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PROJECT

GEOTECHNICAL INVESTIGATION FOR THE PROPOSED RESIDENTIAL HIGH RISE BUILDING CONSISTING OF TWO BASEMENT + STILT + 13 UPPER FLOORS LOCATED IN T.S NO. 9/1, BLOCK NO. 16, OLD DOOR NO. 71 (PART), NEW DOOR NO. 34 (PART), VELACHERY ROAD, GUINDY, CHENNAI – 600 032. VELACHERY TALUK, CHENNAI DISTRICT, GREATER CHENNAI CORPORATION

PROJECT CLIENT

M/s IVAR ESTATES PRIVATE LIMITED.,
NO.:3, MANGESH STREET,
T.NAGAR,
CHENNAI – 600 017

TITLE

GEOTECHNICAL INVESTIGATION REPORT

REPORT NO.: GT- 2398

DATE	REVISON	DESCRIPTION		AUTHORISED SIGNATORY
21/07/2022	00	SUBMISSION OF FINAL GEOTECHNICAL REPORT	SIGN	
			DATE	21/07/2022
			DESIGNATION	MANAGING DIRECTOR
			NAME	DR. C.V.PRASAD

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REPORT TEXT



CHAPTER-1

INTRODUCTION

1.0 PROJECT INFORMATION MATRIX:

NATURE OF PROJECT	: **PROPOSED RESIDENTIAL BUILDING**
STRUCTURE	: **2 BASEMENT + STILT + 13 UPPER FLOORS**
PROJECT OWNER	: **M/s IVAR ESTATES PRIVATE LIMITED**
PROJECT LOCATION	: **VELACHERY ROAD, CHENNAI**
JOB CODE	: **GT-2398**

1.1 SCOPE OF WORK:

1.1.1 FIELD WORK:

- Conducting three soil investigation bore holes of 150 mm diameter in Soil & Overburden.
- In case of rock formation NX Diameter with Core barrel shall be adopted to progress the drilling up the termination depth.
- Conducting Standard Penetration Test (SPT) within the borehole at:
  - Every 1.0m depth interval up to 6.0m.
  - From 6.0m to 16.0m, SPT is conducted at every 1.5m depth interval
- The depth of investigation varies from 11.0m to 13.0m and the termination depends on the continuous core recovery
- Collection of disturbed soil samples at SPT location 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
- Consolidation test on undisturbed samples if applicable
- 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
- Sub-Surface Stratification
- Liquefaction Studies
- Foundation System
- Recommendation
- Annexure

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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 grainsize distribution curve for the representative samples in each bore is presented in Fig. 2.5 to 2.7.

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. 2.8 & 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.

Further, the cross sectional variation of the sub surface profile through different bore holes in vertical and horizontal direction longitudinally or transversely are presented in Figs.2.4

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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.

2.1.3.2 UNDISTURBED SAMPLES:

From the soft to stiff clay layer, representative undisturbed samples were collected. These samples were used primarily to establish the compressibility parameters to estimate the settlements of shallow foundation system wherever applicable.

2.1.4 COLLECTION OF GROUND WATER SAMPLES:

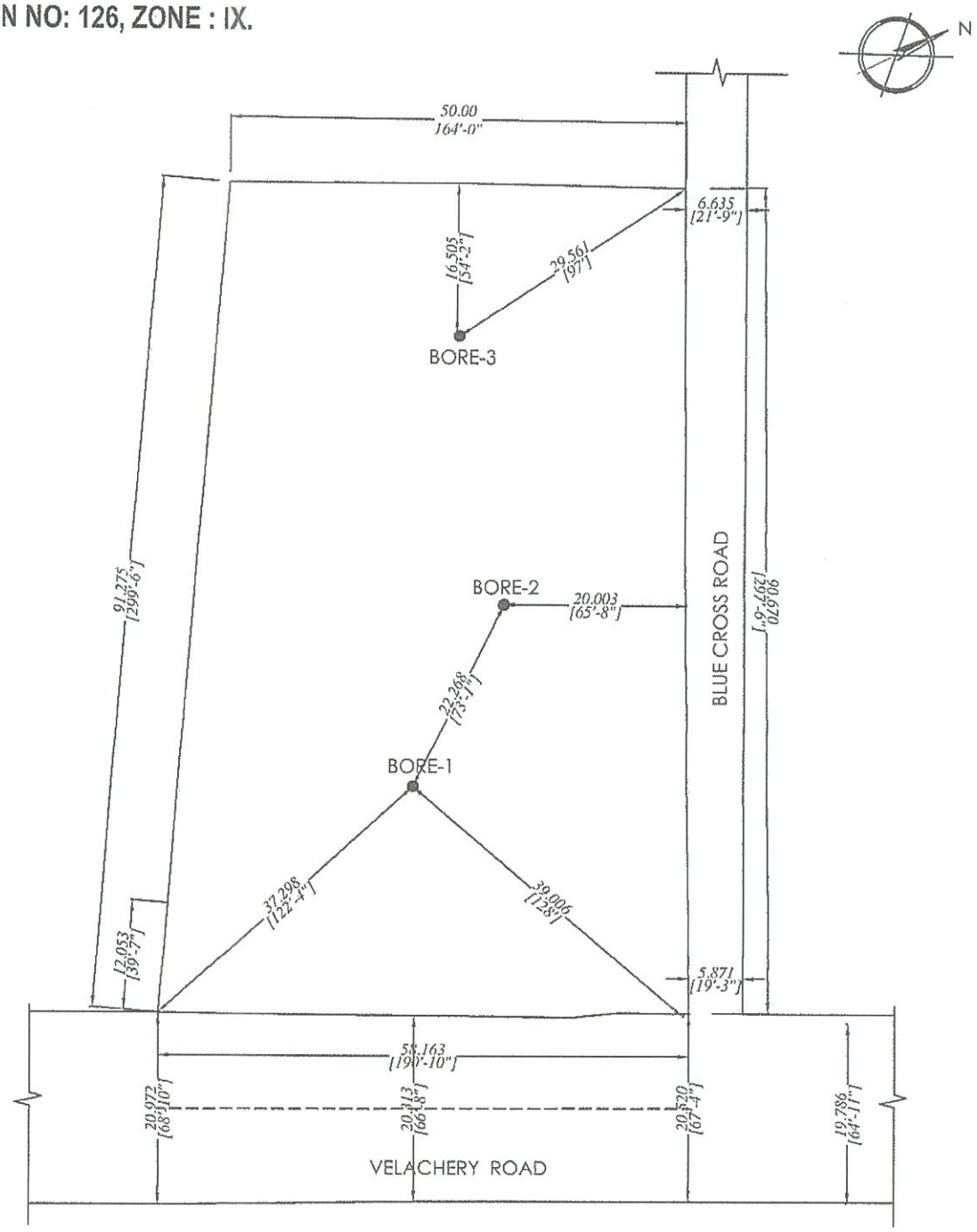
One representative water sample from each borehole was collected after 24 hours of completing the borehole if water table met within the investigated depth.

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SITE PLAN

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PLAN SHOWING THE PROPOSED CONSTRUCTION OF HIGH RISE BUILDING (HRB) (DOUBLE BASEMENT+S+13 FLOORS) T.S.NO: 9 / 1, BLOCK NO: 16, OLD DOOR NO:71(Part),NEW DOOR NO:34(Part) VELACHERY ROAD, VELACHERY TALUK, CHENNAI DISTRICT. GREATER CHENNAI CORPORATION DIVISION NO: 126, ZONE : IX.



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SOIL PROFILES

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SITE INVESTIGATION RECORD

BORE HOLE No.	BH-01
SHEET	1 OF 2
DIA OF BORE HOLE	150mm ✓ / NX ✓
BORE START DATE	01/07/2022
BORE END DATE	05/07/2022
TOTAL DRILL DAYS	4

PROJECT NAME	PROPOSED CONSTRUCTION OF A RESIDENTIAL BUILDING						
LOCATION	Velacherry Main Road, Guindy	MACHINE No.	-	CHAINAGE (m)	-		
STRUCTURE	2B + Stilt + 13 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N	-	
JOB CODE	GT-2398	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
1	01/07/2022	16	00	SC	-	-												
		To 16	03				25	29	45	74	1.00	1	SS	-1.0				Brown,Yellow & Grey Shades at Times, Poorly Graded,Fine & Medium Grains Sand Particles With Traces of Coarse Sand & Gravels,Very Dense & Dense, **Clayey Silty SAND (SC)/ Residual Soil - Grade W5 Rock Formation** Disintegrated Hypersthene Granitic Rock
		16	30								1.45							
		To 16	34	SC	-	-												
2		16	40				16	21	22	43	2.00	2	SS	-2.0				
		To 16	53	SC	-	-					2.45							
3		09	0				30	10cm penet for 55 blows		>100	3.00	3	SS	-3.0	L1	3.0		
		To 09	40	DB	-	-					3.25							
4		10	10				SPT Hammer Rebound			>100	4.00	-	WS	-4.0				
		To 10	50	DB	0	0												
5	02/07/2022	11	20				SPT Hammer Rebound			>100	5.00	-	WS	-5.0				Brown,Grey Brown,Yellow Shades, Pred. Fine & Medium Grains Size Fraction,Traces of Coarse Grain Sand With Gravels, Very Dense,**Completely Weathered Rock - Grade W5 Rock Formatoin** Disintegrated Hypersthene Granitic Rock Formation
		To 12	15	DB	0	0												
6		14	00				SPT Hammer Rebound			>100	6.00	-	WS	-6.0				
		To 15	20	DB	0	0												
7															L2	7.5		
8		15	40				SPT Hammer Rebound			>100	7.50	-	WS	-7.5				Grey,Grey Brown,Medium & Coarse Grain Structure,Highly Fractured & Disintegrated,**Highly Weathered Rock - W4 Rock Formation** Hypersthene Granitic Rock
		To 14	25	DB	9	0												
9	04/07/2022	Total Drilling Time 4Hours					-	-	-	-	9.00	4	CS	-9.0	L3	9.0		
10				DB	19	0												Grey,Grey Brown,Medium & Coarse Grain Structure,Highly Fractured & Disintegrated,**Moderately Weatherd Rock - W3 Rock Formation** Hypersthene Granitic Rock

CS - Core Sample	DS - Disturbed Sample	LOGGED	S. Stephenraj	PROJECT SITE DETAILS		REMARKS	
SS - Split Spoon Sample	SC - Soil Cutter	DATE	04/07/2022	GROUND LEVEL (m)	0.00		
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Sharmila. G	WATER TABLE (m)	2.30		
WS - Wash Sample	DB - Diamond Bit	DATE	13/07/2022	CASING DEPTH (m)	0.00		

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SITE INVESTIGATION RECORD

BORE HOLE No.	BH-01		
SHEET	2	OF	2
DIA OF BORE HOLE	150mm		
	NX	✓	
BORE START DATE	01/07/2022		
BORE END DATE	05/07/2022		
TOTAL DRILL DAYS	4		

PROJECT NAME	PROPOSED CONSTRUCTION OF A RESIDENTIAL BUILDING						
LOCATION	Velacherry Main Road, Guindy	MACHINE No.	-	CHAINAGE (m)	-		
STRUCTURE	2B + Stilt + 13 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N	-	
JOB CODE	GT-2398	FLUSHING MEDIUM	Bentonite		E	-	

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Sample Details: RL (m)	Layer Data: Legend	Layer Data: No	Layer Data: Depth	Geotechnical Description
11	17/08/2012	14	30	DB	16	0					10.50	9	CS	-10.5	+ + +			Grey,Grey Brown,Medium & Coarse Grain Structure,Highly Fractured & Disintegrated,**Moderately Weatherd Rock - W3 Rock Formation** Hypersthene Granitic Rock
		To																
12		16	30				-	-	-	-	12.00	10	CS	-12.0				
	05/07/2022	15	15															
		To		DB	28	0												
13		15	45				-	-	-	-	13.00	11	CS	-13.0	L4	13.0		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

CS - Core Sample	DS - Disturbed Sample	LOGGED	S. Stephenraj	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	05/07/2022	GROUND LEVEL (m)	0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Sharmila. G	WATER TABLE (m)	2.30	
WS - Wash Sample	DB - Diamond Bit	DATE	13/07/2022	CASING DEPTH (m)	0.00	

Borehole terminated at 13 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
SHEET	1 OF 2
DIA OF BORE HOLE	150mm ✓ / NX ✓

PROJECT NAME	PROPOSED CONSTRUCTION OF A RESIDENTIAL BUILDING					BORE START DATE	06/07/2022
LOCATION	Velacherry Main Road, Guindy	MACHINE No.	-	CHAINAGE (m)	-		
STRUCTURE	2B + Stilt + 13 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	07/07/2022
JOB CODE	GT-2398	FLUSHING MEDIUM	Bentonite		E -	TOTAL DRILL DAYS	2

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
1	06/07/2022	10	51	SC	-	-	9	23	46	69	1.00	1	SS	-1.0				
		To 10	52								1.45							
		11	01	SC	-	-												
2		To 11	03				28	4cm penet for 10 blows		>100	2.00	2	SS	-2.0				
		11	18								2.19							
		To 11	22	SC	-	-												
3		11	51				26	13cm penet for 60 blows		>100	3.00	3	SS	-3.0				
		To 11	53	SC	-	-					3.28							
4		12	08				16	20	12Cm penet for 50blows	>100	4.00	4	SS	-4.0				
		To 12	17	SC	-	-					4.42							
5		12	31				24	7cm penet for 50 blows		>100	5.00	5	SS	-5.0				
		To 12	46	SC	-	-					5.22							
6							SPT Hammer Rebound			>100	6.00	-	WS	-6.0				
	07/07/2022	09	00															
		To 11'	00	DB	20	0												
7							-	-	-	-	7.50	6	CS	-7.5				
8		11	30															
		To 13	50	DB	18	0												
9							-	-	-	-	9.00	7	CS	-9.0				
		14	15															
		To 16	17	DB	34	0												
10																		

CS - Core Sample	DS - Disturbed Sample	LOGGED	S. Stephenraj	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	07/07/2022	GROUND LEVEL (m)	0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Sharmila. G	WATER TABLE (m)	2.50	
WS - Wash Sample	DB - Diamond Bit	DATE	13/07/2022	CASING DEPTH (m)	0.00	

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CROSS SECTION PROFILE

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SITE INVESTIGATION RECORD

BORE HOLE No.	BH-03	SHEET	2 OF 2				
PROJECT NAME	PROPOSED CONSTRUCTION OF A RESIDENTIAL BUILDING					DIA OF BORE HOLE	150mm / NX ✓
LOCATION	Velacherry Main Road, Guindy	MACHINE No.	-	CHAINAGE (m)	-	BORE START DATE	01/07/2022
STRUCTURE	2B + Stilt + 13 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N: -	BORE END DATE	05/07/2022
JOB CODE	GT-2398	FLUSHING MEDIUM	Bentonite		E: -	TOTAL DRILL DAYS	4

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 %	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
10.5	04/07						-	-	-	-	10.50	8	CS	-10.5	+ + +			Grey,Grey Brown,Medium & Coarse Grain Structure,Highly Fractured & Disintegrated,**Moderately Weatherd Rock - W3 Rock Formation** Hypersthene Granitic Rock
11	05/07/2022	09 To 10	00 To 15	DB	27	14												
12							-	-	-	-	12.00	9	CS	-12.0		L2	12.0	
13–20																		

CS - Core Sample	DS - Disturbed Sample	LOGGED	S. Stephenraj	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	05/07/2022	GROUND LEVEL (m)	0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Sharmila.G	WATER TABLE (m)	2.40	
WS - Wash Sample	DB - Diamond Bit	DATE	13/07/2022	CASING DEPTH (m)	0.00	

Borehole terminated at 12 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-02		
SHEET	2	OF	2
DIA OF BORE HOLE	150mm		
	NX	✓	

PROJECT NAME	PROPOSED CONSTRUCTION OF A RESIDENTIAL BUILDING					BORE START DATE	06/07/2022
LOCATION	Velacherry Main Road, Guindy	MACHINE No.	-	CHAINAGE (m)	-		
STRUCTURE	2B + Stilt + 13 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	07/07/2022
JOB CODE	GT-2398	FLUSHING MEDIUM	Bentonite		E -	TOTAL DRILL DAYS	2

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Sample Details: RL (m)	Layer Data: Legend	Layer Data: No	Layer Data: Depth	Geotechnical Description
11	07/07/2022						-	-	-	-	↓ 10.50	9	CS	-10.5	+ + + + +	L3	10.5	Grey,Grey Brown,Medium & Coarse Grain Structure,Highly Fractured & Disintegrated,**Moderately Weatherd Rock - W3 Rock Formation** Hypersthene Granitic Rock
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

CS - Core Sample	DS - Disturbed Sample	LOGGED	S. Stephenraj	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	07/07/2022	GROUND LEVEL (m)	0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Sharmila. G	WATER TABLE (m)	2.50	
WS - Wash Sample	DB - Diamond Bit	DATE	13/07/2022	CASING DEPTH (m)	0.00	

Borehole terminated at 10.5 m depth below E.G.L

FIG.2.2 Sub Soil Profile at BH-02 Location

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SITE INVESTIGATION RECORD

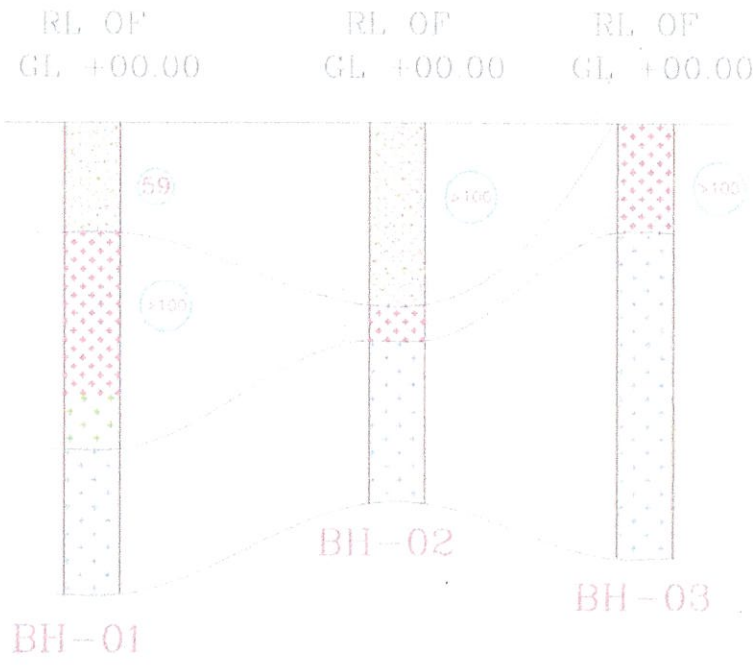
BORE HOLE No.	BH-03
SHEET	1 OF 2
DIA OF BORE HOLE	150mm ✓ / NX ✓
BORE START DATE	01/07/2022
BORE END DATE	05/07/2022
TOTAL DRILL DAYS	4

PROJECT NAME	PROPOSED CONSTRUCTION OF A RESIDENTIAL BUILDING				
LOCATION	Velacherry Main Road, Guindy	MACHINE No.	-	CHAINAGE (m)	-
STRUCTURE	2B + Stilt + 13 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -
JOB CODE	GT-2398	FLUSHING MEDIUM	Bentonite		E -

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Sample Details: RL (m)	Layer Data: Legend	Layer Data: No	Layer Data: Depth	Geotechnical Description
0	01/07/2022	14	00	SC	-	-												
		To 14	05															
1		14	35	SC	-	-	45	7cm penet for 55 blows		>100	1.00 / 1.22	1	SS	-1.0				Brown,Grey Brown,Moist,Fine to Coarse Grains Structure,Very Dense, **Residual Soil & Completely Weathered Rock - Grade W5 Rock Formation** Disintegrated Hypersthene Granitic Rock
		To 14	40															
2		15	30	SC	-	-	48	6cm penet for 55 blows		>100	2.00 / 2.21	2	SS	-2.0				
		To 15	40															
3		09	00	DB	15	0	SPT Hammer Rebound			>100	3.00	-	WS	-3.0	L1	3.0		
		To 09	30															
4	02/07/2022	09	45	DB	28	0	-	-	-	-	4.00	3	CS	-4.0				
		To 10	15															
5		10	45	DB	35	0	-	-	-	-	5.00	4	CS	-5.0				
		To 11	45															
6		Total Drilling Time 2hrs 30min		DB	14	0	-	-	-	-	6.00	5	CS	-6.0				Grey,Grey Brown,Medium & Coarse Grain Structure,Highly Fractured & Disintegrated,**Moderately Weatherd Rock - W3 Rock Formation** Hypersthene Granitic Rock
7																		
8	04/07/2022	09	00	DB	15	0	-	-	-	-	7.50	6	CS	-7.5				
		To 10	30															
9							-	-	-	-	9.00	7	CS	-9.0				
10		Total Drilling Time 4 hrs		DB	24	0												

CS - Core Sample	DS - Disturbed Sample	LOGGED	S. Stephenraj	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	04/07/2022	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Sharmila.G	WATER TABLE (m) 2.40	
WS - Wash Sample	DB - Diamond Bit	DATE	13/07/2022	CASING DEPTH (m) 0.00	

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LEGEND

Clayey Silty SAND (SC)/ Residual Soil – Grade W5 Rock Formation

Completely Weathered Rock – Grade W5 Rock Formatoin

Highly Weathered Rock – W4 Rock Formation

Moderately Weatherd Rock – W3 Rock Formation

FIG No.2.4 CROSS SECTIONAL VARIATION OF SUB SOIL PROFILE THROUGH BH-01 TO 03

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GRAIN SIZE DISTRIBUTION CURVE

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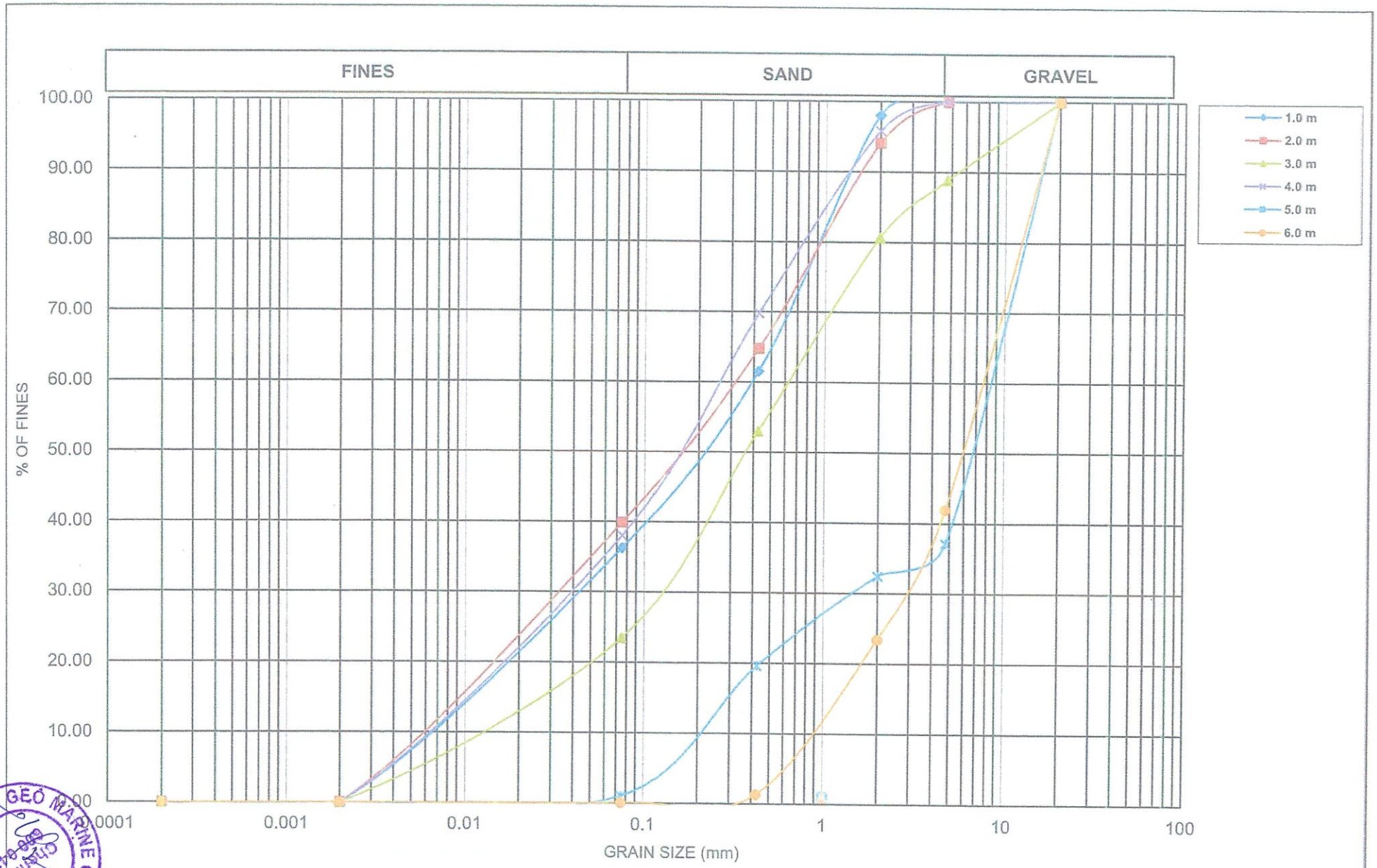


Fig. 2.6 GRAIN SIZE DISTRIBUTION CURVE - BH-02

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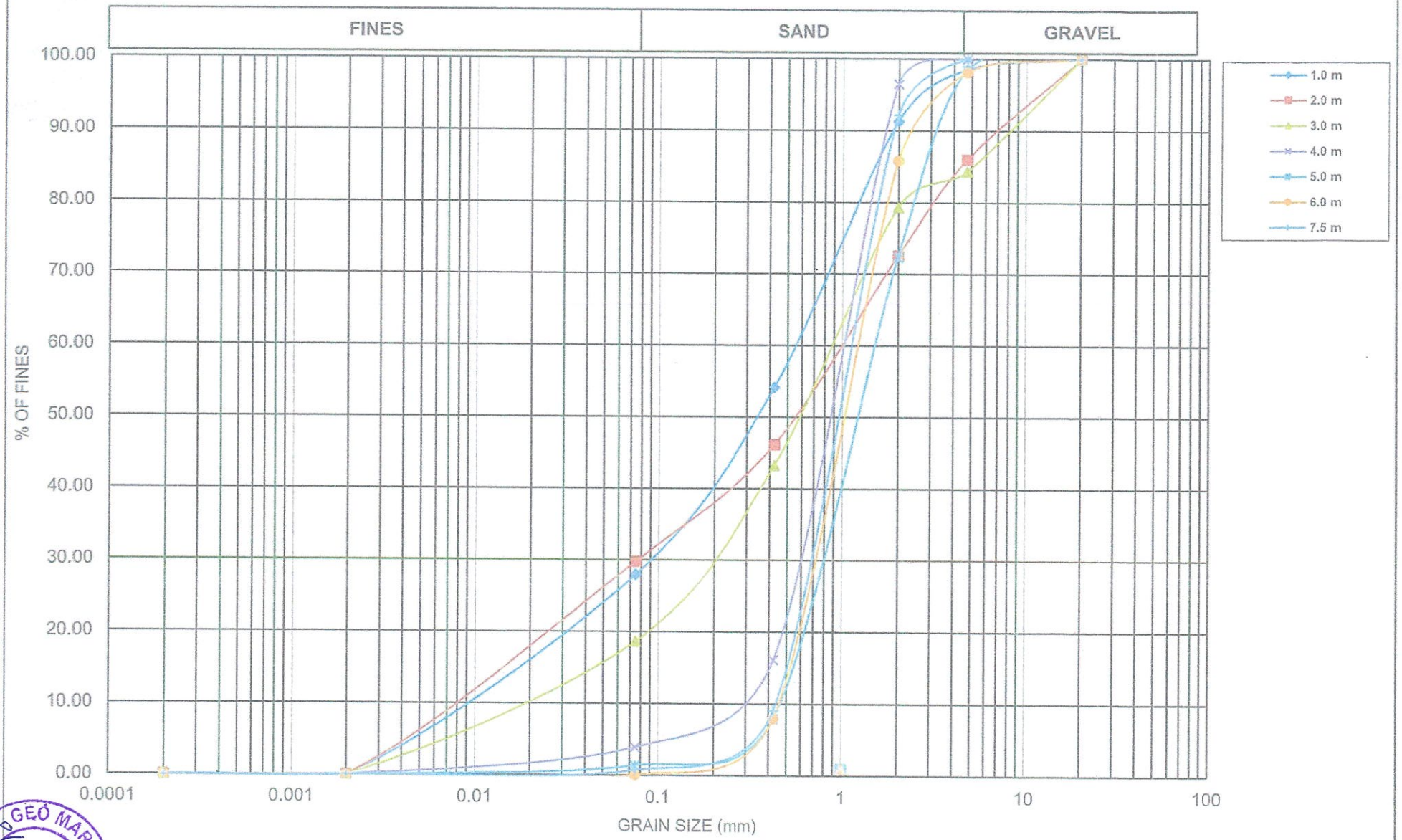


Fig. 2.5 GRAIN SIZE DISTRIBUTION CURVE - BH-01

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HYDROMETER ANALYSIS CURVE

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Chennai
600 041

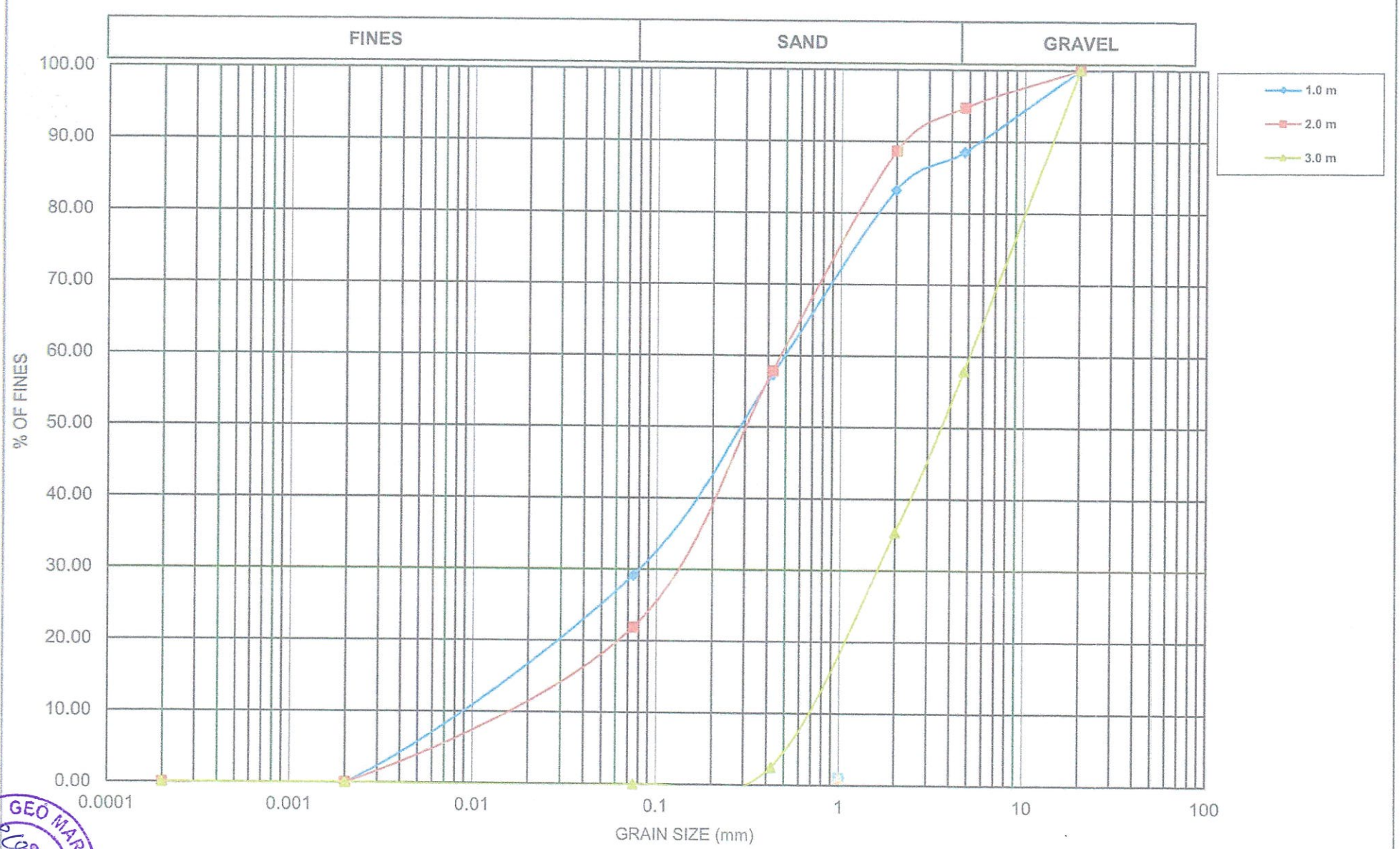


Fig. 2.7 GRAIN SIZE DISTRIBUTION CURVE - BH-03

GEO MARINE CONSULTANTS PVT. LTD. Chennai

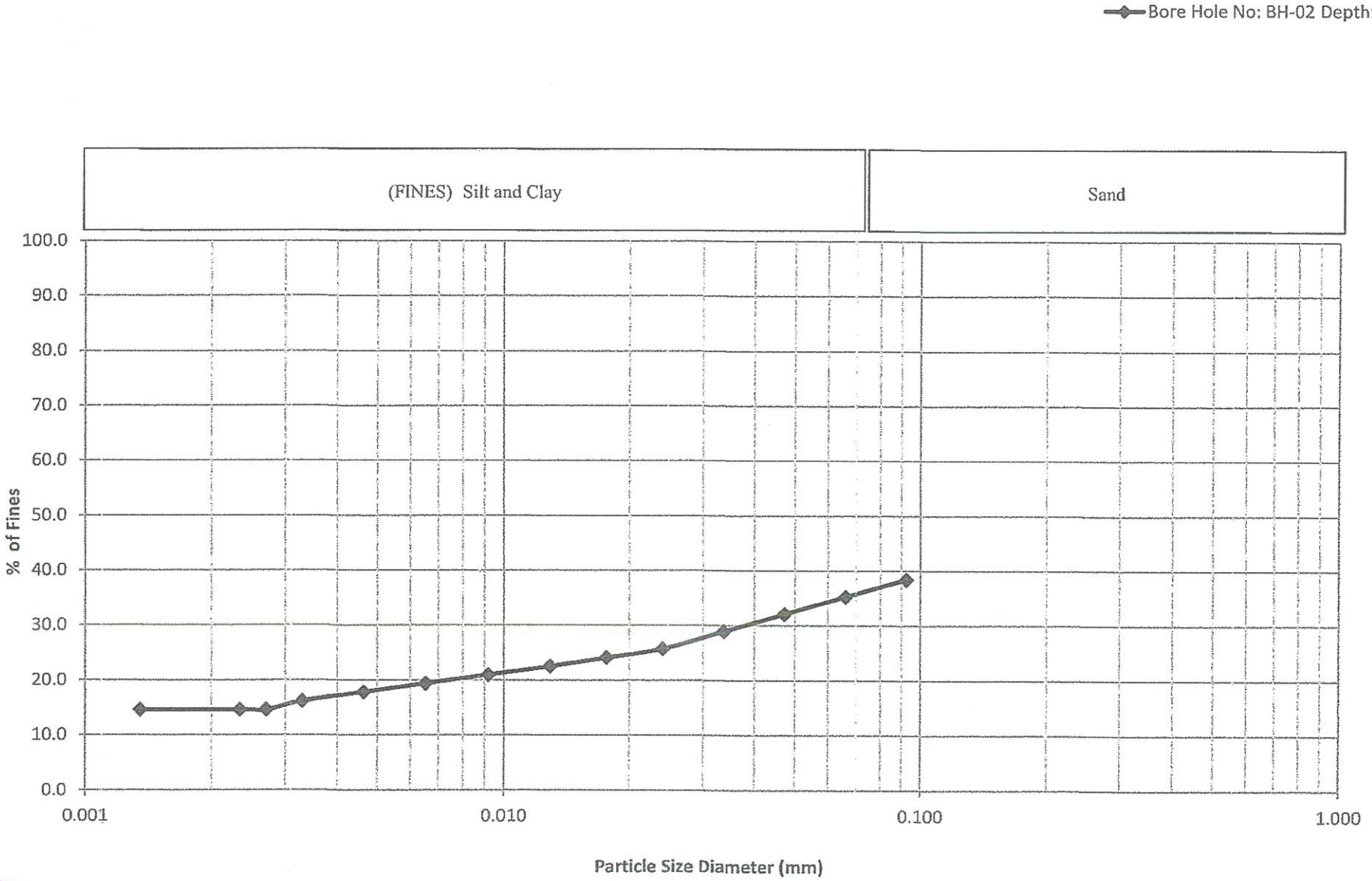


Fig 2.9 Hydrometer Analysis Master Curve

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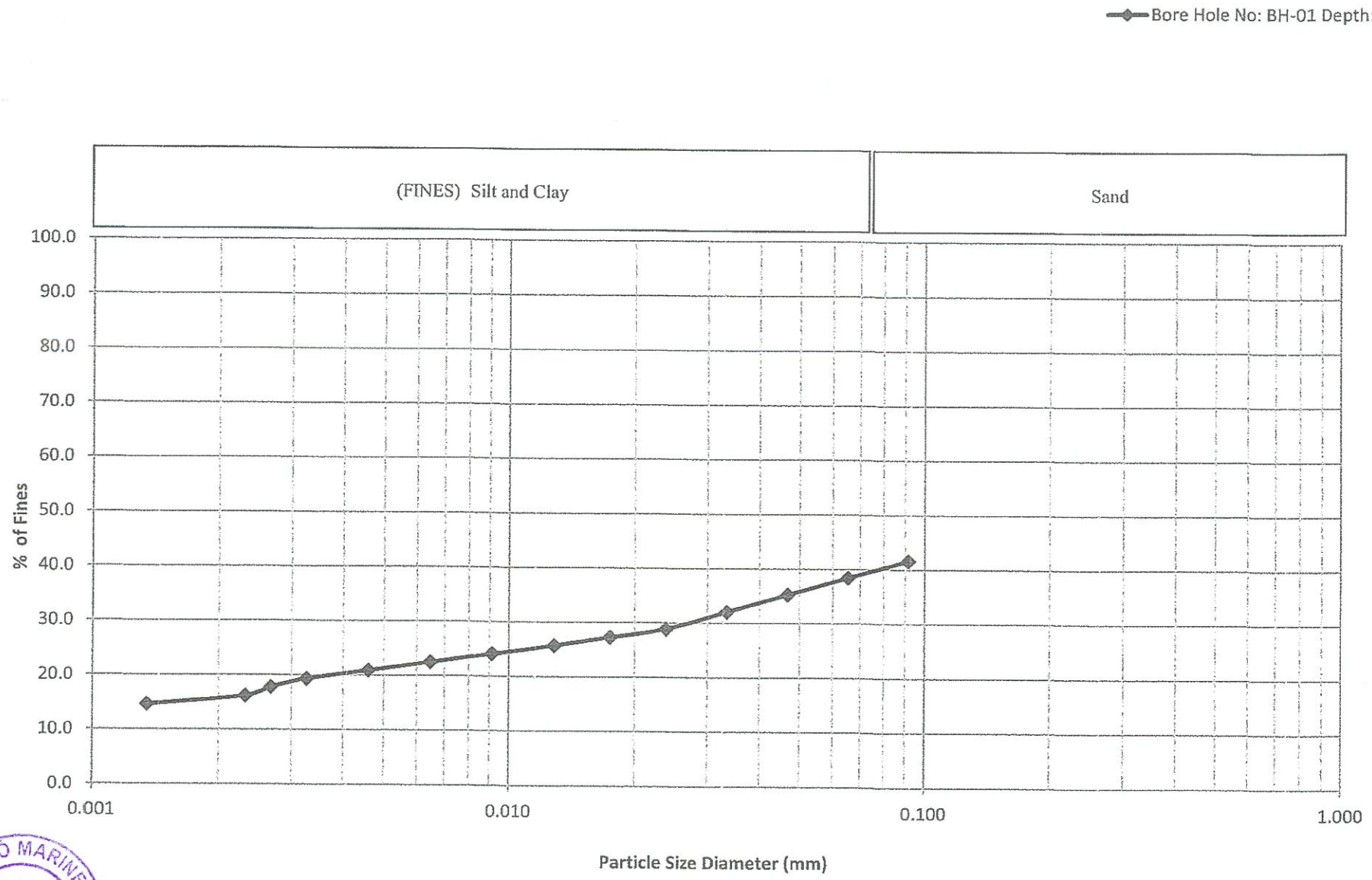


Fig 2.8 Hydrometer Analysis Master Curve

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LABORATORY TEST RESULTS

GEO MARINE CONSULTANTS PVT. LTD. Chennai

GEOMARINE
Phone No.: 044-24481485, 044-24480305

LABORATORY TEST REPORT

GEOMARINE CONSULTANTS PVT LTD- GEOTECHNICAL LABORATORY
NO.11 2nd MAIN ROAD, KANNAPA NAGAR EXTN,
KOTTIVAKKAM. CHENNAI

Name & Address of the Customer	:	**M/s IVAR ESTATES PRIVATE LIMITED**	**Customer Reference**	:	By Email
Sample Description	:	Soil Sample	**Period of Testing**	:	16/07/2022 to 21/07/2022
Source of Sample	:	Customer Supplied- Borehole No. BH-01	**Sample Identification Number**	:	SS/GMC/062022/495/BH01
Sample Condition	:	Satisfactory	**Test Report No.**	:	GT-2398/BH-01
Test Method	:	As per Bureau of Indian Standards	**Report Date**	:	21/07/2022
Sample Receipt Date	:	09/07/2022	**Test Report Pages**	:	One Page

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

Sample Depth (m)	SPT- "N" Value	Type of Sample	Fine Grained (FG)										Coarse Grained (CG)												
			Moisture Content (%) AS PER IS 2720 (P-II) - 1973, RA-2015	LIQUID LIMIT (%) AS PER IS 2720 (P-V) - 1985, RA-2015	PLASTIC LIMIT (%) AS PER IS 2720 (P-V) - 1985, RA-2015	Plasticity Index (I_P= LL-PL)	Consistency Index (Ic=LL-NMC/I_P)	SHRINKAGE LIMIT (%) AS PER IS 2720 (P-VI) - 1972, RA-2011	FREE SWELL INDEX (%) AS PER IS 2720 (P-XL) - 1977, RA-2011	Consistancy	Position With Respect to A-Aline	IS:Notation	SPECIFIC GRAVITY AS PER IS 2720 (P-III, SEC-1) - 1980, RA-2010	GRAIN SIZE ANALYSIS AS PER IS 2720 (P-IV) - 1985, RA-2015						D_{10} (mm)	D_{30}(mm)	D_{60} (mm)	Uniformity Co-Efficient $C_U=D_{60}/D_{10}$	Co-Efficient of Curvature $C_c=D_{30}^2/(D_{10}xD_{60})$	Relative Density	IS:-Notation	
													Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)							Gravel	Sand
1.0	74	SS	-	-	-	-	-	-	-	CG>50%	-	-	-	1.4	7.3	37.1	26.2	28.0		-	-	-	-	-	V.Dense	Residual Soil to Highly Weathered Rock	
2.0	43	SS	12.8	31.1	15.5	15.6	1.2	18.5	5.5	CG>50%	Above	-	-	14.1	13.4	26.4	16.4	25.0	4.8	-	-	-	-	-	Dense		
3.0	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	-	15.7	5.0	36.1	24.6	18.6		-	-	-	-	-	V.Dense		
4.0	>100	WS	-	-	-	-	-	-	-	CG>50%	-	-	-	0.0	3.5	80.4	12.2	3.9		-	-	-	-	-	V.Dense		
5.0	>100	WS	-	-	-	-	-	-	-	CG>50%	-	-	-	1.5	26.1	64.4	6.6	1.4		-	-	-	-	-	V.Dense		
6.0	>100	WS	-	-	-	-	-	-	-	CG>50%	-	-	-	1.8	12.4	77.8	7.9	0.1		-	-	-	-	-	V.Dense		
7.5	>100	WS	-	-	-	-	-	-	-	CG>50%	-	-	-	0.0	7.8	83.1	8.3	0.7		-	-	-	-	-	V.Dense		

** END OF REPORT**

Terms and Conditions

(1) The test results furnished corresponds to the sample received

(2) The tested sample will not be retained for more than 45 days from the date of issue of test report except in the case as required by the applicable regulations.

(3) Any correction in this reports invalidates the reports

Authorised Signatory

A. VINOTH
(Technical Manager)

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ARINE

.: 044-24481485, 044-24480305

LABORATORY TEST REPORT

GEOMARINE CONSULTANTS PVT LTD- GEOTECHNICAL LABORATORY
NO.11 2nd MAIN ROAD, KANNAPA NAGAR EXTN,
KOTTIVAKKAM. CHENNAI

& Address of the Customer	:	M/s IVAR ESTATES PRIVATE LIMITED	Customer Reference	:	By Email
e Description	:	Soil Sample	Period of Testing	:	16/07/2022 to 21/07/2022
e of Sample	:	Customer Supplied- Borehole No. BH-03	Sample Identification Number	:	SS/GMC/062022/495/BH03
e Condition	:	Satisfactory	Test Report No.	:	GT-2398/BH-03
lethod	:	As per Bureau of Indian Standards	Report Date	:	21/07/2022
e Receipt Date	:	09/07/2022	Test Report Pages	:	One Page

Table-2.3 Laboratory Classification of Soil Samples from BH-03

SPT- "N" Value	Type of Sample	Fine Grained (FG)										SPECIFIC GRAVITY AS PER IS 2720 (P-III, SEC-1) - 1980, RA-2010	Coarse Grained (CG)													
		Moisture Content (%) AS PER IS 2720 (P-II) - 1973, RA-2015	LIQUID LIMIT (%) AS PER IS 2720 (P-V) - 1985, RA-2015	PLASTIC LIMIT (%) AS PER IS 2720 (P-V) - 1985, RA-2015	Plasticity Index (I_p= LL-PL)	Consistency Index (Ic=LL-NMC/I_p)	SHRINKAGE LIMIT (%) AS PER IS 2720 (P-VI) - 1972, RA-2011	FREE SWELL INDEX (%) AS PER IS 2720 (P-XL) - 1977, RA-2011	Consistancy	Position With Respect to A-Aline	IS:Notation		GRAIN SIZE ANALYSIS AS PER IS 2720 (P-IV) - 1985, RA-2015						D_{10} (mm)	D_{30}(mm)	D_{60} (mm)	Uniformity Co-Efficient $C_U=D_{60}/D_{10}$	Co-Efficient of Curvature $C_c=D_{30}^2/(D_{10}xD_{60})$	Relative Density	IS-Notation	
													Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)							Gravel	Sand
100	SS	-	-	-	-	-	-	-	CG>50%	-	-	-	11.44	5.38	25.82	28.16	29.2		-	-	-	-	-	V.Dense	Residual Soil & Completely Weathered Rock	
100	SS	Little to Non Plastic Binder						0.0	CG>50%	Above	-	-	5.28	6.1	30.8	35.94	21.9		-	-	-	-	-	V.Dense		
100	SS	-	-	-	-	-	-	-	CG>50%	-	-	-	42.05	22.65	32.88	2.41	0.0		-	-	-	-	-	V.Dense		

** END OF REPORT**

nd Conditions

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ested sample will not be retained for more than 45 days from the date of issue of test report except in the case as required by the applicable regulations.
correction in this reports invalidates the reports

Authorised Signatory

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(Technical Manager)

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GEOMARINE
Phone No. : 044-24481485, 044-24480305

LABORATORY TEST REPORT

GEOMARINE CONSULTANTS PVT LTD- GEOTECHNICAL LABORATORY
NO.11 2nd MAIN ROAD, KANNAPA NAGAR EXTN,
KOTTIVAKKAM. CHENNAI

Name & Address of the Customer	:	**M/s IVAR ESTATES PRIVATE LIMITED**	**Customer Reference**	:	By Email
Sample Description	:	Soil Sample	**Period of Testing**	:	16/07/2022 to 21/07/2022
Source of Sample	:	Customer Supplied- Borehole No. BH-02	**Sample Identification Number**	:	SS/GMC/062022/495/BH02
Sample Condition	:	Satisfactory	**Test Report No.**	:	GT-2398/BH-02
Test Method	:	As per Bureau of Indian Standards	**Report Date**	:	21/07/2022
Sample Receipt Date	:	09/07/2022	**Test Report Pages**	:	One Page

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

Sample Depth (m)	SPT- "N" Value	Type of Sample	Fine Grained (FG)										Coarse Grained (CG)												
			Moisture Content (%) AS PER IS 2720 (P-II) - 1973, RA-2015	LIQUID LIMIT (%) AS PER IS 2720 (P-V) - 1985, RA-2015	PLASTIC LIMIT (%) AS PER IS 2720 (P-V) - 1985, RA-2015	Plasticity Index (I_P= LL-PL)	Consistency Index (I_C=LL-NMC/I_P)	SHRINKAGE LIMIT (%) AS PER IS 2720 (P-VI) - 1972, RA-2011	FREE SWELL INDEX (%) AS PER IS 2720 (P-XL) - 1977, RA-2011	Consistancy	Position With Respect to A-Aline	IS:Notation	SPECIFIC GRAVITY AS PER IS 2720 (P-III, SEC-1) - 1980, RA-2010	GRAIN SIZE ANALYSIS AS PER IS 2720 (P-IV) - 1985, RA-2015						D_{10} (mm)	D_{30}(mm)	D_{60} (mm)	Uniformity Co-Efficient $C_U=D_{60}/D_{10}$	Co-Efficient of Curvature $C_c=D_{30}^2/(D_{10}xD_{60})$	Relative Density	IS-Notati	
													Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)							Gravel	
1.0	69	SS	13.9	35.9	18.2	17.7	1.2	-	7.7	CG>50%	Above	-	-	0.0	2.0	36.5	25.3	31.0	5.3	-	-	-	-	-	V.Dense	Residual Soil t Weathered
2.0	>100	SS	14.4	33.5	17.8	15.7	1.2	17.0	20.0	CG>50%	Above	-	-	0.0	5.9	29.3	24.9	39.9		-	-	-	-	-	V.Dense	
3.0	>100	SS	17.9	35.4	Little Plastic Binder				0.0	CG>50%	-	-	-	11.1	8.2	27.6	29.5	23.5		-	-	-	-	-	V.Dense	
4.0	>100	SS	19.3	27.0					8.3	CG>50%	-	-	-	0.0	4.2	26.0	31.8	38.0		-	-	-	-	-	V.Dense	
5.0	>100	SS	-	-	-	-	-	-	-	-	-	-	-	62.9	4.6	12.9	18.6	1.0		-	-	-	-	-	V.Dense	
6.0	>100	WS	-	-	-	-	-	-	-	-	-	-	-	58.0	18.5	22.1	1.3	0.1		-	-	-	-	-	V.Dense	

** END OF REPORT**

Terms and Conditions

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TABLE - 2.5 ROCK TEST RESULTS				
S.No.	Borehole Number	Depth (m)	Point Load Index Is(50) (mPa)	Unconfined Compressive Strength (mPa)
1	BH - 01	10.50 to 12.00	0.73	-
2	BH - 02	7.50 to 9.00	1.28	-
3	BH - 03	10.50 to 12.00	1.83	34.93

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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)
1.0	BH-01	2.30	7.21	72.3	53.8	1.0	7.09	32.6	26.1
2.0	BH-02	2.50	6.92	49.5	45.1	1.0	7.16	41.7	29.3
3.0	BH-03	2.40	6.95	44.8	43.8	2.0	7.12	35.2	27.6

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CHAPTER-4

LIQUEFACTION EVALUATION

4.0 PHENOMENA:

Liquefaction has historically been used in conjunction with a variety of phenomena that involve soil deformations caused by monotonic, transient, or repeated disturbance of saturated cohesion-less soils under un-drained conditions. The generation of excess pore water pressure under un-drained loading conditions is a hallmark of all liquefaction phenomena. When saturated cohesion-less soils subjected to rapid loading resulting in undrained conditions undergo densification generates excess pore pressures and decreases effective stresses, eventually leading to excess deformation failures, commonly known as liquefaction. Liquefaction phenomena that result from this process is generally divided in two main groups: flow liquefaction and cyclic mobility. Both flow liquefaction and cyclic mobility are very important and any evaluation of liquefaction hazards should carefully consider both.

4.1 LIQUEFACTION SUSCEPTIBILITY:

Not all soils susceptible to liquefaction; consequently, the first step in a liquefaction hazard evaluation is the evaluation of liquefaction susceptibility. There are several criteria by which liquefaction susceptibility can be judged, and some are different for flow liquefaction and cyclic mobility. These include Historical, Geologic, Compositional, and State Criteria (Initial stress state before liquefaction).

Of the above four criteria, except the state criteria, the other three provide a qualitative evaluation of the liquefaction susceptibility of a deposit. The state criteria provide an analytical approach to quantify the liquefaction susceptibility with respect to the stress-strain response of the deposit against the environmental loading conditions.

The evaluation of liquefaction susceptibility based on state criteria is an independent and involved elaborate laboratory monotonic and cyclic loading testing programme and this is beyond the scope of present investigation. However, the liquefaction susceptibility pertinent to the present site sub surface characteristics are qualitatively outlined in the following sections. Further, based on the published correlation with respect to the corrected SPT-values, an attempt is made to provide a basic and guideline analysis on the liquefaction potential pertinent to ZONE-III earthquake coefficient.

4.2 QUALITATIVE APPROACH:

4.2.1 HISTORICAL CRITERIA:

Historically, the present site location never documented any post-earthquake generated soil flows or local liquefaction related effects.

4.2.2 GEOLOGIC CRITERIA:

Geologic process that sort soils into uniform grain size distribution and deposit them in loose states produce soil deposits with high liquefaction susceptibility. Similarly, the older geological formations are less susceptible to liquefaction compared to the recent deposits like Fluvial, Colluvium and Aeolian deposits.

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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/m³	Shear Parameters	
	Top BGL	Bottom BGL	Thickness							(Cu) kPa	(ϕ) Deg.
1.0	0.00	5.00	5.00	Residual Soil	Brown, Yellow Brown	>100	Very Dense	-	21	-	42.5
2.0	5.00	6.00	1.00	Completely Weathered Rock	Brown, Yellow Brown	>100	Very Dense	-	21	-	42.5
3.0	6.00	10.50	4.50	Moderately Weathered Rock	Grey,Grey Brown	CRR-18% to 34%, RQD-0%					

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/m³	Shear Parameters	
	Top BGL	Bottom BGL	Thickness							(Cu) kPa	(ϕ) Deg.
1.0	0.00	3.00	3.00	Residual Soil	Brown Grey	>100	Very Dense	-	21	-	42.5
2.0	3.00	12.00	9.00	Moderately Weathered Rock	Grey, Grey Brown	CRR-14% to 35%, RQD-0% & 14%					

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FOUNDATION SYSTEM



FOUNDATION SYSTEM

5.0 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.

5.1 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 two basement + stilt and thirteen upper floors, and is meant for residential. For this kind of structure, the column loads could vary between 3000 kN to 5000kN.

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.

5.2 SUB SOIL FORMATION:

The sub soil in the project location consists of:

0.0m to 3.0m/5.0m	Very Dense, **Residual Soil & Completely Weathered Rock**
3.0m/5.0m to 11.0m/13.0m	Grade W4 & W3 Rock Formation, **Highly Weathered & Moderately Weathered Rock**

5.3 BEARING STRATA:

It is proposed to construct multi-storey structure with two basement floor. It is informed that the overall depth of excavation up to the top of lower basement floor is 6.0m below the existing ground level. Taking into consideration of thickness of foundation the overall depth of excavation required could be about 7.5m to 8.0m below the existing ground level

The bearing stratum (beyond 6.0m) is Completely to Highly Weathered Rock formation and it is modelled as coarse grain soil (very dense sand). Further, ground water table is encountered at 1.0m below the existing ground level during the time of investigation.

The above criteria is taken into consideration for estimation the bearing capacity computations, the bearing strata is modelled as very dense, coarse grain formation with angle of internal friction $\phi = 45°$.

Since the formation beyond the founding level is rock formation with varying grade of weathering for settlement analysis only immediate elastic settlement is considered.

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3.4 GEOLOGICAL ORDER OF THE STUDY AREA:

The stratigraphy of the study area can be classified as recent formation which is underlain by basement rock of meta-igneous origin (hypersthene granite/ Charnockite rock)

Deposits of Recent Age

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

Archaean Basement Rock (Charnockite Rock / Hypersthene Granite)

3.5 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 BGL	Bottom BGL	Thickness							(C_u) kPa	(ϕ) Deg.
1.0	0.00	3.00	3.00	Residual Soil	Brown	59	Very Dense	-	20.5	-	42.35
2.0	3.00	7.50	4.50	Completely Weathered Rock	Brown,Grey Brown	>100	Very Dense	-	21	-	42.5
3.0	7.50	9.00	1.50	Highly Weathered Rock	Grey, Grey Brown	CRR-9%, RQD-0%					
4.0	9.00	13.00	4.00	Moderately Weathered Rock	Grey,Grey Brown	CRR-16% to 28%, RQD-0%					

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GEOLOGY & SUB-SURFACE STRATIFICATION

3.0 PREAMBLE:

Geotechnical investigation carried out at a specific site provides location specific sub surface engineering characteristics. However in major project sites where the construction activities spread over a very large area location specific sub surface strata characteristics are studied together with the geological mapping data.

This is required to incorporate the impact of any documented macro-level geological characteristics of the region on the foundation design, irrespective of the location specific sub surface strata characteristics.

In view on the above, though it is beyond the scope of the present study to carry out macro-level geological investigation the regional geology based on the published data is presented and discussed.

3.1 CLIMATE AND RAINFALL:

The study area receives the rain under the influence of both southeast and northeast monsoons. Predominantly northeast monsoon contributes rainfall and most of the precipitation occurs in the form of cyclonic storm caused due to the depressions in Bay of Bengal. The north east monsoon occurs between October & December. The southwest monsoon rainfall is highly erratic and summer rains are negligible.

The normal annual rainfall over the study area varies from 1100 mm to 1200mm.

3.2 GEOMORPHOLOGY:

Chennai district forms part of coastal plains of northern Tamil Nadu. Major part of the district is having flat topography with very gentle slope towards east. The altitudes of land surface vary from 10 m above MSL in the west to sea level in the east.

Fluvial, marine and erosional landforms are noticed in the district. Marine transgression and regressions and neo-tectonic activity during the recent past have influenced the morphology and resulted in various present landforms.

Meandering streams with small sand bars are present along the course of Adyar River. The pediment and buried pediment in Guindy area in and around the reserved forest, is the only area where the ecological system is less disturbed, while the other areas are completely disturbed by built up area with large-scale human interference and pollution.

3.3 GEOLOGY OF CHENNAI DISTRICT:

Chennai district is underlain by various geological formations from ancient Archaean to the Recent Alluvium. The geological formations of the district can be grouped into three units, namely

i) Archaean crystalline rocks

ii) Gondwana (Consolidated Clay/Clayey Silt) and Tertiary sediments and

iii) Recent Alluvium.

The Archaean crystalline rocks of the district comprise chiefly of Charnockite, gneisses and the associated basic and ultra-basic intrusive dykes.

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4.3.1.1 LIQUEFACTION RESISTANCE CHARACTERIZATION USING IN SITU TEST RESULTS:

(Ref."GEOTECHNCIAL EARTHQUAKE ENGINEERING" by Steven L. Kramer, University of Washington, Prentice-Hall International Series in Civil Engineering and Engineering Mechanic, 2005, Page77-381.

Seed et al (1975) developed a relationship between cyclic stress ratios (CSR) causing liquefaction and corrected SPT-values $(N_1)_{60}$ for silty sands in M=7.5 earthquakes. Further a magnitude correction factor for cyclic stress approach for different earthquake magnitudes is also developed.

The above relationships are reproduced in Figs.4.1 and Table-4.1. Based on this method, for the present site, the following approach is adopted to arrive at Liquefaction Resistance Characterization of the sub surface deposits encountered in the present site.

Step-I: Using the Zone Factor (Z), Importance Factor (I),Response reduction factor and Average response acceleration coefficient (S_a/g) pertinent to Zone-III, the design horizontal and vertical seismic coefficients are estimated as per IS:1893.

Step-2: Using the design seismic coefficient, compute the design seismic shear for corresponding to effective vertical stress (cyclic shear stress) due to overburden is computed.

Stet-3: Using the average corrected design SPT-value arrive at the design angle of shearing resistance compute the effective shear strength (static strength)

Step-4: Arrive at the CSR value of the deposit by dividing the cyclic shear stress with the effective shear strength.

Step-4: Based on the CSR-N_{160} relation from Fig.4.1 and using the magnitude correction factor corresponding to Zone-III (M=6), the probable liquefaction/no-liquefaction characterization is arrived at and the details are given below:

Table 9-2 Magnitude Correction Factors for Cyclic Stress Approach

Magnitude, M	$CSR_M/CSR_{M=7.5}$
$5\frac{1}{4}$	1.50
6	1.32
$6\frac{3}{4}$	1.13
$7\frac{1}{2}$	1.00
$8\frac{1}{2}$	0.80

TABLE-4.1 MAGNITUDE CORRECTION FACTORS FOR CYCLIC STRESS APPROACH

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FORMATION CHARACTERISTICS:

Sub soil stratigraphy in the project location consists:

0.0m to 3.0m/5.0m	Very Dense, **Residual Soil & Completely Weathered Rock**
3.0m/5.0m to 11.0m/13.0m	Grade W4 & W3 Rock Formation, **Highly Weathered & Moderately Weathered Rock**

4.2.3 COMPOSITION CRITERIA:

Since liquefaction requires the development of excess pore pressure, liquefaction susceptibility is influenced by the compositional characteristics that influence volume change behaviour. These characteristics include particle size, shape and gradation. No specific Indian Standards are available to arrive at the potential particle size that chiefly contributes to the liquefaction. Further, well graded soils are less susceptible to liquefaction than poorly graded soils. Similarly rounded particles are more susceptible than angular particles as they tend to density.

In general, the composition of particles that is susceptible to liquefaction is encountered in loose state of deposition in alluvial and fluvial environment. In the present case, the sub soil from the existing ground level being dense soil followed by rock formation of different degree of weathering which indicates the deposit is non-susceptible to liquefaction phenomena.

4.3 QUANTITATIVE APPROACH:

4.3.1 FLOW LIQUEFACTION:

Flow liquefaction can occur, when the shear stress required for static equilibrium of a soil mass (the static shear stress) is greater than the shear strength of the soil in its liquefied state. Flow liquefaction can occur either under monotonic or under cyclic loading conditions. In this failure, the cyclic stresses bring the soil to an unstable state at which its strength drops sufficiently to allow the static stresses to produce the flow. The flow liquefaction is characterised by sudden nature of occurrence and speed of occurrence.

The cyclic mobility can develop when the static shear stress is smaller than the steady-state shear strength and can occur in both loose and dense soils. A combination of static and cyclic loading generally produces cyclic mobility. However, no cyclic testing programme is carried out as it is beyond the scope of present investigation.

In the absence of cyclic testing programme a basic analysis based on the published data using in situ test results (SPT) is presented below to characterize the Liquefaction Resistance of the sub surface deposits encountered in the present site.

Further, as a first order of approximation and in the absence of rigours testing programme focusing on liquefaction steady, it is pressured that the clayey strata are non-susceptible to liquefaction and analysis is limited to sandy strata.

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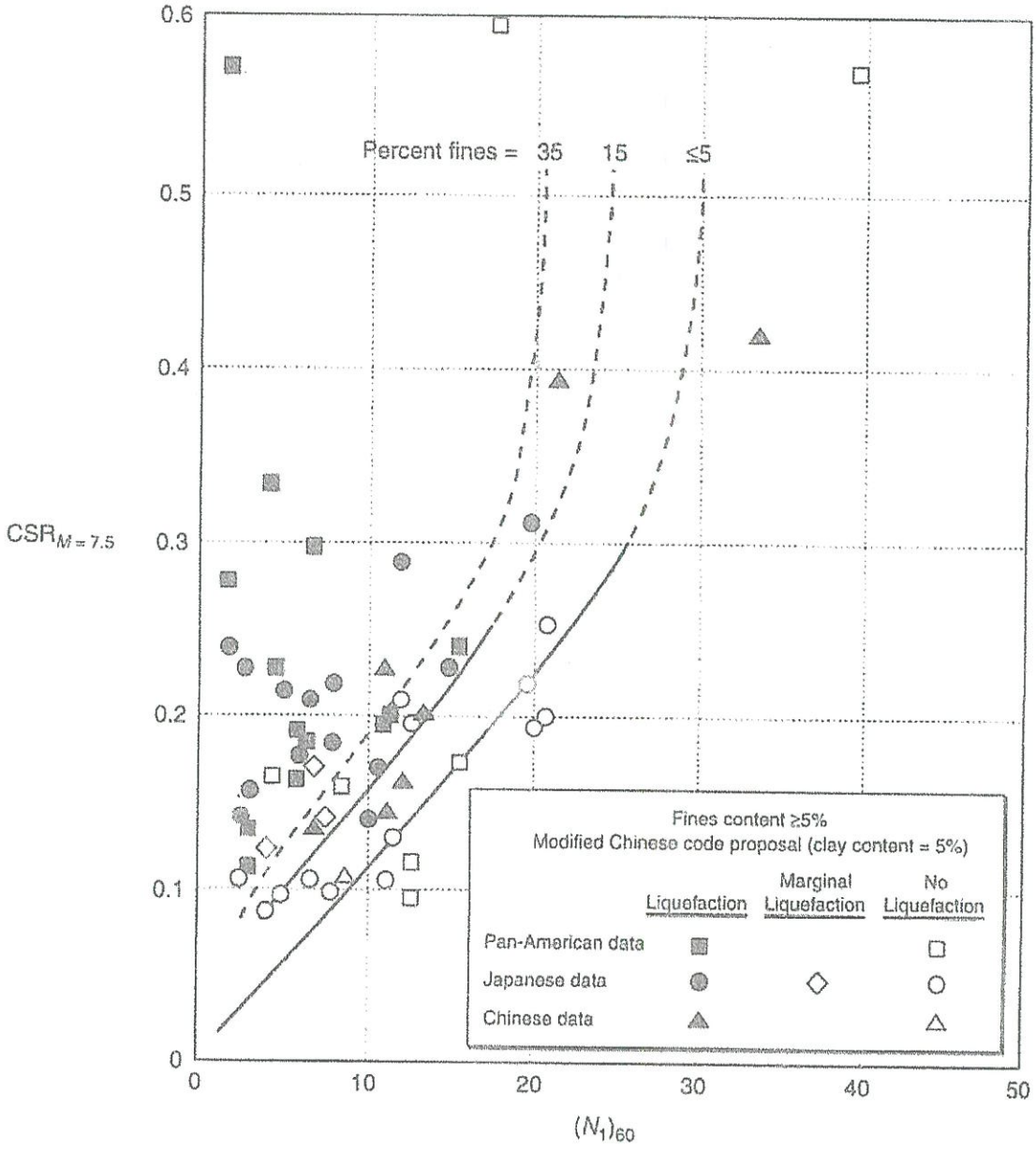


Figure 9.31 Relationship between cyclic stress ratios causing liquefaction and $(N_1)_{60}$ values for silty sands in $M = 7.5$ earthquakes. (After Seed et al. (1975). Influence of SPT procedures in soil liquefaction resistance evaluations, *Journal of Geotechnical Engineering*, Vol. 111, No. 12. Reprinted by permission of ASCE.)

FIG 4.1: RELATIONSHIP BETWEEN CYCLIC STRESS RATIOS OF LIQUEFACTION

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4.4 Susceptibility to Liquefaction:

Liquefaction is a phenomenon occurs in sand and silts having relative density loose to very loose formation. Further the phenomenon can occurs in soft to very soft, clays of low plastic nature. The low plastic nature indirectly infers the predominant percentage of silt size particle which are highly susceptible to liquefaction.

In the project site no silt and sand with relative density having neither very loose nor very soft to soft low plastic clay strata exits within the investigation depth.

- ***The present project site falls in Seismic Zone-III, as per IS 1893 (Part-I)-2016.***
- ***In the project site, the sub soil formation encountered being very dense formation from the existing ground level the formation is not susceptible to liquefaction as per Zone-III seismic intensity.***

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TYPICAL BEARING CAPACITY COMPUTATIONS FOR SHALLOW FOUNDATION

1.0 COMPUTATION OF BEARING CAPACITY AS PER IS:6403

1.1 Geometrical Data :

Shape of the Foundation	Square
Depth of Embedment below the lowest basement floor "D_e"(m):	1.5
Depth of lowest basement floor below E.G.L "D_b"(m):	6.0
Depth of Foundation Below E.G.L "Df" (m):	7.5
Breadth of Footing "B" (m):	2.0
Length of Footing "L" (m):	2.0
B/L	1.00
Inclination of Vertical Load with the Vertical (a)	0.00

1.2 Soil Data :

Type of Effective Bearing Strata : *Weathered Rock*

Type of Shear Failure:	General
SPT "N" of the Bearing Strata :	>100
Angle of Shearing Resistance	45.00

1.3 Design Parameters:

Bulk Density of Soil above the foundation depth (γ_{bulk})	18	kN/m^3
Water Table Correction Factor (w')	0.50	
Effective overburden pressure at foundation level (q)	12.00	kN/m^2

Bearing Capacity Factors:

N_c = N/A

N_q = 134.88

N_g = 271.76

Shape Factors:

S_c = -

S_q = 1.20

S_g = 0.80

Depth Factors :

D_c = -

D_q = 1.00

D_g = 1.00

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' 3884.54 kPa

(g should be read as gama)

1.5 Safe Bearing Capacity (Qsafe) :

Factor of Safety (F.S.) :	2.50	
Qsafe :	1553.82	kPa
Say Q_{safe}	**1300**	**kPa**

2.0 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	1300.00	kPa
Poission's Ratio (μ)	0.30	

Modulus of Elasticity (E_s) for Sands All

(Ref. Joseph E Bowels,1996,page316,Table5.6, Japanese design standards)

Modulus of Elasticity (N X 2600, N=100) (E_s)	260000	
Size of footing considered for maximum settlement(m)	2.00	
Influence factor	0.95	
Rigidity Factor	0.80	
Elastic Settlement (DH_i)	6.92	mm
	<60	mm

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ANNEXURE-I

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CHAPTER-6

RECOMMENDATIONS

- For the kind of sub soil conditions, the foundation system as described in Chapter-5, Section 5.3 can be adopted
- For different sizes of footing, the recommended allowable safe bearing pressure is presented in Table 5.1.
- Since the formation at and beyond founding level is very dense rock formation, the settlement will be of immediate in nature and the estimated settlement for the corresponding safe bearing pressure is within the permissible limit as per IS 1904.
- The present project site fall in seismic zone-III as per IS 1893-P-I
- The recommended modulus of subgrade modulus k_s is 200000 kN/m^3
- For the design of uplift, the recommended hydrostatic head shall be considered from 0.0m that is from the existing ground level.
- The chlorides content in ground water & soil-water extract is less than the permissible limit of 500 mg/l as per IS 456 Table 1.0. Hence no special reinforcement is required for the construction.
- Corresponding to the sulphate content in 2:1 Water-Soil extract and ground water use Table 4.0 of IS 456 Clause 2.0 for minimum cement content and maximum water cement ratio. Hence ordinary Portland cement can be used.
- *Before excavation is started a workshop shall be conducted including the Owner, Architect, Structural Engineer, Geotechnical Engineer and Execution agency to ensure the proposal given by the contractor is workable and safe.*
- *Before construction activities are initiated, a scientific due-diligence of the condition of the neighbouring structures shall be carried out and authenticated. This is required to ensure that no undue claims or interpretations are made by the neighbourhood that the construction activities cause damages to their structures*

GEO MARINE CONSULTANTS PVT. LTD. CHENNAI-41

AUTHORISED SIGNATORY

DR. C. V. PRASAD

GEOMARINE CONSULTANTS PRIVATE LIMITED

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RECOMMENDATIONS



5.5.2 EXCAVATION DESIGN:

For the proposed excavation, open/vertical cut can be adopted. However it is recommended to adopt a minimum slope of 1Horizontal: 6 Vertical in the top 5.0m depth and beyond 5.0m vertical cut is ideal to adopt. Since the strata is of refusal nature no bench/berm is required for the excavation.

In order to prevent rain cuts in the vertical face of excavation during monsoon season it is ideal to cover the slope with 1000 micron HDPE sheet duly anchored in the top and toe either with sand bags or with 1.0m wide PCC of 100mm thickness.

5.6 DEWATERING/ GROUND WATER LOWERING DESIGN:

Since the formation up to the excavation depth is completely to highly weathered rock it is advised to install dewatering borehole up to 13.0m depth and the borehole shall be placed horizontally at every 15.0m Centre to Centre along the periphery and connected with a common header.

The borehole shall be 200mm in diameter and based on the sub soil formation encountered, it is ideal to adopt a solid casing in the top 2.0m followed by filter pipe up to 8.0m and beyond 8.0m no filter pipe may needed as the formation is of highly weathered rock & very dense in nature.

The required pump capacity and yield shall be determined by conducting pump out test before the initiation of excavation.

5.7 BASEMENT SLAB UPLIFT DESIGN:

In the case of basement slab design calls for uplift design it is ideal to consider uplift pressure by considering ground water table (hydrostatic head) at the existing ground level though the ground water table is encountered beyond 2.0m during the time of investigation.

Further, the ingression of surface water below the basement slab through the gaps shall be prevented by providing a pavement connected to the retaining wall.

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5.4 FOUNDATION SYSTEM:

For the kind of proposed construction, either isolated column footing with stitch slab or raft with shear block or rigid raft can be adopted.

In case of isolated footing with stitch slab is adopted the stitch slab shall be anchored against uplift pressure. However in the other two systems slab system design shall be checked for uplift pressure.

In case of raft with shear block or rigid raft, the recommended bearing pressure at 7.5m below the existing ground level is 1500 kPa. In case of isolated footing with stitch slab system, for different sizes of footing the allowable safe bearing pressure is worked out as per IS 6403 and presented in Table 5.1.

TABLE 5.1 RECOMMENDED ALLOWABLE SAFE BEARING CAPACITY

S.NO.	SIZE OF FOOTING (M)		RECOMMENDED ALLOWABLE SAFE BEARING CAPACITY (KPA)	ELASTIC SETTLEMENT (MM)
	Width (B)	Length (L)		
1.0	1.0m X 1.0m		1000	2.7
2.0	2.0m X 2.0m		1300	6.9
3.0	3.0m X 3.0m		1500	12.0
4.0	4.0m X 4.0m		1500	16.0
5.0	5.0m X 5.0m		1500	20.0
6.0	Raft (10.0m X 10.0m)		1500	39.9

Typical computation is presented in the Annexure-I.

For the design of raft, the recommended modulus of sub grade reaction of the bearing strata (k_s) is 200000 kN/m^3

5.5 DEEP EXCAVATION:

5.5.1 EXCAVATABILITY:

The sub surface stratum is classified based on the data derived at the geotechnical investigation borehole location with respect to the excavation or excavatability.

0.0m to 8.0 m — Residual Soil Followed by Completely to Highly Weathered Rock

In the project location, the excavation can be carried out using mechanical excavator like poclain without rock breaker arrangement. However in case of any isolated pockets of rock is encountered the same shall be excavated using rock breaker attached to the mechanical excavator.

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TYPICAL BEARING CAPACITY COMPUTATIONS FOR SHALLOW FOUNDATION

1.0 COMPUTATION OF BEARING CAPACITY AS PER IS:6403

1.1 Geometrical Data :

Shape of the Foundation	Raft
Depth of Embedment below the lowest basement floor "D_e"(m):	1.5
Depth of lowest basement floor below E.G.L "D_b"(m):	6.0
Depth of Foundation Below E.G.L "Df" (m):	7.5
Breadth of Footing "B" (m):	10.0
Length of Footing "L" (m):	10.0
B/L	1.00
Inclination of Vertical Load with the Vertical (a)	0.00

1.2 Soil Data :

Type of Effective Bearing Strata : Weathered Rock

Type of Shear Failure:	General
SPT "N" of the Bearing Strata :	>100
Angle of Shearing Resistance	45.00

1.3 Design Parameters:

Bulk Density of Soil above the foundation depth (γ_{bulk})	18	kN/m^3
Water Table Correction Factor (w')	0.50	
Effective overburden pressure at foundation level (q)	12.00	kN/m^2

Bearing Capacity Factors:

N_c = N/A
N_q = 134.88
N_g = 271.76

Shape Factors:

S_c = -
S_q = 1.20
S_g = 0.60

Depth Factors :

D_c = -
D_q = 1.00
D_g = 1.00

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' 9265.39 kPa
(g should be read as gama)

1.5 Safe Bearing Capacity (Qsafe) :

Factor of Safety (F.S.) :	2.50	
Qsafe :	3706.16	kPa
Say Q_{safe}	**1500**	**kPa**

2.0 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	1500.00	kPa
Poission's Ratio (μ)	0.30	

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

Modulus of Elasticity (N X 2600, N=100) (E_s)	260000	
Size of footing considered for maximum settlement(m)	10.00	
Influence factor	0.95	
Rigidity Factor	0.80	
Elastic Settlement (DH_i)	39.90	mm
		mm

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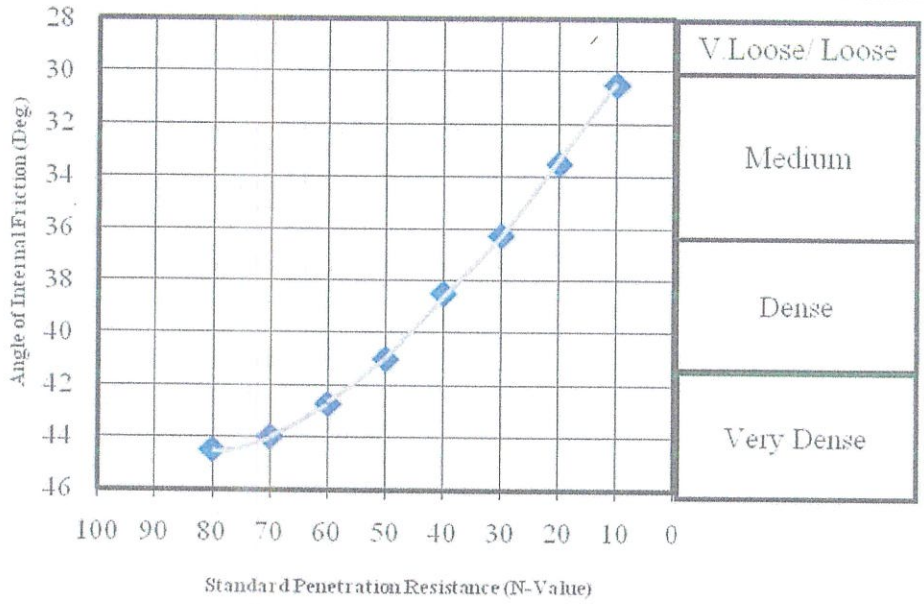


FIG. A1 Relation Ship between Angle of Internal Friction & N-value (Reproduced from IS:6403-1981)

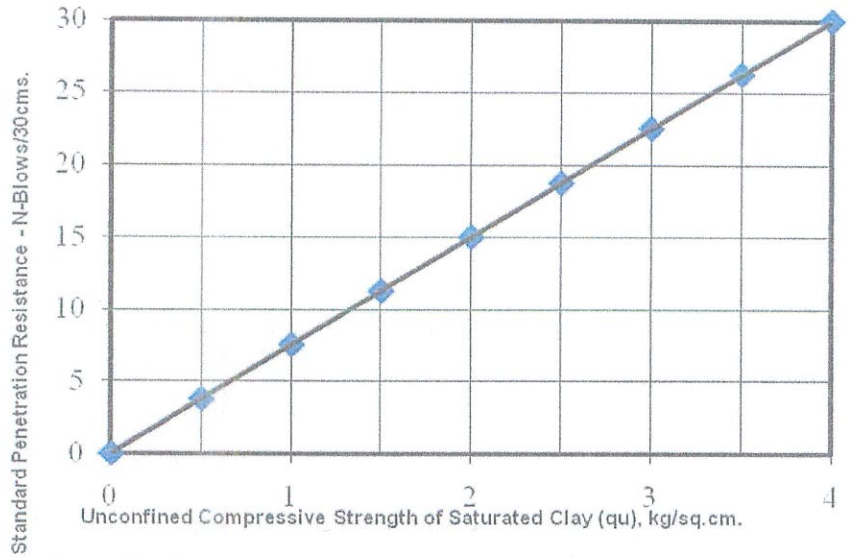


FIG. A2 : Relationship between UCC & SPT-Value (N) of Saturated Clay (AfterTerzhagi & Peck, 1948)

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SITE INVESTIGATION RECORD

BORE HOLE No. 01
PAGE No. 01
DIA OF BORE HOLE 150mm ✓ 100mm
BORE START DATE 01/07/2022
BORE END DATE 05/07/2022
TOTAL DRILLING DAYS

PROJECT NAME: M/S IVAR ESTATES (P) LTD., VELACHERY
LOCATION | MACHINE No. | CHAINAGE (m)
STRUCTURE | DRILLING METHOD: Rotary | CO-ORDINATES: N, E
JOB CODE | FLUSHING MEDIUM: Bentonite

Depth below E.G.L (m)	Drilling progress per metre: Date	Time: Hr.	Min	Type of Drilling (SC / TCB / DB)	Core Details: Total Core Recovery %	RQD %	SPT Details: Blows/cm. 0-15	15-30	30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	Layer Data: Depth (m)	Geotechnical Description
1	01/07/2022	16	00	SC			25	29	45	74	1.0	1	SS.	1.0	Brownish very dense silty fine sand
		16	03												
2		16	30	SC			16	22	43	65	2.0	2	SS.	2.0	Brownish Kankar
		16	34												
3		16	40	SC											
		16	53				30	100/4"			3.0	3	SS.	3.0	Brownish weathered Rock
4		9	00	DB				55 No		NX 10					
		9	40				Hammering Refusal NX 10				4.0	4	WS.	4.0	Brownish Weathered Rock
5	02/07/2022	10	10	DB			Hammering Refusal NX 10				5.0	5	WS.	5.0	Brownish weathered Rock
		10	50												
6		11	20	DB			Hammering Refusal NX 10				6.0	5	WS.	6.0	Brownish weathered Rock
		12	15												
7	03/07/2022	14	42	DB			Hammering Refusal NX 10				7.50	6	WS.	7.50	Brownish weathered Rock
		15	20												
8		15	40	DB	90	0									
		17	25								9.0	7	C.S.	9.0	Brown weathered to hard rock
9	04/07/2022	9	00	DB	10	0									
		11	00								10.50	8	C.C.	10.50	Brown. Grey Hard Rock
10															

CS - Core Sample | DS - Disturbed Sample
SS - Split Spoon Sample | SC - Soil Cutter
UDS-Undisturbed Sample | TCB - Tungsten Carbide Bit
WS - Wash Sample | DB - Diamond Bit

SUPERVISOR NAME: STEPHEN NIXS
SIGNATURE
DATE: 21/07/2022
CLIENT IN-CHARGE

PROJECT SITE DETAILS
GROUND LEVEL (m)
WATER TABLE (m)
CASING DEPTH

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ANNEXURE-II



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SITE INVESTIGATION RECORD

BORE HOLE No.	BH 1
PAGE No.	01
DIA OF BORE HOLE	150mm ✓ / 100mm
BORE START DATE	01/07/2022
BORE END DATE	05/07/2022
TOTAL DRILLING DAYS	

PROJECT NAME	M/s IVAR ESTATES (P) LTD. VELACHERY						
LOCATION		MACHINE No.		CHAINAGE (m)			
STRUCTURE		DRILLING METHOD	Rotary	CO-ORDINATES	N		
JOB CODE		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: RQD %	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	Layer Data: Depth (m)	Layer Data: Geotechnical Description
1	04/07/2022	11	30	DB	19	0					10.50		CS.	10.50	Brown, Grey Hard Rock
		13	30												
2		14	30	DB	16	0					12.0		CS.	12.0	Brown, Grey Hard Rock
		16	30												
3															
4		9	00												
		13	30	DB	28	0					13.0		CS.	14.0	Brown, Grey Hard Rock
5															
	Bore Hole Terminated at 13.00 m Below the Ground Level														
6															
7															
8															
9															
0															

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	S. STEPHEN RAJ
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	05/07/2022
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE	

PROJECT SITE DETAILS	
GROUND LEVEL (m)	
WATER TABLE (m)	
CASING DEPTH (m)	

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GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.	02
PAGE No.	01
DIA OF BORE HOLE	150mm ✓ / 100mm
BORE START DATE	06/09/2022
BORE END DATE	07/09/2022
TOTAL DRILLING DAYS	

PROJECT NAME	M/S IVAR ESTATES (P) LTD., VELACHERY				
LOCATION		MACHINE No.		CHAINAGE (m)	
STRUCTURE		DRILLING METHOD	Rotary	CO-ORDINATES	N
JOB CODE		FLUSHING MEDIUM	Bentonite		E

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit ISC / 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	Layer Data: Depth (m)	Layer Data: Geotechnical Description
1	06/09/2022	10	57	SOIL			9	23	46	69	1.0	1	SS.	1.0	yellowish Gravel
		10	52												
2		11	01				28	46cm/10cm	Hard Blow		2.0	2	SS.	2.0	Pale yellowish Gravel
		11	03												
3		11	18				26	13cm/60cm	N>100		3.0	3	SS.	3.0	-do-
		11	22												
4		11	51				16	20	12cm/50cm		4.0	4	SS	4.0	yellowish Green Gravel
		11	53												
5	07/09/2022	12	06	SOFT ROCK			24	7cm/50cm	N>100		5.0	5	SS.	5.0	yellowish Moderately weathered Rock
		12	21												
6		12	46				Hammer Refusal N>100				6.0	6	WS.	6.0	weathered Rock
7		9	00	DIAMOND BIT	20	0					7.50	7	C.S.	7.50	Grey, Brown Hard ROCK
		11	00												
8		11	30		18	0					9.0	8	C.S.	9.0	Grey, Brown Hard Rock
		15	10												-do-
9		14	15		34	0					10.50	9	CS.	10.50	
		16	17												
10		Bore hole terminated at 10.50m													Below the ground Level

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	S. STEPHEN RAJ	PROJECT SITE DETAILS	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE		GROUND LEVEL (m)	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	07/09/2022	WATER TABLE (m)	
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE		CASING DEPTH (m)	

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SITE INVESTIGATION RECORD

BORE HOLE No.	03
PAGE No.	01
DIA OF BORE HOLE	150mm / 100mm
BORE START DATE	01/07/2022
BORE END DATE	05/07/2022
TOTAL DRILLING DAYS	

PROJECT NAME: M/S EVAR ESTATES (P) LTD. VELACHERY

LOCATION | MACHINE No. | CHAINAGE (m)
STRUCTURE | DRILLING METHOD: Rotary | CO-ORDINATES N / E
JOB CODE | FLUSHING MEDIUM: Bentonite

Depth below E.G.L (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: 15-30	SPT Details: 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Layer Data: Depth (m)	Layer Data: Geotechnical Description
1	01/07/2022	14	00	SC			45	70/55	NT/10		1.0	1	SS	1.0	Brown, Grey Completed weathered Rock
		14	05												
2	01/07/2022	14	35	SC			48	60/55	NT/10		2.0	2	SS	2.0	Brownish weathered Rock
		14	40												
3	01/07/2022	15	30	SC			Hammer Refusal No penetration		NT/10		3.0	3	SS	3.0	Brownish weathered Rock
		15	40												
4	02/07/2022	9	00	DB	15.0						4.0	4	CS	4.0	Brown, Grey weathered Rock
		9	30												
5		9	45	DB	38.0						5.0	5	CS	5.0	Brown, Grey weathered to Hard Rock
		10	15												
6		10	45	DB	35.0						6.0	6	CS	6.0	Brown, Grey Hard Rock
		11	45												
7		12	00	DB	14.0						7.0	7	CS	7.0	Brown, Grey weathered to Hard Rock
		13	00												
		14	00												
		15	00												
8	04/07/2022	9	00	DB	15.0						8.0	8	CS	9.0	Brown, Grey weathered to Hard Rock
		9	30												
		10	30												
9															
10															

CS - Core Sample
SS - Split Spoon Sample
UDS-Undisturbed Sample
WS - Wash Sample

DS - Disturbed Sample
SC - Soil Cutter
TCB - Tungsten Carbide Bit
DB - Diamond Bit

SUPERVISOR NAME: S. STEPHEN RAJ
SIGNATURE
DATE: 04/07/2022
CLIENT IN-CHARGE

PROJECT SITE DETAILS
GROUND LEVEL (m)
WATER TABLE (m)
CASING DEPTH (m)

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SITE INVESTIGATION RECORD

BORE HOLE No.	03
PAGE No.	02
DIA OF BORE HOLE	150mm ✓ / 100mm
BORE START DATE	01/07/2022
BORE END DATE	05/07/2022
TOTAL DRILLING DAYS	

PROJECT NAME: M/S IVAR ESTATES (P) LTD., VELACHERY

LOCATION:
STRUCTURE:
JOB CODE:
MACHINE No.:
DRILLING METHOD: Rotary
FLUSHING MEDIUM: Bentonite
CHAINAGE (m):
CO-ORDINATES: N / E

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D. %	SPT Details: Blows/cm. 0-15	SPT Details: 15-30	SPT Details: 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Layer Data: Depth (m)	Geotechnical Description
1	04/07/2022	11	00								10.50	9	CS	10.50	Grey, Brown Hard Rock
		03	00	DB	24	0									
2		14	00												
		16	00	DB	27	14					12.00	10	CS	12.00	Greyish Hard Rock
3	05/07/2022	9	00												
		10	15												
4															
															Bore hole terminated at 12.00M Below The Ground Level.
5															
6															
7															
8															
9															
10															

CS - Core Sample
SS - Split Spoon Sample
UDS - Undisturbed Sample
WS - Wash Sample

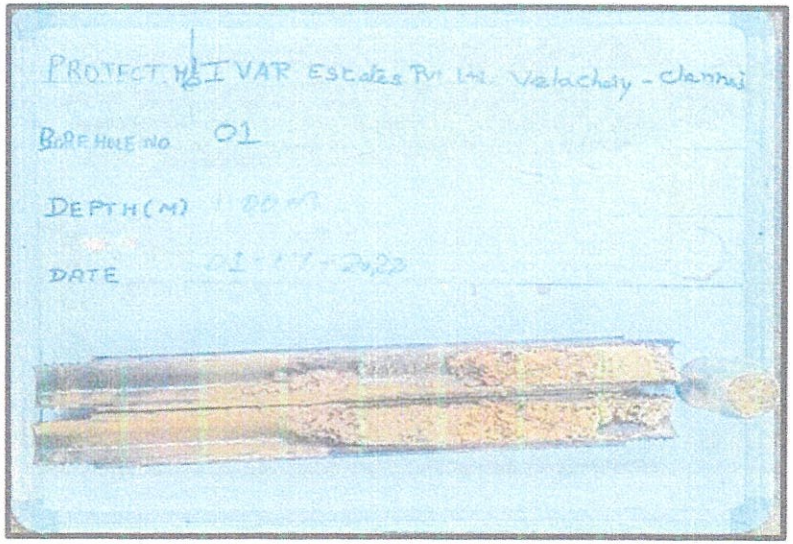
DS - Disturbed Sample
SC - Soil Cutter
TCB - Tungsten Carbide Bit
DB - Diamond Bit

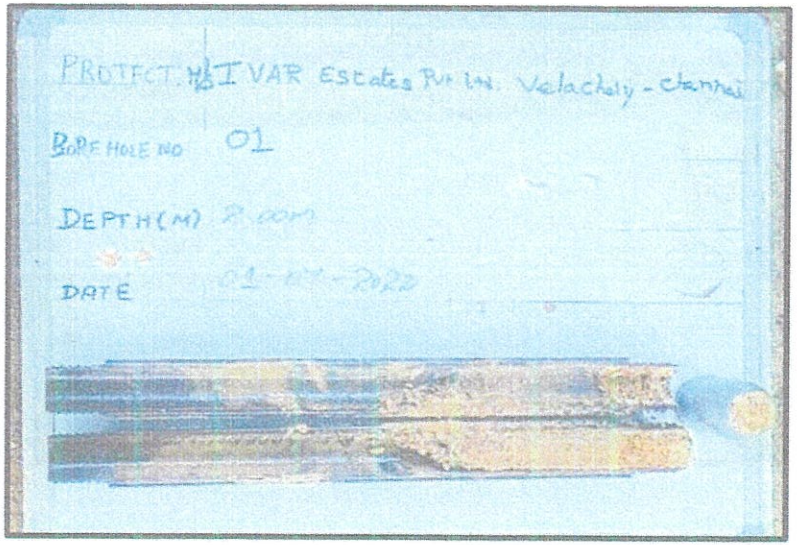
SUPERVISOR NAME: S. STEPHEN RAJ S
SIGNATURE:
DATE: 05/07/2022
CLIENT IN-CHARGE:

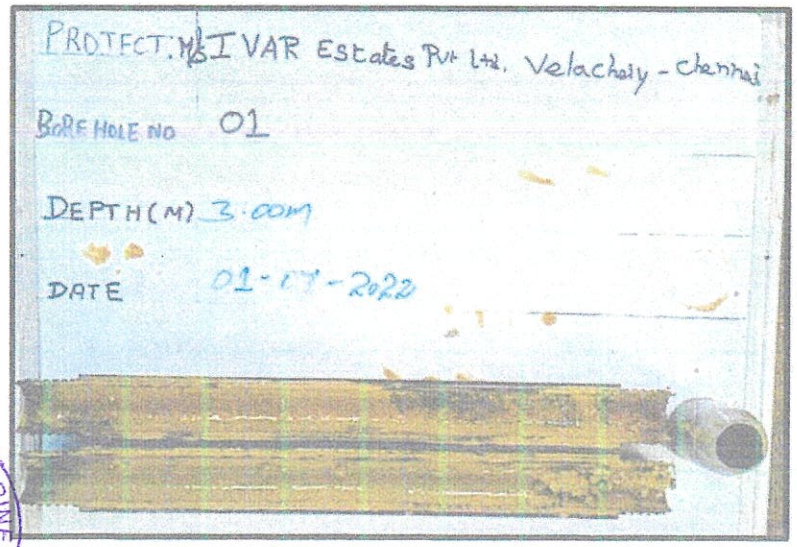
PROJECT ENGINEER:
GROUND LEVEL (m):
WATER TABLE (m):
CASING DEPTH (m):

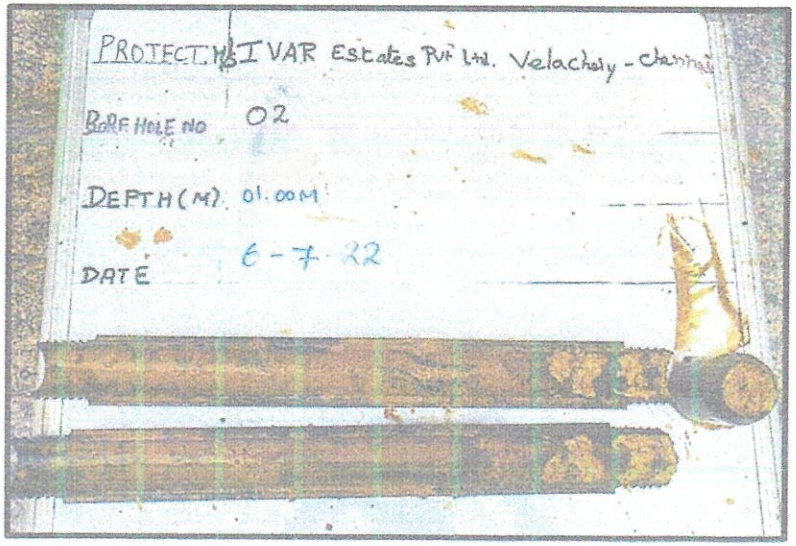
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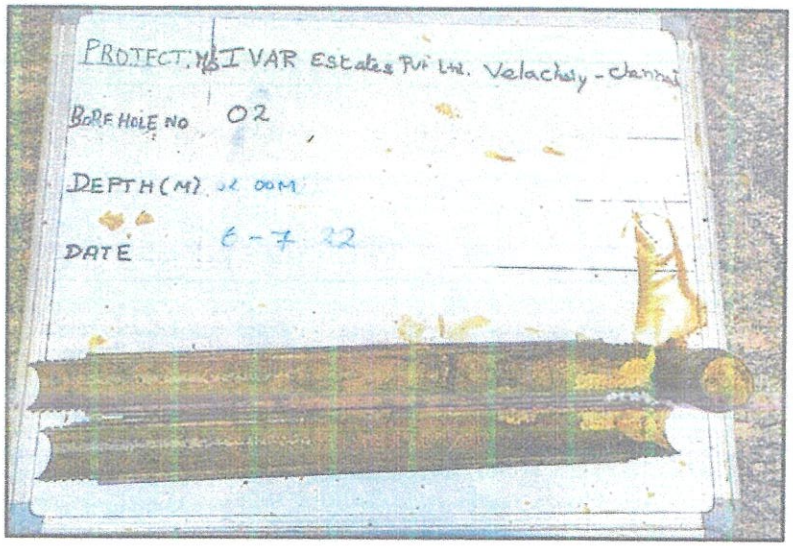


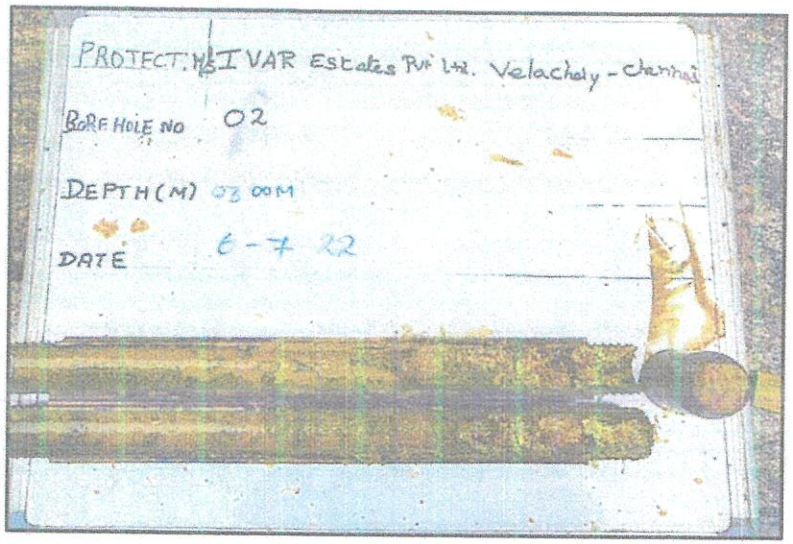


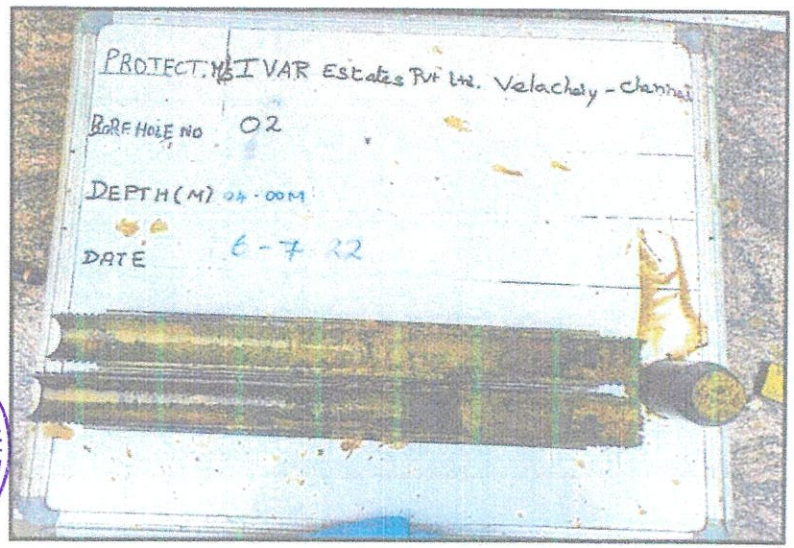


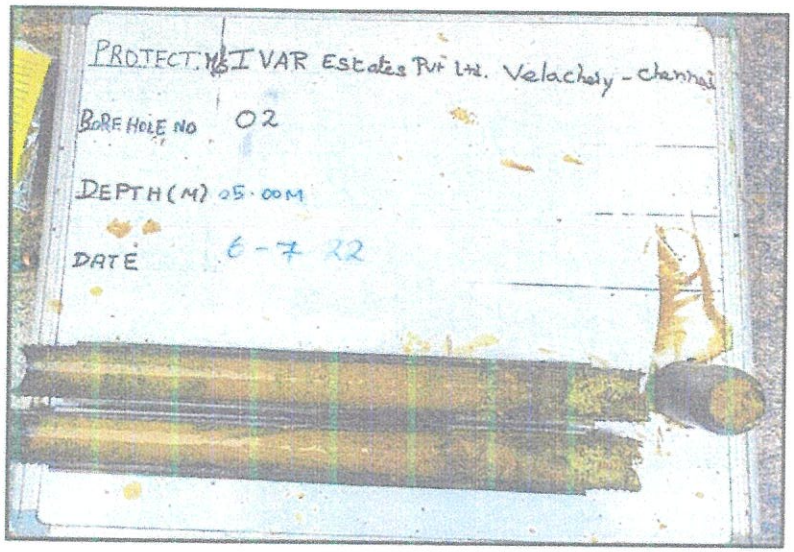
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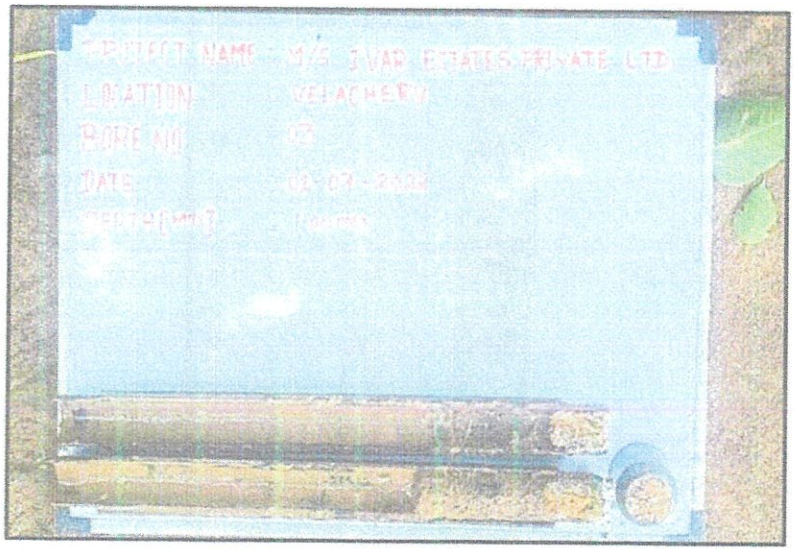
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