0	3	SS	62	75	26	49	0.27	11	75	Soft	Above	CH	-	-	-	-	64	36	-	-	-	-	-	FG>50%	FG>50%	SM
17.5	2	SS	64	74	33	41	0.24	10	85	Very Soft	Above	CH	-	-	-	-	65	35	-	-	-	-	-	FG>50%	FG>50%	SM
19.0	4	SS	65	87	25	62	0.35	12	95	Soft	Above	CH	-	-	-	-	61	39	-	-	-	-	-	FG>50%	FG>50%	SM
21.0	5	SS	44	77	27	50	0.66	11	105	M.Stiff	Above	CH	-	-	-	-	62	38	-	-	-	-	-	FG>50%	FG>50%	FG>50%
23.0	6	SS	45	79	28	51	0.67	12	112	M.Stiff	Above	CH	-	-	-	-	60	40	-	-	-	-	-	FG>50%	FG>50%	FG>50%
25.0	5	SS	45	69	28	41	0.59	13	90	M.Stiff	Above	CH	-	-	-	-	59	41	-	-	-	-	-	FG>50%	FG>50%	FG>50%
27.0	38	SS	19	32	21	11	1.18	18	21	CG>50%	Above	-	2	2	24	41	26	5	-	-	-	-	-	Dense	<50%	SC
29.0	50	SS	23	55	25	30	1.07	14	38	Hard	Above	CH	-	-	-	-	68	32	-	-	-	-	-	FG>50%	FG>50%	FG>50%
31.0	>100	SS	21	59	24	35	1.09	13	42	Hard	Above	CH	-	-	-	-	70	30	-	-	-	-	-	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	GEOTECH TEAM
REVIEWED BY	R.BHUVANA

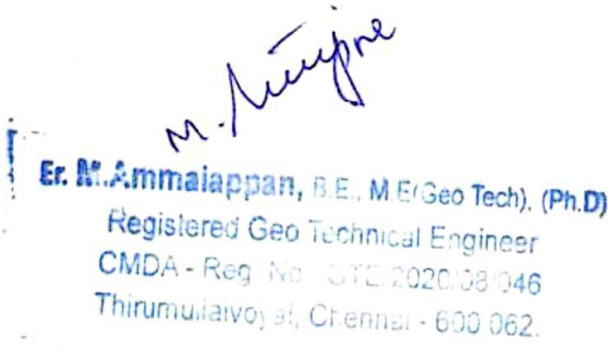
Table-2.2 Laboratory Classification of Soil Samples from BH-02

Depth of Sample below E.G.L. (m)	SPT-Value	Type of Sample	Sub Soil Classification																							
			Fine Grained (FG)										Coarse Grained (CG)												IS-Notation	
			N.M.C(%)	L.L (%)	P.L (%)	I_P	Ic	Shrinkage(cm^3)	D.F.S (%)	Consistancy	Position With Respect to A-Aline	IS:Notation	Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	D_{10} (mm)	D_{30}(mm)	D_{60} (mm)	$C_U=D_{60}/D_{10}$	$C_c=D_{30}^2/(D_{10}xD_{60})$	Relative Density	Gravel	Sand
1.0	6	SS	32	44	23	21	0.57	14	40	M.Stiff	Above	CI	-	-	-	-	70	30	-	-	-	-	-	FG>50%	FG>50%	FG>50%
2.0	18	SS	18	35	19	16	1.06	18	36	CG>50%	Above	-	2	1	39	29	25	4	-	-	-	-	-	M.Dense	<50%	SC
3.0	13	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	2	26	48	23	0	-	-	-	-	-	M.Dense	<50%	SM
4.0	3	SS	45	53	24	29	0.28	13	48	Soft	Above	CH	-	-	-	-	66	34	-	-	-	-	-	FG>50%	FG>50%	FG>50%
5.5	6	SS	32	57	23	34	0.74	14	65	M.Stiff	Above	CH	-	-	-	-	64	36	-	-	-	-	-	FG>50%	FG>50%	FG>50%
7.0	23	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	2	29	40	28	0	-	-	-	-	-	M.Dense	<50%	SM
8.5	19	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	1	34	49	15	0	-	-	-	-	-	M.Dense	<50%	SM
10.0	39	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	2	30	44	23	0	-	-	-	-	-	Dense	<50%	SM
11.5	24	SS	-	-	-	-	-	-	-	CG>50%	-	-	2	1	38	41	18	0	-	-	-	-	-	M.Dense	<50%	SM
13.0	6	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	2	41	35	21	0	-	-	-	-	-	Loose	<50%	SM
14.5	2	SS	60	69	32	37	0.24	10	70	Very Soft	Above	CH	-	-	-	-	69	31	-	-	-	-	-	FG>50%	FG>50%	FG>50%
16.0	3	SS	52	71	28	43	0.44	11	85	Soft	Above	CH	-	-	-	-	62	38	-	-	-	-	-	FG>50%	FG>50%	FG>50%
17.5	4	SS	61	75	30	45	0.31	10	96	Soft	Above	CH	-	-	-	-	64	36	-	-	-	-	-	FG>50%	FG>50%	SM
19.0	4	SS	67	82	29	53	0.28	11	107	Soft	Above	CH	-	-	-	-	67	33	-	-	-	-	-	FG>50%	FG>50%	SM
21.0	7	SS	49	86	34	52	0.71	10	110	M.Stiff	Above	CH	-	-	-	-	61	39	-	-	-	-	-	FG>50%	FG>50%	SM
23.0	6	SS	45	72	32	40	0.68	11	75	M.Stiff	Above	CH	-	-	-	-	64	36	-	-	-	-	-	FG>50%	FG>50%	FG>50%
25.0	22	SS	26	35	28	7	1.29	18	21	V.Stiff	Below	ML	0	0	18	24	45	13	-	-	-	-	-	FG>50%	FG>50%	FG>50%
27.0	43	SS	18	29	21	8	1.38	20	34	CG>50%	Above	-	1	2	26	41	25	5	-	-	-	-	-	Dense	<50%	SC
29.0	64	SS	Clay Binder							CG>50%	Above	-	4	3	45	29	19	0	-	-	-	-	-	V.Dense	<50%	SC
31.0	>100	SS	21	47	23	24	1.08	15	38	Hard	Above	CI	-	-	-	-	69	31	-	-	-	-	-	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	GEOTECH TEAM
REVIEWED BY	R.BHUVANA

Table-2.3 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-02	2.30	7.26	345	286	3.00	7.21	315	245



CHAPTER-3

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 Sriperumbudur (shale/ Sandstone/ Siltstone 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:

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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	1.50	1.50	Filled Up Soil (Old Building Materials)							
2	1.50	3.00	1.50	Sandy Silty Clay	Brown	5	-	Medium Stiff	15	33	-
3	3.00	4.00	1.00	Silty Sand	Brown	13	Medium Dense	-	16.5	-	30.9
4	4.00	5.50	1.50	Silty Clay	Greyish Black	4	-	Soft	14.5	27	-
5	5.50	13.00	7.50	Silty Sand	Grey	14	Medium Dense	-	17	-	31.2
6	13.00	14.50	1.50	Silty Clay	Greyish Black	8	-	Medium Stiff	16.5	53	-
7	14.50	20.50	6.00	Silty Clay	Greyish Black	3	-	Soft	14	20	-
8	20.50	27.00	6.50	Silty Clay	Greyish Black	6	-	Medium Stiff	15.5	40	-
9	27.00	29.00	2.00	Clayey Silty Sand	Brownish Grey	38	Dense	-	19.5	-	38.2
10	29.00	31.00	2.00	Shale	Brownish Grey	>100	-	Hard	21	400	-

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

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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	2.00	2.00	Sandy Silty Clay	Brown	6	-	Medium Stiff	15.5	40	-
2	2.00	3.00	1.00	Clayey Silty Sand	Brown	18	Medium Dense	-	18	-	32.4
3	3.00	4.00	1.00	Silty Sand	Brown	13	Medium Dense	-	16.5	-	30.9
4	4.00	7.00	3.00	Silty Clay	Greyish Black	5	-	Medium Stiff	15	33	-
5	7.00	13.00	6.00	Silty Sand	Grey	26	Medium Dense	-	19	-	34.8
6	13.00	14.50	1.50	Silty Clay	Greyish Black	6	-	Medium Stiff	15.5	40	-
7	14.50	20.50	6.00	Silty Clay	Greyish Black	3	-	Soft	14	20	-
8	20.50	25.00	4.50	Silty Clay	Greyish Black	6	-	Medium Stiff	15.5	40	-
9	25.00	27.00	2.00	Clayey Silt	Grey	22	-	Very Stiff	20.5	147	-
10	27.00	29.00	2.00	Silty Sand	Grey	43	Dense	-	20	-	39.43
11	29.00	30.00	1.00	Clayey Silty Sand	Brownish Grey, Yellow	64	Very Dense	-	21	-	42.5
12	30.00	31.00	1.00	Shale	Brownish Grey	>100	-	Hard	21	400	-

- Note: -Bulk density, & “C”, “ϕ “values are given in SPT correlation

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FOUNDATION SYSTEM

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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 stilt+ five floors, and is meant for residential building occupancy. For this kind of structure, the column loads could vary between 1800kN to 2500 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 as an alternate, deep pile foundation can be adopted.

Since, the present site is developed build-up area driving technique to install the piles is not recommended from vibration considerations. Hence, it is recommended to adopt Bored Cast in Situ piles.

The piles can be installed by drilling with direct mud circulation technique (Bored Cast In-situ Piles) advanced either by rotary auger or by chiselling. In both the cases of advancement 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

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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	Dia.of Pile in (mm)	Length of Pile Below Cutoff (m)	SAFE LOAD CARRYING CAPACITY (kN)		
						Vertical Load Carrying Capacity	Pull Out Capacity	Lateral Load Carrying Capacity
1	BH-01	31.0	1.0	500	30.0	900	500	30
2				550		1000	600	35
3				600		1200	700	40
4				650		1300	800	45
5				750		1500	900	50
6				800		1800	1000	55
7				900		2100	1100	65
8				1000		2400	1200	75
1.0 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.								

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RECOMMENDATIONS

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CHAPTER-5

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 suitable length can be adopted
- The mud used shall be made out of sodium bentonite with minimum frees swell index of more than 300% and liquid limit more than 100%. The silt content in bentonite shall not more than 5%.
- The mud should be prepared using sodium bentonite with a density of range 1.03 g/cc to 1.10 g/cc. However, while flushing before concreting the density should not be more than 1.12 g/cc.

5.2 General Recommendation:

- Since, chlorides and sulphates are well within the permissible limits, no special steel or cement is required for the construction of foundations.

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ANNEXURE

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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)	31	As Per IS:2911-(P-I,S-2)-2010	
Reference Bore Hole	BH-01		600	mm	Surcharge Pressure	0	kPa	

Layer No.	Layer Thk. (m) Top. R.L.	Bot. R.L.	Thickness	Type of Strata	Ave. SPT	(γ) kN/m^3 of Layer	Ave. upto Layer	Shear Parameters (C_u) kPa	(ϕ) Deg.	Effective Overburden Pressure (kPa) At top of Layer	At Bot. of Layer	At Mid. of Layer	Adhesion Factor (α)	Earth Pressure Coefficient (k)	Skin Friction (Q_f) kN		
1	0	1	1	Cut-Off Level													
2	1	3	2.0	Clay	5	15.0	15.0	33	-	0.0	10.0	5.0	1.0	-	qf	2	124.4
3	3	4	1.0	Sand	13	16.5	15.8	-	30.9	10.0	16.5	13.3	-	1.0	qf	3	15.6
4	4	5.5	1.5	Clay	4	14.5	15.5	27	-	16.5	23.3	19.9	1.0	-	qf	4	76.3
5	5.5	13	7.5	Sand	15	17.5	16.0	-	31.5	23.3	79.5	51.4	-	1.1	qf	5	478.9
6	13	14.5	1.5	Clay	8	16.5	17.0	53	-	79.5	89.3	84.4	0.9	-	qf	6	134.9
7	14.5	20	5.5	Clay	3	14.0	15.3	20	-	89.3	111.3	100.3	1.0	-	qf	7	207.3
8	20	27	7.0	Clay	5	15.0	14.5	33	-	111.3	146.3	128.8	1.0	-	qf	8	435.4
9	27	29	2.0	Sand	30	19.0	17.0	-	36.0	146.3	164.3	155.3	-	1.3	qf	9	554.4
10	29	31	2.0	Shale	50	21.0	20.0	333	-	164.3	186.3	175.3	0.3	-	qf	10	326.4

Summation of Positive Skin Resitance (kN) Q_f= 2353.75

Summation of Negative Skin Resistance (kN) -Qf= 0.00

Computation of End Bearing Resistance

		SPT	ϕ	C_u	N_q	N_c			
Bearing Stratum	Clay	60	-	400	-	9	Eff.Ht.of Overburden	9	m
							Effective Overburden Pressure	56.00	kN/m^2

End Bearing Resistance (kN) Q_p= 1017.88

Ultimate Load Carrying Capacity (Q_{ult})	$Q_u=Q_f-Q_f+Q_p$ (kN)	3371.63
Safe Load Carrying Capacity (Q_{safe})	$Q_u/2.5$ (kN)	1348.65
Allowable Safe Load Carrying Capacity	$Q_{A\text{-}safe}$ (kN)	1348.65
Allowable Safe Pull out Capacity	$Q_{A\text{-}pull}$: Qf/3 (kN)	784.58

Skin Resistance in Clay Layer is $\pi*d*T_l*C_u*\alpha$
Skin Resistance in Sand Layer is $\pi*d*T_l*q_l*K*Tan(\phi)$
End Bearing Resistance in Clay Layer is $\pi*d^2/4*C_u*N_c$
End Bearing Resistance in Sand Layer is $\pi*d^2/4*Q*N_q$

Note: The End being is Shale modeld as Clay with restricted to SPT-value of 60 corresponding Cu Value Taken as 400 kPa.

Where

Cu=Undrained Shear Strength of Clay
ϕ=Angle of Shearing Resistance
N_c=Bearing Capacity Factor = 9
K=Coef. Earth Pressure at Rest
q_l=Effecitve Overburden Pressure at middle of Layer
N_q=Bearing Capacity Factor, Ref. Fig.1 of IS: Code Refered above
d=Dia. Of Pile
α=Adhession Factor
T_l=Thickness of Layer
Q (i.e) Effecitve Overburden Pressure at pile tip=Effective height of overburden X (γ-10)

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LATERAL LOAD CARRYING CAPACITY OF BORED CAST- SITU PILES

Reference Bore Hole : BH-01

1.0 Geometrical Data

Type of Pile Head Considered		Fixed	
Diameter of Pile (d)	:	0.60	m
Free standing Length of Pile (e)	:	0	m
Length of Pile below E.G.L (Le)	:	31.0	m
Cut-Off Level From E.G.L	:	1.0	
Length of Pile below Cut-Off Level (Le)	:	30.0	m
Grade of Concrete (M)	:	25	MN/m^2
Young's Modulus of Concrete (E)	:	25000000	kN/m^2
Momemnt of Inertia (I)	:	0.006362	m^4

2.0 Determination of Depth of Fixity

Type of Soil Strata	:	Clay	
Ground Water Condition	:	Submerged	
Average Design SPT "N" Value	:	6	
K=((k1/1.5)*(0.3/B))			
(n can be read as η in the above and below equation in case of Sand)			
K1=	:	15000	kN/m^3
K=	:	5000	kN/m^2
R=	:	2.70	
L1/R	:	0.00	
Lf/R	:	2.20	
Depth of Fixity below Cut off (z_f)	:	5.94	m

3.0 Determincation 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+zf)^3	:	45.61	kN
Recommended Design Lateral Load carrying Capacity	:	**45**	**kN**
Fixed End Moment,M_F=H(e+z_f)/2		135	
Reduction Factor (L_1/T)	:	0.67	m
Actual Moment (Fixed End Moment/Reduction Factor),M_F		**91**	kN-m

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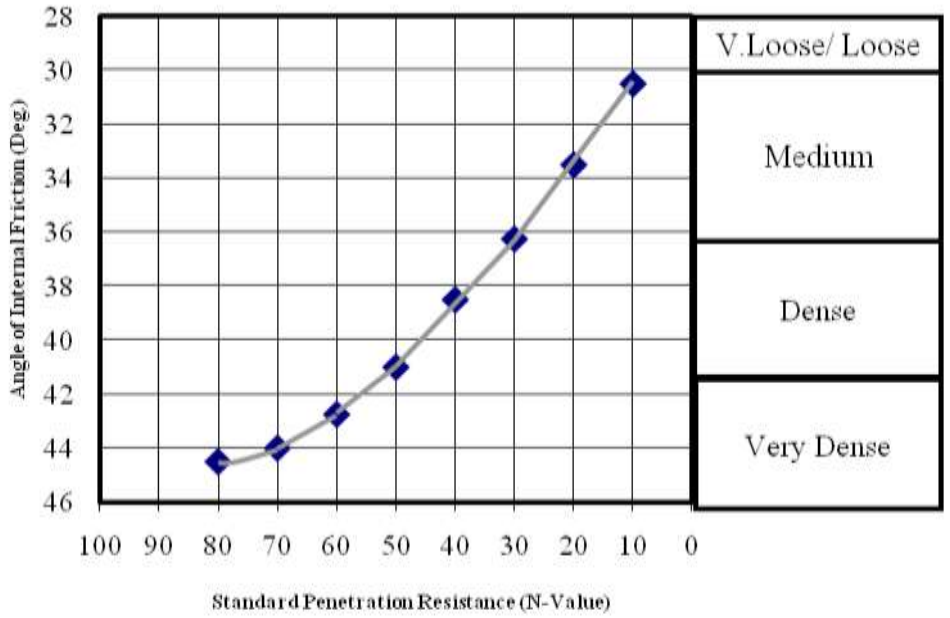


FIG. A1 Relation Ship between Angle of Internal Friction & N-value (Reproduced from IS:6403-1981)

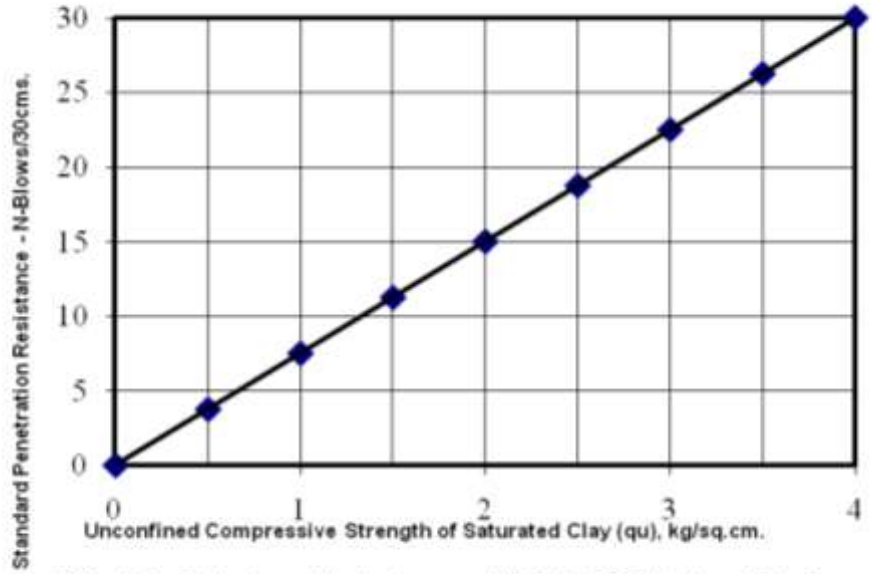


FIG. A2 : Relationship between UCC & SPT-Value (N) of Saturated Clay (AfterTerzhagi & Peck, 1948)

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