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PROJECT

PROPOSED CONSTRUCTION OF RESIDENTIAL ETICA MALARVIZHI APARTMENT
(STILT+9 UPPER FLOORS) AT NO.149/96, KARPAGAM AVENUE, SANTHOME HIGH
ROAD, MRC NAGAR, RAJA ANNAMALAIPURAM, CHENNAI.

CLIENT NAME

ETICA DEVELOPERS,
RAJA ANNAMALAIPURAM,
CHENNAI - 600 028

TITLE

GEOTECHNICAL INVESTIGATION REPORT

PROJECT NO: GEC-JC-GT-4094-A/2022-2023

REPORTING DATE: 18/01/2023



For ETICA DEVELOPERS PVT. LTD.

Managing Director.

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CHAPTER-1

INTRODUCTION

1.0 Project Information Matrix

Nature of project	: Proposed Residential Apartment (Stilt+9 Upper Floors)
Project Client	: M/s ETICA DEVELOPERS,
Project Location	: MRC Nagar, Chennai.
Job Code	: JC-GT-4084-A

1.1 Scope Of Work

1.1.1 Field Work

- ❖ Conducting four soil investigation bore holes of 150 mm & NX diameter up to 22.0m 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 interval up to 20.0m after that 2.0m interval 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

For ETICA DEVELOPERS PVT. LTD.

Managing Director.



CHAPTER-2

INVESTIGATION METHODOLOGY &
TEST RESULTS**2.0 Preamble:**

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

2.1 Methodology of Field Work:**2.1.1 Equipment Used and Method of Drilling:**

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

2.1.2 Standard Penetration Tests:

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

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

2.1.3 Collection of Soil Samples:**2.1.3.1 Disturbed Samples:**

The SPT-samples collected were used as disturbed soil samples. These samples were used for visual and physical identification and for conducting laboratory classification tests as per IS.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 2.4. The graphical representation of grain size distribution curve for the representative samples in each bore is presented in Fig. 2.5 to 2.8.

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 2.4.

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 - 2.5.

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 2.4.

For ETICA DEVELOPERS PVT. LTD.

Managing Director.

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SOIL PROFILE

SITE INVESTIGATION RECORD		BORE HOLE No. BH-01														
PROJECT NAME		SHEET 1 OF 3														
PROPOSED CONSTRUCTION OF RESIDENTIAL APARTMENT BUILDING AT MRC AGAR		DIA OF BORE HOLE 150mm														
LOCATION	MRC Nagar, Channarayana	DATE	07/01/2023													
STRUCTURE	SNR +8 Upper Floors	BORE END DATE	08/01/2023													
JOBS CODE	GED-JC-GT-4094-A	TOTAL DRILL DAYS	2													
MACHINE No.		CHAINAGE (m)														
DRILLING METHOD		CO-ORDINATES														
FLUSHING MEDIUM		Bentonite														
Depth below G.L. (m)	Drilling progress per meter		Core Details		SPT Details		Sample Details		Layer Data							
	Time	Type of Core Bit (SC / TCB / DB)	Total Core Recovery %	R.O.D %	Blows/cm			Depth	No.	Type	RL (m)	Legend	No.	Depth	Geotechnical Description	
					0-15	15-30	30-45									SPT 'N' Value
1	11:05 To 11:08	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	Filled Up Soil Brownish Clayey Sand with Brick waste
2	11:20 To 11:24	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	Brown/Black, Moist, Loose, Poorly Graded, Silty SAND (SP-SM), Sand-Silt Mixture
3	11:40 To 11:43	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	
4	11:50 To 11:53	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	
5	12:05 To 12:10	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	
6	12:20 To 12:25	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	
7	12:43 To 13:50	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	Brownish, Moist, Medium Dense, Poorly Graded, Silty SAND (SP-SM), Sand-Silt Mixture
8	13:50 To 14:00	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	Brownish, Moist, Very Dense, Poorly Graded, Silty SAND (SP-SM), Sand-Silt Mixture
9	14:00 To 14:10	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	
10	14:10 To 14:20	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	

CS - Core Sample	DS - Disturbed Sample	LOGGED	M. RAJA	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	07/01/2023	GROUND LEVEL (m)	0.00	
UDS - Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	JALEEL YASIN	WATER TABLE (m)	2.00	
WS - Wash Sample	DB - Diamond Bit	DATE	10/01/2023	CASING DEPTH (m)	0.00	

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SITE INVESTIGATION RECORD															BORE HOLE No. BH-01		
PROJECT NAME: PROPOSED CONSTRUCTION OF RESIDENTIAL APARTMENT BUILDING AT MRC AGAR															SHEET: 3 OF 3		
LOCATION: MRC Nagar, Chennai		MACHINE No.		CR-01		CHAINAGE (m)				DIA OF BORE HOLE: 150mm		✓					
STRUCTURE: SRI +8 Upper Floors		DRILLING METHOD: Rotary		CO-ORDINATE: N						BORE START DATE: 07/01/2023							
ID# CODE: GEC-JC-GT-0094-A		FLUSHING MEDIUM: Bentonite								BORE END DATE: 08/01/2023							
										TOTAL DRILL DAYS: 2							
Depth below G.O.L. (m)	Logging progress per metre		Type of Soil (SC / TCB / DB)	Core Details		SPT Details			Sample Details			Layer Data					
	Date	Time		Typical Core Recovery %	R.Q.D %	Blows/cm			Depth	No.	Type	R _L (m)	Legend	No.	Depth	Geotechnical Description	
	10	Min.				0-15	15-30	30-45									SPT 'N' Value
11	12	10	SC	-	-	16	13 cm Penet. for 50 Blows	>100	11.00	9	SS	-11.0					Brownish, Moist, Very Dense, Poorly Graded, Silty SAND (SP-SM) Sand-Silt Mixture
12	14	45	SC	-	-	1	1	2	12.50	10	SS	-12.5					Greyish Black, Moist, Very Loose, Poorly Graded, Clayey SAND (SC) Sand-Clay Mixture
13	14	50							12.95 V								
14	15	20	SC	-	-	1	2	3	14.00	11	SS	-14.0					
15	15	25							14.45 V								
16	15	50	SC	-	-	4	8	12	15.50	12	SS	-15.5					Brownish, Moist, Medium Dense, Poorly Graded, Silty SAND (SM), Sand-Silt Mixture
17	16	20	SC	-	-	16	20	22	17.00	13	SS	-17.0					
18	16	25							17.45 V								
19	16	50	SC	-	-	15	27	32	18.50	14	SS	-18.5					Brownish, Moist, Dense to Very Dense, Poorly Graded, Silty SAND (SP-SM), Sand-Silt Mixture
20	16	50							18.95 V								
21	17	20	SC	-	-												
22	17	28															
							5 cm Penet. for 50 Blows	>100	20.00	15	SS	-20.0					Brownish Grey, Moist, Very Dense, Completely Weathered Rock
									20.05 V								

CS - Core Sample	DS - Disturbed Sample	LOGGED	M. RAJA	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	07/01/2023	GROUND LEVEL (m)	0.00	
UDS - Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	JALEEL YASIN	WATER TABLE (m)	2.00	
WS - Wash Sample	DB - Diamond Bit	DATE	18/11/2023	CASING DEPTH (m)	0.00	

EG		SITE INVESTIGATION RECORD										BORE HOLE No. BH-01					
PROJECT NAME		PROPOSED CONSTRUCTION OF RESIDENTIAL APARTMENT BUILDING AT MRC AGAR										SHEET 3 OF 3					
LOCATION		MRC Nagar, Chennai		MACHINE No.		CR-01		CHAINAGE (m)		-		DIA OF BORE HOLE 150mm NW					
STRUCTURE		B8H +8 Upper Floors		DRILLING METHOD		Rotary		CO-ORDINATES		N - E -		BORE START DATE 07/01/2023 BORE END DATE 08/01/2023					
JOB CODE		GEC-JC-GT-4094-A		FLUSHING MEDIUM		Bentonite				E -		TOTAL DRILL DAYS 2					
Depth below E.G.L. (m)	Drilling progress per metre		Type of Drill Bit (SC/TCB/DB)	Core Details		SPT Details				Sample Details			Layer Data				
	Date	Time		Total Core Recovery %	R.Q.D. %	Blow/ftm.			Capn	No.	Type	RL (m)	Legend	No	Depth	Geotechnical Description	
						0-15	15-30	30-45									SPT 'N' Value
21	08/01/2023	08:30 To 10:00	DS	32	0	-	-	-	-	22.00	18	CS	-22.0	+	LB	20.5	Brownish Grey, Moist, Very Dense, Completely Weathered Rock
22														+	L9	22.0	Brownish Grey, Moderately Weathered Rock
23																	
24																	
25																	
26																	
27																	
28																	
29																	
30																	

CS - Core Sample	DS - Disturbed Sample	LOGGED	M. RAJA	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	08/01/2023	GROUND LEVEL (m)	0.00	
UDS - Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	JALEEL YASIN	WATER TABLE (m)	2.00	
WS - Wash Sample	DB - Diamond Bit	DATE	18/01/2023	CASING DEPTH (m)	6.00	

Borehole terminated at 22 m depth below E.G.L.

FIG.2.1 Sub Soil Profile at BH-01 Location

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SITE INVESTIGATION RECORD															BORE HOLE No. BH-02		
PROJECT NAME: PROPOSED CONSTRUCTION OF RESIDENTIAL APARTMENT BUILDING AT MRC AGAR															SHEET: 1 OF 2		
LOCATION: MRC Nagar, Chennai															DIA OF BORE HOLE: 150mm		
STRUCTURE: Still +0 Upper Floors															BOTE START DATE: 05/01/2023		
MACHINE No.: CR-01															BOTE END DATE: 05/01/2023		
DRILLING METHOD: Rotary															TOTAL DRILL DAYS: 1		
JOB CODE: DEC-JC-GT-1094-A																	
FLUSHING MEDIUM: Bentonite																	
CO-ORDINATES: N - E																	
Depth below G.L. (m)	Drilling progress per metre		Type of Soil Bl. (BC / TC8 / DN)	Core Details	SPT Details				Sample Details			Layer Data					
	Time	Type of Soil Bl. (BC / TC8 / DN)			Total Core Recovery %	F.L.Q.D. %	Blowdown			Depth	No.	Type	PL (m)	Legend	No	Depth	Geotechnical Description
							0-15	15-30	30-45								
1	11:45	SC	-	-	-	-	-	-	-	-	-	-	-	L1	1.0	Filled Up Soil Brownish Clayey Sand with Brick waste	
2	12:00	SC	-	-	3	4	4	8	2.00	2	SS	-2.0				Brownish, Moist, Loose to Medium Dense, Poorly Graded, Silty SAND (SP-SM), Sand-Silt Mixture	
3	12:10	SC	-	-	2	4	5	9	3.00	3	SS	-3.0					
4	12:25	SC	-	-	3	5	5	11	4.00	4	SS	-4.0					
5	12:40	SC	-	-	2	3	3	6	5.00	5	SS	-5.0					
6	14:02	SC	-	-	2	5	7	12	6.50	6	SS	-6.5		L2	6.5	Brownish, Moist, Medium Dense, Poorly Graded, Silty SAND (SP-SM), Sand-Silt Mixture	
7	14:25	SC	-	-	5	10	13	23	8.00	7	SS	-8.0					
8	14:30	SC	-	-	8	12	16	28	9.50	8	SS	-8.5					
9														L3	10.0		

CS - Core Sample	DS - Disturbed Sample	LOGGED	M. RAJA	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	08/01/2023	GROUND LEVEL (m)	0.00	
UDS - Undisturbed Sample	TC8 - Tungsten Carbide Bit	CHECKED	JALEEL YASIN	WATER TABLE (m)	2.00	
WS - Wash Sample	DB - Diamond Bit	DATE	10/01/2023	CASING DEPTH (m)	0.00	

SITE INVESTIGATION RECORD		BORE HOLE No. BH-02														
PROJECT NAME		SHEET 2 OF 3														
PROPOSED CONSTRUCTION OF RESIDENTIAL APARTMENT BUILDING AT MRC AGAR		DIA OF BORE HOLE 150mm														
LOCATION	MRC Nagar, Chennai	MACHINE No.	CR-01													
STRUCTURE	SBH +8 Upper Floors	DRILLING METHOD	Rotary													
JOB CODE	GEC-JC-GT-4284-A	FLUSHING MEDIUM	Bentonite													
CHAINAGE (m)		SCORE START DATE 08/01/2023														
CO-ORDINATES		BORE END DATE 08/01/2023														
TOTAL DRILL DAYS		1														
Depth below E.G.L. (m)	Drilling progress per metre		Core Details	SPT Details			Sample Details			Layer Data						
	Date	Time		Blows/cm	Cap	No.	Type	RL (m)	Log	No.	Depth	Geotechnical Description				
	To	Min.		0-15	15-30	30-45	SPT 'N' Value									
11	14	55	SC	-	-	-	13 cm Penet. for 50 Blows	>100	11.00	9	SS	-11.0				Brownish, Moist, Very Dense, Poorly Graded, Silty SAND (SP-SM) Sand - Silty Mixture
	15	15							11.42 V				L4	11.5		
12	15	32	SC	-	-	-	2	2	1	3	SS	-12.5				Greyish Black, Moist, Very Loose, Poorly Graded, Clayey SAND (SC) Sand-Clay Mixture
	15	09														
13	15	58	SC	-	-	-	1	2	2	4	SS	-14.0				
	16	02														
14	16	21	SC	-	-	-	5	10	13	23	SS	-15.5				Brownish, Moist, Medium Dense, Poorly Graded, Silty SAND (SM), Sand - Silty Mixture
	16	31														
15	16	55	SC	-	-	-	18	23	27	50	SS	-17.0				Brownish, Moist, Dense, Poorly Graded, Silty SAND (SM), Sand - Silty Mixture
	17	08														
16	17	30	SC	-	-	-	15	23	22	45	SS	-18.5				Brownish, Moist, Dense, Poorly Graded, Silty SAND (SM), Sand - Silty Mixture
	17	07														
17	17	55	SC	-	-	-	2 cm Penet. for 50 Blows	>100	20.00	15	SS	-20.0				Brownish Gray, Moist, Very Dense, Completely Weathered Rock
	18	10														
20	18	10														

CS - Core Sample	DS - Disturbed Sample	LOGGED	M. RAJA	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	08/01/2023	GROUND LEVEL (m)	0.00	
UDS - Undisturbed Sample	TCS - Tungsten Carbide Bit	CHECKED	JALEEL YASIN	WATER TABLE (m)	2.00	
WS - Wash Sample	DB - Diamond Bit	DATE	18/01/2023	CASING DEPTH (m)	0.00	

Borehole terminated at 20 m depth below E.G.L.

FIG.2.2 Sub Soil Profile at BH-02 Location

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SITE INVESTIGATION RECORD															BORE HOLE No.: BH-03		
PROJECT NAME: PROPOSED CONSTRUCTION OF RESIDENTIAL APARTMENT BUILDING AT MRC AGAR															SHEET: 1 OF 2		
LOCATION: MRC Nagar, Chennai															DIA OF BORE HOLE: 150mm		
STRUCTURE: Silt +9 Upper Floors															NX		
MACHINE No.: CR-01															BORE START DATE: 09/01/2023		
DRLING METHOD: Rotary															BORE END DATE: 09/01/2023		
JOB CODE: GEC-JC-GT-4894-A															TOTAL DRILL DAYS: 1		
FLUSHING MEDIUM: Bentonite																	
Depth below G.L. (m)	Drilling progress per metre		Type of Soil Bl. (SC / TC3 / DB)	Core Details	SPT Details			Sample Details			Layer Data						
	Time				Blowcount	SPT 'N' Value	Depth	No.	Type	PL (m)	Layer	No.	Depth	Geotechnical Description			
	Hr.	Min.															
1	10	25	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	Filled Up Soil Brownish Clayey Sand with Brick waste
2	10	30	SC	-	-	4	5	6	11	2.00	2	SS	-2.0	-	-	-	Brownish/Grey, Moist, Medium Dense, Poorly Graded, Silty SAND (SP-SM), Sand-Silt Mixture
3	12	45	SC	-	-	-	-	-	-	2.45	-	-	-	-	-	-	
4	12	49	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	
5	13	03	SC	-	-	9	10	9	19	3.00	3	SS	-3.0	-	-	-	Grey, Moist, Loose, Poorly Graded, Silty SAND (SP-SM), Sand-Silt Mixture
6	13	05	SC	-	-	-	-	-	-	3.45	-	-	-	-	-	-	
7	13	20	SC	-	-	4	5	7	12	4.00	4	SS	-4.0	-	-	-	
8	13	24	SC	-	-	-	-	-	-	4.45	-	-	-	-	-	-	Brownish Grey, Moist, Medium Dense, Poorly Graded, Silty SAND (SP-SM), Sand-Silt Mixture
9	13	35	SC	-	-	2	3	3	6	5.00	5	SS	-5.0	-	-	-	
10	13	40	SC	-	-	-	-	-	-	5.45	-	-	-	-	-	-	
11	13	50	SC	-	-	2	6	7	13	6.50	6	SS	-6.5	-	-	-	Brownish Grey, Moist, Medium Dense, Poorly Graded, Silty SAND (SP-SM), Sand-Silt Mixture
12	13	53	SC	-	-	-	-	-	-	6.95	-	-	-	-	-	-	
13	14	03	SC	-	-	5	12	10	22	8.00	7	SS	-8.0	-	-	-	
14	14	06	SC	-	-	-	-	-	-	8.45	-	-	-	-	-	-	Brownish Grey, Moist, Medium Dense, Poorly Graded, Silty SAND (SP-SM), Sand-Silt Mixture
15	-	-	-	-	-	4	5	7	12	9.50	8	SS	-9.5	-	-	-	
16	-	-	-	-	-	-	-	-	-	9.78	-	-	-	-	-	-	

CS - Core Sample	DS - Disturbed Sample	LOGGED	M. RAJA	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	09/01/2023	GROUND LEVEL (m)	0.00	
UDS - Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	JALEEL YASH	WATER TABLE (m)	2.90	
WS - Wash Sample	DB - Diamond Bit	DATE	18/01/2023	CASING DEPTH (m)	0.00	

SITE INVESTIGATION RECORD															Bore Hole No. BH-03		
PROJECT NAME: PROPOSED CONSTRUCTION OF RESIDENTIAL APARTMENT BUILDING AT MRC AGAR															SHEET: 2 OF 2		
LOCATION: MRC Nagar, Chennai															DIA OF BORE HOLE: 150mm		
STRUCTURE: 5th +5 Upper Floors															Bore Start Date: 09/01/2023		
JOB CODE: GEC-JC-GT-4054-A															Bore End Date: 09/01/2023		
MACHINE No. CR-01															TOTAL DRILL DAYS: 1		
FLUSHING MEDIUM: Bentonite																	
CO-ORDINATES: N - E -																	
Depth below E.G.L. (m)	Drilling progress per metre		Type of Soil (SC / TCS / DB)	Core Details		SPT Details				Sample Details			Layer Data				
	Date	Time		Total Core Recovery %	R.Q.D. %	Blows/m	SPT 'N' Value	Depth	No	Type	RL (m)	Legend	Rs	Depth	Geotechnical Description		
11	14	59	SC	-	-	10	15	13	28	11.00	9	SS	-11.0				Brownish, Moist, Medium Dense, Poorly Graded, Silty SAND (SP-SM) Sand-Silt Mixture
	14	57								11.40				L4	11.5		
12	15	25	SC	-	-	5	2	1	3	12.50	10	SS	-12.5				Greyish Black, Moist, Very Loose, Poorly Graded, Clayey SAND (SC) Sand-Clay Mixture
	15	35								12.95							
13	16	00	SC	-	-	1	2	1	3	14.00	11	SS	-14.0				
	16	10								14.40							
14	16	35	SC	-	-	4	7	10	17	15.50	12	SS	-15.5				Brownish, Moist, Medium Dense, Poorly Graded, Silty SAND (SM), Sand-Silt Mixture
	16	40								15.95							
15	17	05	SC	-	-	15	18	21	39	17.00	13	SS	-17.0				Brownish, Moist, Dense, Poorly Graded, Silty SAND (SM), Sand-Silt Mixture
	17	15								17.45							
16	17	43	SC	-	-	8	16	19	35	18.50	14	SS	-18.5				
	17	52								18.95							
17	18	17	SC	-	-	5 cm Penetration 50 Blows				>100	20.00	15	SS	-20.0			Brownish Grey, Moist, Very Dense, Completely Weathered Rock
	18	32								20.08							
18																	
19																	
20																	

CS - Core Sample	DS - Disturbed Sample	LOGGED	M. RAJA	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	09/01/2023	GROUND LEVEL (m)	0.00	
UDS - Undisturbed Sample	TCS - Tungsten Carbide Bit	CHECKED	JALEEL YASIN	WATER TABLE (m)	2.00	
WS - Wash Sample	DB - Diamond Bit	DATE	10/01/2023	CASING DEPTH (m)	0.00	

Borehole terminated at 20 m depth below E.G.L.

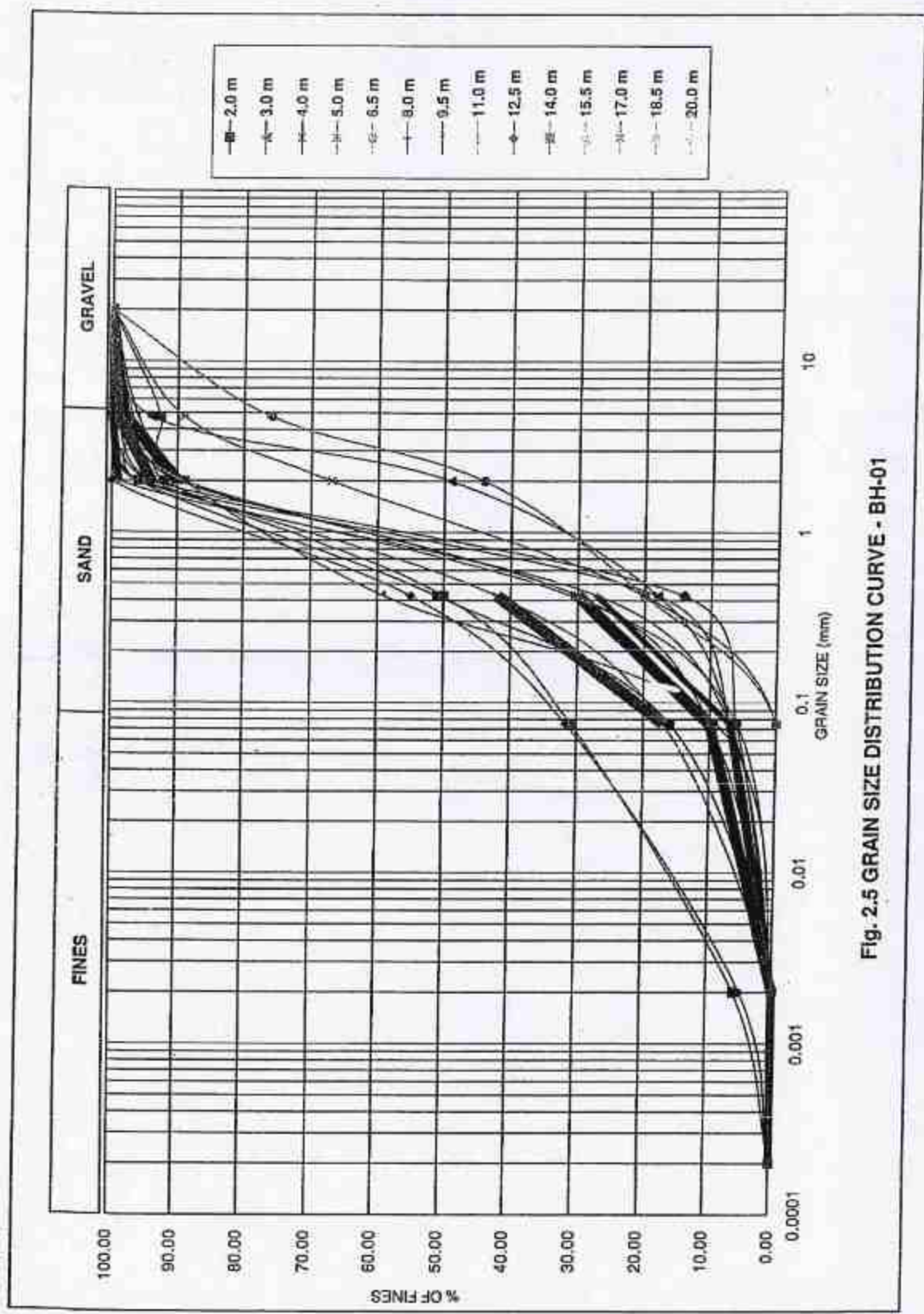
FIG.2.3 Sub Soil Profile at BH-03 Location

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SITE INVESTIGATION RECORD															BORE HOLE NO. BH-04		
PROJECT NAME: PROPOSED CONSTRUCTION OF RESIDENTIAL APARTMENT BUILDING AT MRC AGAR															SHEET 1 OF 2		
LOCATION: MRC Nagar, Chennai		MACHINE No.		CR-01		DIAMETER (m)		-		BORE START DATE: 10/01/2023		110mm		✓			
STRUCTURE: Still +9 Upper Floors		DRILLING METHOD: Rotary		CO-ORDINATES: N		-		BORE END DATE: 10/01/2023		-		-		-			
JOB CODE: GEC-JC-GT-40M-A		FLUSHING MEDIUM: Bentonite		CO-ORDINATES: E		-		TOTAL DRILL DAYS: 1		-		-		-			
Depth below G.L. (m)	Drilling progress per metre			Core Details			SPT Details			Sample Details			Layer Data				
	Date	Time		Type of Soil (IS / TCS / DB)	Total Core Recovery %	R.Q.D. %	Blows/30cm			Depth	No.	Type	RL (m)	Legend	No.	Depth	Geotechnical Description
		Hr.	Min.				0-15	15-30	30-45								
1	10/01/2023	12:30	30	SC	-	-											Filled Up Soil Brownish Clayey Sand with Brick waste
2		12:34	34	SC	-	-	2	2	3	5	2.00	2	SS	-2.0			Brownish, Moist, Very Loose, Poorly Graded, Silty SAND (SM), Sand-Silt Mixture
3		12:40	40	SC	-	-	4	5	6	11	3.00	3	SS	-3.0			
4		12:45	45	SC	-	-					2.45						
5		12:57	57	SC	-	-					3.45						
6		13:00	00	SC	-	-	3	4	4	8	4.00	4	SS	-4.0			
7		13:13	13	SC	-	-					4.45						
8		13:16	16	SC	-	-	3	5	7	12	5.00	5	SS	-5.0			
9		13:27	27	SC	-	-					5.45						
10		13:33	33	SC	-	-	4	4	7	11	6.50	6	SS	-6.5			Brownish Grey, Moist, Loose to Medium Dense, Poorly Graded, Silty SAND (SP-SM), Sand-Silt Mixture
11		13:50	50	SC	-	-					6.95						
12		13:55	55	SC	-	-	5	3	6	9	8.00	7	SS	-8.0			
13		14:10	10	SC	-	-					8.45						
14		14:15	15	SC	-	-	5	7	7	14	9.50	8	SS	-9.5			
15											9.78						Brownish, Moist, Medium Dense, Poorly Graded, Silty SAND (SP-SM), Sand-Silt Mixture

CS - Core Sample	DS - Disturbed Sample	LOGGED	M. RAJA	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	GC - Soil Grout	DATE	10/01/2023	GROUND LEVEL (m)	0.00	
UDS - Undisturbed Sample	TCS - Tugster Cable Bit	CHECKED	JALEEL YASIN	WATER TABLE (m)	2.00	
WS - Wash Sample	DB - Diamond Bit	DATE	10/01/2023	CASING DEPTH (m)	0.00	

Grain Size Distribution Curves



For ETICA DEVELOPERS PVT. LTD.
Managing Director.

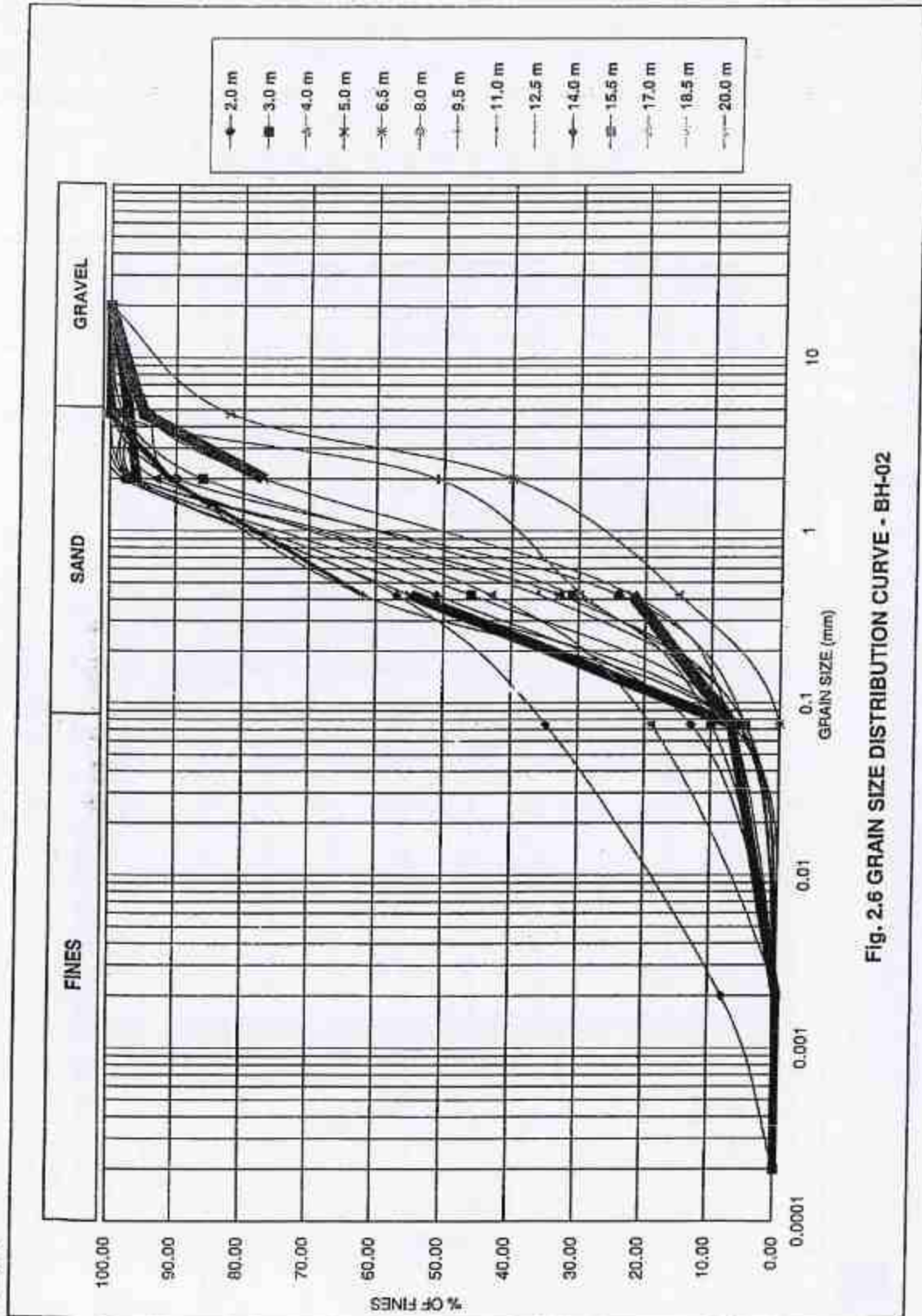


Fig. 2.6 GRAIN SIZE DISTRIBUTION CURVE - BH-02

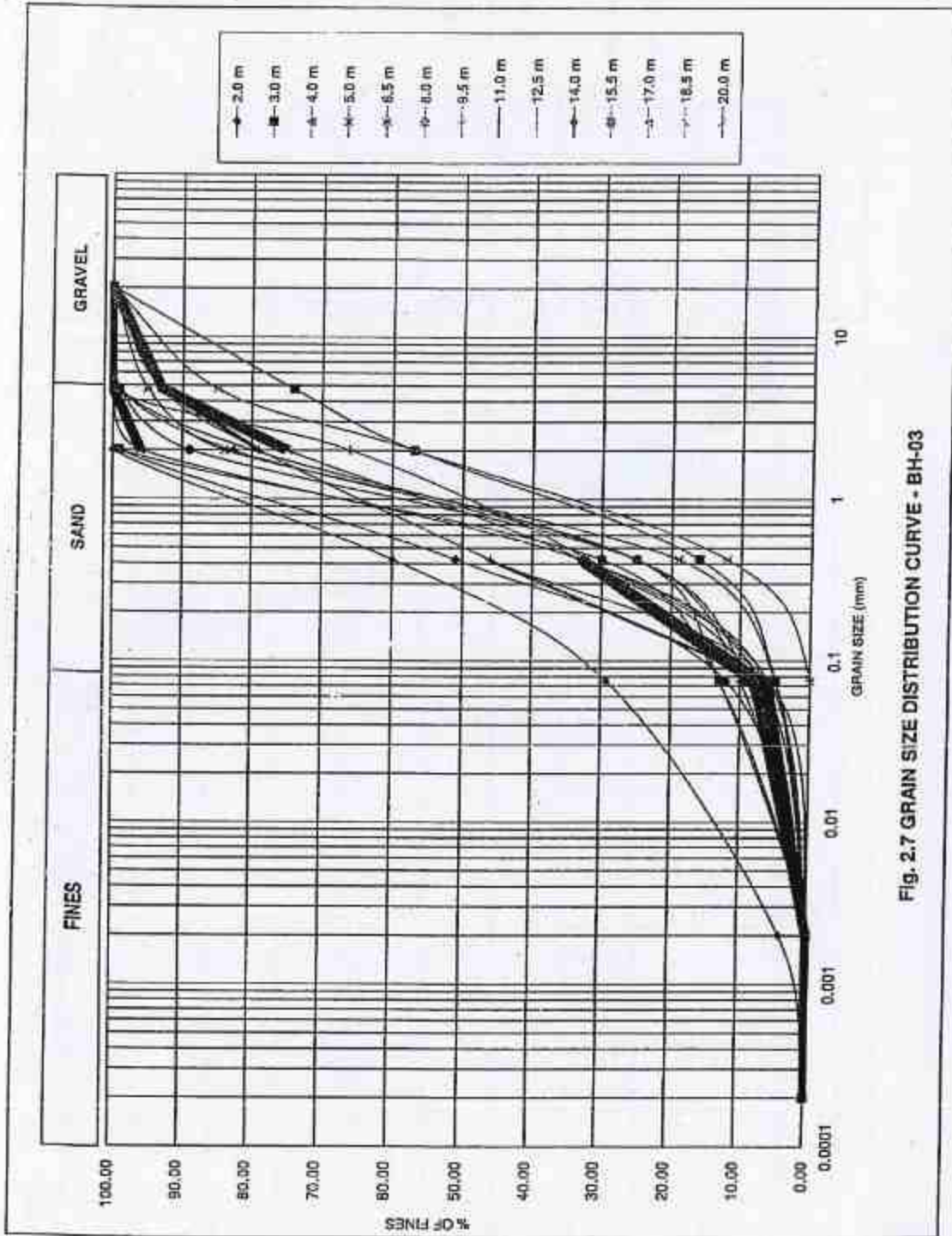


Fig. 2.7 GRAIN SIZE DISTRIBUTION CURVE - BH-03

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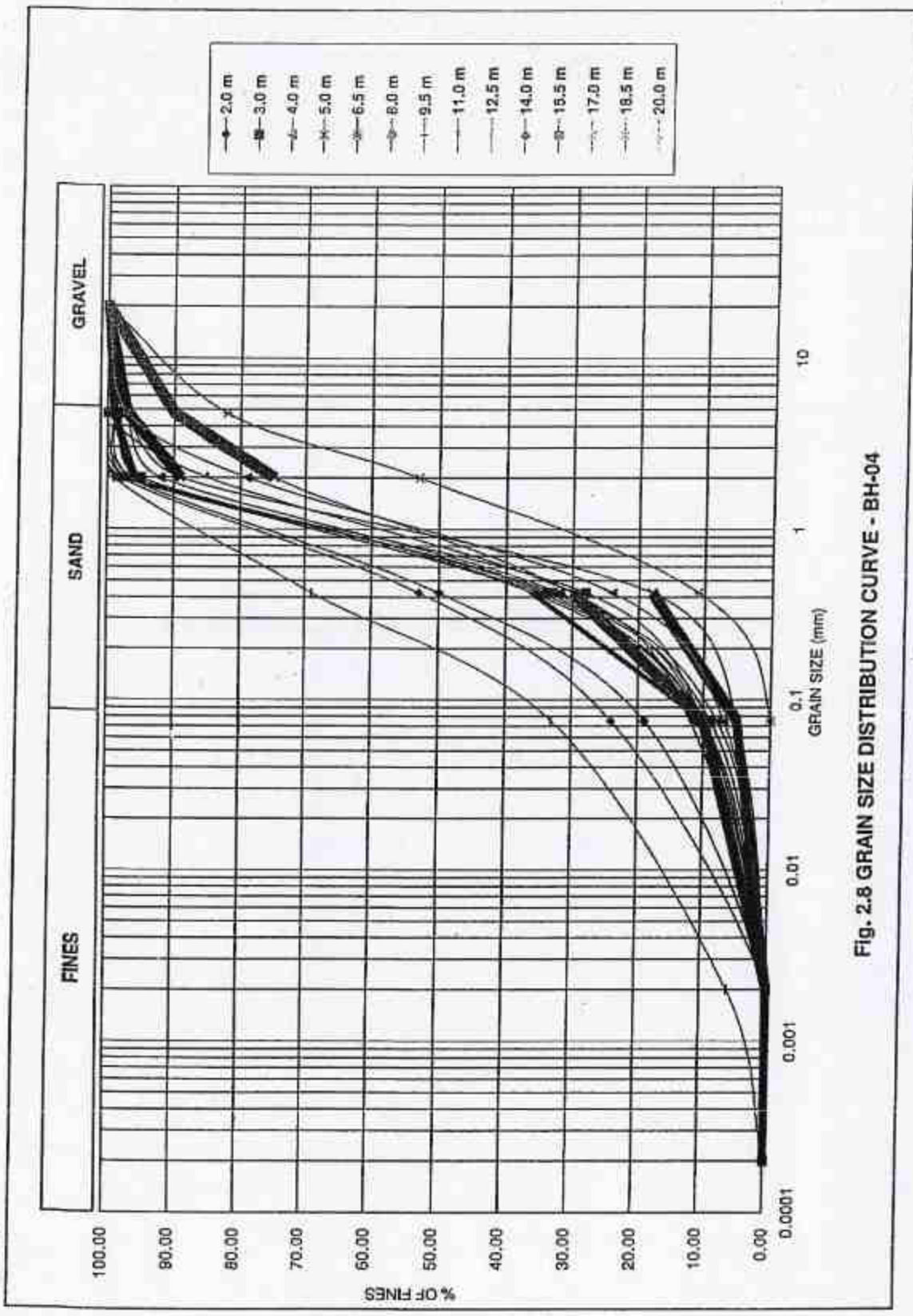


Fig. 2.8 GRAIN SIZE DISTRIBUTION CURVE - BH-04

[Signature]
Managing Director.

LABORATORY TEST RESULTS

10/10/2020



Table-2.1 Laboratory Classification of Soil Samples from BH-01																												
Sub Soil Classification																												
Fine Grained (FG)												Coarse Grained (CG)																
Depth of Sample below E.G.L (m)	SPT-Value	Type of Sample	NMC(%)	LL (%)	PL (%)	Ip	SL (%)	FS (%)	Consistency	Position With Respect to A-Aline	IS-Notation	Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	D ₁₀ (mm)	D ₃₀ (mm)	D ₆₀ (mm)	C _u =D ₆₀ /D ₃₀	C _u =D ₆₀ ² /D ₃₀ D ₁₀	Relative Density	IS-Notation				
																								Gravel	Sand			
2.0	8	SS	-	-	-	-	-	-	CG-50%	-	-	0	4	45	35	16	0	-	-	-	-	-	Loose	<50%	SM			
3.0	9	SS	-	-	-	-	-	-	CG-50%	-	-	6	45	31	11	7	0	-	-	-	-	-	Loose	<50%	SP-SM			
4.0	6	SS	-	-	-	-	-	-	CG-50%	-	-	2	8	80	20	10	0	-	-	-	-	-	Loose	<50%	SP-SM			
5.0	6	SS	-	-	-	-	-	-	CG-50%	-	-	0	4	78	11	7	0	-	-	-	-	-	Loose	<50%	SP-SM			
6.5	6	SS	-	-	-	-	-	-	CG-50%	-	-	0	6	80	8	6	0	-	-	-	-	-	Loose	<50%	SP-SM			
8.0	16	SS	-	-	-	-	-	-	CG-50%	-	-	0	1	72	20	7	0	-	-	-	-	-	M.Dense	<50%	SP-SM			
9.5	>100	SS	-	-	-	-	-	-	CG-50%	-	-	4	7	30	50	9	0	-	-	-	-	-	V.Dense	<50%	SP-SM			
11.0	>100	SS	-	-	-	-	-	-	CG-50%	-	-	3	1	85	25	6	0	-	-	-	-	-	V.Dense	<50%	SP-SM			
12.5	3	SS	25	30	16	14	0.36	17	60	Above	-	0	0	45	20	30	5	-	-	-	-	-	V.Loose	<50%	SC			
14.0	5	SS	20	31	18	15	0.73	18	48	Above	-	7	1	42	15	29	6	-	-	-	-	-	Loose	<50%	SC			
15.5	20	SS	-	-	-	-	-	-	CG-50%	-	-	1	10	69	20	10	0	-	-	-	-	-	M.Dense	<50%	SP-SM			
17.0	42	SS	-	-	-	-	-	-	CG-50%	-	-	1	5	52	25	17	0	-	-	-	-	-	Dense	<50%	SM			
18.5	56	WS	-	-	-	-	-	-	CG-50%	-	-	11	22	47	20	0	0	-	-	-	-	-	V.Dense	<50%	SP			
20.0	>100	WS	-	-	-	-	-	-	CG-50%	-	-	24	32	24	20	0	0	-	-	-	-	-	V.Dense	<50%	SP			
FG = Fine Grained CG = Coarse Grained NMC= Nature Moisture Content LL = Liquid Limit												FS = Differential Free Well Index Cu = Uniformity Coefficient Cc = Coefficient of Curvature IP-L-PL													LAB IN-CHARGE		M.PRAVEEN	
																									REVIEWED BY		JALEEL YASIN	

For ETICA DEVELOPERS VT. LTD.

Managing Director.

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Table-2.2 Laboratory Classification of Soil Samples from BH-02																														
Sub Soil Classification																														
Fine Grained (FG)												Coarse Grained (CG)																		
Depth of Sample below E.G.L (m)	SPT-Value	Type of Sample	Consistency					Position With Respect to A-Aline	IS-Notation	Gravel (%)					Fine (%)					Clay (%)	D ₁₅ (mm)	D ₃₀ (mm)	D ₆₀ (mm)	C _u =D ₆₀ /D ₁₀	C _c =D ₃₀ ³ /(D ₁₀ x D ₆₀)	Relative Density	IS-Notation			
			FS (%)	SL (%)	IL	PL (%)	LL (%)			NMC(%)	Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Gravel	Loose	Gravel	Dense												
2.0	8	SS	-	-	-	-	-	-	-	0	2	47	28	13	0	-	-	-	-	-	-	-	-	-	-	-	Loose	Gravel	SM	
3.0	9	SS	-	-	-	-	-	-	-	0	3	51	40	6	0	-	-	-	-	-	-	-	-	-	-	-	Loose	Gravel	SP-SM	
4.0	11	SS	-	-	-	-	-	-	-	0	4	63	28	5	0	-	-	-	-	-	-	-	-	-	-	-	M.Dense	Gravel	SP-SM	
5.0	6	SS	-	-	-	-	-	-	-	0	1	41	48	7	0	-	-	-	-	-	-	-	-	-	-	-	Loose	Gravel	SP-SM	
6.5	12	SS	-	-	-	-	-	-	-	0	4	63	28	5	0	-	-	-	-	-	-	-	-	-	-	-	M.Dense	Gravel	SP-SM	
8.0	23	SS	-	-	-	-	-	-	-	6	4	66	19	5	0	-	-	-	-	-	-	-	-	-	-	-	M.Dense	Gravel	SP-SM	
9.5	28	SS	-	-	-	-	-	-	-	0	9	29	55	7	0	-	-	-	-	-	-	-	-	-	-	-	M.Dense	Gravel	SP-SM	
11.0	>100	SS	-	-	-	-	-	-	-	2	2	60	30	6	0	-	-	-	-	-	-	-	-	-	-	-	V.Dense	Gravel	SP-SM	
12.5	3	SS	-	-	-	-	-	-	-	0	1	48	18	28	6	-	-	-	-	-	-	-	-	-	-	-	V.Loos	Gravel	SC	
14.0	4	SS	-	-	-	-	-	-	-	2	1	40	17	32	8	-	-	-	-	-	-	-	-	-	-	-	V.Loos	Gravel	SC	
15.5	23	SS	-	-	-	-	-	-	-	2	12	55	21	10	0	-	-	-	-	-	-	-	-	-	-	-	M.Dense	Gravel	SP-SM	
17.0	50	SS	-	-	-	-	-	-	-	1	8	50	24	18	0	-	-	-	-	-	-	-	-	-	-	-	Dense	Gravel	SM	
18.5	45	SS	-	-	-	-	-	-	-	5	18	55	15	7	0	-	-	-	-	-	-	-	-	-	-	-	Dense	Gravel	SP-SM	
20.0	>100	WS	-	-	-	-	-	-	-	18	42	25	15	0	0	-	-	-	-	-	-	-	-	-	-	-	V.Dense	Gravel	SP	
FG = Fine Grained CG = Coarse Grained NMC= Nature Moisture Content LL = Liquid Limit												FS = Plastic Limit Ip = Plasticity Index Ic = (LL-NMC)/Ip SL = Shrinkage Limit													FS = Differential Free Well Index C _u = Uniformity Coefficient C _c = Coefficient of Curvature IP=LL-PL		LAB IN-CHARGE		REVIEWED BY	
																									M.PRABVEEN		JALEEL YASIN			

For ETICA DEVELOPERS PVT. LTD.

Managing Director.

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Table-2.3 Laboratory Classification of Soil Samples from BH-03																										
Sub Soil Classification																										
Depth of Sample below E.G.L. (m)	SPT-Value	Type of Sample	Fine Grained (FG)										Coarse Grained (CG)										IS-Notation			
			NMC(%)	LL (%)	PL (%)	Ip	SL (%)	FS (%)	Consistency	Position With Respect to A-Airline	IS-Notation	Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	SLH (%)	Clay (%)	D ₁₀ (mm)	D ₃₀ (mm)	D ₆₀ (mm)	C _u =D ₆₀ /D ₁₀	C _c =D ₃₀ ² /(D ₁₀ D ₆₀)	Relative Density	Gravel	IS-Notation	
2.0	10	SS	-	-	-	-	-	-	CG>50%	-	-	0	1	43	39	12	0	-	-	-	-	-	-	Loose	<50%	SP-SM
3.0	10	SS	-	-	-	-	-	-	CG>50%	-	-	26	17	41	11	5	0	-	-	-	-	-	-	M.Dense	<50%	SP-SM
4.0	12	SS	-	-	-	-	-	-	CG>50%	-	-	0	4	63	27	6	0	-	-	-	-	-	-	M.Dense	<50%	SP-SM
5.0	6	SS	-	-	-	-	-	-	CG>50%	-	-	0	4	63	26	7	0	-	-	-	-	-	-	Loose	<50%	SP-SM
6.5	13	SS	-	-	-	-	-	-	CG>50%	-	-	5	11	65	14	5	0	-	-	-	-	-	-	M.Dense	<50%	SP-SM
8.0	22	SS	-	-	-	-	-	-	CG>50%	-	-	1	10	64	16	9	0	-	-	-	-	-	-	M.Dense	<50%	SP-SM
9.5	9	SS	-	-	-	-	-	-	CG>50%	-	-	7	14	33	40	6	0	-	-	-	-	-	-	Loose	<50%	SP-SM
11.0	28	SS	-	-	-	-	-	-	CG>50%	-	-	1	19	55	12	13	0	-	-	-	-	-	-	M.Dense	<50%	SM
12.5	9	SS	25	32	16	16	0.44	18	55	Above	-	0	0	34	30	30	8	-	-	-	-	-	-	V.Loose	<50%	SC
14.0	3	SS	23	28	15	13	0.38	16	42	Above	-	0	0	40	28	28	4	-	-	-	-	-	-	V.Loose	<50%	SC
15.5	17	SS	-	-	-	-	-	-	CG>50%	-	-	0	1	69	17	13	0	-	-	-	-	-	-	M.Dense	<50%	SM
17.0	39	SS	-	-	-	-	-	-	CG>50%	-	-	1	15	58	15	10	0	-	-	-	-	-	-	Dense	<50%	SP-SM
18.5	35	SS	-	-	-	-	-	-	CG>50%	-	-	7	18	42	25	6	0	-	-	-	-	-	-	Dense	<50%	SP-SM
20.0	>100	WS	-	-	-	-	-	-	CG>50%	-	-	15	28	45	12	0	0	-	-	-	-	-	-	V.Dense	<50%	SP
FG = Fine Grained			PL = Plastic Limit										FS = Differential Free Well Index										LAB IN-CHARGE		M.PRAVEEN	
CG = Coarse Grained			Ip = Plasticity Index										C _u = Uniformity Coefficient										REVIEWED BY		JALEEL YASIN	
NMC= Nature Moisture Content			I _p = (LL-NMC)/Ip										C _c = Coefficient of Curvature													
LL = Liquid Limit			SL = Shrinkage Limit										IP-1-L-PL													

For ETICA DEVELOPERS PVT. LTD.

Managing Director.



Table-2.4 Laboratory Classification of Soil Samples from BH-04

Table-2.4 Laboratory Classification of Soil Samples from BH-04																												
Sub Soil Classification																												
Fine Grained (FG)													Coarse Grained (CG)															
Depth of Sample below E.G.L. (m)	SPT-Value	Type of Sample	NMC(%)	LL (%)	PL (%)	Ip	Ic	FS (%)	Consistency	Position With Respect to A-Aline	IS-Notation	Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	D ₁₀ (mm)	D ₃₀ (mm)	D ₆₀ (mm)	C _u =D ₆₀ /D ₁₀	C _c =D ₃₀ /D ₁₀ ^{0.6}	Relative Density	IS-Notation				
																								Gravel	Sand			
2.0	5	SS	-	-	-	-	-	-	CG>50%	-	-	1	2	47	21	19	0	-	-	-	-	-	Loose	<50%	SM			
3.0	11	SS	-	-	-	-	-	-	CG>50%	-	-	2	3	62	24	9	0	-	-	-	-	-	M.Dense	<50%	SP-SM			
4.0	6	SS	-	-	-	-	-	-	CG>50%	-	-	3	5	60	24	6	0	-	-	-	-	-	Loose	<50%	SP-SM			
5.0	12	SS	-	-	-	-	-	-	CG>50%	-	-	3	8	71	13	5	0	-	-	-	-	-	M.Dense	<50%	SP-SM			
6.5	11	SS	-	-	-	-	-	-	CG>50%	-	-	0	3	62	25	10	0	-	-	-	-	-	M.Dense	>50%	SP-SM			
8.0	9	SS	-	-	-	-	-	-	CG>50%	-	-	0	4	62	23	11	0	-	-	-	-	-	Loose	<50%	SP-SM			
9.5	14	SS	-	-	-	-	-	-	CG>50%	-	-	1	3	60	26	10	0	-	-	-	-	-	M.Dense	<50%	SP-SM			
11.0	23	SS	-	-	-	-	-	-	CG>50%	-	-	0	15	55	18	12	0	-	-	-	-	-	M.Dense	<50%	SP-SM			
12.5	3	SS	24	30	10	14	0.43	52	CG>50%	Above	-	0	1	30	32	31	6	-	-	-	-	-	V Loose	<50%	SC			
14.0	12	SS	-	-	-	-	-	-	CG>50%	-	-	0	2	45	29	24	0	-	-	-	-	-	M.Dense	<50%	SM			
15.5	27	SS	-	-	-	-	-	-	CG>50%	-	-	0	2	70	18	10	0	-	-	-	-	-	M.Dense	<50%	SP-SM			
17.0	47	SS	-	-	-	-	-	-	CG>50%	-	-	3	16	55	17	7	0	-	-	-	-	-	Dense	<50%	SP-SM			
18.5	49	SS	-	-	-	-	-	-	CG>50%	-	-	10	15	45	20	10	0	-	-	-	-	-	Dense	<50%	SP-SM			
20.0	>100	WS	-	-	-	-	-	-	CG>50%	-	-	18	29	42	11	0	0	-	-	-	-	-	V Dense	<50%	SP			
FG = Fine Grained CG = Coarse Grained NMC= Nature Moisture Content LL = Liquid Limit												FS = Differential Free Well Index Cu = Uniformity Coefficient Cc = Coefficient of Curvature Ip =LL-PL SL = Shrinkage Limit												LAB IN-CHARGE			M.PRAVEEN	
REVIEWED BY JALEEL YASIN																												

For ETICA DEVELOPERS PVT. LTD.

Managing Director.



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Table-2.5 Results of Chemical Analysis

SL No.	Bore Hole No.	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	2.00	7.39	256	321	2.0	7.37	231	389
2	BH-03	2.00	7.39	248	318	2.0	7.37	228	375

For ETICA DEVELOPERS PVT. LTD.

Managing Director.

GEOLOGY & SUB-SURFACE STRATIFICATION

3.0 Preamble:

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

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

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

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

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

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

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

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

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REFERENCE BORE HOLE-BH:				01	Ref R.L. of G.L. (m):			0.00			
Layer No.	Layer Thk. (m)			Type of Strata	Colour	Ave. Design SPT	Relative Density	Consistency	(γ) kN/m ³	Shear Parameters	
	Top. R.L.	Bot. R.L.	Thickness							(C _u) kPa	(φ) Deg.
1	0.00	1.00	1.00	Filled Up Soil	Brown	-	-	-	-	-	-
2	1.00	8.00	7.00	Silty Sand	Brown/Black	8	Loose	-	14.5	-	29.6
3	8.00	9.50	1.50	Silty Sand	Brown	18	Medium Dense	-	18	-	32.4
4	9.50	11.50	2.00	Silty Sand	Brownish	>100	Very Dense	-	21	-	42.5
5	11.50	15.50	4.00	Clayey Silty Sand	Greyish Black	4	Very Loose	-	13.5	-	20.22
6	15.50	17.00	1.50	Silty Sand	Brownish	20	Medium Dense	-	18	-	33
7	17.00	20.00	3.00	Silty Sand	Brownish	51	Very Dense	-	20.5	-	41.15
8	20.00	20.50	0.50	Completely Weathered Rock	Brownish Grey	>100	Very Dense	-	21	-	42.5
9	20.50	22.00	1.50	Moderately Weathered Rock	Brownish Grey	CRR-32%, RQD-0%					

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REFERENCE BORE HOLE-BH:				02	Ref R.L. of G.L. (m):			0.00			
Layer No.	Layer Thk. (m)			Type of Strata	Colour	Ave. Design SPT	Relative Density	Consistency	(γ) kN/m ³	Shear Parameters	
	Top. R.L.	Bot. R.L.	Thickness							(C _u) kPa	(φ) Deg.
1	0.00	1.00	1.00	Filled Up Soil	Brown	-	-	-	-	-	-
2	1.00	6.50	5.50	Silty Sand	Brown	9	Loose	-	14.5	-	29.8
3	6.50	10.00	3.50	Silty Sand	Brownish	21	Medium Dense	-	18.5	-	33.3
4	10.00	11.50	1.50	Silty Sand	Brownish	>100	Very Dense	-	21	-	42.5
5	11.50	15.50	4.00	Clayey Silty Sand	Greyish Black	4	Very Loose	-	13.5	-	20.22
6	15.50	17.00	1.50	Silty Sand	Brownish	23	Medium Dense	-	18.5	-	33.9
7	17.00	19.50	2.50	Silty Sand	Brownish	48	Dense	-	20	-	40.55
8	19.50	20.00	0.50	Completely Weathered Rock	Brownish Grey	>100	Very Dense	-	21	-	42.5

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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	1.00	1.00	Filled Up Soil	Brown	-	-	-	-	-	-
2	1.00	5.00	4.00	Silty Sand	Brownish Grey	14	Medium Dense	-	17	-	31.2
3	5.00	6.50	1.50	Silty Sand	Grey	6	Loose	-	14.5	-	29.2
4	6.50	11.50	5.00	Silty Sand	Brownish	19	Medium Dense	-	18	-	32.7
5	11.50	15.50	4.00	Clayey Silty Sand	Greyish Black	3	Very Loose	-	13	-	20.07
6	15.50	17.00	1.50	Silty Sand	Brownish	17	Medium Dense	-	18	-	32.1
7	17.00	19.50	2.50	Silty Sand	Brownish	37	Dense	-	19.5	-	37.93
8	19.50	20.00	0.50	Completely Weathered Rock	Brownish Grey	>100	Very Dense	-	21	-	42.5

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REFERENCE BORE HOLE-BH:				04	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	1.00	1.00	Filled Up Soil	Brown	-	-	-	-	-	-
2	1.00	3.00	2.00	Silty Sand	Brownish	5	Loose	-	14	-	20.37
3	3.00	9.50	6.50	Silty Sand	Brown/Grey	10	Loose	-	15	-	30
4	9.50	11.50	2.00	Silty Sand	Brownish	19	Medium Dense	-	18	-	32.7
5	11.50	14.00	2.50	Clayey Silty Sand	Greyish Bkack	3	Very Loose	-	13	-	20.07
6	14.00	17.00	3.00	Silty Sand	Brownish	20	Medium Dense	-	18	-	33
7	17.00	19.50	2.50	Silty Sand	Brownish	48	Dense	-	20	-	40.55
8	19.50	20.00	0.50	Completely Weathered Rock	Brownish Grey	>100	Very Dense	-	21	-	42.5

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FOUNDATION SYSTEM

FOR THE NEW YORK STATE

DEPARTMENT OF



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 nine upper floors, and is meant for residential use. For this kind of structure, the column loads could vary between 2500kN to 4000kN. The above mentioned loads have no bearing on the design of either sub or super structures and are mentioned just to provide an insight to choose an appropriate foundation system with respect to subsoil conditions.

4.2 Foundation System

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

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

Typical computations are presented in Annexure

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Table:- 4.1 Recommended Safe Load Carrying Capacities of Bored Cast-in Situ Piles

Sl.No	Reference Bore hole No.	Length of Pile below E.G.L	Assumed Length of Cut-Off Below E.G.L	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	21.0	1.0	20.00	500	1200	500	30
2					550	1400	550	35
3					600	1600	600	40
4					650	1900	650	45
5					750	2500	750	60
6					800	3000	800	67
7					900	3500	900	80

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RECOMMENDATIONS

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CHAPTER-5

RECOMMENDATIONS

5.1 Recommendation for Deep pile foundation system:

- ❖ If deep pile foundation system adopt, Bored Cast in situ piles are recommended as the suitable foundation system.
- ❖ The allowable safe load carrying capacities as per IS 2911-Part-I-Section-2 (2010) for different diameters of piles with two different approaches are 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.

5.2 Construction method statement of pile foundation:

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

5.3 General Recommendation:

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



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5.4 Special Recommendations

- ❖ Since, the sub soil strata are very loose to loose silty sand layer between top to 8.0m depth and Clayey Silty Sand layer between 11.50m & 15.50m depth below ground level. The loose 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

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ESTIMATION OF SAFE LOAD CARRYING CAPACITY OF BORED CAST-IN-SITU PILES																		
Type of Pile		Bored		Diameter of Pile		Length of Pile below E.G.L. (m)		As Per IS:2911-(P-1)-S-25-2010										
Reference Bore Hole		BH-01				500 mm		Surcharge Pressure		Earth Pressure								
Layer No.	Layer Thk. (m)		Type of Strata	Ave. SPT	Ave. up to Layer	Shear Parameters		Effective Overburden Pressure (kPa)	Adhesion Factor (k)	Skin Friction (Qs) kN								
	Top. R.L.	Bot. R.L.				(C) kPa	(ϕ) Deg				At top of Layer		At Mid. of Layer					
Cut-Off Level																		
1	0	1	1	8	14.5	14.5	-	29.6	0.0	31.5	15.8	-	1.0	qf 1				
2	1	8	7.0	18	18.0	16.3	-	32.4	31.5	43.5	37.5	-	1.1	qf 2				
3	8	9.5	1.5	50	20.5	19.3	-	41.0	43.5	64.5	54.0	-	1.5	qf 3				
4	9.5	11.5	2.0	4	13.5	17.0	-	20.2	64.5	78.5	71.5	-	1.0	qf 4				
5	11.5	15.5	4.0	20	18.0	15.8	-	33.0	78.5	90.5	84.5	-	1.2	qf 5				
6	15.5	17	1.5	40	20.0	19.0	-	38.8	90.5	120.5	105.5	-	1.4	qf 6				
7	17	20	3.0	50	20.5	20.3	-	42.5	120.5	131.0	125.8	-	1.5	qf 7				
8	20	21	1.0											qf 8				
Summation of Positive Skin Resistance (kN)										1853.35								
Summation of Negative Skin Resistance (kN) - Qf =										0.00								
Computation of End Bearing Resistance																		
Bearing Stratum	Weathered Rock	SPT	ϕ	Cu	Nq	Nc	Elf. Ht. of Overburden	g	m									
		80	40.33	-	135.50	-	Effective Overburden Pressure	66.85	kN/m ²									
Ultimate Load Carrying Capacity (Q _{ult})										Q _{ult} = Q _p + Q _s (kN)								
Safe Load Carrying Capacity (Q _{safe})										Q _{safe} (kN)								
Allowable Safe Load Carrying Capacity										Q _{allow} (kN)								
Allowable Safe Pull out Capacity										Q _{allow} (kN)								
End Bearing Resistance (kN) Q _p =										2551.41								
Safe Load Carrying Capacity (Q _{safe})										4414.76								
Allowable Safe Load Carrying Capacity										1765.91								
Allowable Safe Pull out Capacity										1600.00								
End Bearing Resistance (kN) Q _p =										617.78								

Skin Resistance in Clay Layer is $\pi \times d \times C_u \times \alpha$
 Skin Resistance in Sand Layer is $\pi \times d \times \frac{1}{2} \times K \times \tan(\phi)$
 End Bearing Resistance in Clay Layer is $\pi \times d^2 \times q_c \times \alpha$
 End Bearing Resistance in Sand Layer is $\pi \times d^2 \times q_c \times \alpha$
 where
 α = Undrained Shear Strength of Clay
 α = Angle of Shearing Resistance
 K = Bearing Capacity Factor = 9
 q_c = Effective Overburden Pressure at pile tip Effective height of overburden $X \times 10$

Note: The End being in Compactly Weathered Rock modeled as Very Dense Sand with restricted to SPT value of 50 corresponding to q_c value 40.33

K = Coef. Earth Pressure at Rest
 α = Effective Overburden Pressure at middle of Layer
 N_q = Bearing Capacity Factor, Ref. Fig. 1 of IS: Code Related above
 q_c = (1/2) Effective Overburden Pressure at pile tip Effective height of overburden $X \times 10$

d = Dia. of Pile
 α = Adhesion Factor
 T = Thickness of Layer

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LATERAL LOAD CARRYING CAPACITY OF BORED CAST- SITU PILES

Reference Bore Hole : BH-01

1.0 Geometrical Data

Type of Pile Head Considered	Fixed
Diameter of Pile (d)	0.60 m
Free standing Length of Pile (e)	0 m
Length of Pile below E.G.L (Le)	21.0 m
Cut-Off Level From E.G.L	1.0 m
Length of Pile below Cut-Off Level (Lc)	20.0 m
Grade of Concrete (M)	25 MN/m ²
Young's Modulus of Concrete (E)	25000000 kN/m ²
Moment of Inertia (I)	0.006362 m ⁴

2.0 Determination of Depth of Fixity

Type of Soil Strata	Sand
Ground Water Condition	Submerged
Average Design SPT "N" Value	8

$$T = (EI/nh)^{1/5}$$

(n can be read as η in the above and below equation in case of Sand)

nh	1000	kN/m ³
In Case of Sand	-	kN/m ²
T	2.76	
L ₁ /T	0.00	
L/T	2.20	
Depth of Fixity below Cut off (z _f)	6.06	m

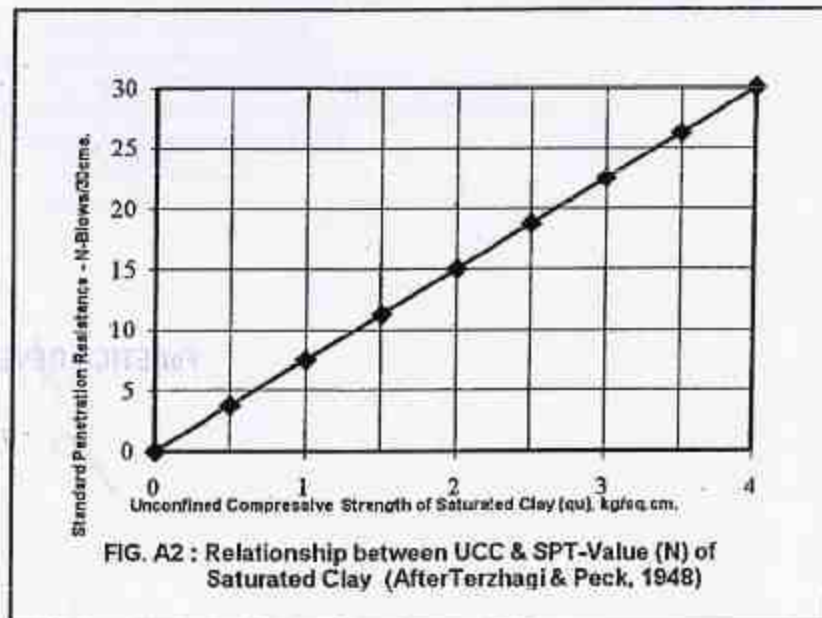
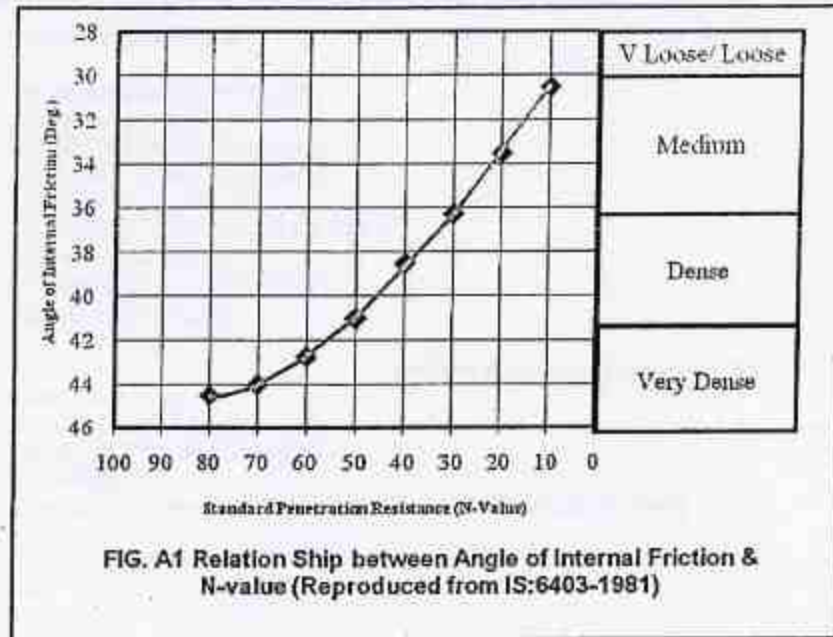
3.0 Determination of Lateral Load and Moment Carrying Capacity for

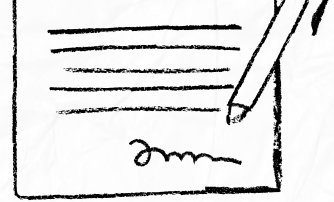
0.005 m Lateral Deflection:

Allowable Lateral Deflection (Y)	0.005	m
Lateral Load Carrying Capacity (H) = $Y \cdot 12EI / (e + z_f)^3$	42.80	kN
Recommended Design Lateral Load carrying Capacity	42	kN
Fixed End Moment, $M_F = H(e + z_f)/2$	130	
Reduction Factor (L_1/T)	0.83	m
Actual Moment (Fixed End Moment/Reduction Factor), M_F	108	kN-m

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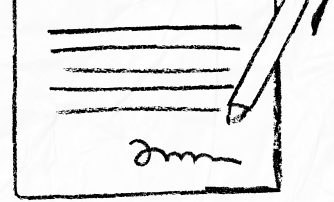
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