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PROJECT NAME

THE PROPOSED CONSTRUCTION OF RESIDENITAL BUILDING (STILT+5 UPPER FLOORS) WITH 40 DWELLING UNITS (18.00m HEIGHT) 816 & 663, AT THIRUVOTTIYUR HIGH ROAD, THIRU NAGAR, THIRUVOTTIYUR , CHENNAI - 600 019. COMPRISED IN PUNJA S.NO - 17, T.S.NO:50/11, 51 SITUATED AT MUNICIPAL DOOR NO - 27, BLOCK 01, WARD - I, THIRUVOTTIYUR VILLAGE, THIRUVOTTIYUR TALUK, CHENNAI DISTRICT.WITH IN THE LIMIT OF GREATER CHENNAI CORPORATION.

PROEJCT CLIENT NAME

M/S WELLDONE PROMOTERS PRIVATE LIMITED,
3RD FLOOR, BLOCK-II,
#16 RAJIV GANDHI SALAI,
KARAPAKKAM, CHENNAI 600 009.

TITLE

GEOTECHNICAL INVESTIGATION REPORT



PROJECT NO: GECS-JC-GT-1168-2023-2024

REPORT SUBMISSION DATE:19/10/2023

CONTENTS

	SEC. NO.	CONTENTS	PAGE NO.
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 Tests	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
	2.1to 2.3	Soil Profile	5-13
	2.4to 2.6	Graphical Representation of grain size distribution curve	14-16
	2.7to 2.11	Graphical Representation of hydrometer analysis curve	17-21
TABLES			
	2.1to 2.3	Laboratory Test Results	22-24
	2.4	Results of Chemical analysis	25
CHAPTER-3		GEOLOGY & SUB-SURFACE STRATIFICATION	
	3.0	Preamble	26
	3.1	Geology of region	26
	3.2	Design sub soil profile	26-29
CHAPTER-4		FOUNDATION SYSTEM	
	4.0	Preamble	30
	4.1	Proposed Structures	30

	4.2	Sub Surface Stratification	30
	4.3	Foundation System	30-31
FIGURE	4.1	Schematic Arrangement of Foundations	32
TABLE	4.1	Recommended Safe Load Carrying Capacities of Bored Cast-in Situ Piles	33
CHAPTER-5		**RECOMMENDATION**	34-35
ANNEXURE-I		Typical bearing capacity computations for shallow foundations	36-37
		Estimation of safe load carrying capacity of vertical pile design	38
		Lateral Load Carrying Capacity of Bored Cast- Situ Piles	39
	A1	Relationship Between Angle of Internal Friction & N-Value	40
	A2	Relationship Between UCC & SPT -Value (N) of Saturated Clay	40
ANNEXURE-II		Field Investigation photos	41-42

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REPORT TEXT

INTRODUCTION

CHAPTER-1

1.0 PROJECT INFORMATION MATRIX

Nature of project	: Proposed Construction of Residential Building
Type of Structures	: Stilt+5UpperFloors
Project Client	: **M/S WELLDONE PROMOTERS PRIVATE LIMITED,**
Project Location	: Thiruvottiyur High Road, Thiru Nagar, Thiruvottiyur, Chennai.
Job Code	: GECS-JC-GT-1168

1.1 SCOPE OF WORK

1.1.1 Field Work

- Conducting Three soil investigation bore holes of 150 mm diameter up to 26.50m depth or up to the refusal strata with SPT>100
- Conducting Standard Penetration Test (SPT) within the borehole at every 1.0m depth interval up to 4.0m and thereafter at every 1.5m depth interval up termination depth.
- Collection of Soil Samples and undisturbed samples from the clayey strata with SPT-value less than 15.
- Collection of water samples if groundwater table met within the investigation depth

1.1.2 Laboratory Work

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

1.2 Structure of the Report

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

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CHAPTER-2

INVESTIGATION METHODOLOGY & TEST RESULTS

2.0 Preamble:

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

2.1 Methodology of Field Work:

2.1.1 Equipment Used and Method of Drilling:

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

2.1.2 Standard Penetration Tests:

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

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

2.1.3 Collection of Soil Samples:

2.1.3.1 Disturbed Samples:

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

2.1.4 Collection of Ground Water Samples:

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

Note on Groundwater Table Record:

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

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

2.2 Laboratory testing:

2.2.1 On Coarse Grained Soil

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

2.2.2 On Fine Grained Soil

On the SPT sample index property tests were conducted to estimate consistency. These test results are presented in Tables-2.1 to 2.3. The graphical representation of hydrometer analyses curve for the representative samples in each bore is presented in Fig.2.7 to 2.11.

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 – 2.4.

2.3 Summary:

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

SITE PLAN



FIG-2.0 THE SITE PLAN SHOWING FIELD INVESTIGATION POINT AT THIRUVOTTIYUR HIGH ROAD, THIRU NAGAR, THIRUVOTTIYUR, CHENNAI - 600 019. COMPRISED IN PUNJA S.NO - 17, T.S.NO: 50/11, 51,SITUATED AT MUNICIPAL DOOR NO - 27, BLOCK 01, WARD - I, THIRUVOTTIYUR VILLAGE, THIRUVOTTIYUR TALUK, CHENNAI DISTRICT.WITH IN THE LIMIT OF GREATER CHENNAI CORPORATION.

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SOIL PROFILES

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-01		
SHEET	1	OF	3
DIA OF BORE HOLE	150mm ✓ / NX		
BORE START DATE	07/10/2023		
BORE END DATE	09/10/2023		
TOTAL DRILL DAYS	3		

PROJECT NAME	THE PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING						
LOCATION	~~Thiruvottiyur High Road,~~ Thiru Nagar, ~~Thiruvottiyur, Chennai~~	MACHINE No.	CR-02	CHAINAGE (m)	-		
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N	-	
JOB CODE	GECS-JC-GT-1168	FLUSHING MEDIUM	Bentonite		E	-	

Depth below E.G.L. (m)	Date	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	07/10/2023	SC	-	-	3	5	7	12	1.00	1	SS	-1.0		L1	1.2	**Filled Up Soil** (Old Building Rough Pieces Materials)
2		SC	-	-	3	6	10	16	2.00 / 2.45	2	SS	-2.0				Brownish Grey,Moist,Poorly Graded,Fine to Medium,Medium Dense to Dense,**Silty SAND (SM/SP)** Sand-Silt Mixture
3		SC	-	-	6	12	17	29	3.00 / 3.45	3	SS	-3.0				
4		SC	-	-	7	14	22	36	4.00 / 4.45	4	SS	-4.0				
5		SC	-	-	25	40	11CM Penet. For 50 Blows	>100	5.50 / 5.91	5	SS	-5.5		L2	5.5	
6																
7		SC	-	-	27	15CM Penet. For 50 Blows		>100	7.00 / 7.30	6	SS	-7.0				Greyish Brown,Moist,Poorly Graded,Fine to Medium Grains,Very Dense,**Silty SAND (SM/SP)** Sand-Silt Mixture
8																
9		SC	-	-	24	13CM Penet.For 50 Blows		>100	8.50 / 8.78	7	SS	-8.5				
10		SC	-	-	5	14	10	24	10.00 / 10.45	8	SS	-10.0		L3	10.0	
														L4	10.5	Grey,Moist,Poorly Graded,Fine to Medium Grains,Medium Dense,**Silty SAND (SM)** Sand-Silt Mixture

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CS - Core Sample	DS - Disturbed Sample	LOGGED	Subash	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	07/10/2023	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	R.Bhuvana	WATER TABLE (m) 2.80	
WS - Wash Sample	DB - Diamond Bit	DATE	18/10/2023	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-01						
SHEET	2	OF	3				
PROJECT NAME	THE PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING					DIA OF BORE HOLE	150mm ✓ / NX
LOCATION	Thiruvottiyur High Road, Thiru Nagar, Thiruvottiyur, Chennai	MACHINE No.	CR-02	CHAINAGE (m)	-	BORE START DATE	07/10/2023
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	09/10/2023
JOB CODE	GECS-JC-GT-1168	FLUSHING MEDIUM	Bentonite		E -	TOTAL DRILL DAYS	3

Depth below E.G.L. (m)	Date	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
11	07/10/2023	SC	-	-	25	15CM Penet. For 50 Blows		>100	11.50 / 11.80	9	SS	-11.5				Grey,Moist,Poorly Graded,Fine to Medium Grains,Very Dense,**Silty SAND (SM)** Sand-Silt Mixture
12																
13		SC	-	-	9	16	7	23	13.00 / 13.45	10	SS	-13.0		L5	13.0	
14		SC	-	-	2	3	4	7	14.50 / 14.95	11	SS	-14.5		L6	14.5	Grey,Moist,Poorly Graded,Fine to Medium Grains,Medium Dense,**Silty SAND(SM)** Sand-Silt Mixture
15																
16	08/10/2023	SC	-	-	2	3	4	7	16.00 / 16.50	12	SS	-16.0				Greyish Black,Moist,Medium Stiff,**Silty CLAY (CH)** Clays of High Plasticity
17		SC	-	-	3	4	5	9	17.50 / 17.95	19	SS	-17.5		L7	17.5	
18																
19		SC	-	-	4	7	3	10	19.00 / 19.45	20	SS	-19.0			20.5	Blackish Grey,Moist,Stiff,**Sandy Silty Clay(CH)** Clays of High Plasticity
20																

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CS - Core Sample	DS - Disturbed Sample	LOGGED	Subash	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	07/10/2023	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	R.Bhuvana	WATER TABLE (m) 2.80	
WS - Wash Sample	DB - Diamond Bit	DATE	18/10/2023	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-01						
SHEET	3	OF	3				
PROJECT NAME	THE PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING					DIA OF BORE HOLE	150mm ✓ / NX
LOCATION	Thiruvottiyur High Road, Thiru Nagar, Thiruvottiyur, Chennai	MACHINE No.	CR-02	CHAINAGE (m)	-	BORE START DATE	07/10/2023
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	09/10/2023
JOB CODE	GECS-JC-GT-1168	FLUSHING MEDIUM	Bentonite		E -	TOTAL DRILL DAYS	3

Depth below E.G.L. (m)	Date	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	08/10/2023	SC	-	-	4	4	8	12	20.50 / 20.95	18	SS	-20.5				Blackish Grey,Moist,Stiff,**Sandy Silty Clay(CH)** Clays of High Plasticity
22		SC	-	-	22	40	44	84	22.00 / 22.45	19	SS	-22.0		L8	22.0	
23		SC	-	-	25	40	45	85	23.50 / 23.95	20	SS	-23.5				Grey,Moist,Poorly Graded,Fine to Medium Coarse,Grains,Very Dense,**Silty SAND (SM)** Sand-Silt Mixture
24																
25	09/10/2023	SC	-	-	21	42	51	93	25.00 / 25.45	21	SS	-25.0				
26																
27		SC	-	-	23	42	47	89	26.50 / 26.95	22	SS	-26.5		L9	26.5	
28																
29																
30																

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CS - Core Sample	DS - Disturbed Sample	LOGGED	Subash	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sam	SC - Soil Cutter	DATE	07/10/2023	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Sar	TCB - Tungsten Carbide Bit	CHECKED	R.Bhuvana	WATER TABLE (m) 2.80	
WS - Wash Sample	DB - Diamond Bit	DATE	18/10/2023	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-02						
SHEET	1	OF	3				
PROJECT NAME	THE PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING					DIA OF BORE HOLE	150mm ✓ / NX
LOCATION	Thiru Nagar,	MACHINE No.	CR-02	CHAINAGE (m)	-	BORE START DATE	09/10/2023
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	10/10/2023
JOB CODE	GECS-JC-GT-1168	FLUSHING MEDIUM	Bentonite		E -	TOTAL DRILL DAYS	2

Depth below E.G.L. (m)	Date	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	09/10/2023	SC	-	-	5	5	7	12	1.00	1	SS	-1.0		L1	1.2	**Filled Up Soil** (Old Building Rough Pieces Materials)
2		SC	-	-	7	11	15	26	2.00 / 2.45	2	SS	-2.0				Brownish Grey,Moist,Poorly Graded,Fine to Medium,Medium Dense,**Silty SAND (SM/SP)** Sand-Silt Mixture
3		SC	-	-	12	25	34	59	3.00 / 3.45	3	SS	-3.0		L2	3.0	
4		SC	-	-	12	16	21	37	4.00 / 4.45	4	SS	-4.0				Brownish Grey,Moist,Poorly Graded,Fine to Medium,Medium Dense to Very Dense,**Silty SAND (SM/SP)** Sand-Silt Mixture
5		SC	-	-	28	44	10CM Penet. For 50 Blows	>100	5.50 / 5.90	5	SS	-5.5		L3	5.5	
6																
7		SC	-	-	32	10CM Penet. For 50 Blows		>100	7.00 / 7.30	6	SS	-7.0				Greyish Brown,Moist,Poorly Graded,Fine to Medium Grains,Very Dense,**Silty SAND (SM/SP)** Sand-Silt Mixture
8																
9		SC	-	-	20	35	38	73	8.50 / 8.95	7	SS	-8.5				
10		SC	-	-	7	12	14	26	10.00 / 10.45	8	SS	-10.0		L4	10.0	
														L5	10.5	Greyish Brown,Moist,Medium Dense,Poorly Graded,**Clayey Silty Sand(SC)** Sand-Clay mixtures

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CS - Core Sample	DS - Disturbed Sample	LOGGED	Subash	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	09/10/2023	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	R.Bhuvana	WATER TABLE (m) 2.90	
WS - Wash Sample	DB - Diamond Bit	DATE	18/10/2023	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-02						
SHEET	2	OF	3				
PROJECT NAME	THE PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING			DIA OF BORE HOLE	150mm	✓	
					NX		
LOCATION	~~Thiruvottiyur High Road,~~ Thiru Nagar, ~~Thiruvottiyur, Chennai~~	MACHINE No.	CR-02	CHAINAGE (m)	-	BORE START DATE	09/10/2023
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	10/10/2023
JOB CODE	GECS-JC-GT-1168	FLUSHING MEDIUM	Bentonite		E -	TOTAL DRILL DAYS	2

Depth below E.G.L. (m)	Date	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		SC	-	-	1	2	2	4	11.50 / 11.95	11	SS	-11.5				Greyish Black,Moist,Soft,**Sandy Silty Clay (CH)** Clays of High Plasticity
12																
13		SC	-	-	1	1	2	3	13.00 / 13.45	12	SS	-13.0				
14	09/10/2023	SC	-	-	2	4	5	9	14.50 / 14.95	13	SS	-14.5		L6	14.5	
15																Greyish Black,Moist,Stiff,**Silty CLAY (CH)** Clays of High Plasticity
16		SC	-	-	3	3	5	8	16.00 / 16.50	14	SS	-16.0				
17		SC	-	-	1	2	3	5	17.50 / 17.95	19	SS	-17.5		L7	17.5	
18	10/10/2023															
19		SC	-	-	1	5	6	11	19.00 / 19.45	20	SS	-19.0				Blackish Grey,Moist,Medium Stiff to Stiff,**Sandy Silty Clay(CH)** Clays of High Plasticity
20														L8	20.5	

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CS - Core Sample	DS - Disturbed Sample	LOGGED	Subash	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	09/10/2023	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	R.Bhuvana	WATER TABLE (m) 2.90	
WS - Wash Sample	DB - Diamond Bit	DATE	18/10/2023	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-02		
SHEET	3	OF	3
DIA OF BORE HOLE	150mm ✓	NX	
BORE START DATE	09/10/2023		
BORE END DATE	10/10/2023		
TOTAL DRILL DAYS	2		

PROJECT NAME	THE PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING				
LOCATION	Thiruvottiyur High Road, Thiru Nagar, Thiruvottiyur, Chennai	MACHINE No.	CR-02	CHAINAGE (m)	-
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -
JOB CODE	GECS-JC-GT-1168	FLUSHING MEDIUM	Bentonite		E -

Depth below E.G.L. (m)	Date	Type of Drill Bit (SC / TCB / DB)	Core Details		SPT Details				Sample Details				Layer Data			
			Total Core Recovery %	R.Q.D %	Blows/cm. 0-15	15-30	30-45	SPT "N" Value	Depth	No.	Type	RL (m)	Legend	No	Depth	Geotechnical Description
21	10/10/2023	SC	-	-	4	17	37	54	20.50 / 20.95	18	SS	-20.5				
22		SC	-	-	18	29	45	74	22.00 / 22.45	19	SS	-22.0				
23		SC	-	-	21	38	44	82	23.50 / 23.95	20	SS	-23.5				Grey,Moist,Poorly Graded,Fine to Medium Coarse,Grains,Very Dense,**Silty SAND (SM)** Sand-Silt Mixture
24																
25		SC	-	-	22	45	50	95	25.00 / 25.45	21	SS	-25.0				
26																
27		SC	-	-	24	39	46	85	26.50 / 26.95	22	SS	-26.5		L9	26.5	
28																
29																
30																

GEO ENGINEERING CONSULTANTS & SERVICES * Chennai 600 087

CS - Core Sample	DS - Disturbed Sample	LOGGED	Subash	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sam	SC - Soil Cutter	DATE	10/10/2023	GROUND LEVEL (m)	0.00	
UDS- Undisturbed San	TCB - Tungsten Carbide Bit	CHECKED	R.Bhuvana	WATER TABLE (m)	2.90	
WS - Wash Sample	DB - Diamond Bit	DATE	18/10/2023	CASING DEPTH (m)	0.00	

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-03		
SHEET	1	OF	3
DIA OF BORE HOLE	150mm ✓	NX	
BORE START DATE	11/10/2023		
BORE END DATE	12/10/2023		
TOTAL DRILL DAYS	2		

PROJECT NAME	THE PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING						
LOCATION	~~Thiruvottiyur High Road, Thiruvottiyur, Chennai~~ Thiru Nagar,	MACHINE No.	CR-02	CHAINAGE (m)	-		
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N	-	
JOB CODE	GECS-JC-GT-1168	FLUSHING MEDIUM	Bentonite		E	-	

Depth below E.G.L. (m)	Date	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	11/10/2023	SC	-	-	3	4	3	7	1.00	1	SS	-1.0		L1	1.2	**Filled Up Soil** (Old Building Rough Pieces Materials)
2		SC	-	-	3	5	6	11	2.00 / 2.45	2	SS	-2.0				Brownish Grey,Moist,Poorly Graded,Fine to Medium,Loose to Medium Dense,**Silty SAND (SM/SP)** Sand-Silt Mixture
3		SC	-	-	6	8	10	18	3.00 / 3.45	3	SS	-3.0		L2	3.0	
4		SC	-	-	9	12	12	24	4.00 / 4.45	4	SS	-4.0				Brownish Grey,Moist,Poorly Graded,Fine to Medium,Medium Dense,**Silty SAND (SM/SP)** Sand-Silt Mixture
5		SC	-	-	12	25	40	65	5.50 / 5.95	5	SS	-5.5		L3	5.5	
6																
7		SC	-	-	40	11CM Penet. For 50 Blows		>100	7.00 / 7.29	6	SS	-7.0				Greyish Brown,Moist,Poorly Graded,Fine to Medium Grains,Very Dense,**Silty SAND (SM/SP)** Sand-Silt Mixture
8																
9		SC	-	-	15CM Penet. For 50 Blows			>100	8.50 / 8.65	7	SS	-8.5				
10		SC	-	-	3	3	4	7	10.00 / 10.45	8	SS	-10.0		L4	10.0	
														L5	10.5	Grey,Moist,Loose,Poorly Graded,**Clayey Silty Sand(SC)** Sand-Clay mixtures

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CS - Core Sample	DS - Disturbed Sample	LOGGED	Subash	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sampl	SC - Soil Cutter	DATE	11/10/2023	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Samp	TCB - Tungsten Carbide Bit	CHECKED	R.Bhuvana	WATER TABLE (m) 2.80	
WS - Wash Sample	DB - Diamond Bit	DATE	18/10/2023	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-03				
SHEET	2	OF	3		
PROJECT NAME	THE PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING	DIA OF BORE HOLE	150mm ✓ / NX		
LOCATION	Thiruvottiyur High Road, Thiru Nagar, Thiruvottiyur, Chennai	MACHINE No.	CR-02	CHAINAGE (m)	-
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -
JOB CODE	GECS-JC-GT-1168	FLUSHING MEDIUM	Bentonite		E -
BORE START DATE	11/10/2023				
BORE END DATE	12/10/2023				
TOTAL DRILL DAYS	2				

Depth below E.G.L. (m)	Date	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
11	11/10/2023	SC	-	-	1	2	3	5	11.50 / 11.95	11	SS	-11.5				Greyish Black,Moist,Soft to Medium Stiff,**Sandy Silty Clay (CH)** Clays of High Plasticity
12																
13		SC	-	-	1	2	2	4	13.00 / 13.45	12	SS	-13.0				
14		SC	-	-	1	2	4	6	14.50 / 14.95	13	SS	-14.5	L6	14.5		
15																
16		SC	-	-	3	3	4	7	16.00 / 16.50	14	SS	-16.0				
17																
18	12/10/2023	SC	-	-	1	2	4	6	17.50 / 17.95	19	SS	-17.5				Greyish Black,Moist,Medium Stiff to Stiff,**Silty CLAY (CH)** Clays of High Plasticity
19		SC	-	-	2	3	5	8	19.00 / 19.45	20	SS	-19.0				
20													L7	20.5		

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CS - Core Sample	DS - Disturbed Sample	LOGGED	Subash	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	11/10/2023	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	R.Bhuvana	WATER TABLE (m) 2.80	
WS - Wash Sample	DB - Diamond Bit	DATE	18/10/2023	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-03						
SHEET	3	OF	3				
PROJECT NAME	THE PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING			DIA OF BORE HOLE	150mm ✓ / NX		
LOCATION	Thiruvottiyur High Road, Thiru Nagar, Thiruvottiyur, Chennai	MACHINE No.	CR-02	CHAINAGE (m)	-	BORE START DATE	11/10/2023
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	12/10/2023
JOB CODE	GECS-JC-GT-1168	FLUSHING MEDIUM	Bentonite		E -	TOTAL DRILL DAYS	2

Depth below E.G.L. (m)	Date	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
21	12/10/2023	SC	-	-	11	25	38	63	20.50 / 20.95	18	SS	-20.5				
22		SC	-	-	21	32	51	83	22.00 / 22.45	19	SS	-22.0				Grey,Moist,Poorly Graded,Fine to Medium Coarse,Grains,Very Dense,**Silty SAND (SM)** Sand-Silt Mixture
23																
24		SC	-	-	23	41	47	88	23.50 / 23.95	20	SS	-23.5				
25		SC	-	-	27	40	51	91	25.00 / 25.45	21	SS	-25.0		L8	25.5	
26																
27																
28																
29																
30																

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CS - Core Sample	DS - Disturbed Sample	LOGGED	Subash	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sam	SC - Soil Cutter	DATE	12/10/2023	GROUND LEVEL (m)	0.00	
UDS- Undisturbed Sar	TCB - Tungsten Carbide Bit	CHECKED	R.Bhuvana	WATER TABLE (m)	2.80	
WS - Wash Sample	DB - Diamond Bit	DATE	18/10/2023	CASING DEPTH (m)	0.00	

GRAIN SIZE DISTRIBUTION CURVE

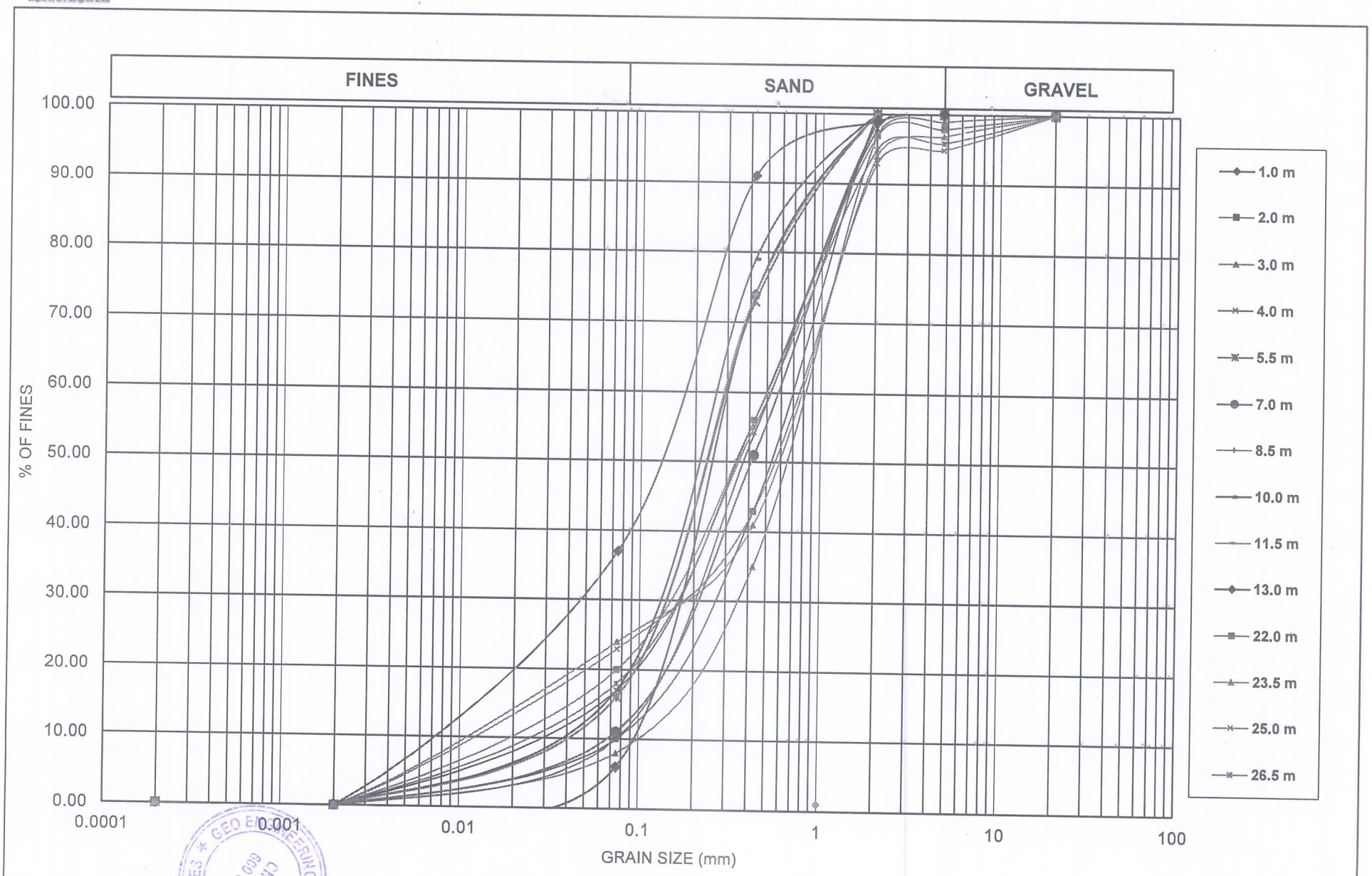


Fig. 2.4 GRAIN SIZE DISTRIBUTION CURVE - BH-01

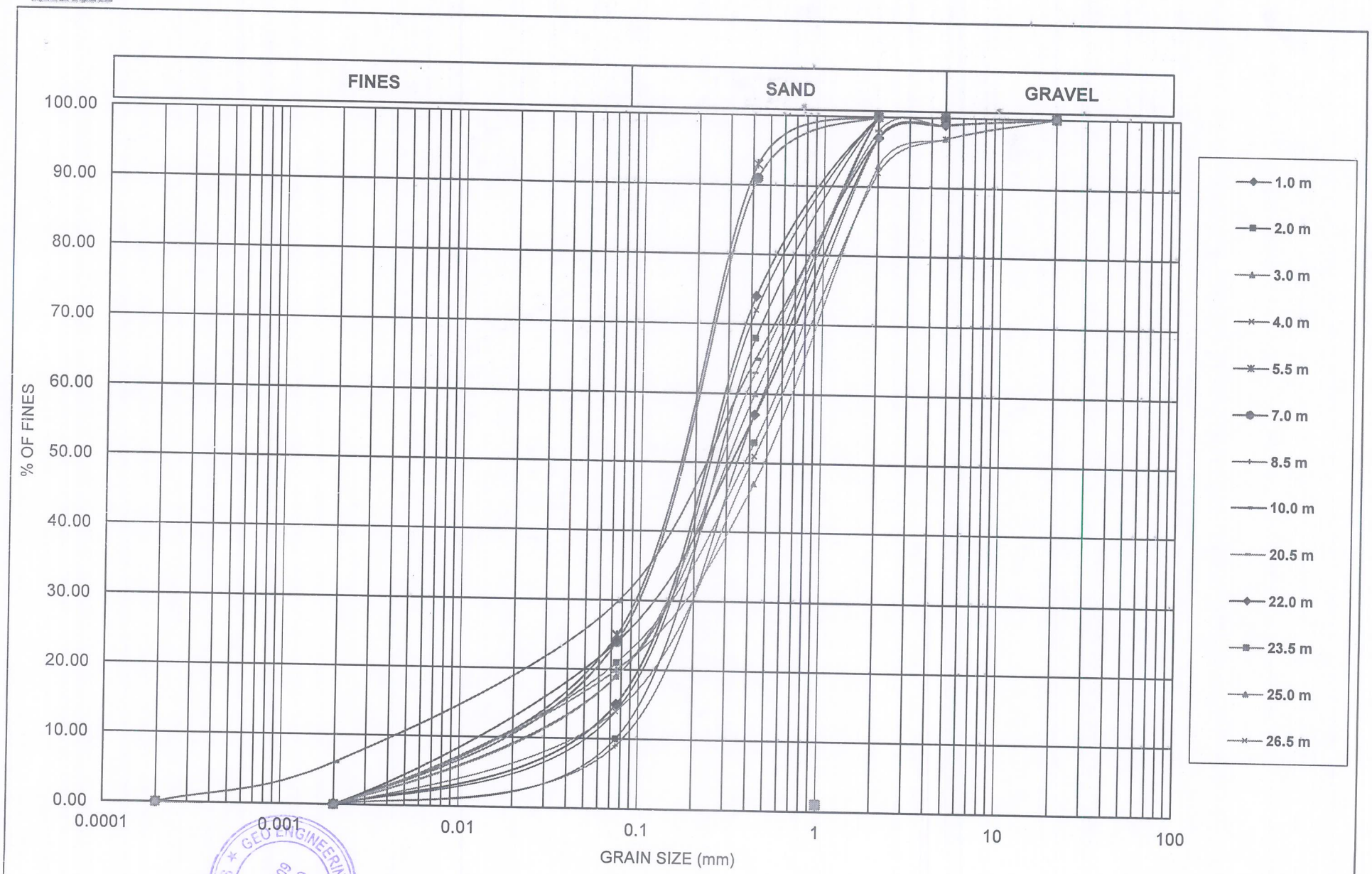


Fig. 2.5 GRAIN SIZE DISTRIBUTION CURVE - BH-02

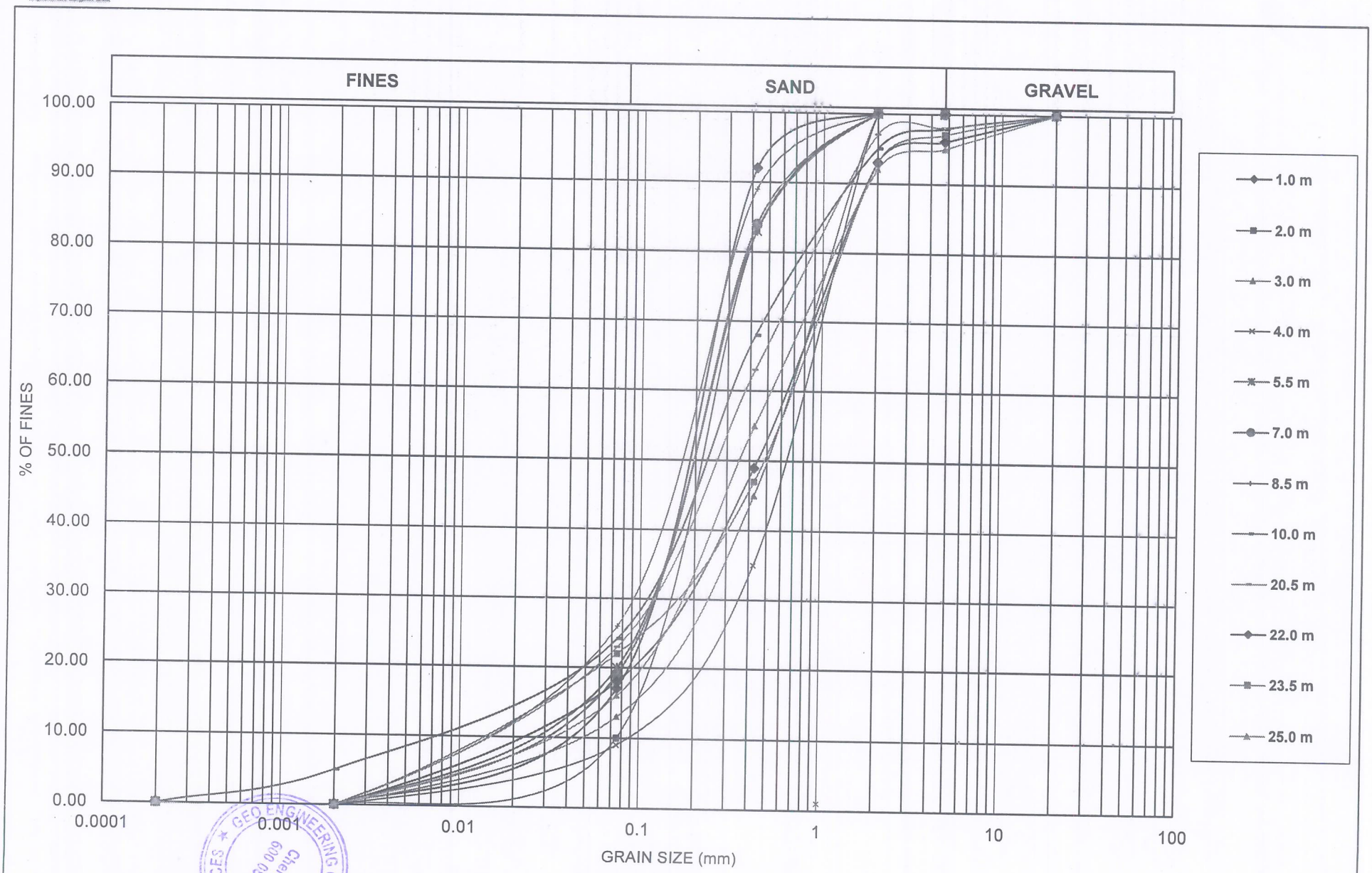


Fig. 2.6 GRAIN SIZE DISTRIBUTION CURVE - BH-03

HYDROMETER ANALYSIS CURVE

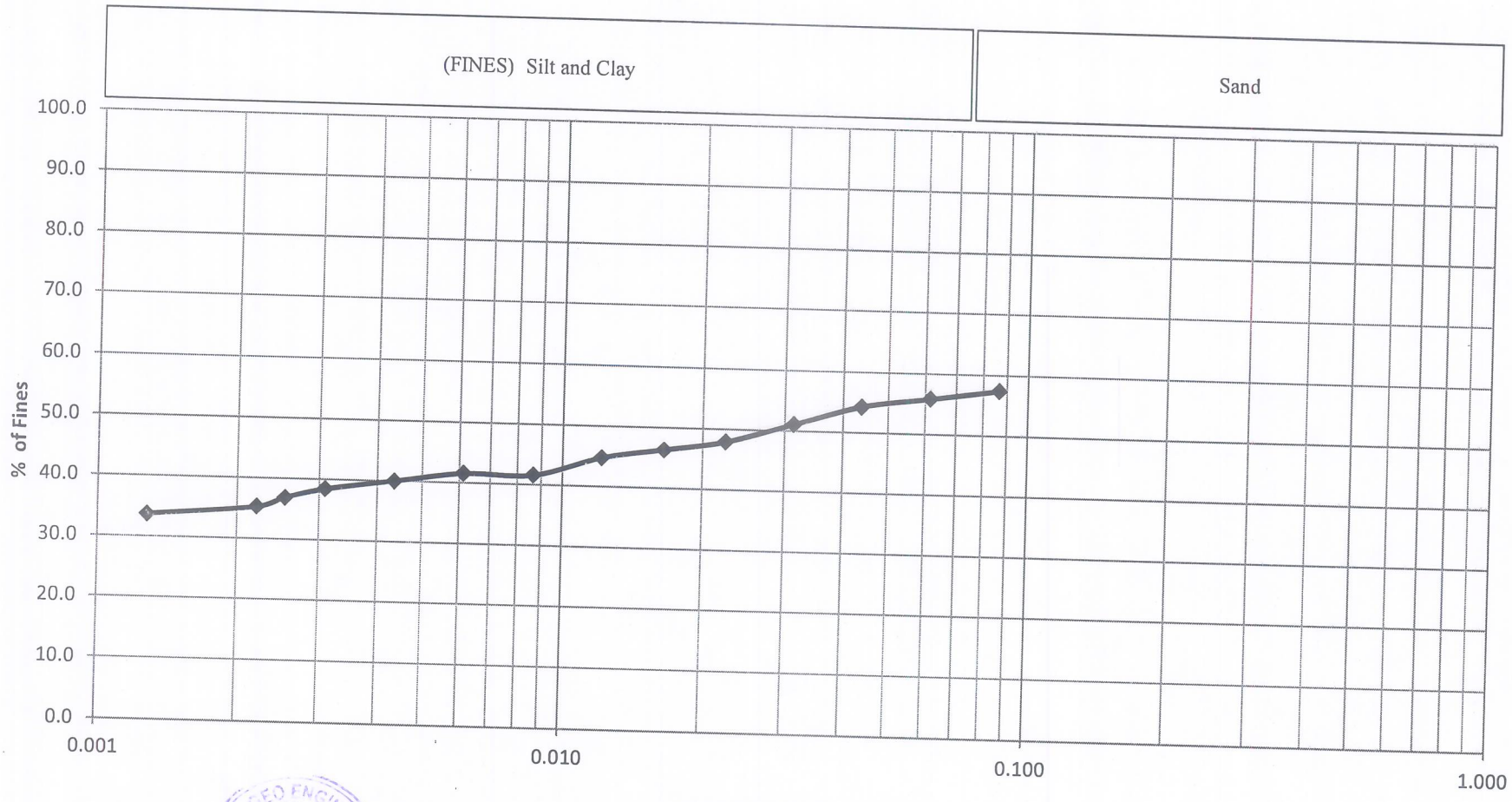


Fig 2.7 Hydrometer Analysis Master Curve

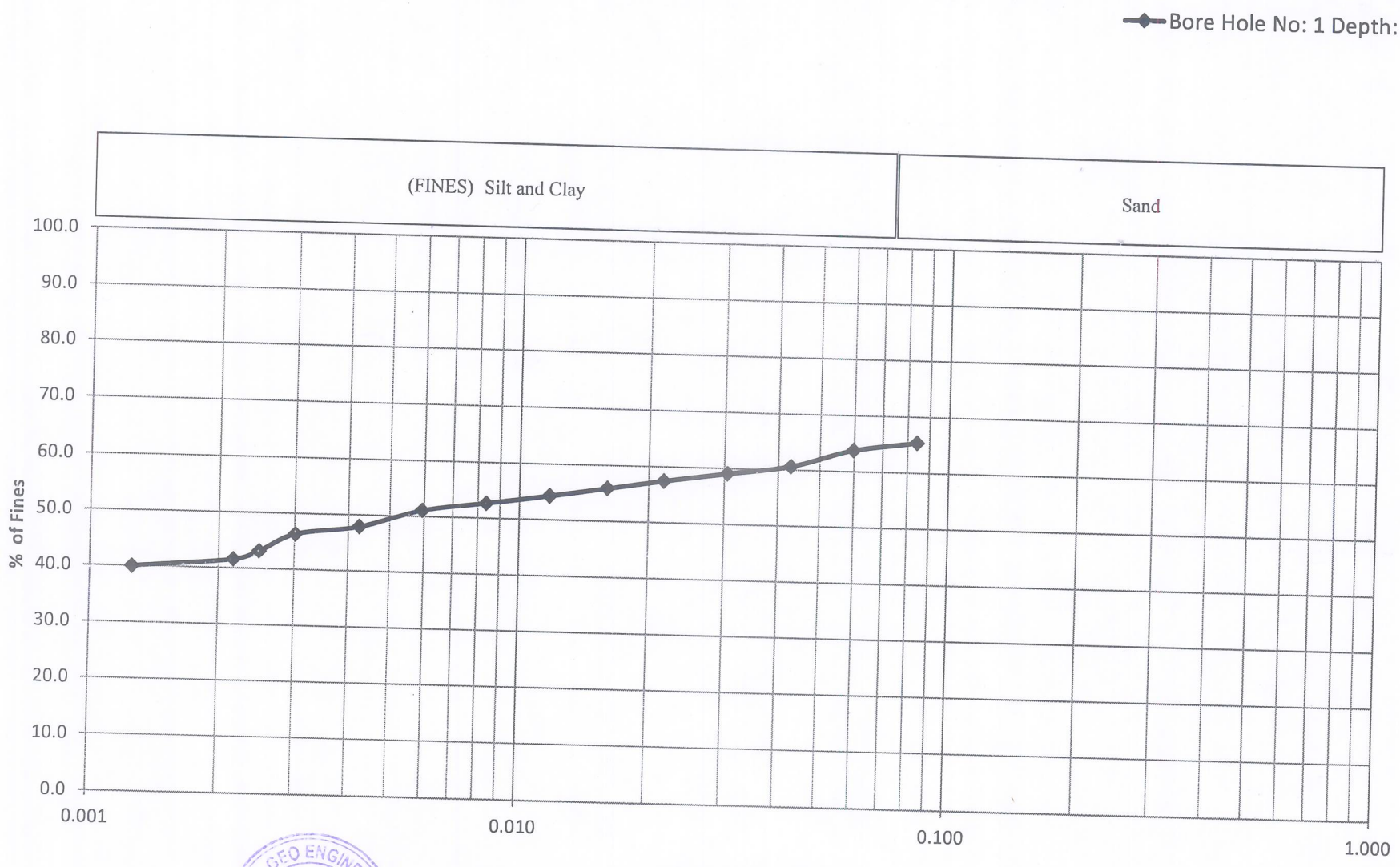


Fig 2.8 Hydrometer Analysis Master Curve

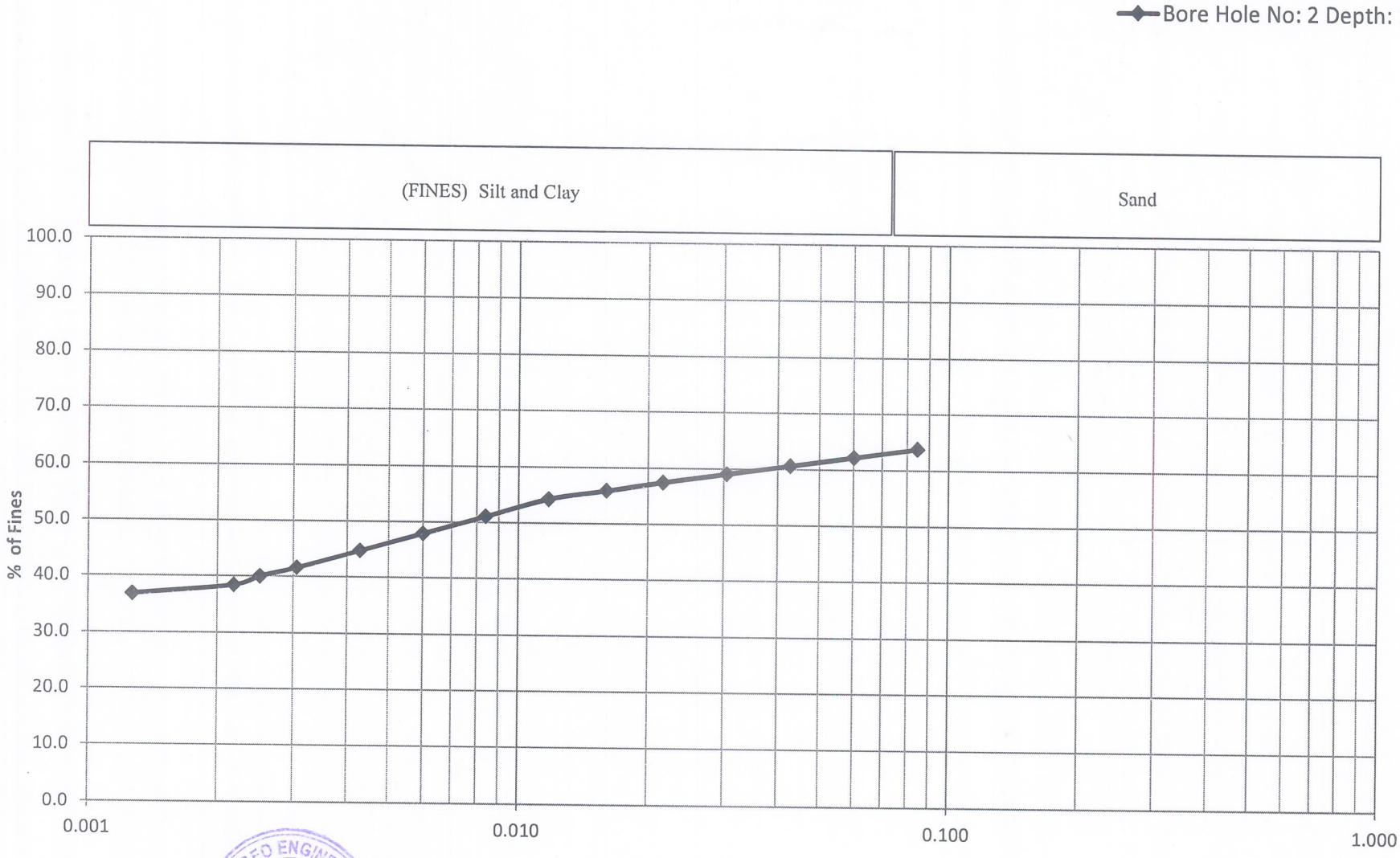


Fig 2.9 Hydrometer Analysis Master Curve

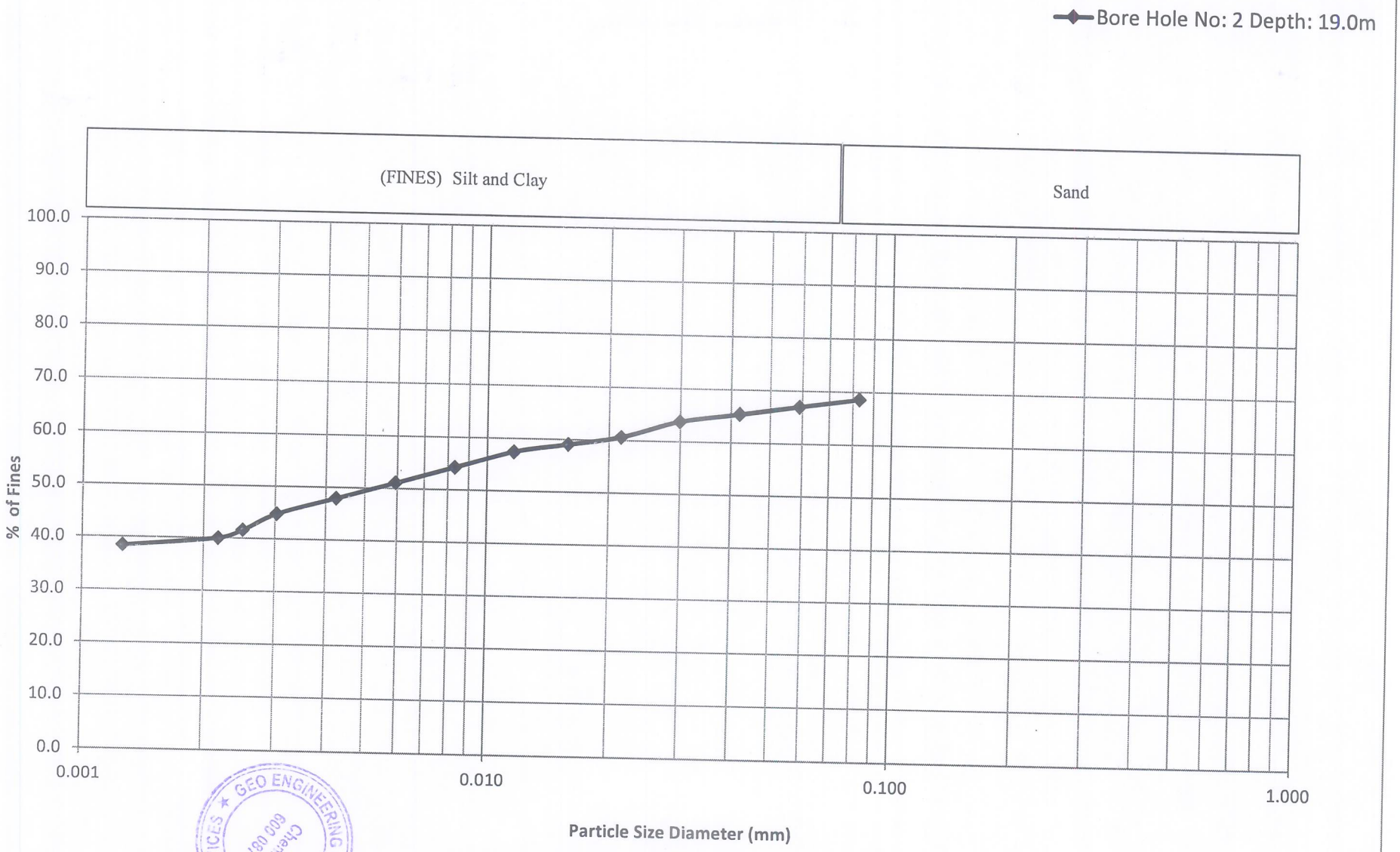


Fig 2.10 Hydrometer Analysis Master Curve

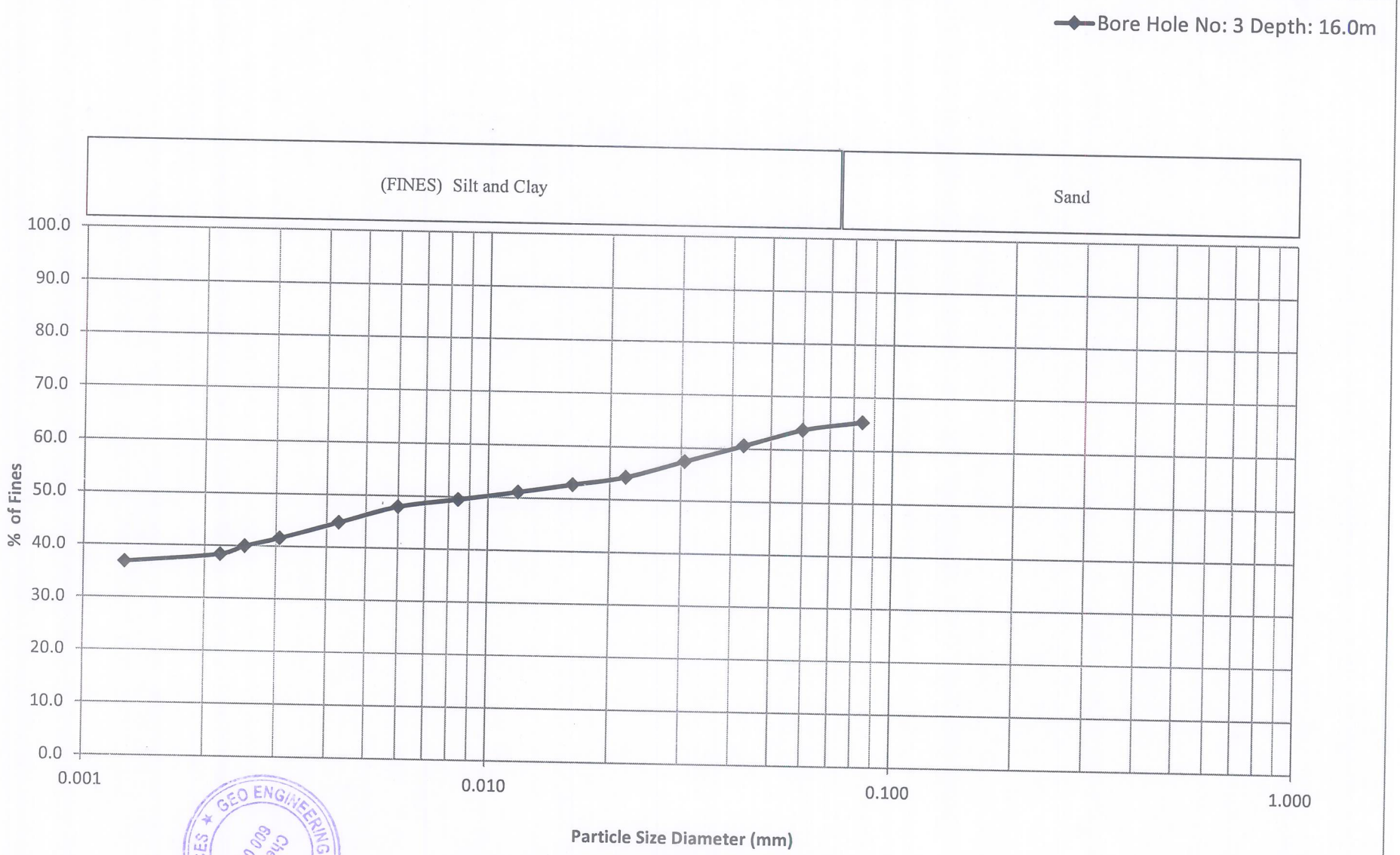


Fig 2.11 Hydrometer Analysis Master Curve

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)													IS-Notation	
			NMC(%)	LL (%)	PL (%)	I_P	Ic	SL (%)	FS (%)	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	12	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	26	68	6	0	-	-	-	-	-	M.Dense	<50%	SP-SM
2.0	16	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	57	33	10	0	-	-	-	-	-	M.Dense	<50%	SP-SM
3.0	29	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	2	62	27	8	0	-	-	-	-	-	M.Dense	<50%	SP-SM
4.0	36	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	2	42	39	17	0	-	-	-	-	-	Dense	<50%	SM
5.5	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	27	57	16	0	-	-	-	-	-	V.Dense	<50%	SM
7.0	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	1	48	40	11	0	-	-	-	-	-	V.Dense	<50%	SP-SM
8.5	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	1	45	44	10	0	-	-	-	-	-	V.Dense	<50%	SP-SM
10.0	24	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	21	62	17	0	-	-	-	-	-	M.Dense	<50%	SM
11.5	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	26	58	16	0	-	-	-	-	-	V.Dense	<50%	SM
13.0	23	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	1	8	54	37	0	-	-	-	-	-	M.Dense	<50%	SM
14.5	7	SS	35	54	24	30	0.63	14	46	M.Stiff	Above	CH	-	-	-	-	67	33	-	-	-	-	-	FG>50%	FG>50%	FG>50%
16.0	7	SS	32	52	22	30	0.66	13	37	M.Stiff	Above	CH	-	-	-	-	65	35	-	-	-	-	-	FG>50%	FG>50%	FG>50%
17.5	9	SS	36	68	32	36	0.89	10	85	Stiff	Above	CH	-	-	-	-	60	40	-	-	-	-	-	FG>50%	FG>50%	FG>50%
19.0	10	SS	32	72	30	42	0.95	11	94	Stiff	Above	CH	-	-	-	-	62	38	-	-	-	-	-	FG>50%	FG>50%	FG>50%
20.5	12	SS	38	75	34	41	0.90	9	102	Stiff	Above	CH	-	-	-	-	58	42	-	-	-	-	-	FG>50%	FG>50%	FG>50%
22.0	84	SS	-	-	-	-	-	-	-	CG>50%	-	-	2	1	41	36	20	0	-	-	-	-	-	V.Dense	<50%	SM
23.5	85	SS	-	-	-	-	-	-	-	CG>50%	-	-	3	3	53	17	24	0	-	-	-	-	-	V.Dense	<50%	SM
25.0	93	SS	-	-	-	-	-	-	-	CG>50%	-	-	5	2	50	20	23	0	-	-	-	-	-	V.Dense	<50%	SM
26.5	89	SS	-	-	-	-	-	-	-	CG>50%	-	-	4	1	40	37	18	0	-	-	-	-	-	V.Dense	<50%	SM

FG = Fine Grained
CG = Coarse Grained
NMC= Nature Moisture Content
LL = Liquid Limit
PL = Plastic Limit
Ip = Plasticity Index
Ic = (LL-NMC)/Ip
SL = Shrinkage Limit
FS = Differential Frees Well 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	Fine Grained (FG)										Sub Soil Classification													
			NMC(%)	LL (%)	PL (%)	I_P	Ic	SL (%)	DFI (%)	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	IS-Notation	
																									Gravel	Sand
1.0	12	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	26	59	15	0	-	-	-	-	-	M.Dense	<50%	SM
2.0	26	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	32	58	10	0	-	-	-	-	-	M.Dense	<50%	SP-SM
3.0	59	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	40	41	19	0	-	-	-	-	-	V.Dense	<50%	SM
4.0	37	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	28	58	14	0	-	-	-	-	-	Dense	<50%	SM
5.5	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	7	68	25	0	-	-	-	-	-	V.Dense	<50%	SM
7.0	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	9	67	24	0	-	-	-	-	-	V.Dense	<50%	SM
8.5	73	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	43	48	9	0	-	-	-	-	-	V.Dense	<50%	SP-SM
10.0	26	SS	14	29	15	14	1.07	19	32	CG>50%	Above	-	1	2	32	31	28	6	-	-	-	-	-	M.Dense	<50%	SC
11.5	4	SS	52	67	26	41	0.37	10	65	Soft	Above	CH	-	-	-	-	62	38	-	-	-	-	-	FG>50%	FG>50%	FG>50%
13.0	3	SS	52	71	32	39	0.49	9	104	Soft	Above	CH	-	-	-	-	51	49	-	-	-	-	-	FG>50%	FG>50%	FG>50%
14.5	9	SS	45	82	34	48	0.77	10	85	Stiff	Above	CH	-	-	-	-	52	48	-	-	-	-	-	FG>50%	FG>50%	FG>50%
16.0	8	SS	40	75	29	46	0.76	11	75	Stiff	Above	CH	-	-	-	-	62	38	-	-	-	-	-	FG>50%	FG>50%	FG>50%
17.5	5	SS	35	57	25	32	0.69	10	69	M.Stiff	Above	CH	-	-	-	-	61	39	-	-	-	-	-	FG>50%	FG>50%	FG>50%
19.0	11	SS	24	62	23	39	0.97	13	70	Stiff	Above	CH	-	-	-	-	60	40	-	-	-	-	-	FG>50%	FG>50%	FG>50%
20.5	54	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	1	35	44	19	0	-	-	-	-	-	V.Dense	<50%	SM
22.0	74	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	2	40	33	24	0	-	-	-	-	-	V.Dense	<50%	SM
23.5	82	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	2	44	32	21	0	-	-	-	-	-	V.Dense	<50%	SM
25.0	95	SS	-	-	-	-	-	-	-	CG>50%	-	-	3	4	46	27	20	0	-	-	-	-	-	V.Dense	<50%	SM
26.5	85	SS	-	-	-	-	-	-	-	CG>50%	-	-	3	5	41	37	14	0	-	-	-	-	-	V.Dense	<50%	SM

FG = Fine Grained
CG = Coarse Grained
NMC= Nature Moisture Content
LL = Liquid Limit
PL = Plastic Limit
Ip = Plasticity Index
Ic = (LL-NMC)/Ip
SL = Shrinkage Limit
DFI = Differential Frees Well 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 Laboratory Classification of Soil Samples from BH-03

Depth of Sample below E.G.L. (m)	SPT-Value	Type of Sample	Sub Soil Classification																										
			Fine Grained (FG)										Coarse Grained (CG)													IS-Notation		
			NMC(%)	LL (%)	PL (%)	I_p	Ic	SL (%)	FS (%)	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	7	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	8	75	17	0	-	-	-	-	-	Loose	<50%	SM
2.0	11	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	17	73	10	0	-	-	-	-	-	M.Dense	<50%	SP-SM
3.0	18	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	55	32	13	0	-	-	-	-	-	M.Dense	<50%	SM
4.0	24	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	65	26	9	0	-	-	-	-	-	M.Dense	<50%	SP-SM
5.5	65	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	17	63	20	0	-	-	-	-	-	V.Dense	<50%	SM
7.0	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	16	65	19	0	-	-	-	-	-	V.Dense	<50%	SM
8.5	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	11	63	26	0	-	-	-	-	-	V.Dense	<50%	SM
10.0	7	SS	21	32	18	14	0.79	19	36	CG>50%	Above	-	2	3	27	40	23	5	-	-	-	-	-	Loose	<50%	SC
11.5	5	SS	45	65	26	39	0.51	11	67	M.Stiff	Above	CH	-	-	-	-	58	42	-	-	-	-	-	FG>50%	FG>50%	FG>50%
13.0	4	SS	62	79	31	48	0.35	10	82	Soft	Above	CH	-	-	-	-	60	40	-	-	-	-	-	FG>50%	FG>50%	FG>50%
14.5	6	SS	41	72	30	42	0.74	11	70	M.Stiff	Above	CH	-	-	-	-	59	41	-	-	-	-	-	FG>50%	FG>50%	FG>50%
16.0	7	SS	55	84	29	55	0.53	9	89	M.Stiff	Above	CH	-	-	-	-	61	39	-	-	-	-	-	FG>50%	FG>50%	FG>50%
17.5	6	SS	45	69	28	41	0.59	10	94	M.Stiff	Above	CH	-	-	-	-	62	38	-	-	-	-	-	FG>50%	FG>50%	FG>50%
19.0	8	SS	38	76	27	49	0.78	11	105	Stiff	Above	CH	-	-	-	-	64	36	-	-	-	-	-	FG>50%	FG>50%	FG>50%
20.5	63	SS	-	-	-	-	-	-	-	CG>50%	-	-	2	1	34	40	23	0	-	-	-	-	-	V.Dense	<50%	SM
22.0	83	SS	-	-	-	-	-	-	-	CG>50%	-	-	4	3	44	31	18	0	-	-	-	-	-	V.Dense	<50%	SM
23.5	88	SS	-	-	-	-	-	-	-	CG>50%	-	-	3	4	46	25	22	0	-	-	-	-	-	V.Dense	<50%	SM
25.0	91	SS	-	-	-	-	-	-	-	CG>50%	-	-	5	3	37	39	16	0	-	-	-	-	-	V.Dense	<50%	SM

FG = Fine Grained
CG = Coarse Grained
NMC= Nature Moisture Content
LL = Liquid Limit
PL = Plastic Limit
Ip = Plasticity Index
Ic = (LL-NMC)/Ip
SL = Shrinkage Limit
FS = Differential Frees Well Index
C_U = Uniformity Coefficient
C_c = Coefficient of Curvature
IP=LL-PL

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REVIEWED BY	R.BHUVANA

Table-2.4 Results of Chemical Analysis									
SL No.	Bore HoleNo.	Water				Soil(2:1)			
		Depth of Sample (m)	pH	Chlorides (ppm)	Sulphates (ppm)	Depth of Sample (m)	pH	Chlorides (ppm)	Sulphates (ppm)
1	BH-01	2.80	7.33	212	365	3.0	7.32	185	327
2	BH-02	2.90	7.34	192	339	4.0	7.33	189	305
3	BH-03	2.80	7.33	189	357	2.0	7.32	186	319

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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:				1		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/m³	Shear Parameters	
	Top. R.L.	Bot. R.L.	Thickness							* (C_u) kPa	* (ϕ) Deg.
1	0.00	1.20	1.20	Filled Up Soil (Old Building Rough Pieces Materials)							
2	1.20	5.50	4.30	Silty Sand	Brownish Grey	23	Medium Dense	-	18.5	-	33.9
3	5.50	10.00	4.50	Silty Sand	Greyish Brown	>100	Very Dense	-	21	-	42.5
4	10.00	10.50	0.50	Silty Sand	Grey	24	Medium Dense	-	18.5	-	34.2
5	10.50	13.00	2.50	Silty Sand	Grey	>100	Very Dense	-	21	-	42.5
6	13.00	14.50	1.50	Silty Sand	Grey	23	Medium Dense	-	18.5	-	33.9
7	14.50	17.50	3.00	Silty Clay	Blackish Grey	7	-	Medium Stiff	16	47	-
8	17.50	22.00	4.50	Silty Clay	Blackish Grey	12	-	Stiff	18.5	80	-
9	22.00	26.50	4.50	Silty Sand	Grey	>60	Very Dense	-	21	-	42.5

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

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REFERENCE BORE HOLE-BH:					2	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/m³	Shear Parameters	
	Top. R.L.	Bot. R.L.	Thickness							* (C_u) kPa	* (ϕ) Deg.
1	0.00	1.20	1.20	Filled Up Soil (Old Building Rough Pieces Materials)							
2	1.20	3.00	1.80	Silty Sand	Brownish Grey	19	Medium Dense	-	18	-	32.7
3	3.00	5.50	2.50	Silty Sand	Greyish Brown	48	Dense	-	20	-	40.55
4	5.50	10.00	4.50	Silty Sand	Greyish Brown	>100	Very Dense	-	21	-	42.5
5	10.00	10.50	0.50	Clayey Silty Sand	Grey	26	Medium Dense	-	19	-	34.8
6	10.50	14.50	4.00	Silty Clay	Greyish Black	3	-	Soft	14	20	-
7	14.50	17.50	3.00	Silty Clay	Greyish Black	9	-	Stiff	17	60	-
8	17.50	20.50	3.00	Silty Clay	Blackish Grey	8	-	Medium Stiff	16.5	53	-
9	20.50	26.50	6.00	Silty Sand	Grey	>60	Very Dense	-	21	-	42.5

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

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REFERENCE BORE HOLE-BH:				3		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 (Old Building Rough Pieces Materials)							
2	1.20	3.00	1.80	Silty Sand	Brownish Grey	9	Loose	-	14.5	-	29.8
3	3.00	5.50	2.50	Silty Sand	Brownish Grey	21	Medium Dense	-	18.5	-	33.3
4	5.50	10.00	4.50	Silty Sand	Greyish Brown	>100	Very Dense	-	21	-	42.5
5	10.00	10.50	0.50	Clayey Silty Sand	Grey	7	Loose	-	14.5	-	29.4
6	10.50	14.50	4.00	Silty Clay	Greyish Black	5	-	Medium Stiff	15	33	-
7	14.50	20.50	6.00	Silty Clay	Greyish Black	7	-	Medium Stiff	16	47	-
8	20.50	25.50	5.00	Silty Sand	Grey	>60	Very Dense	-	21	-	42.5

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

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FOUNDATION SYSTEM

CHAPTER-4

FOUNDATION SYSTEM

4.0 Preamble:

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

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

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

4.1 Proposed Structures

An understanding of the proposed construction and the order of loads on the foundations is needed for choosing the appropriate foundation system. In the present case, the proposed structure is configured with Stilt+5 upper floors, and is meant for residential use. For this kind of structure, the column loads could vary between 2500kN to 3000kN. The above-mentioned loads have no bearing on the design of either sub or super structures and are mentioned just to provide an insight to choose an appropriate foundation system with respect to subsoil conditions.

4.2 Sub Soil Stratification:

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

0.0m to 1.20m	: Filled Up Soil (Old Building Rough Pieces Materials)
1.20m to 5.50m	:Medium Dense Silty Sand
5.50m to 10.0m	: Very Dense Silty Sand
10.0m to 10.50m	: Medium Dense to Loose Claye Silty Sand
10.50m to 14.50m	: Soft Silty Clay
14.50m to 20.50m	: Medium Stiff to Stiff Silty Clay
20.50m to 26.50m	: Very Dense Silty Sand

During the time of investigation (3rd Week of Oct-2023) the ground water table observed at 2.8m below existing ground level.

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4.3 Foundation System

4.3.1 Option-I-R.C.C Strip Raft

For the kind of proposed structure and the sub soil condition, shallow foundation system shall be adopted. The R.C.C Strip Raft shall be located at a depth of 1.90m below the existing ground level. The R.C.C Strip raft can be design for recommended allowable safe bearing pressure of 150kPa. All the foundation shall rest on 100mm thick M10 grade levelling coarse bed. The schematic arrangement of foundation system is presented in Fig.4.1.

Typical computations are presented in Annexure

4.3.2 Option-II(Raft Foundation)

In the present case the proposed construction consists of stilt plus five upper floors height informed to be 18.0m. Hence, the foundation depth is 2.3m from the existing ground level.

The foundation shall be designed as a **Rigid R.C.C Raft**. For a minimum raft width of 10.0m, the recommended allowable safe bearing pressure is worked out to be 100kPa.

Typical computation is presented in the annexure.

4.3.2 Option-III-Deep Pile foundation system:

In case of shallow foundation not feasible alternative 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

4.4 Dewatering System:

The present site sub soil condition is coarse grain type with clay binder, ground water table observed at depth of 2.8m below existing ground level, during time of investigation periods. The provision shall be made the continuous dewatering arrangement should be made. The foundation excavation pits surface keep it dry condition.

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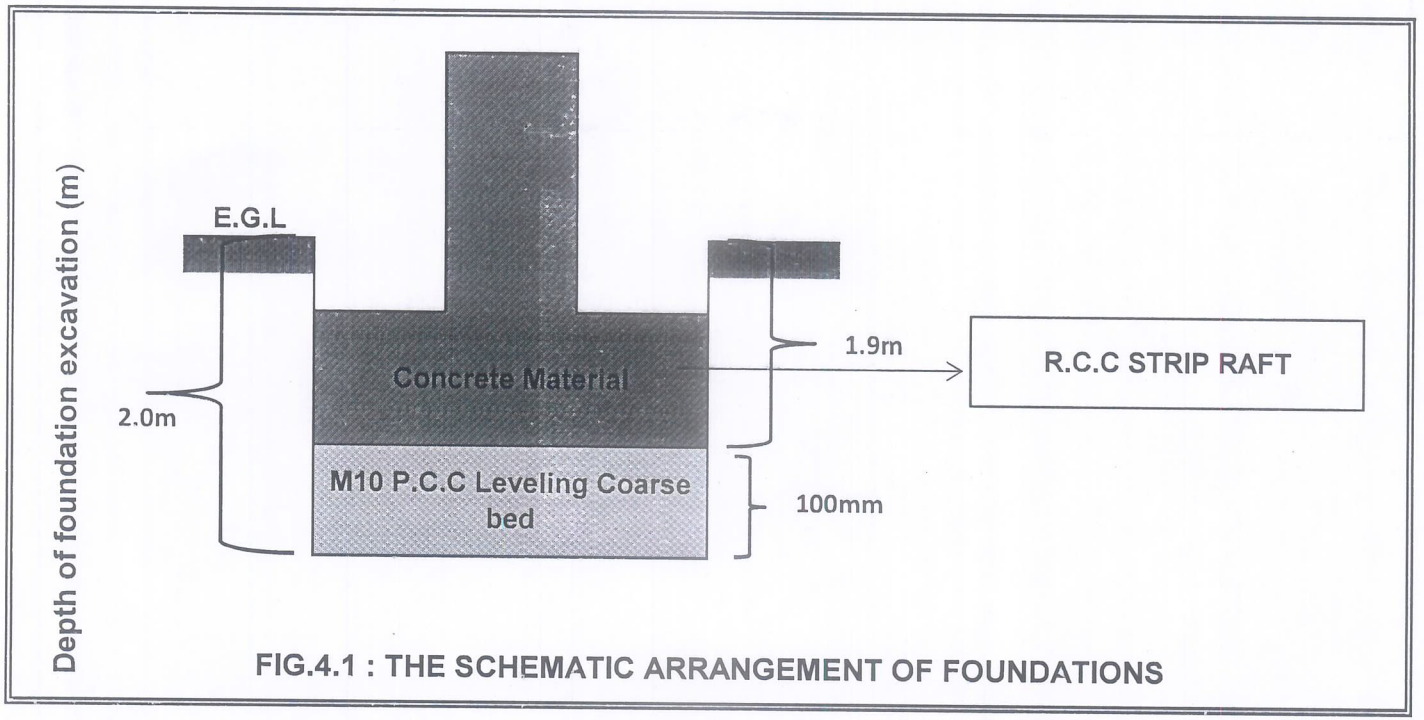


FIG.4.1 : THE SCHEMATIC ARRANGEMENT OF FOUNDATIONS

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-01	25.0	1.0	24.00	500	900	750	50
2					550	1000	800	55
3					600	1100	900	60
4					650	1200	1000	65
5					750	1300	1100	75
6					800	1400	1200	85
7					900	1600	1300	95

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RECOMMENDATIONS

CHAPTER-5

RECOMMENDATIONS

5.0 Recommendation for R.C.C Strip Raft:

- For the kind of proposed structure and the sub soil conditions, open foundation system shall be adopted.
- The **R.C.C Strip Raft** can be located at a depth of 1.5m over the prepared bed and can be designed for an allowable safe bearing pressure of 150kPa.
- The maximum width of strip shall be restricted to 2.0m due to settlement consideration.
- Excavated soil shall be use for foundation trench.
- All columns shall be connected with grade beams in both the directions irrespective of wall layout.
- The ground floor shall be minimum 1.0m above the natural ground and the plinth shall be filled with sand gravel mixed/hill earth/moorrum soil/quarry dust/excavated soil any kind of soil non-swelling-non-shrinking type of soil shall be use. This height is recommended to contain the influence of soil volume change on the flooring. In case, floor is not raised, the ground floor shall be constructed as a suspended R.C.C. slab.
- During the course of foundation excavation if the subsurface seepage water is encountered the bearing strata under wet condition may exhibit a slushy nature, hence in such conditions the slush shall be removed and sand or quarry dust of minimum 200mm shall be laid and compacted to ensure confinement of bearing strata without being subjected to swelling under wet conditions

5.1 Recommendation for R.C.C Rigid Raft:

- The **R.C.C Rigid Raft** can be located at a depth of 2.3m from the existing ground level.
- For a minimum raft width of 10.0m, the allowable bearing pressure is worked out to be 100kPa.
- During time of investigation periods the ground water table observed is 2.8m below existing ground level, in case of raft foundation system adopt, raft slab shall be designed for the uplift pressure considering the ground water table at ground level.

5.2 Recommendation for Bored Cast In-situ Pile Foundation:

- In case of deep pile foundation system adopted. 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.

5.3 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.

5.4 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-I

TYPICAL BEARING CAPACITY COMPUTATIONS FOR SHALLOW FOUNDATIONS

1.0 COMPUTATION OF BEARING CAPACITY AS PER IS:6403

Ref.BH-01

1.1 Geometrical Data :

Shape of the Foundation	Strip	
Depth of Foundation Below E.G.L"Df" (m)	1.90	
Soil Replacement CNS Layer(m)	0.00	
M10 Leveling Coarse Bed(m)	0.10	
Total Depth of Foundation (m)	2.00	
Breadth of Footing "B" (m)	2.00	
Length of Footing "L" (m)	15.00	
B/L	0.13	
Inclination of Vertical Load with the Vertical (a)	0.00	

1.2 Soil Data :

Type of Effective Bearing Strata :	Sand	
Design SPT-value of the Bearing Strata	15.00	
Type of Shear Failure:	General	
Angle of Shearing Resistance	31.50	Phi

1.3 Design Parameters:

Bulk Density of Soil above the foundation depth (γ_{bulk})	18.00	kN/m^3
Water Table Correction Factor (w')	0.50	
Effective Overburden pressure at foundation level (q)	16.00	kPa

Bearing Capacity Factors:

N_c = N/A

N_q = 22.87

N_g = 30.09

Shape Factors:

S_c = -

S_q = 1.00

S_g = 1.00

Depth Factors :

D_c = -

D_q = 1.02

D_g = 1.02

Inclination Factor:

I_c = 1.00

I_q = 1.00

I_g = 1.00

1.4 Ultimate Bearing Capacity (Qu) :

Qu=q*(Nq-1)*Sq*Dq*Iq + 0.5*B*g*Ng*Sg*Dg*Ig*w' 634.88 kPa

(g should be read as gama)

1.5 Safe Bearing Capacity (Qsafe) :

Factor of Safety (F.S.) :	2.50	
Qsafe :	253.95	kPa
Recommended **Allowable Safe Bearing Pressure Say Q_{safe}**	**150**	**kPa**

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

The immediate elastic settlement (S_i)= $qB(1-m^2)*I/E_s$

q= bearing pressure	150.00	kPa
Poission's Ratio (μ)	0.20	

Modulus of Elasticity (E_s)(Ref. Joseph E Bowels,1996,page316,Table5.6, Japanese design standards)

Modulus of Elasticity (E_s)	39000.00	kPa
Size of Strip considered for maximum settlement(m)	2.00	
Influence factor	1.00	
Rigidity Factor	1.00	
Elastic Settlement (DH_i)	7.38	mm
	<75	mm

TYPICAL BEARING CAPACITY COMPUTATIONS FOR SHALLOW FOUNDATIONS

1.0 COMPUTATION OF BEARING CAPACITY AS PER IS:6403

Ref.BH-03

1.1 Geometrical Data :

Shape of the Foundation	Raft	
Depth of Foundation Below E.G.L"Df' (m)	2.30	
Soil Replacement CNS Layer(m)	0.00	
M10 Leveling Coarse Bed(m)	0.10	
Total Depth of Foundation (m)	2.40	
Breadth of Footing "B" (m)	10.00	
Length of Footing "L" (m)	10.00	
B/L	1.00	
Inclination of Vertical Load with the Vertical (a)	0.00	

1.2 Soil Data :

Type of Effective Bearing Strata :	Sand	
Design SPT-value of the Bearing Strata	15.00	
Type of Shear Failure:	General	
Angle of Shearing Resistance	31.50	Phi

1.3 Design Parameters:

Bulk Density of Soil above the foundation depth (γ_{bulk})	18.00	kN/m^3
Water Table Correction Factor (w')	0.50	
Effective Overburden pressure at foundation level (q)	19.20	kPa

Bearing Capacity Factors:

N_c = N/A

N_q = 22.87

N_g = 30.09

Shape Factors:

S_c = -

S_q = 1.20

S_g = 0.60

Depth Factors :

D_c = -

D_q = 1.01

D_g = 1.01

Inclination Factor:

I_c = 1.00

I_q = 1.00

I_g = 1.00

1.4 Ultimate Bearing Capacity (Qu) :

Qu=q*(Nq-1)*Sq*Dq*Iq + 0.5*B*g*Ng*Sg*Dg*Ig*w'	1323.56	kPa
(g should be read as gama)		

1.5 Safe Bearing Capacity (Qsafe) :

Factor of Safety (F.S.) :	2.50	
Qsafe :	529.42	kPa
Recommended Allowable Safe Bearing Pressure Say Q_{safe}	**100**	**kPa**

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

The immediate elastic settlement (S_i)= $qB(1-m^2)*I/E_s$

q= bearing pressure	100.00	kPa
Poission's Ratio (μ)	0.20	

Modulus of Elasticity (E_s)(Ref. Joseph E Bowels,1996,page316,Table5.6, Japanese design standards)

Modulus of Elasticity (E_s)	39000.00	kPa
Size of Raft considered for maximum settlement(m)	10.00	
Influence factor	1.00	
Rigidity Factor	1.00	
Elastic Settlement (DH_i)	24.62	mm
	<100	mm

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)	25	As Per IS:2911-(P-I,S-2)-2010
Reference Bore Hole	BH-03		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/m³ 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	Sand	9	14.5	14.5	-	29.8	0.0	9.0	4.5	-	1.0	qf 2 9.7
3	3	5.5	2.5	Sand	20	18.0	16.3	-	33	9.0	29.0	19.0	-	1.2	qf 3 67.0
4	5.5	10.5	5.0	Sand	50	20.5	19.3	-	41	29.0	81.5	55.3	-	1.5	qf 4 679.0
5	10.5	14.5	4.0	Clay	4	14.5	17.5	27	-	81.5	99.5	90.5	1.0	-	qf 5 203.6
6	14.5	20.5	6.0	Clay	7	16.0	15.3	47	-	99.5	135.5	117.5	0.9	-	qf 6 478.4
7	20.5	25	4.5	Sand	50	20.5	18.3	-	41	135.5	182.8	159.1	-	1.5	qf 7 1760.0

Summation of Positive Skin Resitance (kN) Q_f= 3197.68

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

Computation of End Bearing Resistance

Bearing Stratum	Sand	SPT	ϕ	C_u	N_q	N_c	Eff.Ht.of Overburden	9	m
		40	36.00	-	57.50	-	Effective Overburden Pressure	61.50	kN/m²

End Bearing Resistance (kN) Q_p= 999.85

Ultimate Load Carrying Capacity (Q_{ult})	$Q_u=Q_f-Q_f+Q_p$ (kN)	4197.53
Safe Load Carrying Capacity (Q_{safe})	$Q_u/2.5$ (kN)	1679.01
Allowable Safe Load Carrying Capacity	$Q_{A\text{-}safe}$ (kN)	1679.01
Allowable Safe Pull out Capacity	$Q_{A\text{-}pull}$: Qf/3 (kN)	1065.89

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 $\pi*d^2/4*Q*N_q$

Where

Cu=Undrained Shear Strength of Clay

ϕ=Angle of Shearing Resistance

N_c=Bearing Capacity Factor = 9

Q (i.e) Effecitve Overburden Pressure at pile tip=Effective height of overburden X (γ-10)

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=Adhesion Factor

T_l=Thickness of Layer

Note: The End being is Sand modeld as Dense Sand with restricted to SPT-value of 40 corresponding phi value take design 36°, The pile design for Friction pile shall be consider for design computation.

LATERAL LOAD CARRYING CAPACITY OF BORED CAST- SITU PILES

Reference Bore Hole : BH-03

1 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) :	25.0	m
Cut-Off Level From E.G.L :	1.0	
Length of Pile below Cut-Off Level (Le) :	24.0	m
Grade of Concrete (M) :	25	MN/m^2
Young's Modulus of Concrete (E) :	25000000	kN/m^2
Momemnt of Inertia (I) :	0.003068	m^4

2 Determination of Depth of Fixity

Type of Soil Strata :	Sand	
Ground Water Condition :	Submerged	
Design SPT "N" Value :	12	
T=(EI/nh)1/5		
(n can be read as h in the above and below equation in case of Sand)		
nh= :	1688	kN/m^3
In Case of Sand :	-	kN/m^4
T= :	2.15	m
L1/T :	0.00	
Lf/T :	2.00	
Depth of Fixity below Cut off (z_f) :	4.29	m

3 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 :	58.26	kN
Recommended Design Lateral Load carrying Capacity :	**58**	**kN**
Fixed End Moment,M_F=H(e+z_f)/2	125	
Reduction Factor (L_1/T) :	0.83	m
Actual Moment (Fixed End Moment/Reduction Factor),M_F	**104**	kN-m

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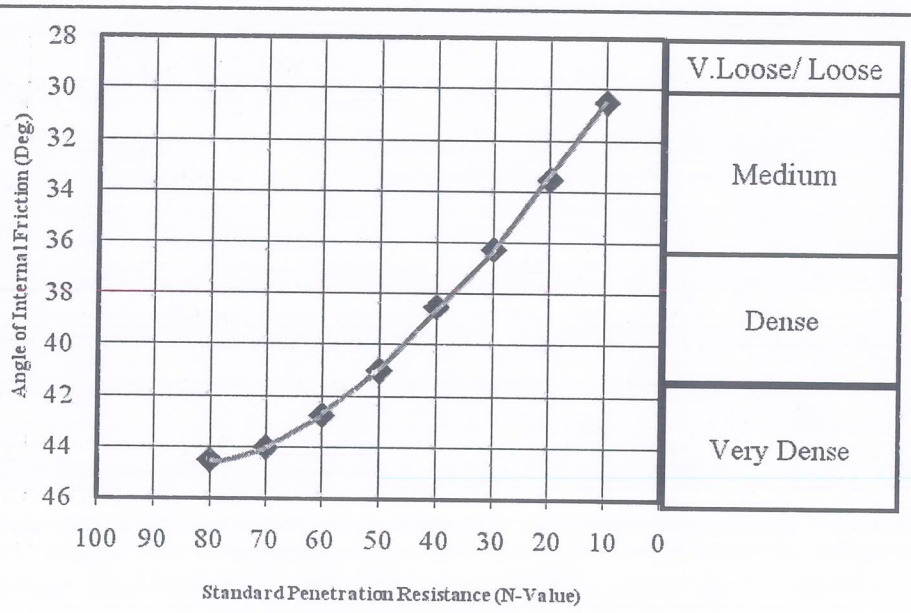


FIG. A1 Relation Ship between Angle of Internal Friction & N-value (Reproduced from IS:6403-1981)

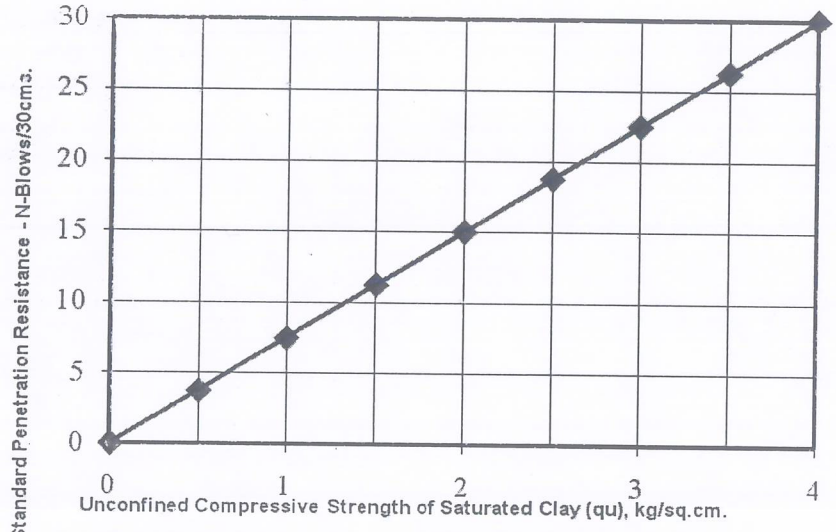
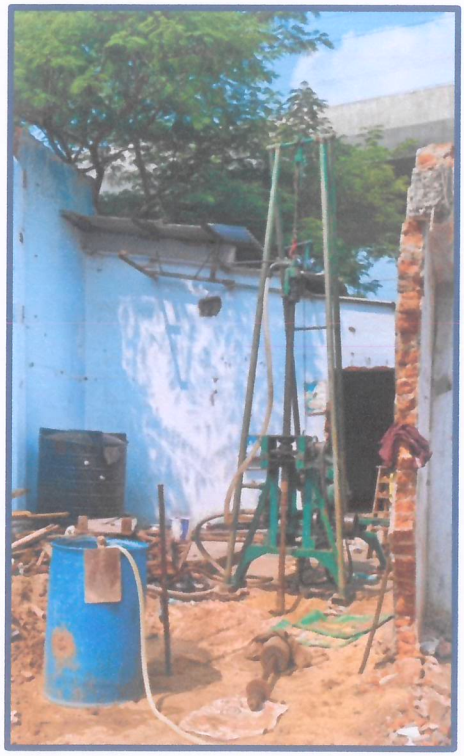


FIG. A2 : Relationship between UCC & SPT-Value (N) of Saturated Clay (AfterTerzhagi & Peck, 1948)

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ANNEXURE-II







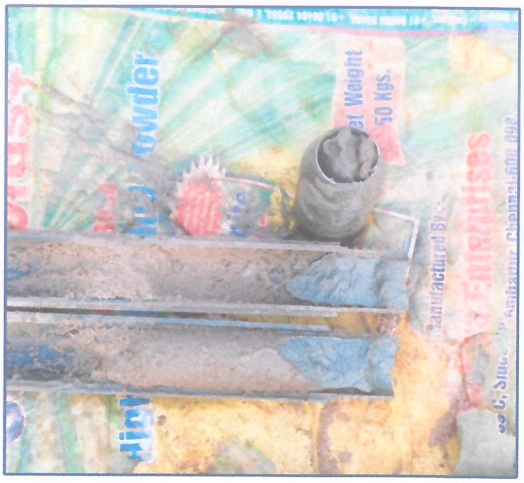
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FIG-1.0 FIELD INVESTIGATION BORE HOLE LOCATIONS











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FIG-2.0 FIELD INVESTIGATION SOME OF SPT SAMPLES PHOTOS



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