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GEO ENGINEERINGCONSULTANTS

(An ISO 9001:2015 Certified Company)

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PROJECT NAME

PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING (STILT+5 UPPER FLOORS) AT MADIPAKKAM, CHENNAI.

CLIENTNAME

UPSTAY BUILDER PVT LTD.,
NPL DEVI, 111, LATTICE BRIDGE ROAD,
THIRUVANMIYUR,
CHENNAI - 600 041.

TITLE

GEOTECHNICAL INVESTIGATION REPORT

GEO ENGINEERING CONSULTANTS
G. MANOJ KUMAR
DDTC - No: GTE/TVLR/01/2019
CMDA No: GTE/19/03/012
IInd Floor, No.15, Murphy Das Street,
Dr. Seethapathy Nagar, Velachery,
Chennai - 600 042

PROJECT NO: GEC-JC-GT-5022/2023-2024

DATE:22/06/2023

CONTENTS

REPORT TEXT

CHAPTER-1

INTRODUCTION

1.0 Project Information Matrix

Nature of project	: Proposed Residential Building (Stilt + 5 Upper Floors)
Project Client	: **M/s UPSTAY BUILDER PVT LTD.,**
Project Location	: Madipakkam, Chennai
Job Code	: GEC-JC-GT-5022

1.1 Scope Of Work

1.1.1 Field Work

- Conducting three soil investigation bore holes of 150 mm& NX diameter up to 7.0m depth or up to the refusal strata with SPT>100
- Conducting Standard Penetration Test (SPT) within the borehole at every 1.0m depth interval up to 5.0m and thereafter at every 1.5m up to the 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

CHAPTER-2

INVESTIGATION METHODOLOGY & TEST RESULTS

2.0 Preamble:

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

2.1 Methodology of Field Work:

2.1.1 Equipment Used and Method of Drilling:

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

2.1.2 Standard Penetration Tests:

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

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

2.1.3 Collection of Soil Samples:

2.1.3.1 Disturbed Samples:

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

2.1.4 Collection of Ground Water Samples:

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

Note on Groundwater Table Record:

- Groundwater table observation in geotechnical report is predominantly to arrive at foundation design criteria and shall not be construed as design guidelines for the design of dewatering systems
- The groundwater level indicated in the bore logs is specific to the duration of investigation and intensity of the monsoon rains during the time of investigation.

Hence, the level shall be taken as guidelines only to plan the investigation for the dewatering system

- ❖ No foundation excavation or basement excavations if anticipated within the groundwater table zone shall be carried out without implementing groundwater lowering schemes

2.2 Laboratory testing:

2.2.1 On Coarse Grained Soil

On the representative samples, sieve analysis tests were conducted to arrive at grain size distribution. These tests were conducted as per I.S.2720 (part 4)-1985 and the results are presented in Tables-2.1 to 2.3. 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 2.9.

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 - 2.4.

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.

SOIL PROFILE

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-01		
SHEET	1	OF	1
PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING AT MADIPAKKAM,CHENNAI.	DIA OF BORE HOLE	150mm ✓ / NX
LOCATION	Madipakkam,Chennai	MACHINE No.	CR-01
CHAINAGE (m)	-	BORE START DATE	14/06/2023
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary
CO-ORDINATES	N -	BORE END DATE	14/06/2023
JOB CODE	JC-GT-5022	FLUSHING MEDIUM	Bentonite
CO-ORDINATES	E -	TOTAL DRILL DAYS	1

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	14/06/2023	15	36	SC	-	-	-	-	-	-	1.00	1	SS	-1.0		L1	1.5	**Filled Up Soil** (Clayey Sand and Bricks)
		To																
		15	39															
		15	47	SC	-	-												
2		To					1	2	2	4	2.00	2	SS	-2.0				
		15	50								2.45							
		15	58															Greyish Brown, Moist, Soft,**Silty CLAY (CH)**, Clays of High Plasticity
		To		SC	-	-										L2	3.0	
3		16	02				2	3	4	7	3.00	3	SS	-3.0				
		16	12								3.45							Greyish, Moist, Medium Stiff, **Sandy Silty CLAY (CI),** Clays of Medium Plasticity
		To		SC	-	-										L3	3.8	
		16	15															
4		16	25				SPT Hammer Rebounded			>100	4.00	4	WS	-4.0				
		To		SC	-	-												Pale Brownish/ Dark Greyish/ Brownish Grey, Moist, Very Dense, **Completely Weathered Rock** Descented from Charnockite
		16	27													L4	5.0	
5		16	37				SPT Hammer Rebounded			>100	5.00	5	WS	-5.0				
		To		DB	4	-												Brownish Grey, **Highly Weathered Rock** Descented from Charnockite
		17	08													L5	6.0	
6		17	18				-	-	-	-	6.00	6	CS	-6.0				
		To		DB	17	-												Brownish Grey, **Moderately Weathered Rock** Descented from Charnockite
		17	45													L6	7.0	
7							-	-	-	-	7.00	7	CS	-7.0				
8																		
9																		
10																		

CS - Core Sample	DS - Disturbed Sample	LOGGED	N.PANDIARAJAN	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	14/06/2023	GROUND LEVEL (m)	0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Jaleel Yasin	WATER TABLE (m)	0.40	
WS - Wash Sample	DB - Diamond Bit	DATE	22/06/2023	CASING DEPTH (m)	0.00	

Borehole terminated at 7 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	1
PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING AT MADIPAKKAM,CHENNAI.	DIA OF BORE HOLE	150mm ✓ / NX
LOCATION	Madipakkam,Chennai	MACHINE No.	CR-01
CHAINAGE (m)	-	BORE START DATE	15/06/2023
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary
CO-ORDINATES	N -	BORE END DATE	15/06/2023
JOB CODE	JC-GT-5022	FLUSHING MEDIUM	Bentonite
CO-ORDINATES	E -	TOTAL DRILL DAYS	1

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	15/06/2023	08	00 To 08 04	SC	-	-	-	-	-	-	1.00	1	SS	-1.0		L1	1.5	**FilledUp Soil** (Sand and Bricks)
2		08	12 To 08 15	SC	-	-	2	2	2	4	2.00 – 2.45	2	SS	-2.0		L2	3.0	Greyish Brown, Moist, Soft,**Silty CLAY (CH)**, Clays of High Plasticity
3		08	23 To 08 27	SC	-	-	3	4	4	8	3.00 – 3.45	3	SS	-3.0		L3	3.8	Pale Brownish Grey, Moist, Medium Stiff, **Sandy Silty CLAY (CI)**, Clays of Medium Plasticity
4		08	37 To 08 41	SC	-	-	2cm Penet. For 50Blows			>100	4.00 – 4.02	4	WS	-4.0		L4	5.0	Greyish, Moist, Very Dense, **Completely Weathered Rock** Descented from Charnockite
5		08	51 To 08 53	SC	-	-	SPT Hammer Rebounded			>100	5.00	5	WS	-5.0		L5	6.0	Brownish Grey, **Highly Weathered Rock** Descented from Charnockite
6		09	03 To 09 31	DB	5	-	-	-	-	-	6.00	6	CS	-6.0		L6	7.0	Brownish Grey, **Moderately Weathered Rock** Descented from Charnockite
7		09	43 To 10 13	DB	15	-	-	-	-	-	7.00	7	CS	-7.0				
8																		
9																		
10																		

CS - Core Sample	DS - Disturbed Sample	LOGGED	N.PANDIARAJAN	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	15/06/2023	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Jaleel Yasin	WATER TABLE (m) 0.40	
WS - Wash Sample	DB - Diamond Bit	DATE	22/06/2023	CASING DEPTH (m) 0.00	

Borehole terminated at 7 m depth below E.G.L

FIG.2.2 Sub Soil Profile at BH-02 Location

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-03		
SHEET	1	OF	1
DIA OF BORE HOLE	150mm ✓	NX	
BORE START DATE	15/06/2023		
BORE END DATE	15/06/2023		
TOTAL DRILL DAYS	1		

PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING AT MADIPAKKAM,CHENNAI.						
LOCATION	Madipakkam,Chennai	MACHINE No.	CR-01	CHAINAGE (m)	-		
STRUCTURE	Stilt+5 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N	-	
JOB CODE	JC-GT-5022	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	Blows/cm. 15-30	Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
0	15/06/2023	11	30	SC	-	-												
		To																
		11	34															
1							-	-	-	-	1.00	1	SS	-1.0				**FilledUp Soil** (Sand and Bricks)
		11	42								1.45					L1	1.5	
		To		SC	-	-												
		11	45															
2							1	2	2	4	2.00	2	SS	-2.0				Greyish Brown, Moist, Soft, **Silty CLAY (CH)**, Clays of High Plasticity
		11	53								2.45							
		To		SC	-	-												
		11	57															
3							3	3	4	7	3.00	3	SS	-3.0		L2	3.0	
		12	07								3.45							Pale Brownish Grey, Moist, Loose, Poorly Graded, **Clayey Silty SAND (SC)** Sand-Clay mixtures
		To		SC	-	-										L3	3.8	
		12	11															
4							3cm Penet. For 50Blows			>100	4.00	4	WS	-4.0				Greyish, Moist, Very Dense, **Completely Weathered Rock** Descented from Charnockite
		12	21								4.03							
		To		SC	-	-												
		12	24															
5							SPT Hammer Rebounded			>100	5.00	5	WS	-5.0				
		12	34															
		To		SC	-	-												
		12	37															
6							SPT Hammer Rebounded			>100	6.00	6	WS	-6.0		L4	6.0	
		12	47															
		To		DB	12	-												Brownish Grey, **Moderately Weathered Rock** Descented from Charnockite
		13	20													L5	7.0	
7							-	-	-	-	7.00	7	CS	-7.0				
8																		
9																		
10																		

CS - Core Sample	DS - Disturbed Sample	LOGGED	N.PANDIARAJAN	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	15/06/2023	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Jaleel Yasin	WATER TABLE (m) 0.40	
WS - Wash Sample	DB - Diamond Bit	DATE	22/06/2023	CASING DEPTH (m) 0.00	

Borehole terminated at 7 m depth below E.G.L

FIG.2.3 Sub Soil Profile at BH-03 Location

Grain Size Distribution Curves

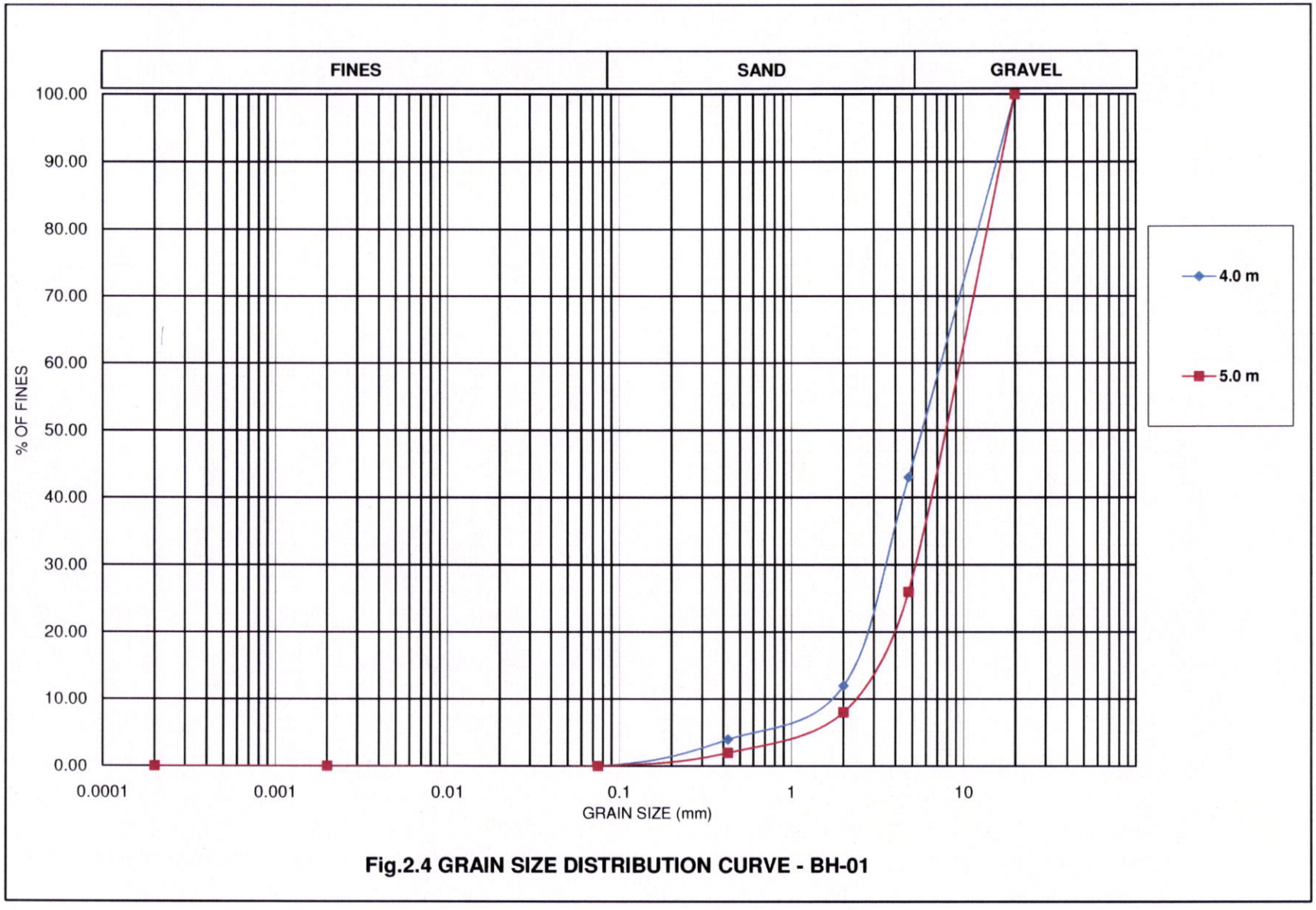

Fig.2.4 GRAIN SIZE DISTRIBUTION CURVE - BH-01

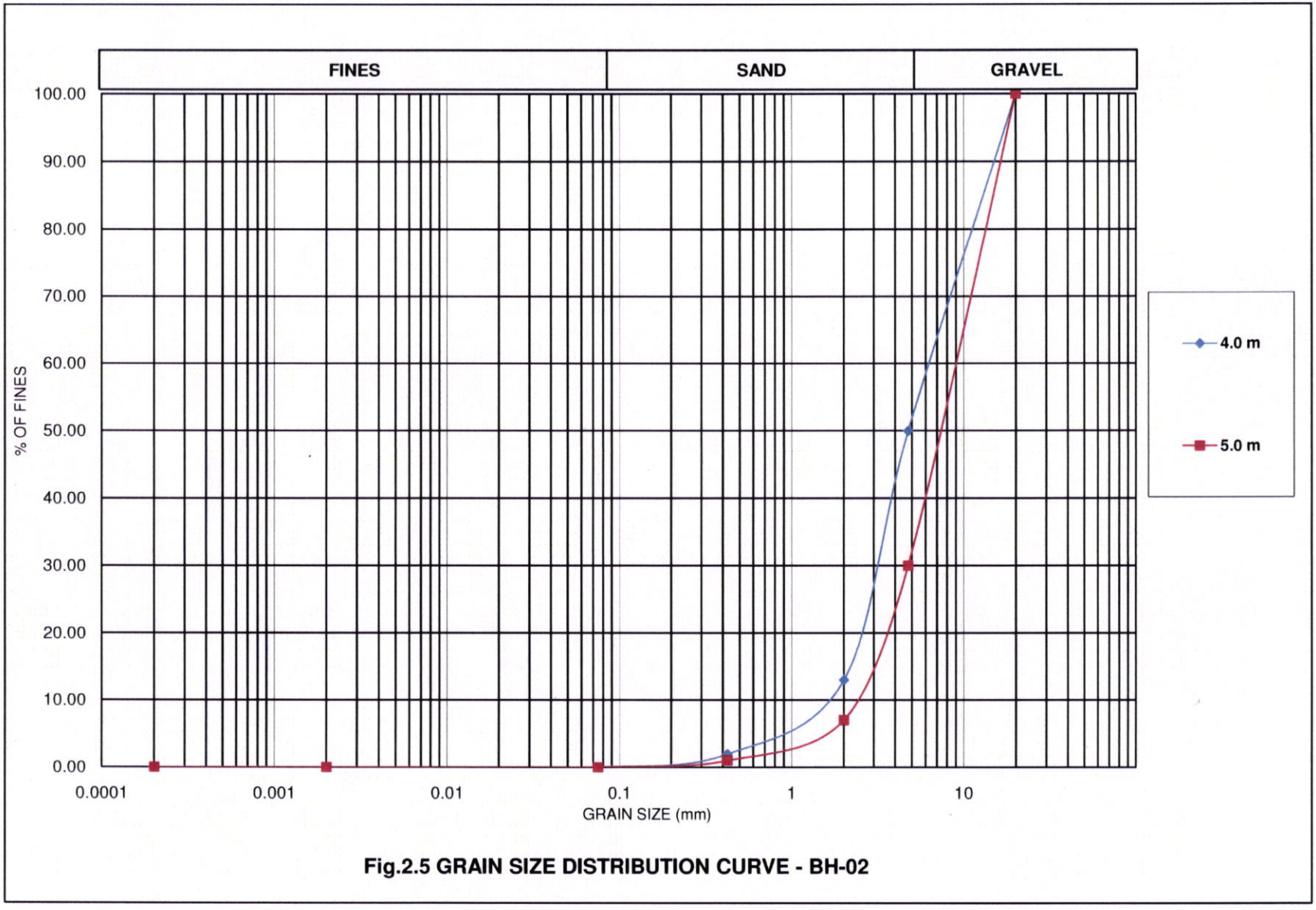

Fig.2.5 GRAIN SIZE DISTRIBUTION CURVE - BH-02

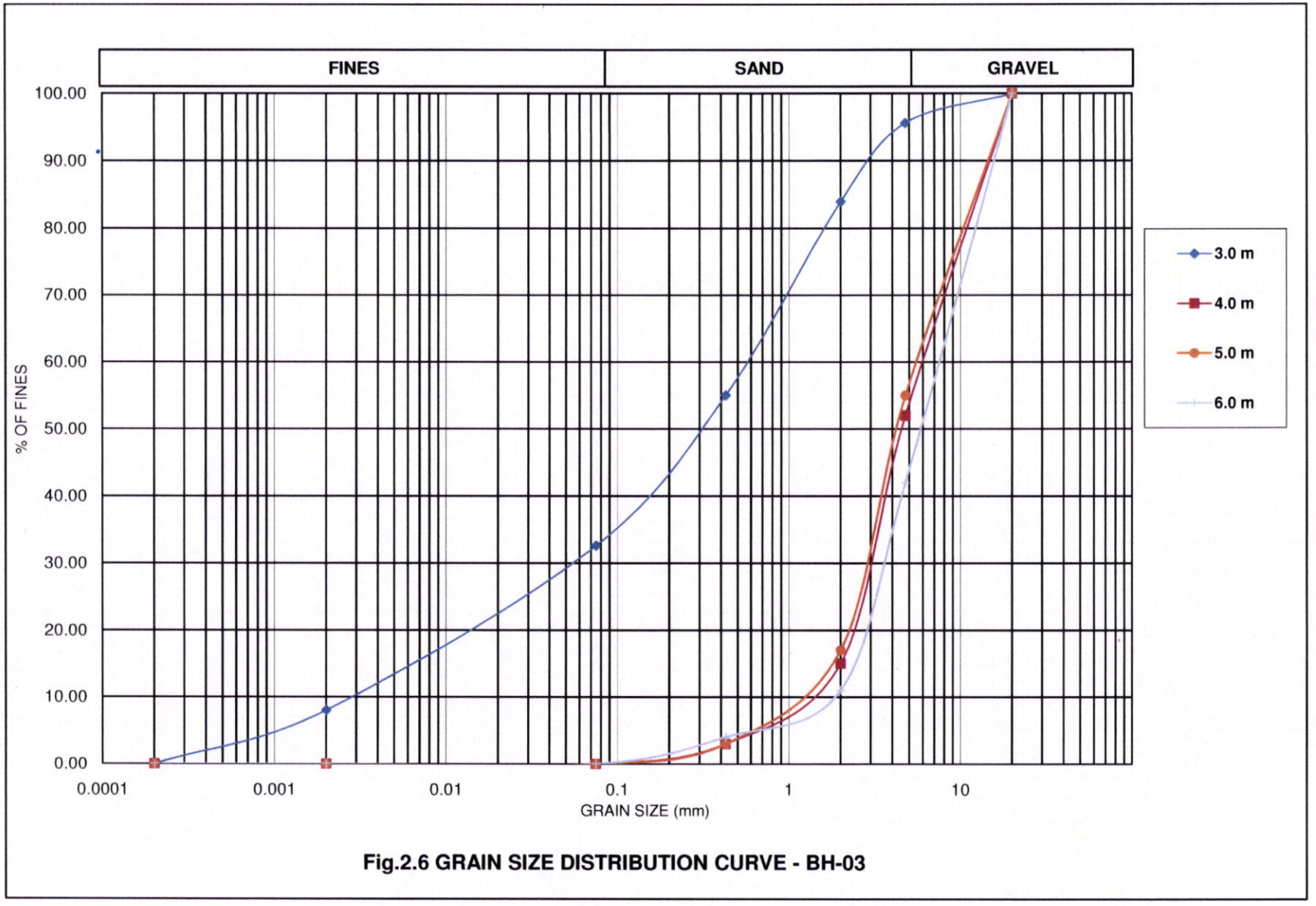

Fig.2.6 GRAIN SIZE DISTRIBUTION CURVE - BH-03

HYDROMETER ANALYSIS CURVE

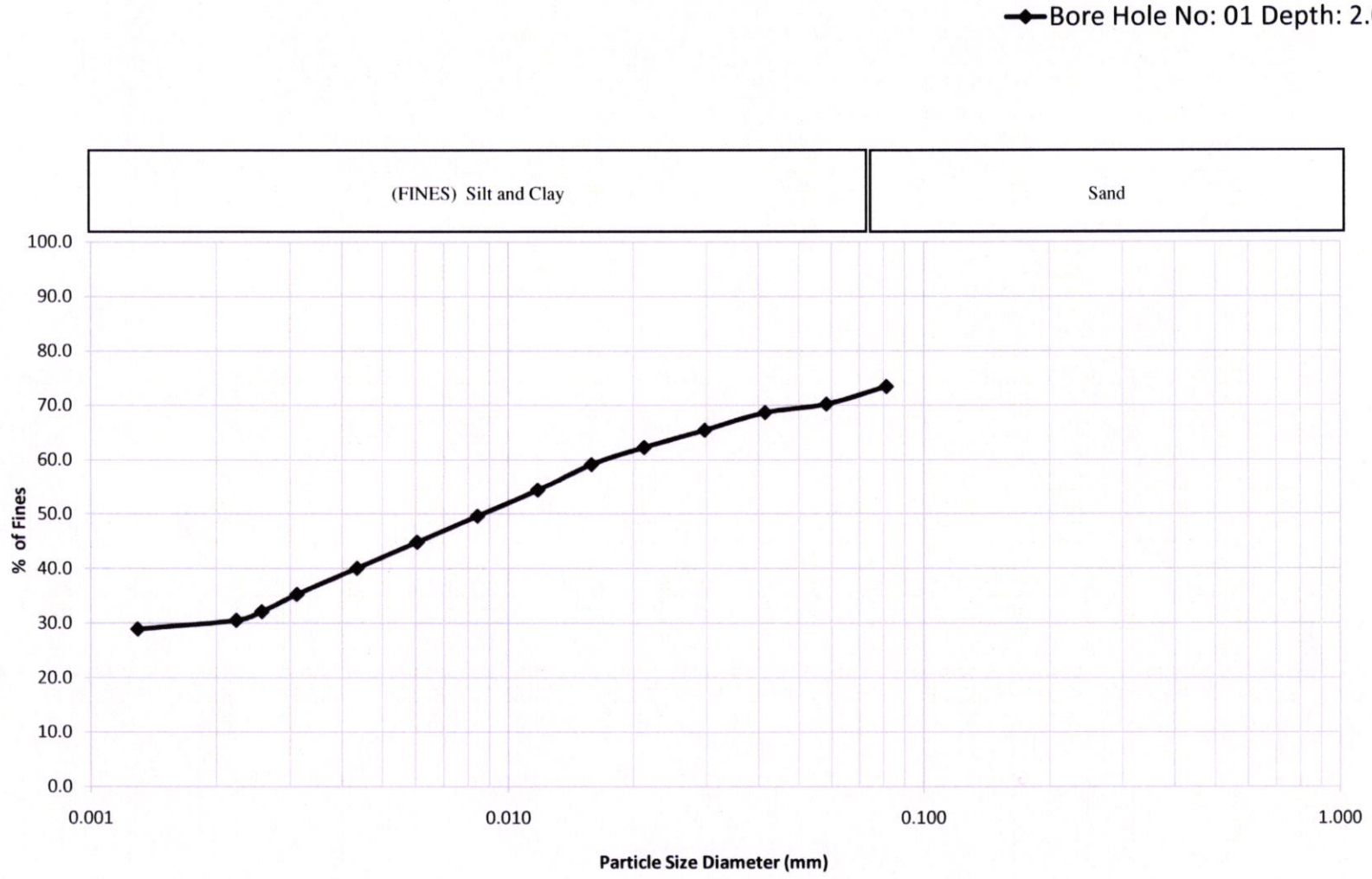

Fig 2.7 Hydrometer Analysis Master Curve

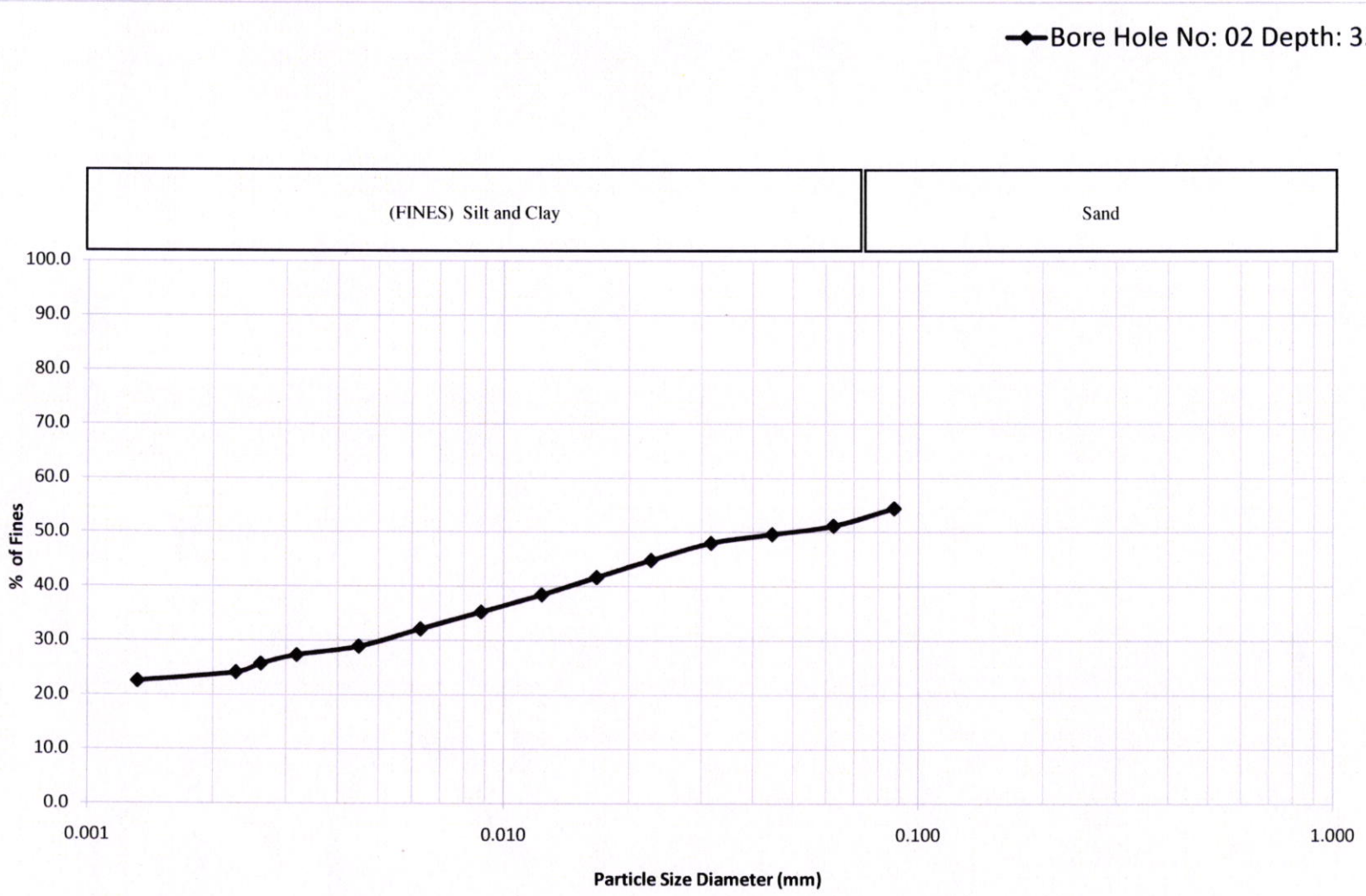

Fig 2.8 Hydrometer Analysis Master Curve

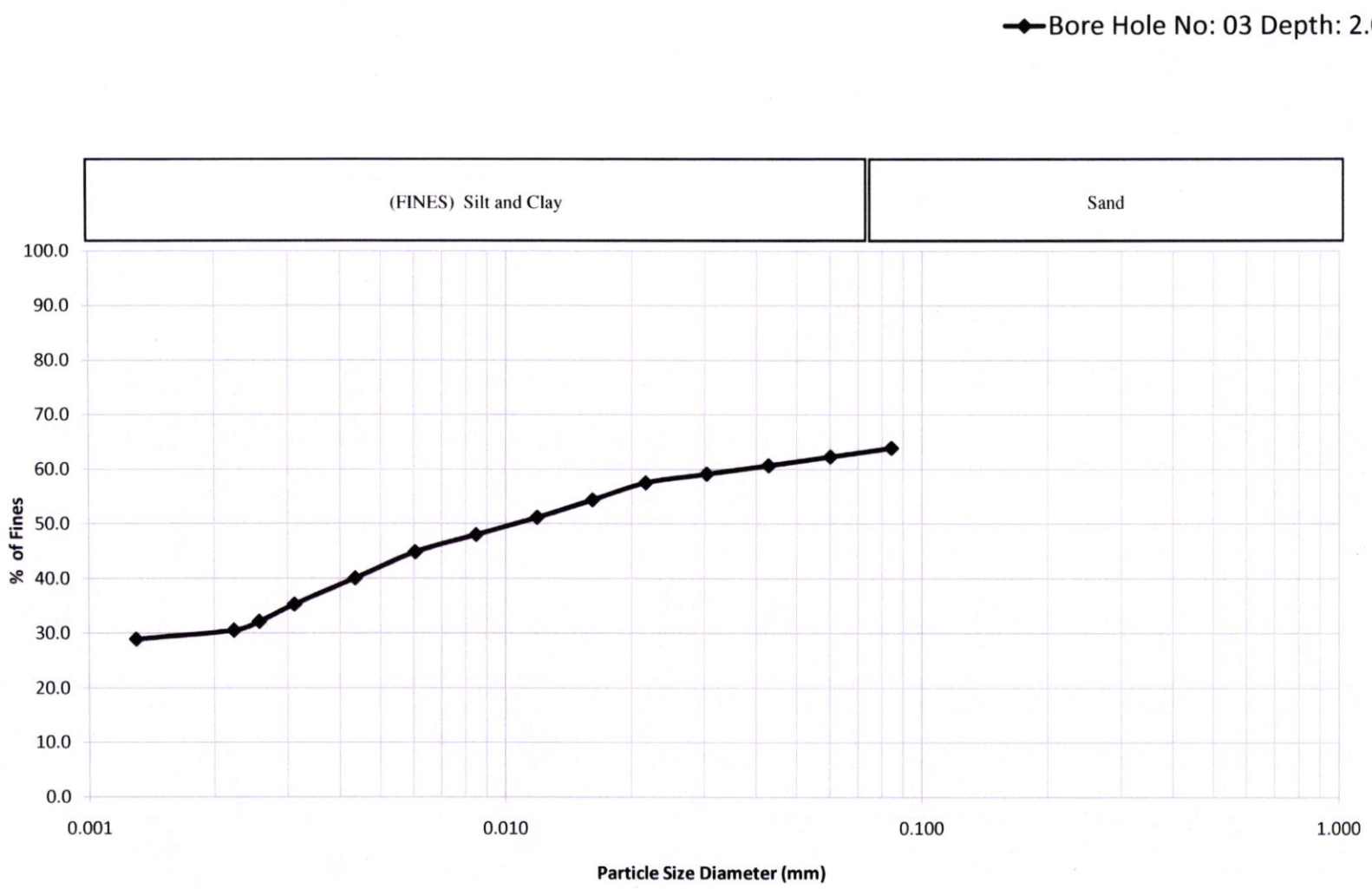

Fig 2.9 Hydrometer Analysis Master Curve

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
2.0	4	SS	48	70	24	46	0.48	10	85	Soft	Above	CH	-	-	-	-	72	28	-	-	-	-	-	FG>50%	FG>50%	FG>50%
3.0	7	SS	25	41	18	23	0.70	13	63	M.Stiff	Above	CI	8	1	19	13	39	20	-	-	-	-	-	FG>50%	FG>50%	FG>50%
4.0	>100	WS	-	-	-	-	-	-	-	CG>50%	-	-	57	31	8	4	0	0	-	-	-	-	-	V.Dense	GP	<50%
5.0	>100	WS	-	-	-	-	-	-	-	CG>50%	-	-	74	18	6	2	0	0	-	-	-	-	-	V.Dense	GP	<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 Frees Well Index
C_U = Uniformity Coefficient
C_C = Coefficient of Curvature
IP=LL-PL

LAB IN-CHARGE	M.PRAVEEN
REVIEWED BY	JALEEL YASIN

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	
			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
2.0	4	SS	48	68	26	42	0.48	10	82	Soft	Above	CH	-	-	-	-	71	29	-	-	-	-	-	FG>50%	FG>50%	FG>50%
3.0	8	SS	25	48	22	26	0.88	13	78	Stiff	Above	CI	3	4	13	15	42	23	-	-	-	-	-	FG>50%	FG>50%	FG>50%
4.0	>100	WS	-	-	-	-	-	-	-	CG>50%	-	-	50	37	11	2	0	0	-	-	-	-	-	V.Dense	GP	<50%
5.0	>100	WS	-	-	-	-	-	-	-	CG>50%	-	-	70	23	6	1	0	0	-	-	-	-	-	V.Dense	GP	<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 Frees Well Index
C_U = Uniformity Coefficient
C_C = Coefficient of Curvature
IP=LL-PL

LAB IN-CHARGE	M.PRAVEEN
REVIEWED BY	JALEEL YASIN

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
2.0	4	SS	55	70	27	43	0.35	11	64	Soft	Above	CH	-	-	-	-	72	28	-	-	-	-	-	FG>50%	FG>50%	FG>50%
3.0	7	SS	24	34	16	18	0.56	18	22	CG>50%	Above	-	4	12	29	17	30	8	-	-	-	-	-	Loose	<50%	SC
4.0	>100	WS	-	-	-	-	-	-	-	CG>50%	-	-	48	37	12	3	0	0	-	-	-	-	-	V.Dense	<50%	SP
5.0	>100	WS	-	-	-	-	-	-	-	CG>50%	-	-	45	38	14	3	0	0	-	-	-	-	-	V.Dense	<50%	SP
6.0	>100	WS	-	-	-	-	-	-	-	CG>50%	-	-	58	31	7	4	0	0	-	-	-	-	-	V.Dense	GP	<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 Frees Well Index
C_U = Uniformity Coefficient
C_C = Coefficient of Curvature
IP=LL-PL

LAB IN-CHARGE	M.PRAVEEN
REVIEWED BY	JALEEL YASIN

Table-2.4 Results of Chemical Analysis									
SL No.	Bore HoleNo.	Water				Soil (2:1)			
		Depth of Sample (m)	pH	Chlorides (mg/l)	Sulphates (mg/l)	Depth of Sample (m)	pH	Chlorides (mg/l)	Sulphates (mg/l)
1	BH-01	0.40	7.66	>2500	1461	3.0	7.42	>2500	1235
2	BH-03	0.40	7.66	>2500	1389	3.0	7.42	>2500	1211

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)

Formation Characteristics:

The present location falls under Madipakkam, Chennai, geologically it is classified as recent alluvium deposits consisting of Silty Clay/Clayey Silty Sand, which is underlain with basement rock.

Recent Clays/Sand (Alluvium Deposits)

---------- Eparchean Unconformity ----------

Archaean Basement Rock (Charnockite Rock / Hypersthene Granite)

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

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

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

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

REFERENCE BORE HOLE-BH:					01	Ref R.L. of G.L. (m):			0.00		
Layer No.	Layer Thk. (m)			Type of Strata	Colour	Ave. Design SPT	Relative Density	Consistency	(γ) kN/m^3	Shear Parameters	
	Top. R.L.	Bot. R.L.	Thickness							(C_u) kPa	(ϕ) Deg.
1	0.00	1.50	1.50	FilledUp Soil	-	-	-	-	-	-	-
2	1.50	3.00	1.50	Silty Clay	Greyish Brown	4	-	Soft	14.5	27	-
3	3.00	3.80	0.80	Sandy Silty Clay	Greyish	7	-	Medium Stiff	16	47	-
4	3.80	5.00	1.20	Completely Weathered Rock	Pale Brownish	>100	Very Dense	-	21	-	42.5
5	5.00	6.00	1.00	Highly Weathered Rock	Brownish Grey	CRR-4%, RQD-0%					
6	6.00	7.00	1.00	Moderately Weathered Rock	Brownish Grey	CRR-17%, RQD-0%					

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

REFERENCE BORE HOLE-BH:					02	Ref R.L. of G.L. (m):			0.00		
Layer No.	Layer Thk. (m)			Type of Strata	Colour	Ave. Design SPT	Relative Density	Consistency	(γ) kN/m^3	Shear Parameters	
	Top. R.L.	Bot. R.L.	Thickness							(C_u) kPa	(ϕ) Deg.
1	0.00	1.50	1.50	FilledUp Soil	-	-	-	-	-	-	-
2	1.50	3.00	1.50	Silty Clay	Greyish Brown	4	-	Soft	14.5	27	-
3	3.00	3.80	0.80	Sandy Silty Clay	Pale Brownish Grey	8	-	Medium Stiff	16.5	53	-
4	3.80	5.00	1.20	Completely Weathered Rock	Greyish	>100	Very Dense	-	21	-	42.5
5	5.00	6.00	1.00	Highly Weathered Rock	Brownish Grey	CRR-5%, RQD-0%					
6	6.00	7.00	1.00	Moderately Weathered Rock	Brownish Grey	CRR-15%, RQD-0%					

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

REFERENCE BORE HOLE-BH:					03	Ref R.L. of G.L. (m):			0.00		
Layer No.	Layer Thk. (m)			Type of Strata	Colour	Ave. Design SPT	Relative Density	Consistency	(γ) kN/m^3	Shear Parameters	
	Top. R.L.	Bot. R.L.	Thickness							(C_u) kPa	(ϕ) Deg.
1	0.00	0.50	0.50	Filled Up Soil	-	-	-	-	-	-	-
2	0.50	2.00	1.50	Silty Clay	Greyish Brown	4	-	Soft	14.5	27	-
3	2.00	3.80	1.80	Clayey Sand	Pale Brownish Grey	7	Loose	-	21	-	42.5
4	3.80	6.00	2.20	Completely Weathered Rock	Greyish	>100	Very Dense	-	21	-	42.5
5	6.00	7.00	1.00	Highly Weathered Rock	Brownish Grey	CRR-12%, RQD-0%					

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

FOUNDATION SYSTEM

CHAPTER-4

FOUNDATION SYSTEM

4.0 Preamble:

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

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

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

4.1 Proposed Structures

An understanding of the proposed construction and the order of loads on the foundations is needed for choosing the appropriate foundation system. In the present case, the proposed structure is configured with stilt and five upper floors, and is meant for commercial use. For this kind of structure, the column loads could vary between 2,000kN to 2,500kN. 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

The sub soil stratification consists of the following soil layers:

0.0m to 1.5m	:	Filled Up Soil
1.5m to 3.0m	:	Soft Silty Clay
3.0m to 3.8m	:	Stiff Sandy Silty Clay/Loose Clayey Silty Sand
3.8m to 6.00	:	Very Dense Completely to Highly Weathered Rock
6.00m to 7.0m	:	Moderately Weathered Rock

During the time of investigation (2nd Week of Jun 2023) the ground water table is observed to be at 0.4m below the existing ground level.

4.3 Foundation System

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

The piles can be installed by drilling with direct mud circulation technique **(Bored Cast In-situ Piles)** and the recommended safe load carrying capacity of bored cast in-situ piles in compression, tension and lateral for different 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 with Rock Scoketing

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)	Rock Socket	Depth of Rock Socketing (m)	Total Length of Pile (m)	Length of Pile Below Cutoff (m)	SAFE LOAD CARRYING CAPACITY (kN)		
									Vertical Load Carrying Capacity	Pull Out Capacity	Lateral Load Carrying Capacity
1	BH-03	5.5	0.5	450	1D	0.5	6.0	5.5	600	200	23
2				500		0.5	6.0	5.5	750	250	25
3				550		0.6	6.1	5.6	900	275	28
4				600		0.6	6.1	5.6	1100	350	30
5				650		0.7	6.2	5.7	1250	400	33

D=Diameter of the Pile

Note:

1.0 As per IS:14593 Table-1.0 Suggested Minimum Length of Socket (Clause 6.5.1) Sound relatively homogeneous rock igneous rock including including granite, gneiss 1D to 2D. In the present proejct site is Igneous rock formation we recommended socket length 1D.

2.0 The above load carrying capacities are valid only recommended socket length should be achieved.

3.0 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.

RECOMMENDATIONS

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 2.0m to 3.0m 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 was prepared using sodium bentonite with a density of 1.10 to 1.15 g/cc.

5.2 General Recommendation:

- Since, the chloride levels are more than the permissible limits, the reinforcement in all substructure construction shall be of corrosion resistant steel or steel with epoxy based anticorrosion paint.
- Recommendations of the type of cement used for the construction of substructure with chloride and sulphate concentration in soil & water as per IS: 456-2000 is presented in Table 5.1

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5.3 Special Recommendations

- Since, the sub soil strata is soft clay layer top 3.0m depth below ground level. The soft layer will affect when the pile boring of sub soil is necking and bulging factor upon the installation of pile, due to Lateral soil expansion. hence, in order to assure quality of the pile, it is ideal to carryout pile integrity test on all piles.

FOR GEO ENGINEERING CONSULTANTS, CHENNAI

AUTHORIZED SIGNATURE

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ANNEXURE

Table-5.1 Recommendations of the Type of Cement used for the Construction of Substructure along with extract of permissible limits as per IS: 456-2000							
Concentration of Sulphates expressed as SO_3				Type of Cement	Cement Content (kg/m^3)	Max. Water-Cement Raio	Recommended Cement
In 2:1 water Soil		In Ground Water					
g/l	ppm	g/l	ppm				
<1	<1000	<0.3	<300	OPC/PPC/PSC	280	0.55	
1 to 1.9	1000-1900	0.3-1.2	300-1200	OPC/PPC/PSC	330	0.5	Recommended
				SSC/SRPC	310	0.5	
1.9 to 3.1	1900-3100	1.2-2.5	1200-2500	SSC/SRPC	330	0.5	
				PPC/PSC	350	0.45	
3.1-5	3100-5000	2.5-5	2500-5000	SSC/SRPC	370	0.45	
>5	>5000	>5	>5000	SSC/SRPC	400	0.4	
Where chloride is encountered along with sulphates in soil or ground water, ordinary portland cement with C_3A content form 5 to 8 percent shall be desirable to be used in concrete, instead of sulphate resisting cement. Alternatively, Portland slag cement conformng to IS 455 having more than 50 percent slag or a blend of ordinary portland cement and slag may be used provided sufficent information is available on performance of such blended cements in these conditions.							Recommended

OPC	Oridnary Port Land Cement	SSC	Supersulphated Cement
PPC	Portland Pozzolana Cement	SRPC	Sulpahte Resistant Port Land Cement
PSC	Portland Slag Cement		

NOTES:

However, the structural consultant shall refer the notes below Table-4, page-19 of IS:456-2000 for any required additional information on the use of cement for the construction of substrucutre.

ESTIMATION OF SAFE LOAD CARRYING CAPACITY OF BORED CAST-INSITU PILES																		As Per IS:2911-(P-I,S-2)-2010		
Type of Pile				Bored	Diameter of Pile					Length of Pile below E.G.L.(m)				5.5				Excluding rock socket depth		
Reference Bore Hole				BH-3						500	mm	Surcharge Pressure						0	kPa	
Layer No.	Layer Thk. (m)			Type of Strata	Ave. SPT	(γ) kN/m³		Shear Parameters		Effective Overburden Pressure (kPa)			Adhesion Factor (α)	Earth Pressure Coefficient (k)	Skin Friction (Q_f) kN					
	Top. R.L.	Bot. R.L.	Thickness			of Layer	Ave. upto Layer	(C_u) kPa	(φ) Deg.	At top of Layer	At Bot. of Layer	At Mid. of Layer								
1	0	0.5	0.5	Cut-Off Level for single basement floor																
2	0.5	3	2.5	Clay	4	14.5	14.5	27	-	0.0	11.3	5.6	1.0	-	qf	2	106.0			
3	3	3.8	0.8	Sand	8	14.5	14.5	-	29.6	11.3	14.9	13.1	-	1.0	qf	3	9.3			
4	3.8	5.5	1.7	Weathered Rock	60	20.5	17.5	-	42.5	14.9	32.7	23.8	-	1.5	qf	4	87.4			
Summation of Positive Skin Resitance (kN) Q_f= 202.72																				
Summation of Negative Skin Resistance (kN) -Qf= 0.00																				

Computation of End Bearing Resistance and Socketing Capacity (Cole and Stroud Method)

Type of Strata: Highly Weathered Rock		**Allowable Safe Pull out Capacity**	$Q_{A\text{-}pull}$: Qf/3 (kN) 67.57
Diameter of the Pile (D):	0.50 m		
Shear Strenght of Rock at Pile Tip (Grade-D, Ref Figure-3, Page No. 13, IS 2911/1/2-2010) (Cu_1):	900 kN/m^2		
Bearing Capacity Factor (Nc), Ref B-8, Page No.13, IS 2911/1/2-2010:	9.0		
Cross Sectional Area of Pile Toe (A_p):	0.2 m^2		
Factor of Safety (Fs):	**3.0**		
Safe End Bearing Capacity ($QEnd=C_{u1}NcAp/Fs$):	**530.14 kN**		

Computation of Rock Socket Capacity

Type of Strata: Highly Weathered Rock	
Diameter of the Pile (D):	0.50 m
Shear Strenght of Rock in the Socketed Length (Grade-D, Ref Figure-3, Page No. 13, IS 2911/1/2-2010)(Cu_2):	800 kN/m^2
α:	0.90
Socket Length into the rock 1D (L):	**0.5 m**
Factor of Safety (Fs):	**3.0**
Safe Socketing Capacity ($QSoc= \alpha C_{u2}\pi DL/Fs$):	**188.50 kN**

Safe Load Capacity ($Qs=Q_{end}+Q_{soc}+Q_{fric}$)	**786.00 kN**
Safe Load Capacity of Pull out:	**256.07 kN**

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

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)

d=Dia. Of Pile
α=Adhession Factor
T_l=Thickness of Layer

LATERAL LOAD CARRYING CAPACITY OF BORED CAST- SITU PILES

Reference Bore Hole : BH-03

1.0 Geometrical Data

Type of Pile Head Considered		Fixed	
Diameter of Pile (d)	:	0.50	m
Free standing Length of Pile (e)	:	0	m
Length of Pile below E.G.L (Le)	:	6.0	m
Cut-Off Level From E.G.L	:	0.5	
Length of Pile below Cut-Off Level (Le)	:	5.5	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

2.0 Determination of Depth of Fixity

Type of Soil Strata	:	Clay	
Ground Water Condition	:	Submerged	
Average Design SPT "N" Value	:	4	
K=((k1/1.5)*(0.3/B))			
(n can be read as η in the above and below equation in case of Sand)			
K1=	:	9000	kN/m^3
K=	:	3600	kN/m^2
R=	:	2.55	
L1/R	:	0.00	
Lf/R	:	2.20	
Depth of Fixity below Cut off (z_f)	:	5.62	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	:	25.91	kN
Recommended Design Lateral Load carrying Capacity	:	**25**	**kN**
Fixed End Moment,M_F=H(e+z_f)/2		73	
Reduction Factor (L_1/T)	:	0.67	m
Actual Moment (Fixed End Moment/Reduction Factor),M_F		**49**	kN-m

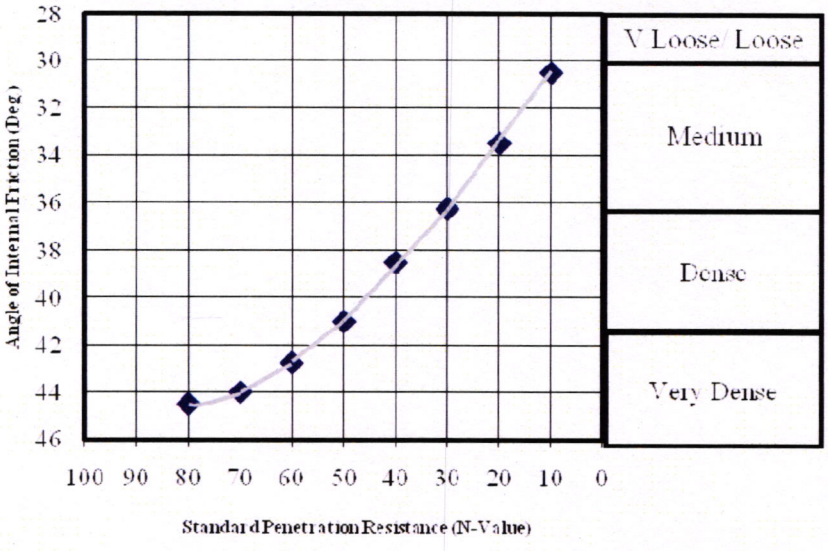

FIG. A1 Relation Ship between Angle of Internal Friction & N-value (Reproduced from IS:6403-1981)

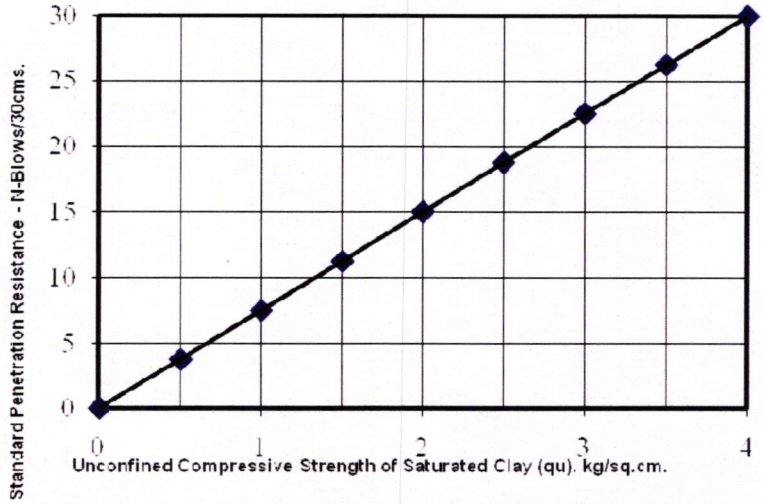

FIG. A2 : Relationship between UCC & SPT-Value (N) of Saturated Clay (AfterTerzhagi & Peck, 1948)

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