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PROJECT

GEOTECHNICAL INVESTIGATION FOR THE PROPOSED CONSTRUCTION OF RESIDENTIAL DEVELOPMENT CONSISTING OF STILT PLUS ELEVEN UPPER FLOORS AT S NO. 310/2A3A, 2B1, 310/3B, 311/1A, 311/1B1 & 311/1B2, GANDHI NAGAR MAIN ROAD, PERUMBAKKAM VILLAGE, TAMBARAM TALUK, CHENGALPATTU DISTRICT

CLIENT

M/s URBANDO HOUSING LLP,
T-1, 3RD FLOOR, CHONA CENTRE,
45, NUNGAMBAKKAM, COLLEGE ROAD,
CHENNAI- 600 006

TITLE

GEOTECHNICAL INVESTIGATION REPORT

REPORT NO.: GT- 2737

DATE	REVISON	DESCRIPTION		AUTHORISED SIGNATORY
27/02/2024	0.0	SUBMISSION OF GEOTECHNICAL REPORT	SIGN	
			Date	27/02/2024
			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	: **RESIDENTIAL BUILDING**
Structure	: **STILT + 11 UPPER FLOORS**
Project Owner	: **M/s URBANDO HOUSING LLP**
Project Location	: **PERUMBAKKAM, CHENNAI**
Job Code	: **GT-2737**

1.1 SCOPE OF WORK:

1.1.1 FIELD WORK

- Conducting five 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 15.0m, SPT is conducted at every 1.5m depth interval
  - Further in the case of rock formation is encountered, NX size core drilling will be carried out and the recovery shall be checked at an interval of 1.5m or 1.0m intervals
- The depth of investigation is 15.0m or 16.5m below the existing ground level.
- 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
- Foundation System
- Recommendation
- Annexure

CHAPTER-2

INVESTIGATION METHODOLOGY & TEST RESULTS

2.0 PREAMBLE:

Five 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.

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 2.5. The graphical representation of grainsize distribution curve for the representative samples in each bore is presented in Fig. 2.8 to 2.12.

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 2.5. The graphical representation of hydrometer analyses curve for the representative samples in each bore is presented in Fig. 2.13 to 2.19.

2.2.3 CHEMICAL ANALYSIS TESTS:

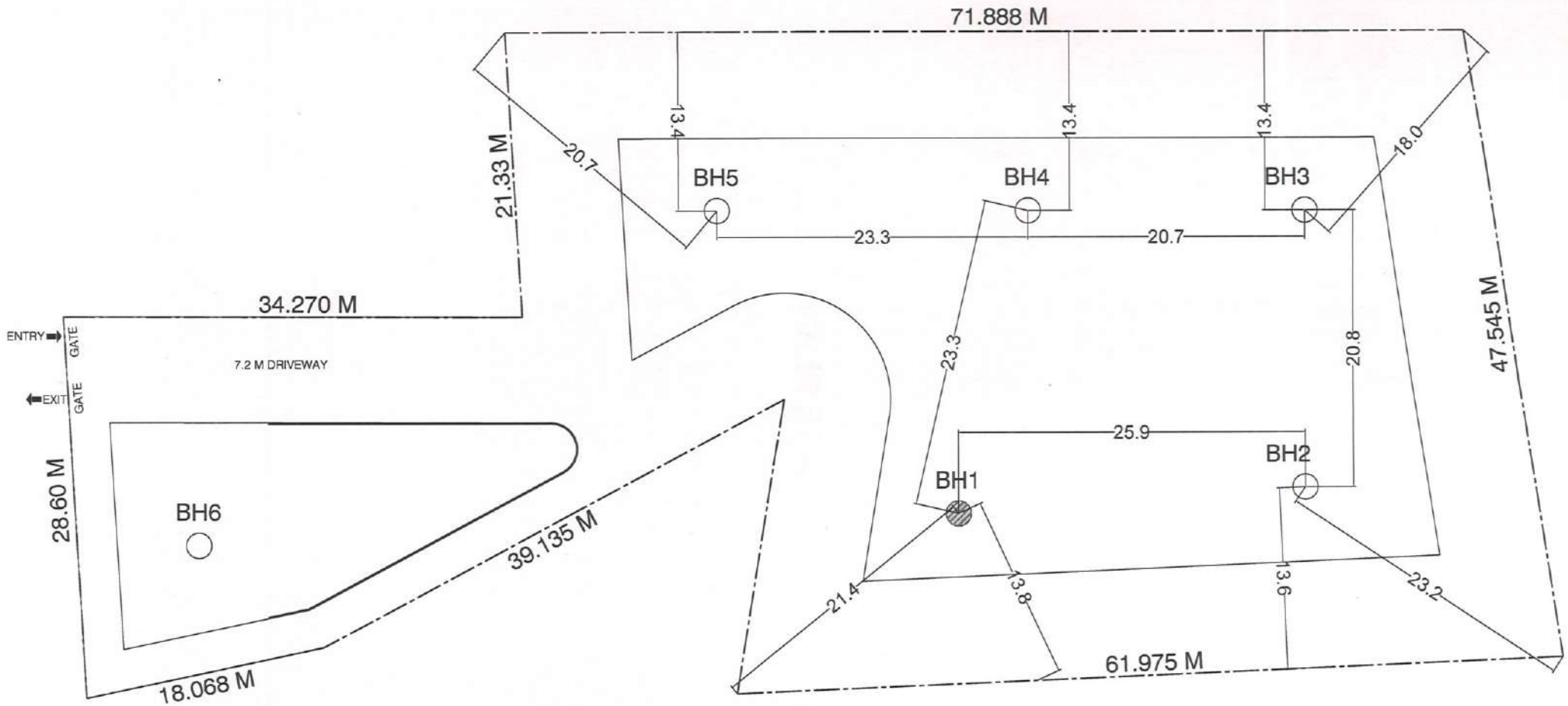
On representative soil and water samples chemical analysis tests were conducted to estimate pH, Chloride and Sulphates and these results are presented in Table - 2.7 to 2.9.

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 2.5.

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.2.6 & 2.7.

SITE PLAN



URBANDO

PROPOSED RESIDENTIAL DEVELOPMENT AT PERUMBAKKAM.

TYPICAL FLOOR PLAN

REVISED ON 02.11.2023

North
W
E
S

KAVIYA KUMAR
ARCHITECT

DATE :25.09.2023

SOIL PROFILES

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SITE INVESTIGATION RECORD

BORE HOLE No.	BH-01						
SHEET	1	OF	2				
PROJECT NAME	PROPOSED CONSTRUCTION OF A RESIDENTIAL BUILDING			DIA OF BORE HOLE	150mm ✓		
					NX ✓		
LOCATION	Perumbakkam, Chennai	MACHINE No.	CR-02	Free Fall Energy (%)	60	BORE START DATE	10/02/2024
STRUCTURE	Stilt + 11 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	12/02/2024
JOB CODE	GT-2737	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 Value: N80	SPT Value: N	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
		09	27																
		To		SC	-	-													
		09	27				0	1	2	-	3	0.50	1	SS	-0.5				Grey Brown,Fine & Medium Sand Grains, **Clayey Sand With Brick Pieces & Constrcutional Debris Filled Up Soil**
		09	39									0.95							
1		To		SC	-	-													
		09	40				-	-	-	-	-	1.25	2	UDS	-1.25		L1	1.3	
		09	58																
		To		SC	-	-													
		10	00																
2							2	3	4	-	7	2.00	3	SS	-2.0				Grey,Moist,Fine & Medium Sand Grains Mixture With Gravel Traces,Medium Stiff,**Sandy Silty CLAY (CH)** Sandy Clay of High Plasticity
		10	14									2.45							
		To		SC	-	-													
		10	15																
3							10	12	17	-	29	3.00	4	SS	-3.0		L2	3.0	
		10	31									3.45							Brown,Grey Brown,Moist,Fine & Medium Sand Grains With Gravel Fractions,Medium Dense, **Disintegrated Rock-Grade W5 Rock/ Residual Soil (Clayey Sand)** Disintegrated Hypersthene Granitic Rock
		To		SC	-	-													
		10	33						10Cm Pene: for 40Blows										
4							12	23		-	>100	4.00	5	SS	-4.0		L3	4.0	
		10	48									4.40							
		To		SC	-	-													
		10	50						3Cm Penet for 30Blows										
5	10/02/2024						40	34		-	>100	5.00	6	SS	-5.0				Grey Brown,Brown,Fine to Coarse Sand Size Particles With Gravels Fraction,Very Dense,**Completely Weathered Rock-Grade W5 Rock Formation** Disintegrated Hypersthene Granitic Rock
		11	07									5.33							
		To		SC	-	-													
		11	09																
6							SPT-Hammer Rebounded			-	>100	6.00	-	WS	-6.0				
		11	24														L4	6.6	
		To		DB	10	0													
		12	32																Grey,Brown Grey,Medium to Coarse Grained Structure,Highly Fractured & Weathered,Discoloured,**Completely Weathered Rock-Grade W5 Rock Formation** Fractured Hypersthene Granitic Rock
7							-	-	-	-	-	7.50	7	CS	-7.5		L5	7.6	
		13	12																
8		To		DB	21	0													
		14	35																
9							-	-	-	-	-	9.00	8	CS	-9.0				Grey,Brown Grey,Medium to Coarse Grained Structure,Highly Fractured & Discolured,**Highly Weathered Rock-Grade W4 Rock Formation** Fractured Hypersthene Grantic Rock
		14	52																
		To		DB	21	0													
10		15	27																

CS - Core Sample	DS - Disturbed Sample	LOGGED	Susil	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	10/02/2024	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	S. Dhanapal	WATER TABLE (m) 2.90	
WS - Wash Sample	DB - Diamond Bit	DATE	17/02/2024	CASING DEPTH (m) 0.00	

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SITE INVESTIGATION RECORD

BORE HOLE No.	BH-01						
SHEET	2	OF	2				
PROJECT NAME	PROPOSED CONSTRUCTION OF A RESIDENTIAL BUILDING					DIA OF BORE HOLE	150mm / NX ✓
LOCATION	Perumbakkam, Chennai	MACHINE No.	CR-02	Free Fall Energy (%)	60	BORE START DATE	10/02/2024
STRUCTURE	Stilt + 11 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	12/02/2024
JOB CODE	GT-2737	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 Value: N80	SPT Value: N	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	10/02/2024	15	45	DB	23	0	-	-	-	-	-	10.50	9	CS	-10.5	+ + +			Grey,Brown Grey,Medium to Coarse Grained Structure,Highly Fractured & Discolured,**Highly Weathered Rock-Grade W4 Rock Formation** Fractured Hypersthene Grantic Rock
		To																	
		16	17																
12							-	-	-	-	-	12.00	10	CS	-12.0	+ + +	L6	12.0	
13	12/02/2024	09	18	DB	33	0										+ + +			Grey,Brown Grey,Medium to Coarse Grained Strcture,Highly Fractured & Discoloured @ Locations,**Moderately Weathered Rock-Grade W3 Rock Formation** Fractured Hypersthene Granitic Rock
		To																	
		11	02																
14							-	-	-	-	-	13.50	11	CS	-13.5				
		11	32																
		To		DB	42	8													
		12	48																
15							-	-	-	-	-	15.00	12	CS	-15.0	+ + +	L7	15.0	
16																			
17																			
18																			
19																			
20																			

CS - Core Sample	DS - Disturbed Sample	LOGGED	Susil	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	12/02/2024	GROUND LEVEL (m)	0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	S. Dhanapal	WATER TABLE (m)	2.90	
WS - Wash Sample	DB - Diamond Bit	DATE	17/02/2024	CASING DEPTH (m)	0.00	

Borehole terminated at 15 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	14/02/2024
LOCATION	Perumbakkam, Chennai	MACHINE No.	CR-08	Free Fall Energy (%)	60		
STRUCTURE	Stilt + 11 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	15/02/2024
JOB CODE	GT-2737	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 Value: N80	SPT Value: N	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
0	14/02/2024	11	02	SC	-	-				-									
		To																	
		11	02				1	1	2	-	3	0.50	1	SS	-0.5				Grey, **Clayey Sand With Brick Pieces & Constructional Debris Filled Up Soil**
		11	21									0.95							
1		To		SC	-	-											L1	1.3	
		11	22				-	-	-	-	-	1.25	2	UDS	-1.25				
		12	01																
		To		SC	-	-													
2		12	02				4	6	9	-	15	2.00	3	SS	-2.0				Grey, Moist, Fine & Medium Sand Grains Mixture, Stiff, **Sandy Silty CLAY (CH)** Sandy Clay of High Plasticity
		12	17									2.45							
		To		SC	-	-													
		12	20																
3							24	11Cm Penet for 40Blows		-	>100	3.00	4	SS	-3.0				
		12	40									3.26							
		To		SC	-	-													
		12	43																Grey Brown, Yellow Shades, Moist, Fine & Medium Sand Grains With Gravels Sizes Weathered Particles, Very Dense, **Disintegrated Rock-Grade W5 Rock Formation/ Residual Soil** Disintegrated Hypersthene Granitic Rock
4							9Cm Penet for50Blows			-	>100	4.00	5	SS	-4.0				
		13	09									4.09							
		To		SC	-	-													
		14	00																
5							SPT Hammer Rebounded			-	>100	5.00	-	WS	-5.0		L3	5.0	
		14	22																
		To		DB	0	0													
		15	18																
6							-	-	-	-	-	6.00	-	WS	-6.0				
		15	34																
		To		DB	0	0													No Core Recovered Based on Wash Sample Observation **Completely Weathered Rock - Grade W5 Rock Formation** Fractured & Weathered Hypersthene Granitic Rock
7		16	39																
							-	-	-	-	-	7.50	-	WS	-7.5				
8		16	53																
		To		DB	0	0													
		17	50																
9							-	-	-	-	-	9.00	-	WS	-9.0		L4	9.0	
		09	38																Brown, Grey Brown, Medium to Coarse Grains Structure, Highly Fractured & Weathered, Highly Discoloured, **Highly Weathered Rock-Grade W4 Rock Formation** Fractured Hypersthene Granitic Rock
		To		DB	9	0													
10		10	19																

CS - Core Sample	DS - Disturbed Sample	LOGGED	Susil	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	14/02/2024	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	S. Dhanapal	WATER TABLE (m) 1.80	
WS - Wash Sample	DB - Diamond Bit	DATE	17/02/2024	CASING DEPTH (m) 0.00	

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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	14/02/2024
LOCATION	Perumbakkam, Chennai	MACHINE No.	CR-08	Free Fall Energy (%)	60			BORE END DATE	15/02/2024
STRUCTURE	Stilt + 11 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N	-		TOTAL DRILL DAYS	2
JOB CODE	GT-2737	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 Value: N80	SPT Value: N	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	15/02/2024	10	45	DB	0	0	-	-	-	-	-	10.50	6	CS	-10.5	+ + +			
		To														+ + +			
		11	20													+ + +			
12							-	-	-	-	-	12.00	-	WS	-12.0	+ + +			Brown,Grey Brown,Medium to Coarse Grains Structure,Highly Fractured & Weathered, Highly Discoloured,**Highly Weathered Rock-Grade W4 Rock Formation**
		11	34													+ + +			
13		To		DB	5	0										+ + +			Fractured Hypersthene Granitic Rock
		12	29													+ + +			
							-	-	-	-	-	13.50	7	CS	-13.5	+ + +			
14																+ + +			
		12	44													+ + +			
		To		DB	10	0										+ + +			
		13	39													+ + +			
15							-	-	-	-	-	15.00	8	CS	-15.0	+ + +	L5	15.0	
16																			
17																			
18																			
19																			
20																			

CS - Core Sample	DS - Disturbed Sample	LOGGED	Susil	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	15/02/2024	GROUND LEVEL (m)	0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	S. Dhanapal	WATER TABLE (m)	1.80	
WS - Wash Sample	DB - Diamond Bit	DATE	17/02/2024	CASING DEPTH (m)	0.00	

Borehole terminated at 15 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				
PROJECT NAME	PROPOSED CONSTRUCTION OF A RESIDENTIAL BUILDING					DIA OF BORE HOLE	150mm ✓ / NX ✓
LOCATION	Perumbakkam, Chennai	MACHINE No.	CR-02	Free Fall Energy (%)	60	BORE START DATE	12/02/2024
STRUCTURE	Stilt + 11 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	14/02/2024
JOB CODE	GT-2737	FLUSHING MEDIUM	Bentonite		E -	TOTAL DRILL DAYS	3

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	15-30	30-45	SPT Value: N80	SPT Value: N	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
		12	52																
		To		SC	-	-													
		12	52				1	3	3	-	6	0.50	1	SS	-0.5				
		13	02									0.95							
1		To		SC	-	-													
		13	03				2	3	4	-	7	1.25	2	SS	-1.25				Grey,Moist,Fine & Medium Sand Grains Mixture,Sitff,**Sandy Silty CLAY (CH) & Sandy Silty CLAY (CI)**
		14	12									1.70							
		To		SC	-	-													Sandy Clay of Medium & High Plasticity
2		14	15				-	-	-	-	-	2.00	3	UDS	-2.0				
		14	26																
		To		SC	-	-													
		14	27																
3							5	5	9	-	14	3.00	4	SS	-3.0		L1	3.0	
		14	43									3.45							Brown,Moist,Poorly Graded,Fine & Medium Sand Grains With Gravel Fractions,Medium Dense,**Clayey Silty SAND (SC)** With Pieces of Rock/ Partly Disintegrated Rock Formation
		To		SC	-	-													
		14	45																
4							12Cm Penet for 40Blows			-	>100	4.00	5	SS	-4.0		L2	4.0	
		15	02									4.12							
		To		SC	-	-													
	12/02/2024	15	04																Brown,Fine to Coarse Sand Size Particles With Gravel Fractions Weathered Formation,Very Dense, **Disintegrated Rock-Grade W5 Rock Formation/ Residual Soil**
5							10Cm Penet for 40Blows			-	>100	5.00	-	WS	-5.0				
		15	17									5.10							
		To		SC	-	-													Disintegrated Hypersthene Granitic Rock
		15	19																
6							SPT Hammer Rebounded			-	>100	6.00	-	WS	-6.0		L3	6.0	
		15	34																
		To		DB	0	0													
		16	18																
7							-	-	-	-	-	7.50	-	WS	-7.5				
		16	39																No Core Recovered Representative Wash Sample Observed to be **Completely Weathered Rock**
8		To		DB	0	0													
		17	12																
9							-	-	-	-	-	9.00	-	WS	-9.0				
		17	21																
		To		DB	0	0													
10		18	18																

CS - Core Sample	DS - Disturbed Sample	LOGGED	Susil	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	12/02/2024	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	S. Dhanapal	WATER TABLE (m) 1.60	
WS - Wash Sample	DB - Diamond Bit	DATE	17/02/2024	CASING DEPTH (m) 0.00	

GEOMARINE THE SPIRIT OF ENGINEERING

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	Perumbakkam, Chennai	MACHINE No.	CR-02	Free Fall Energy (%)	60	BORE START DATE	12/02/2024
STRUCTURE	Stilt + 11 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	14/02/2024
JOB CODE	GT-2737	FLUSHING MEDIUM	Bentonite		E -	TOTAL DRILL DAYS	3

Depth below E.G.L (m)	Date	Time Hr.	Time Min.	Type of Drill Bit (SC / TCB / DB)	Total Core Recovery %	R.Q.D %	Blows/cm. 0-15	15-30	30-45	SPT Value N80	N	Sample Depth	No.	Type	RL (m)	Legend	Layer No	Layer Depth	Geotechnical Description
	12/02						-	-	-	-	-	10.50	-	WS	-10.5	+ + +	L4	10.5	No Core Recovered Representative Wash Sample Observed to be Completely Weathered Rock
11	13/02/2024	15 To 16	32 23	DB	4	0													
12							-	-	-	-	-	12.00	6	CS	-12.0				
13		16 To 17	52 49	DB	5	0	-	-	-	-	-	13.50	7	CS	-13.5				
14–15	14/02/2024	08 To 09	50 47	DB	12	0	-	-	-	-	-	15.00	8	CS	-15.0	+ + +	L5	15.0	Brown,Grey Brown,Medium to Coarse Grains Structure,Highly Fractured & Weathered,Discoloured,**Highly Weathered Rock-Grade W4 Rock Formation** Fractured Hypersthene Granitic Rock
16		10 To 11	23 38	DB	20	0	-	-	-	-	-	16.50	9	CS	-16.5	+ + +	L6	16.5	Grey,Brown Grey,Medium to Coarse Grains Structure,Highly Fractured,Discoloured @ Locations,**Moderately Weathered Rock-Grade W3 Rock Formation** Fractured Hypersthene Granitic Rock
17																			
18																			
19																			
20																			

CS - Core Sample	DS - Disturbed Sample	LOGGED	Susil	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	13/02/2024	GROUND LEVEL (m)	0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	S. Dhanapal	WATER TABLE (m)	1.60	
WS - Wash Sample	DB - Diamond Bit	DATE	17/02/2024	CASING DEPTH (m)	0.00	

Borehole terminated at 16.5 m depth below E.G.L

FIG.2.3 Sub Soil Profile at BH-03 Location

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-04		
SHEET	1	OF	2
DIA OF BORE HOLE	150mm ✓		
	NX ✓		

PROJECT NAME	PROPOSED CONSTRUCTION OF A RESIDENTIAL BUILDING					BORE START DATE	12/02/2024
LOCATION	Perumbakkam, Chennai	MACHINE No.	CR-08	Free Fall Energy (%)	60		
STRUCTURE	Stilt + 11 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	13/02/2024
JOB CODE	GT-2737	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 Value: N80	SPT Value: N	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
0	12/02/2024	09	25	SC	-	-													
		To																	
		09	25				0	1	2	-	3	0.50	1	SS	-0.5				Grey,Poorly Graded,Fine & Medium Sand Grains,Very Loose,**Clayey Silty SAND (SC)**
		11	00									0.95							
1		To		SC	-	-											L1	1.3	
		11	03				-	-	-	-	-	1.25	2	UDS	-1.25				
		11	14																
		To		SC	-	-													Grey,Brown Grey,Moist,Fine & Medium Sand Grains Mixure With Gravel Fractions,Medium Stiff,**Sandy Silty CLAY (CH)** Sandy Clay of High Plasticity
2		11	14				2	3	4	-	7	2.00	3	SS	-2.0				
		11	25									2.45							
		To		SC	-	-													
		11	26																
3							8	12	19	-	31	3.00	4	SS	-3.0		L2	3.0	
		11	38									3.45							
		To		SC	-	-													Brown,Moist,Poorly Graded,Fine to Coarse Sand Grains With Gravel Fractions,Dense & Very Dense, **Disintegrated Rock-Grade W5 Rock Formation/ Residual Soil** Disintegrated Hypersthene Granitic Rock
		11	39																
4							13	21	36	-	57	4.00	5	SS	-4.0				
		12	02									4.45							
		To		SC	-	-													
		12	05														L3	5.0	
5							SPT-Hammer Rebounded			-	>100	5.00	-	WS	-5.0				
		12	24																
		To		DB	0	0													
		12	58																
6							-	-	-	-	-	6.00	-	WS	-6.0				
		14	12																
		To		DB	0	0													
		15	23																No Core Recovered Representative Wash Sample Observed to be Completely Weathered Rock
7							-	-	-	-	-	7.50	-	WS	-7.5				
		15	48																
		To		DB	0	0													
		16	57																
8																			
9							-	-	-	-	-	9.00	-	WS	-9.0		L4	9.0	
		17	28																Grey,Grey Brown,Offwhite Shades, Medium to Coarse Grians Structure, Highly Fractured & Weathered,,**Highly Weathered Rock- Grade W4 Rock Formation**
		To		DB	8	0													
10		18	41																

CS - Core Sample	DS - Disturbed Sample	LOGGED	Susil	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	12/02/2024	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	S. Dhanapal	WATER TABLE (m) 2.75	
WS - Wash Sample	DB - Diamond Bit	DATE	17/02/2024	CASING DEPTH (m) 0.00	

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-04		
SHEET	2	OF	2
DIA OF BORE HOLE	150mm		
	NX	✓	

PROJECT NAME	PROPOSED CONSTRUCTION OF A RESIDENTIAL BUILDING					BORE START DATE	12/02/2024
LOCATION	Perumbakkam, Chennai	MACHINE No.	CR-08	Free Fall Energy (%)	60		
STRUCTURE	Stilt + 11 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	13/02/2024
JOB CODE	GT-2737	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 Value: N80	SPT Value: N	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
11	12/02	09	32																
		To		DB	12	0	-	-	-	-	-	10.50	6	CS	-10.5				
		10	52																
12							-	-	-	-	-	12.00	-	CS	-12.0				Grey,Grey Brown,Offwhite Shades,Medium to Coarse Grians Structure,Highly Fractured & Weathered,Discoloured,**Highly Weathered Rock- Grade W4 Rock Formation**
		11	38																
13	13/02/2024	To		DB	13	0													Fractured Hypersthene Granitic Rock
		12	52																
							-	-	-	-	-	13.50	7	CS	-13.5				
14		13	12																
		To		DB	19	0													
		15	21																
15							-	-	-	-	-	15.00	8	CS	-15.0		L5	15.0	
16																			
17																			
18																			
19																			
20																			

CS - Core Sample	DS - Disturbed Sample	LOGGED	Susil	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	13/02/2024	GROUND LEVEL (m)	0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	S. Dhanapal	WATER TABLE (m)	2.75	
WS - Wash Sample	DB - Diamond Bit	DATE	17/02/2024	CASING DEPTH (m)	0.00	

Borehole terminated at 15 m depth below E.G.L

FIG.2.4 Sub Soil Profile at BH-04 Location

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-05						
SHEET	1	OF	2				
PROJECT NAME	PROPOSED CONSTRUCTION OF A RESIDENTIAL BUILDING					DIA OF BORE HOLE	150mm ✓ / NX ✓
LOCATION	Perumbakkam, Chennai	MACHINE No.	CR-08	Free Fall Energy (%)	60	BORE START DATE	09/02/2024
STRUCTURE	Stilt + 11 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	10/02/2024
JOB CODE	GT-2737	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	15-30	30-45	SPT Value: N80	SPT Value: N	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
0		10	58																
		To		SC	-	-													
		10	58				2	3	4	-	7	0.50	-	*SS	-0.5				
		11	10									0.95							
1		To		SC	-	-													
		11	10				1	1	3	-	4	1.25	1	SS	-1.25				Grey,Brown Grey,Moist,Fine & Medium Sand Grains Mixture With Gravel Fractions,Soft & Medium Stiff,**Sandy Silty CLAY (CH)**
		11	27									1.70							
		To		SC	-	-													
2		11	29				-	-	-	-	-	2.00	2	UDS	-2.0				sandy Clay of High Plasticity
		11	43																
		To		SC	-	-													
		11	44																
3							10	15	21	-	36	3.00	3	SS	-3.0		L1	3.0	
		12	00									3.45				+ + +			Brown,Offwhite Shades,Moist,Poorly Graded,Fine & Medium Sand Grains With Gravels Weathered Formation, Dense,**Disintegrated Rock-Grade W5 Rock Formation/ Residual Soil**
		To		SC	-	-										+ + +			
		12	03													+ + +	L2	4.0	
4							19	13Cm Penet for 40Blows		-	>100	4.00	4	SS	-4.0	+ + +			
		12	20									4.28				+ + +			
		To		SC	-	-										+ + +			Brown,Grey Brown,**Fine** & Medium Sand Grains Size & Gravel Size Weathered Particles,Very Dense,**Disintegrated Rock-Grade W5 Rock Formation/Residual Soil**
		12	23													+ + +			
5	09/02/2024						15Cm Penet for 50Blows			-	>100	5.00	5	SS	-5.0	+ + +			
		12	34									5.15				+ + +			
		To		SC	-	-										+ + +			Disintegrated Hypersthene Granitic Rock
		12	36													+ + +			
6							SPT Hammer Rebounded			-	>100	6.00	-	WS	-6.0	+ + +	L3	6.0	
		13	09													+ + +			
		To		DB	0	0										+ + +			
		13	40													+ + +			
7																+ + +			
							-	-	-	-	-	7.50	-	WS	-7.5	+ + +			
																+ + +			No Core Recovered
8		14	52													+ + +			Representative Wash Sample Observed to be Completely Weathered Rock
		To		DB	0	0										+ + +			
		15	30													+ + +			
9																+ + +			
							-	-	-	-	-	9.00	-	WS	-9.0	+ + +			
																+ + +			
		16	04													+ + +			
		To		DB	0	0										+ + +			
10		17	12													+ + +			

CS - Core Sample	DS - Disturbed Sample	LOGGED	Susil	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	09/02/2024	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	S. Dhanapal	WATER TABLE (m) 3.20	(*SS)-SAMPLE FAILED
WS - Wash Sample	DB - Diamond Bit	DATE	17/05/2023	CASING DEPTH (m) 0.00	

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-05						
SHEET	2	OF	2				
PROJECT NAME	PROPOSED CONSTRUCTION OF A RESIDENTIAL BUILDING			DIA OF BORE HOLE	150mm		
					NX	✓	
LOCATION	Perumbakkam, Chennai	MACHINE No.	CR-08	Free Fall Energy (%)	60	BORE START DATE	09/02/2024
STRUCTURE	Stilt + 11 Upper Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	10/02/2024
JOB CODE	GT-2737	FLUSHING MEDIUM	Bentonite		E -	TOTAL DRILL DAYS	2

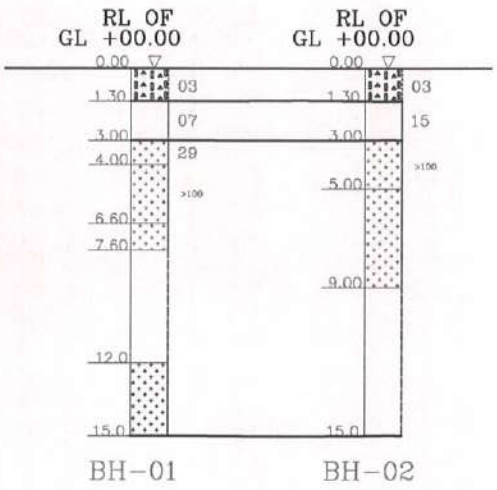
Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	Blows/cm. 15-30	Blows/cm. 30-45	SPT Value: N80	SPT Value: N	Sample Details: Depth	No.	Type	RL (m)	Legend	Layer Data: No	Depth	Geotechnical Description
10												10.50	-	WS	-10.5	+ + + + + + + + +	L4	10.5	No Core Recovered Representative Wash Sample Observed to be Completely Weathered Rock
11	10/02/2024	17	32	DB	9	0	-	-	-	-	-					+ + + + + + + + +			
		To														+ + + + + + + + +			
12		18	24									12.00	7	CS	-12.0	+ + + + + + + + +			Grey,Brown Grey,Medium to Coarse Grains Structure,Highly Fractured & Weathered,Discoloured,**Highly Weathered Rock-Grade W4 Rock Formation** Fractured Hypersthene Granitic Rock
		08	50													+ + + + + + + + +			
13		To		DB	4	0										+ + + + + + + + +			
		09	45									13.50	8	CS	-13.5	+ + + + + + + + +	L5	13.5	
14	10/02/2024	10	02													+ + + + + + + + +			
		To		DB	35	0										+ + + + + + + + +			
15		10	54				-	-	-	-	-	15.00	9	CS	-15.0	+ + + + + + + + +			Grey,Brown Grey,Medium to Coarse Grains Structure,Fractured & Weathered,Discoloured @ Locations,**Moderately Weathered Rock-Grade W3 Rock Formation** Fractured Hypersthene Granitic Rock
		11	22													+ + + + + + + + +			
16		To		DB	47	9										+ + + + + + + + +			
		12	48									16.50	10	CS	-16.5	+ + + + + + + + +	L6	16.5	
17																			
18																			
19																			
20																			

CS - Core Sample	DS - Disturbed Sample	LOGGED	Susil	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	10/02/2024	GROUND LEVEL (m) 0.00	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	S. Dhanapal	WATER TABLE (m) 3.20	
WS - Wash Sample	DB - Diamond Bit	DATE	17/05/2023	CASING DEPTH (m) 0.00	

Borehole terminated at 16.5 m depth below E.G.L

FIG.2.5 Sub Soil Profile at BH-05 Location

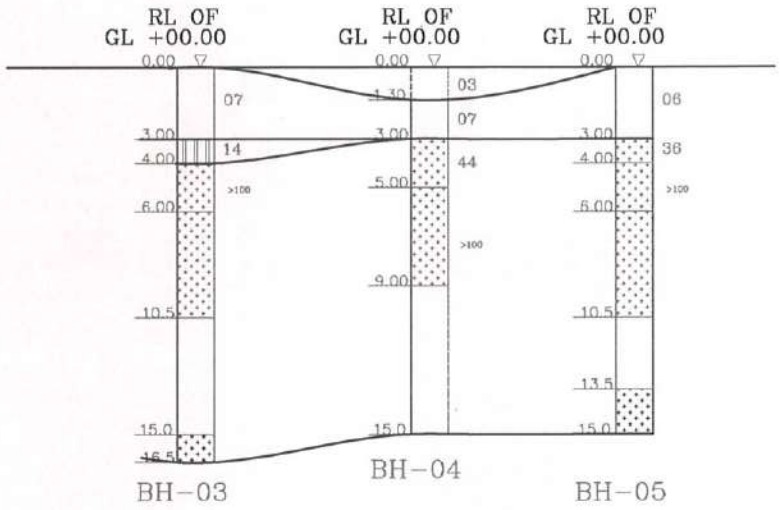
CROSS SECTION PROFILE



LEGEND

- CLAYEY SILTY SAND (SC)
- Silty Clay (CH)
- Highly to Moderately Weathered Rock & Moderately Weathered Rock
- Residual Soil,Residual Soil to Completely Weathered & Completely Weathered Rock
- Completely to Highly Weathered Rock & Highly Weathered Rock

FIG.No.2.6 CROSS SECTIONAL VARIATION OF SUB SOIL PROFILE THROUGH BH-01 & 02



LEGEND

- CLAYEY SILTY SAND (SC)
- Silty Clay (CH)
- SILTY SAND (SM)
- Residual Soil,Residual Soil to Completely Weathered & Completely Weathered Rock
- Completely to Highly Weathered Rock & Highly Weathered Rock
- Highly to Moderately Weathered Rock & Moderately Weathered Rock

FIG.No.2.7 CROSS SECTIONAL VARIATION OF SUB SOIL PROFILE THROUGH BH-03 TO 05

GRAIN SIZE DISTRIBUTION CURVE

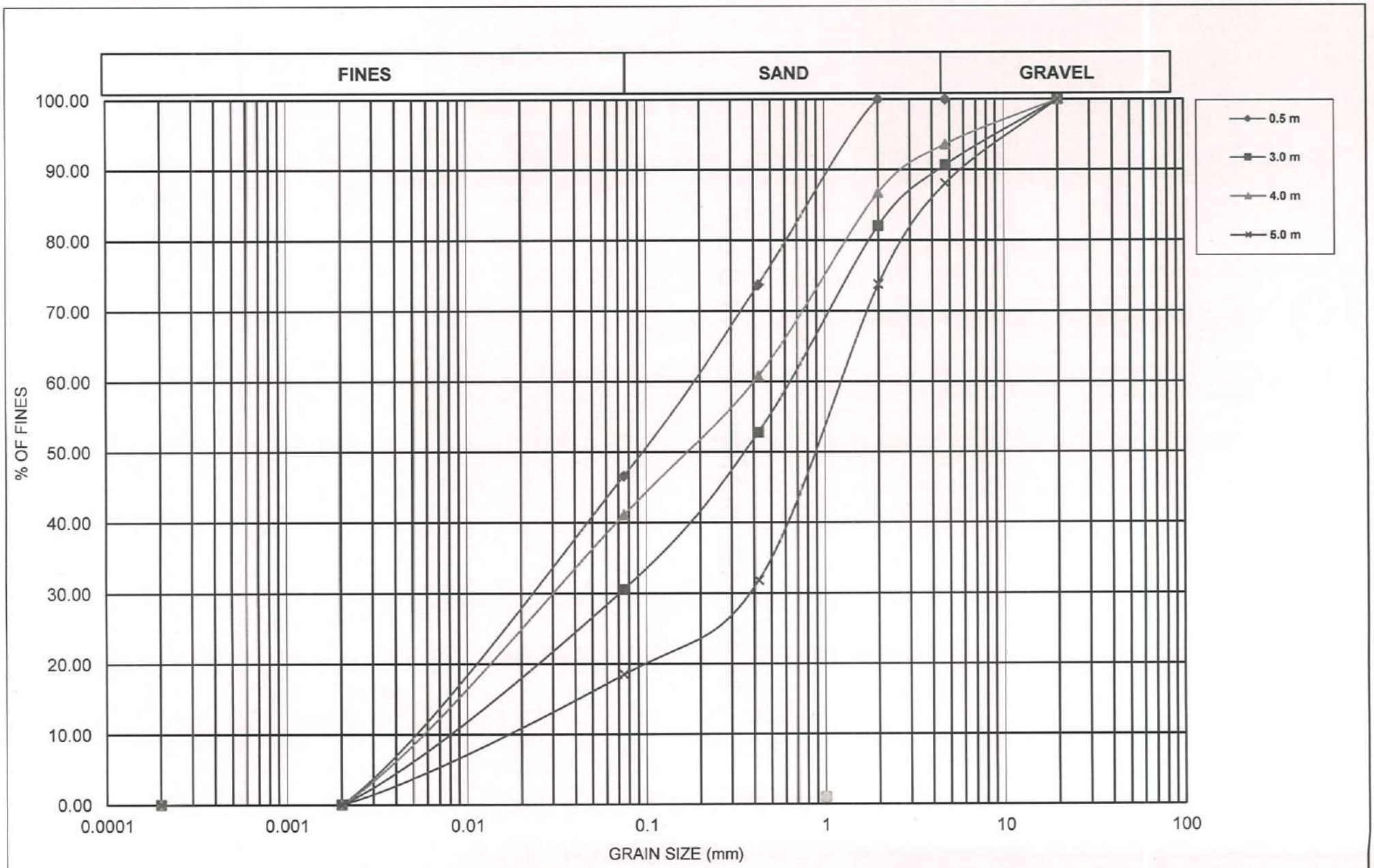


Fig. 2.8 GRAIN SIZE DISTRIBUTION CURVE - BH-01

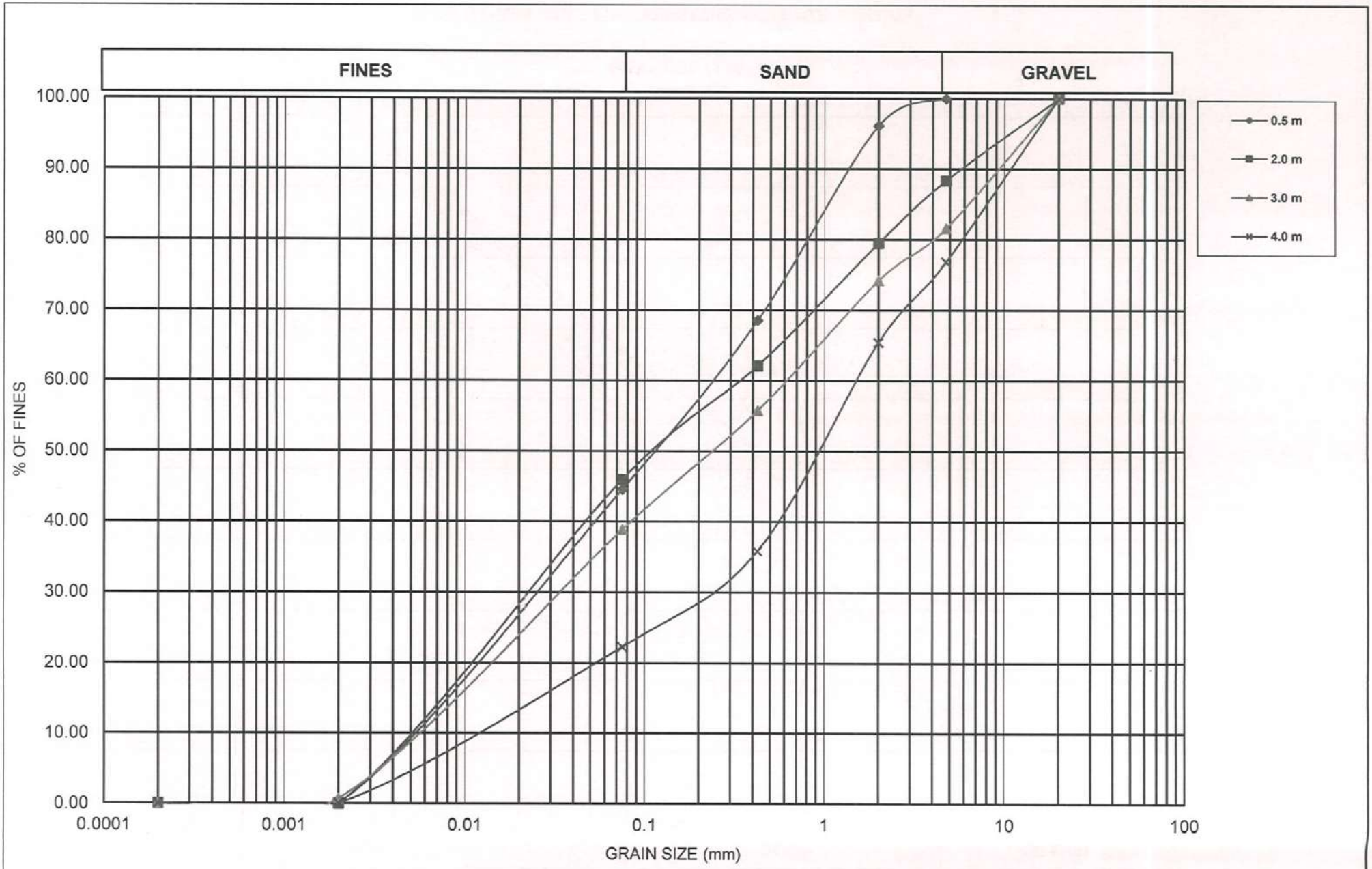


Fig. 2.9 GRAIN SIZE DISTRIBUTION CURVE - BH-02

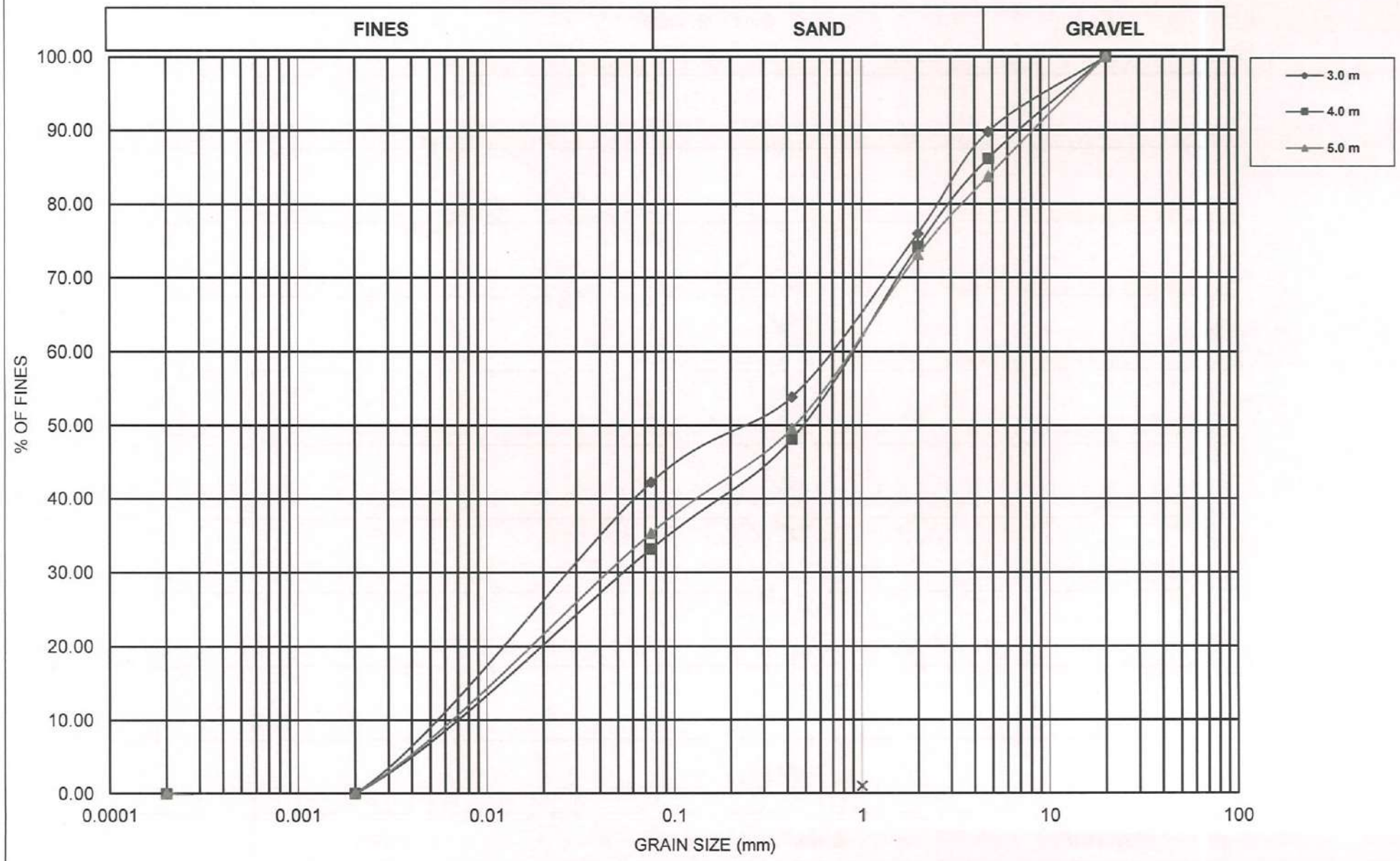


Fig. 2.10 GRAIN SIZE DISTRIBUTION CURVE - BH-03

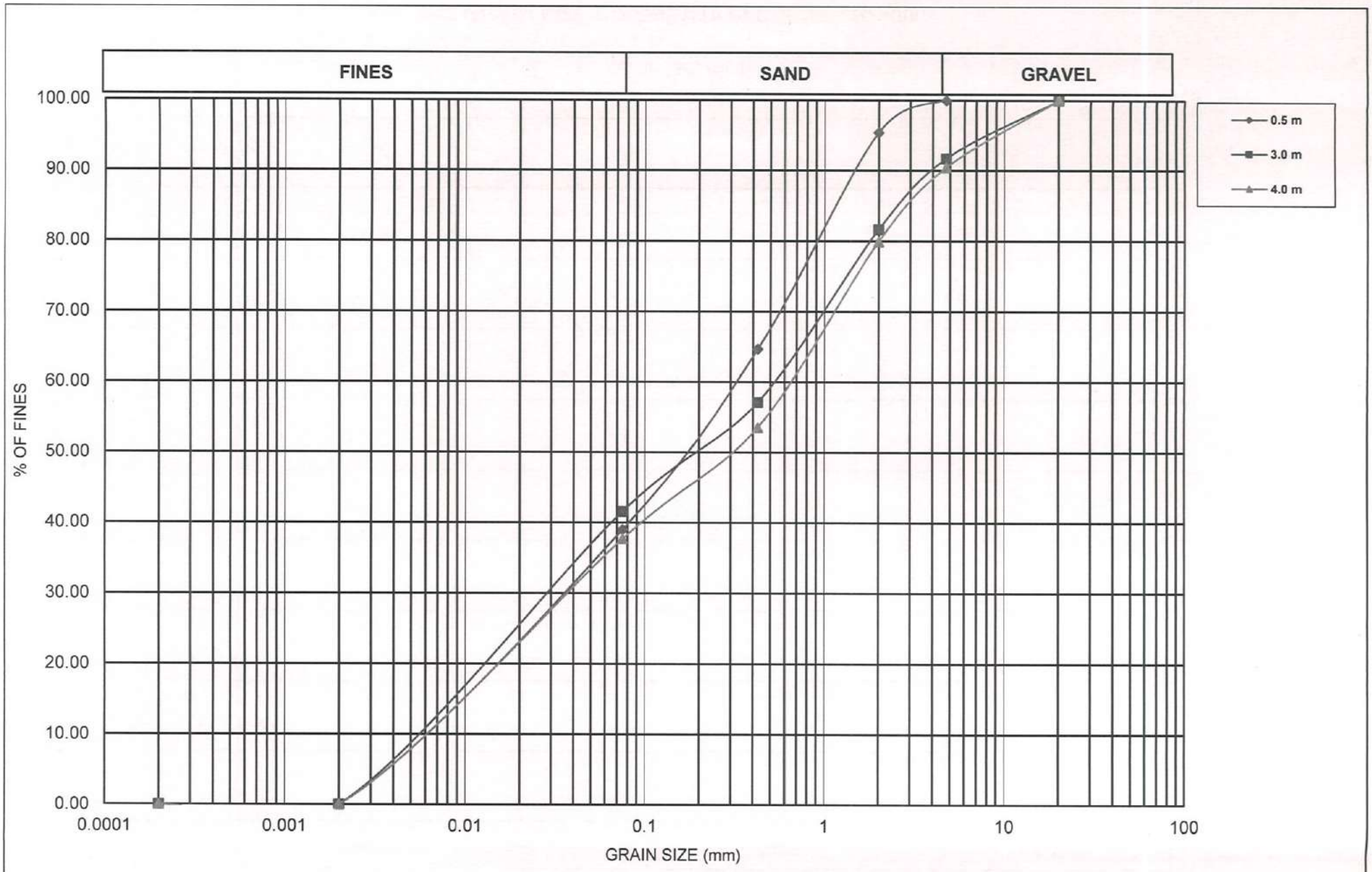


Fig. 2.11 GRAIN SIZE DISTRIBUTION CURVE - BH-04

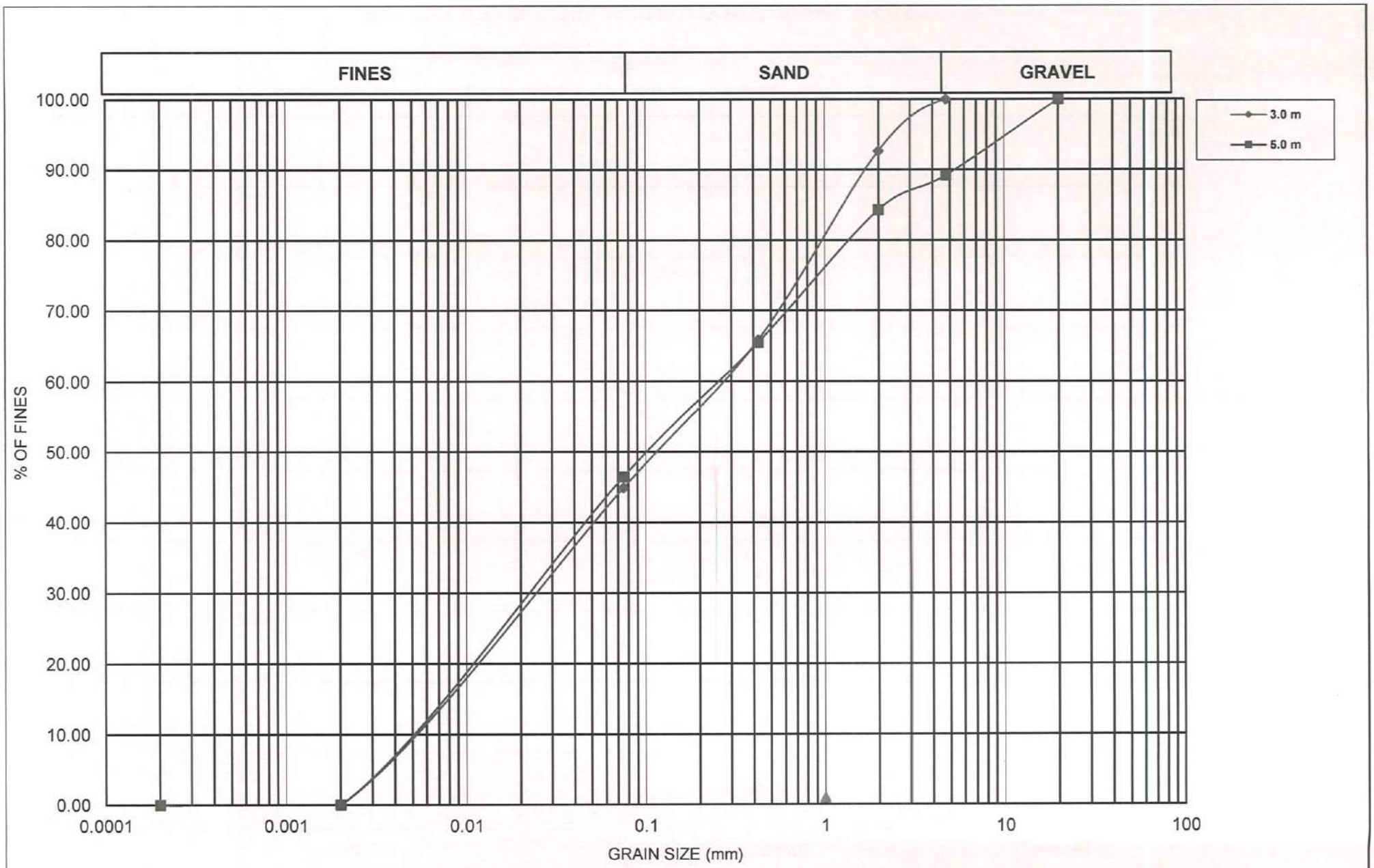


Fig. 2.12 GRAIN SIZE DISTRIBUTION CURVE - BH-05

HYDROMETER ANALYSIS CURVE

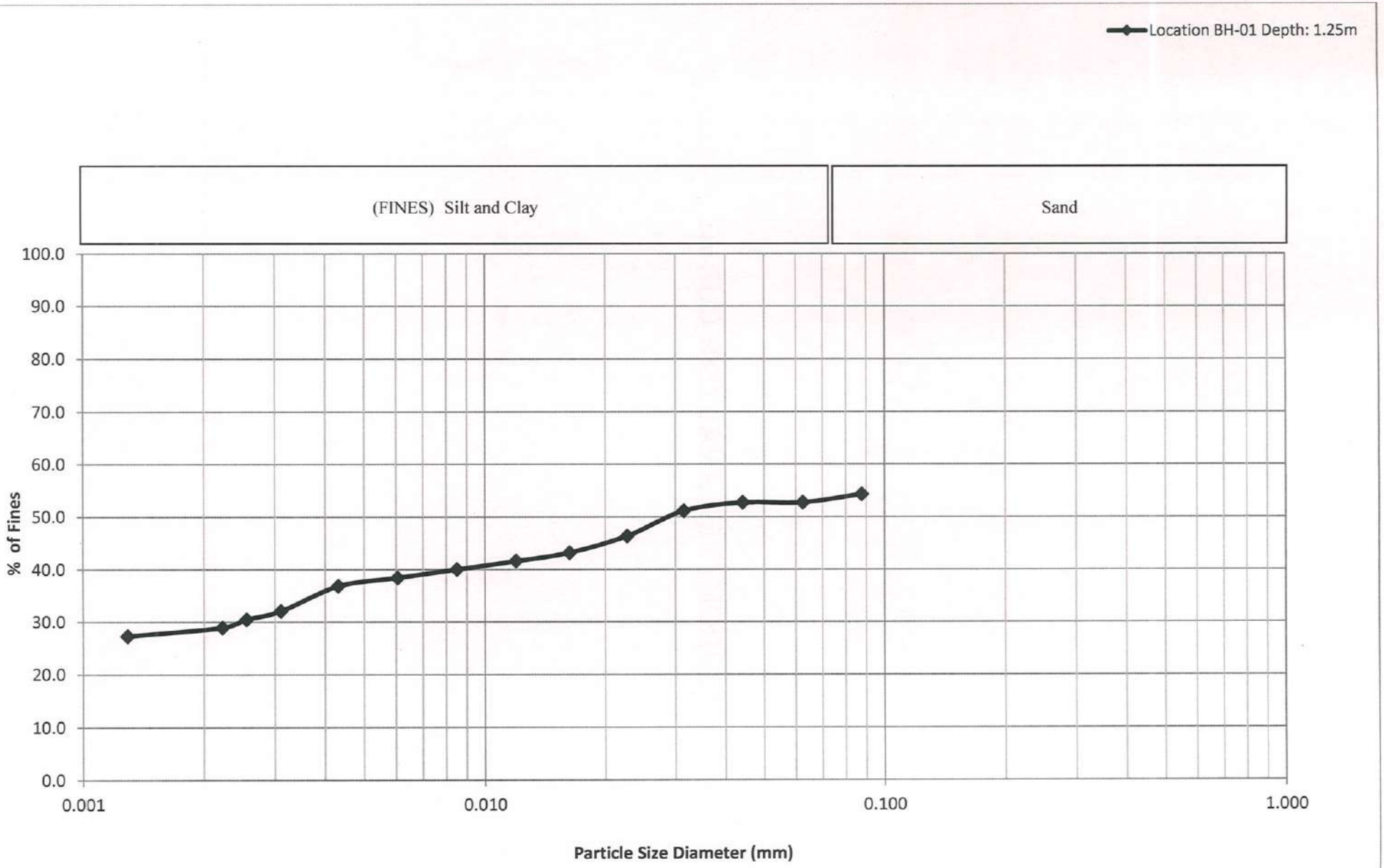


Fig 2.13 Hydrometer Analysis Master Curve

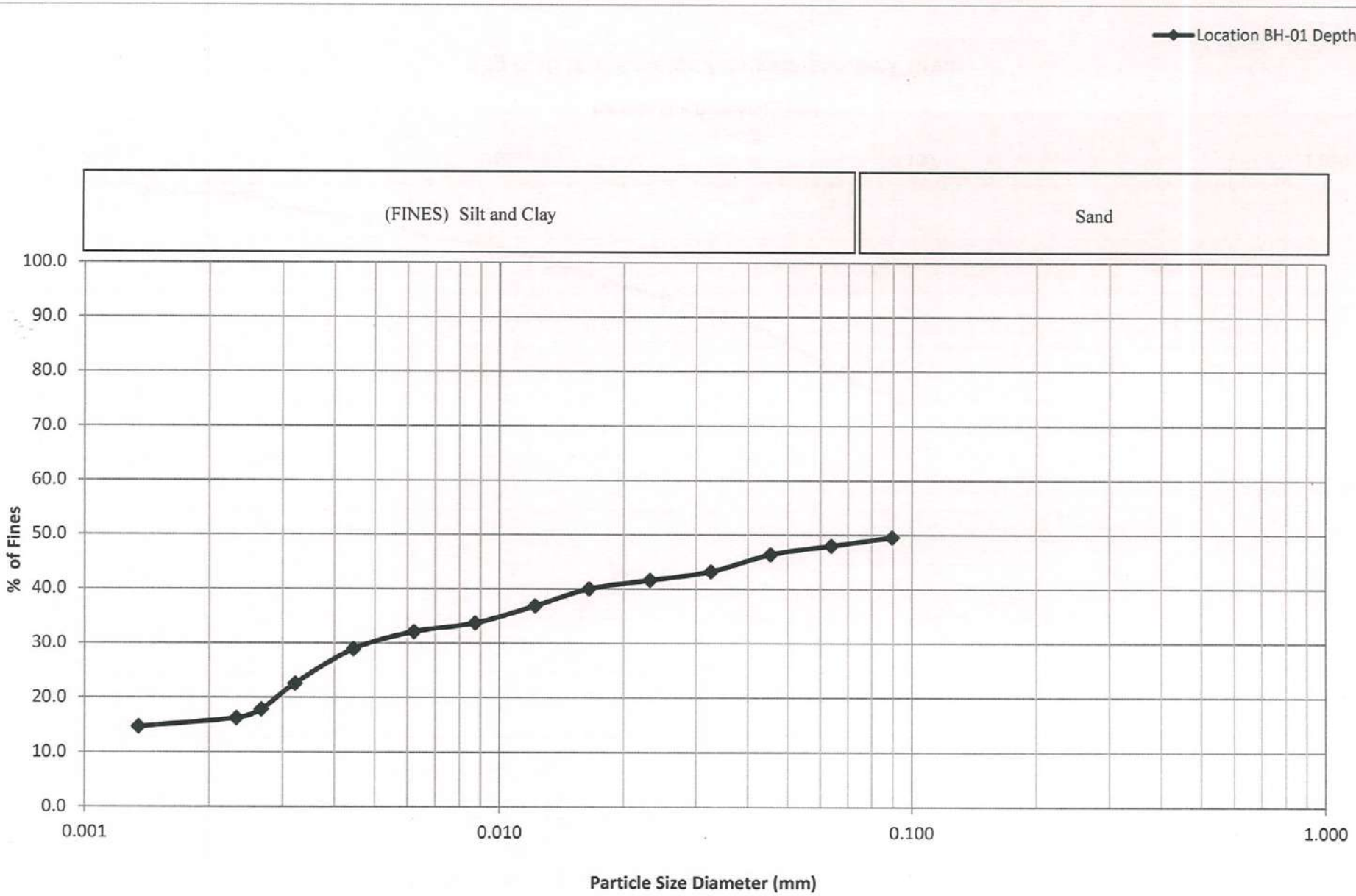


Fig 2.14 Hydrometer Analysis Master Curve

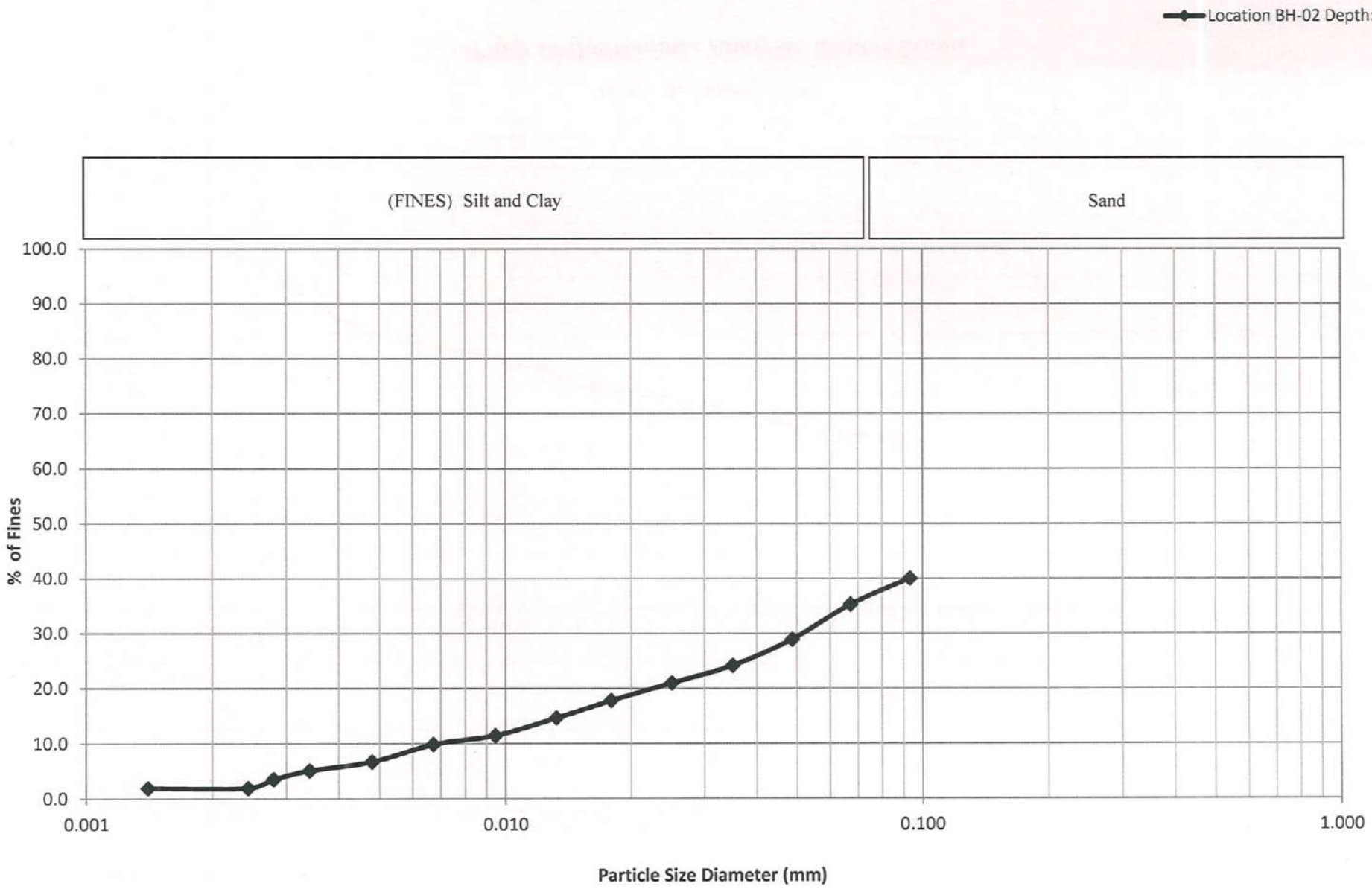


Fig 2.15 Hydrometer Analysis Master Curve

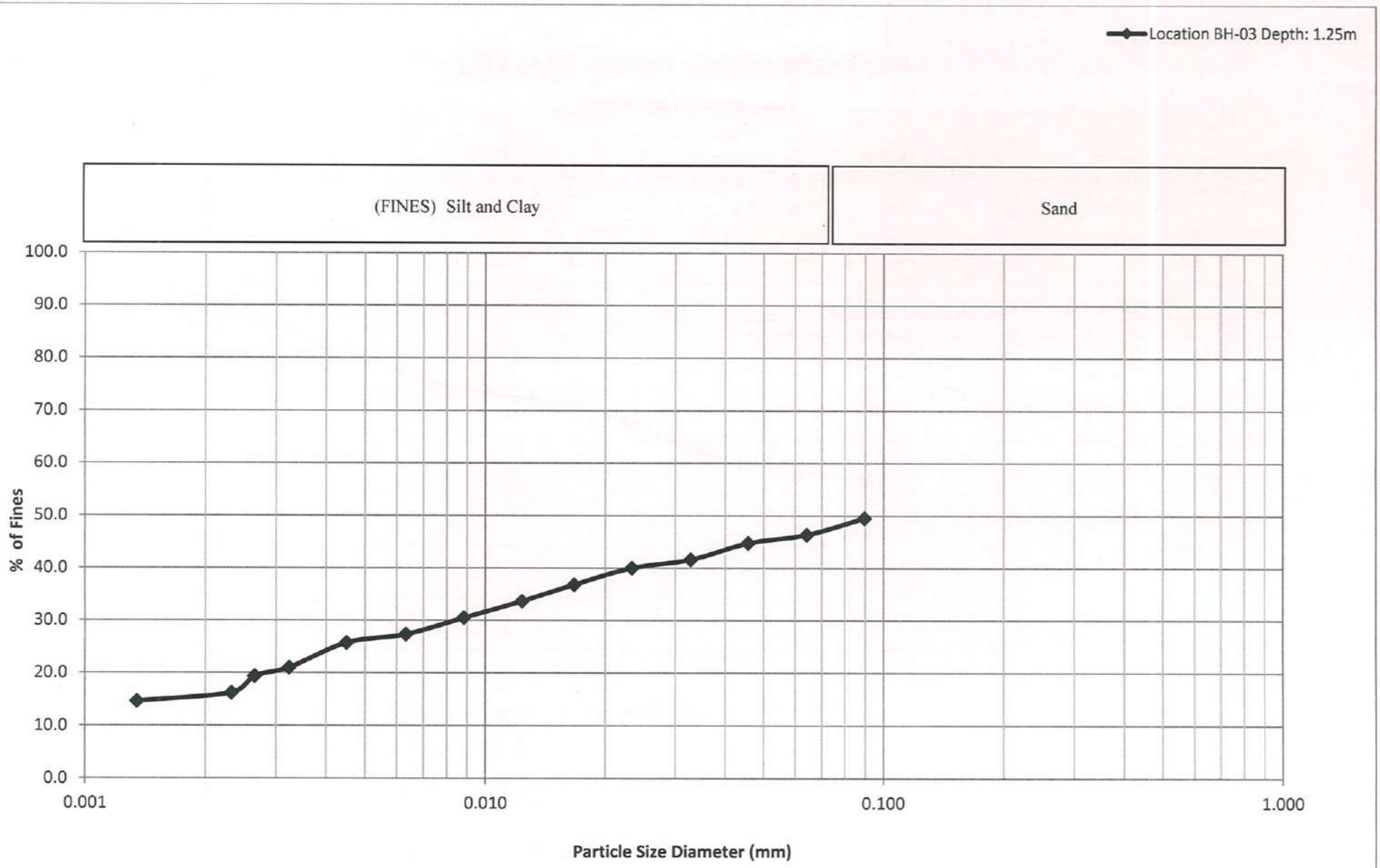


Fig 2.16 Hydrometer Analysis Master Curve

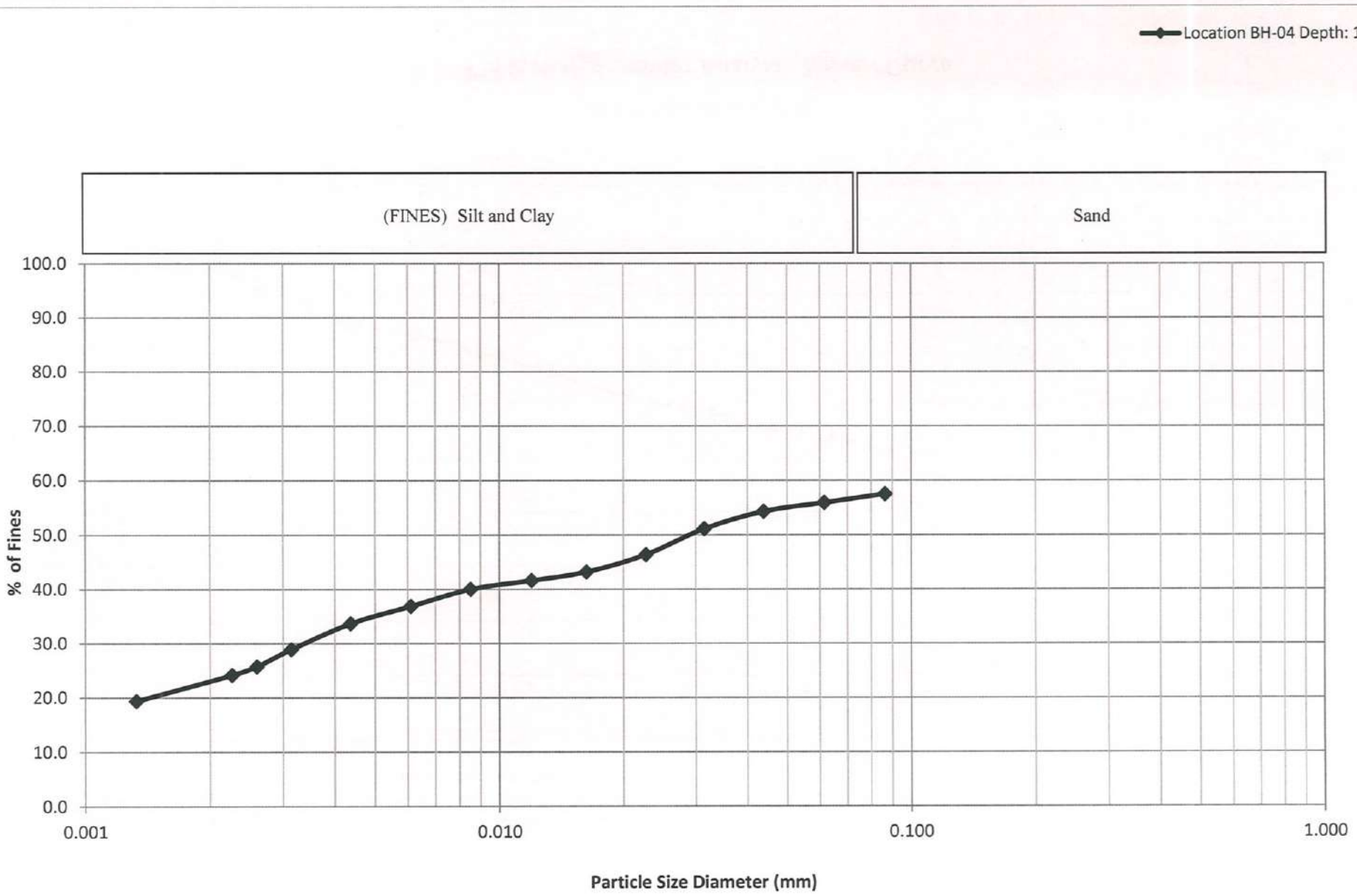


Fig 2.17 Hydrometer Analysis Master Curve

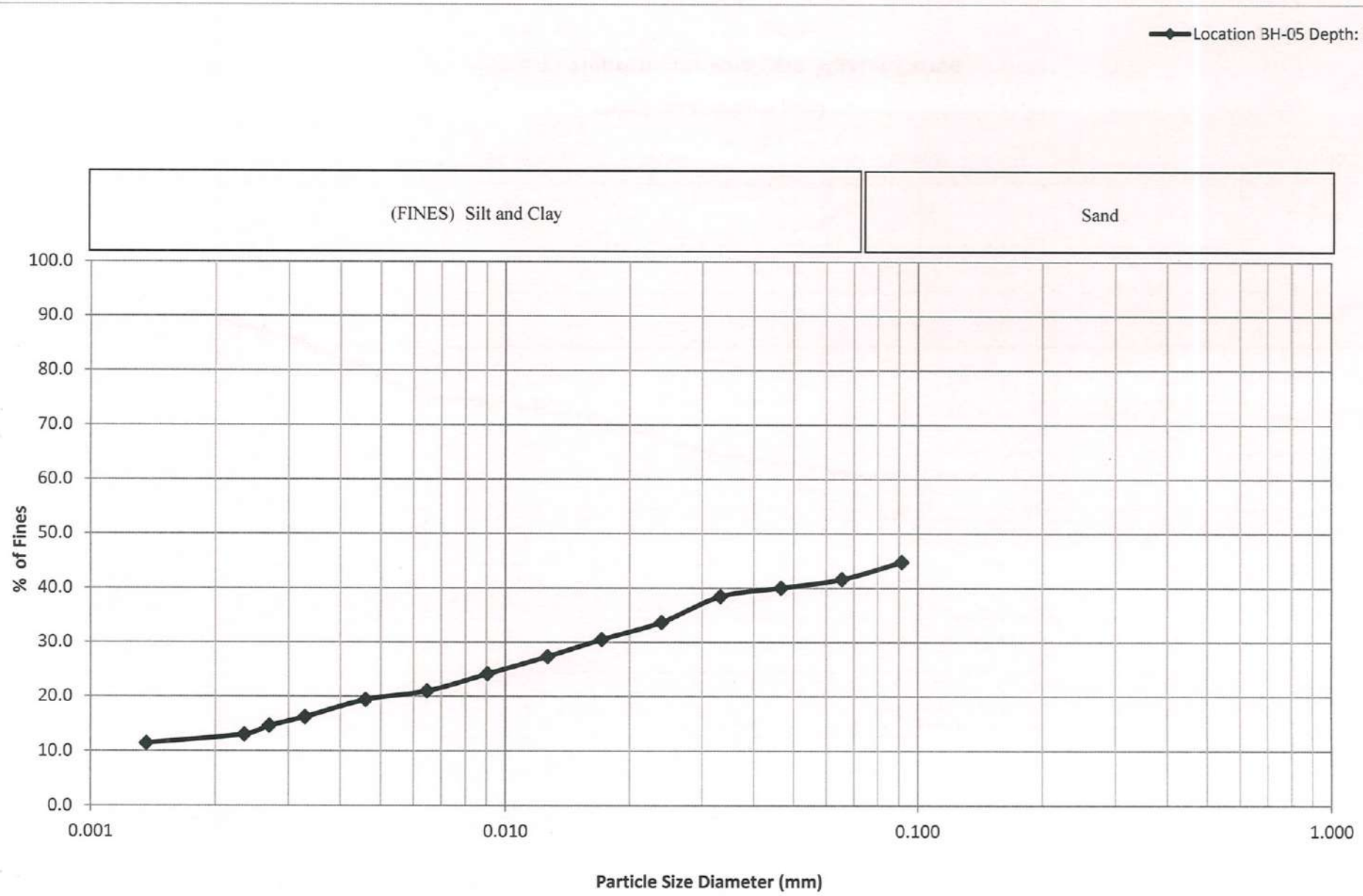


Fig 2.18 Hydrometer Analysis Master Curve

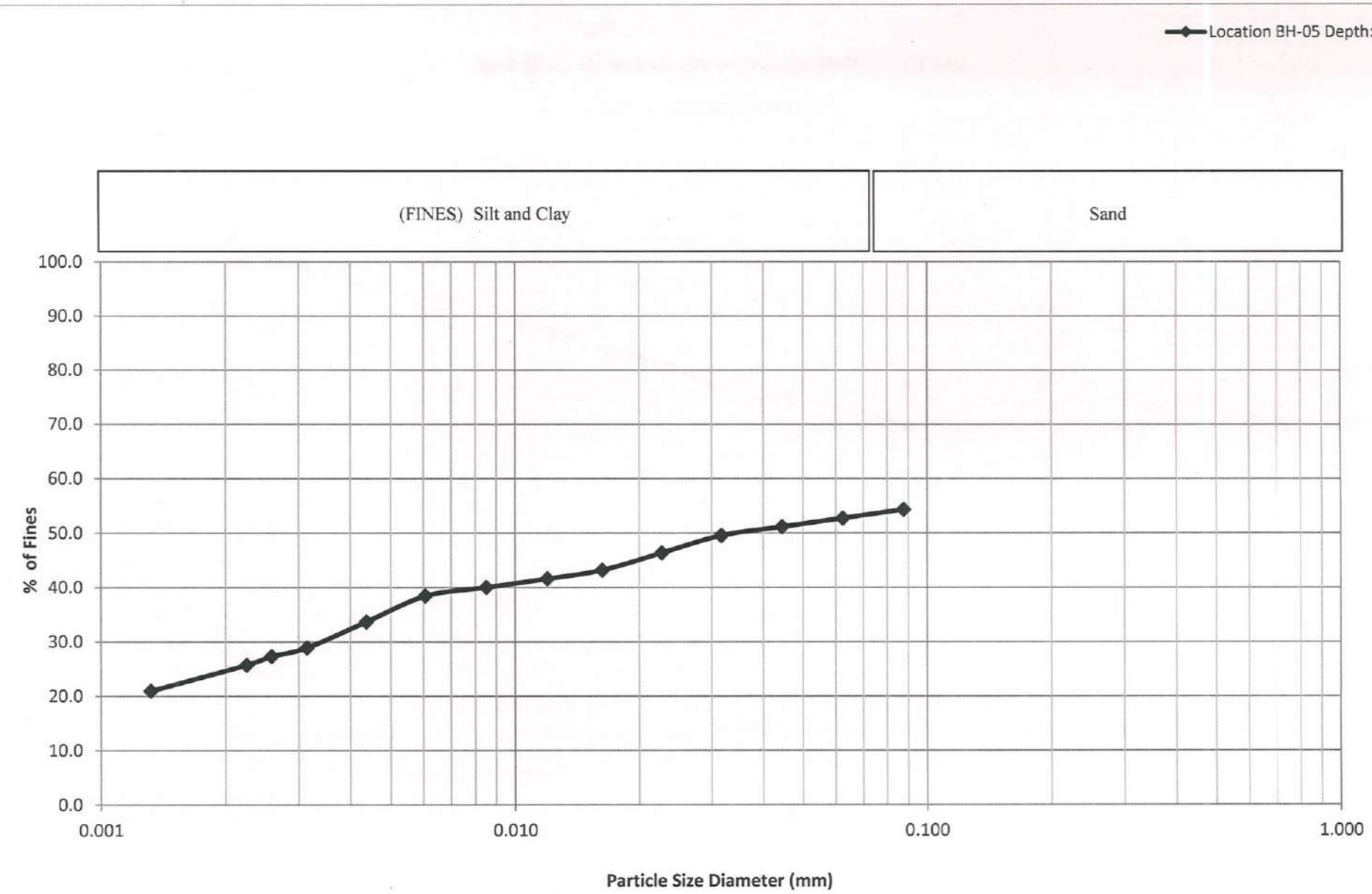


Fig 2.19 Hydrometer Analysis Master Curve

LABORATORY TEST RESULTS

GEOMARINE
THE SPIRIT OF ENGINEERING
Phone No.: 044-24481485, 044-24480305

LABORATORY TEST REPORT

GEOMARINE CONSULTANTS PVT LTD- TESTING LABORATORY

NO.11 2nd MAIN ROAD, KANNAPA NAGAR, CHENNAI-600041

ULR NO.	:	TC114102400000433F	SAMPLE IDENTIFICATION NUME	:	GMC/0224/823
REPORT ISSUED TO	:	M/s URBANDO HOUSING LLP	TEST REPORT NUMBER	:	GT-2737
DISCIPLINE/GROUP	:	MECHANICAL / SOIL AND ROCK	SAMPLE RECEIPT DATE	:	12/02/2024
SAMPLE DESCRIPTION	:	CLAY AND SOIL	PERIOD OF TESTING	:	14/02/2024 to 21/02/2024
SAMPLE CONDITION	:	SATISFACTORY	REPORT ISSUE DATE	:	27/02/2024
TEST METHOD	:	BUREAU OF INDIAN STANDARDS	NO. OF PAGES	:	One

TABLE-2.1 LABORATORY CLASSIFICATION OF SOIL SAMPLES FROM BH-01

Sampling Depth (m)	"N" Value	Type of Sample	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)	SHRINKAGE LIMIT (%) AS PER IS 2720 (P-VI) - 1972, RA-2011	FREE SWELL INDEX (%) AS PER IS 2720 (P-XL) - 1977, RA-2011	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						DIRECT SHEAR TEST IS 2720 PART 13:1986 (RA 2016)		Uniformity Co-Efficient $C_U=D_{60}/D_{10}$	Co-Efficient of Curvature $C_c=D_{30}^2/(D_{10}xD_{60})$	Consistancy	Relative Density	IS-Notation		
										Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	Cohesion (kg/cm^2)	ϕ (Degrees)					Fine Grain Soils	Gravely Soils	Sandy Soils
0.5	3	SPT	23	74	19	55	11.8	240	-	0.0	0.0	26.3	27.2	46.6		-	-	-	-	-	V.Loose	-	-	SC
1.25	-	UDS	28	118	31	88	-	283	2.51	5.6	3.3	17.3	15.5	41.5	16.8	-	-	-	-	-	-	CH	-	-
2.0	7	SPT	25	103	24	79	12.5	336	-	-	-	-	-	83.8	16.2	-	-	-	-	M.Stiff	-	CH	-	-
3.0	29	SPT	16	Little/No Plasticity				25	-	9.4	8.6	29.3	22.2	30.6		-	-	-	-	-	M.Dense	Disintegrated Rock/ Residual Soil		
4.0	>100	SPT	24	Test Not Applicable/No Plasticity						6.4	6.9	26.0	19.7	41.1		-	-	-	-	-	V.Dense	Completely to Highly Weathered Rock		
5.0	>100	SPT	18							12.0	14.3	42.0	13.3	18.5		-	-	-	-	-	V.Dense			
6.0	>100	DS	-							35.4	41.0	20.6	1.6	1.4		-	-	-	-	-	V.Dense			

** END OF REPORT**

Terms and Conditions

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(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
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(Technical Manager)

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LABORATORY TEST REPORT

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REPORT ISSUED TO	:	M/s URBANDO HOUSING LLP	TEST REPORT NUMBER	:	GT-2737
DISCIPLINE/GROUP	:	MECHANICAL / SOIL AND ROCK	SAMPLE RECEIPT DATE	:	19/02/2024
SAMPLE DESCRIPTION	:	CLAY AND SOIL	PERIOD OF TESTING	:	19/02/2024 to 26/02/2024
SAMPLE CONDITION	:	SATISFACTORY	REPORT ISSUE DATE	:	27/02/2024
TEST METHOD	:	BUREAU OF INDIAN STANDARDS	NO. OF PAGES	:	One

TABLE-2.2 LABORATORY CLASSIFICATION OF SOIL SAMPLES FROM BH-02

Sampling Depth (m)	"N" Value	Type of Sample	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)	SHRINKAGE LIMIT (%) AS PER IS 2720 (P-VI) - 1972, RA-2011	FREE SWELL INDEX (%) AS PER IS 2720 (P-XL) - 1977, RA-2011	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						DIRECT SHEAR TEST IS 2720 PART 13:1986 (RA 2016)		Uniformity Co-Efficient $C_U=D_{60}/D_{10}$	Co-Efficient of Curvature $C_c=D_{30}^2/(D_{10}xD_{60})$	Consistancy	Relative Density	IS-Notation		
										Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	Cohesion (kg/cm^2)	ϕ (Degrees)					Fine Grain Soils	Gravely Soils	Sandy Soils
0.5	3	SPT	23	25	16	10	-	25	-	0.0	3.9	27.6	23.9	44.6		-	-	-	-	-	V.Loose	-	-	SC
2.0	15	SPT	15	78	26	52	-	214	-	11.7	8.9	17.4	16.1	46.0		-	-	-	-	-	M.Dense	-	-	SC
3.0	>100	SPT	25	32	20	12	-	33	-	18.3	7.5	18.4	16.4	38.6	0.7	-	-	-	-	-	V.Dense	Disintegrated Rock/ Residual Soil		
4.0	>100	SPT	20	Test No Applicable						23.2	11.4	29.6	13.5	22.3		-	-	-	-	-	V.Dense	Completely to Highly Weathered Rock		
5.0	>100	DS	Test Not Applicable/No Plasticity							4.2	19.3	59.8	12.6	4.1		-	-	-	-	-	V.Dense			
6.0	>100	DS								9.3	28.0	55.0	5.9	1.8		-	-	-	-	-	V.Dense			
7.5	-	DS								7.7	28.1	58.5	5.0	0.7		-	-	-	-	-	V.Dense			
9.0	-	DS								27.0	27.5	41.7	2.5	1.3		-	-	-	-	-	V.Dense			
10.5 to 12	-	DS								30.7	27.5	39.4	2.5	0.0		-	-	-	-	-	V.Dense			

** END OF REPORT**

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LABORATORY TEST REPORT

GEOMARINE CONSULTANTS PVT LTD- TESTING LABORATORY
NO.11 2nd MAIN ROAD, KANNAPA NAGAR, CHENNAI-600041

ULR NO.	:	TC114102400000433F	SAMPLE IDENTIFICATION NUME	:	GMC/0224/823
REPORT ISSUED TO	:	M/s URBANDO HOUSING LLP	TEST REPORT NUMBER	:	GT-2737
DISCIPLINE/GROUP	:	MECHANICAL / SOIL AND ROCK	SAMPLE RECEIPT DATE	:	19/02/2024
SAMPLE DESCRIPTION	:	CLAY AND SOIL	PERIOD OF TESTING	:	19/02/2024 to 26/02/2024
SAMPLE CONDITION	:	SATISFACTORY	REPORT ISSUE DATE	:	27/02/2024
TEST METHOD	:	BUREAU OF INDIAN STANDARDS	NO. OF PAGES	:	One

TABLE-2.3 LABORATORY CLASSIFICATION OF SOIL SAMPLES FROM BH-03

Sampling Depth (m)	"N" Value	Type of Sample	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)	SHRINKAGE LIMIT (%) AS PER IS 2720 (P-VI) - 1972, RA-2011	FREE SWELL INDEX (%) AS PER IS 2720 (P-XL) - 1977, RA-2011	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						DIRECT SHEAR TEST IS 2720 PART 13:1986 (RA 2016)		Uniformity Co-Efficient $C_U=D_{60}/D_{10}$	Co-Efficient of Curvature $C_c=D_{30}^2/(D_{10}xD_{60})$	Consistancy	Relative Density	IS-Notation		
										Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	Cohesion (kg/cm^2)	ϕ (Degrees)					Fine Grain Soils	Gravely Soils	Sandy Soils
0.5	6	SPT	28	40	21	19	-	75	-	0.0	0.0	17.2	22.0	60.9		-	-	-	-	M.Stiff	-	CI	-	-
1.25	7	SPT	37	71	23	48	-	217	-	0.0	1.8	14.7	22.0	51.6	9.9	-	-	-	-	M.Stiff	-	CH	-	-
3.0	14	SPT	23	71	25	46	-	309	-	10.2	13.8	22.1	11.7	42.2		-	-	-	-	-	M.Dense	-	-	SC
4.0	>100	SPT	20	28	19	10	-	0	-	13.8	11.9	26.1	14.9	33.2		-	-	-	-	-	V.Dense	Disintegrated Rock/ Residual Soil		
5.0	>100	SPT	18	31	19	12	-	58	-	16.3	10.6	23.6	14.2	35.3		-	-	-	-	-	V.Dense			
6.0	>100	DS	Test Not Applicable/No Plasticity							23.5	34.6	40.2	1.8	0.0		-	-	-	-	-	V.Dense	Completely to Highly Weathered Rock		
7.5	-	DS								16.1	23.6	56.3	4.0	0.0		-	-	-	-	-	V.Dense			
9.0	-	DS								0.0	0.5	78.7	19.6	1.1		-	-	-	-	-	V.Dense			
10.5	-	DS								0.0	0.0	78.0	16.3	5.7		-	-	-	-	-	V.Dense			

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Authorised Signatory
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LABORATORY TEST REPORT

GEOMARINE CONSULTANTS PVT LTD- TESTING LABORATORY
NO.11 2nd MAIN ROAD, KANNAPA NAGAR, CHENNAI-600041

ULR NO.	:	TC114102400000433F	SAMPLE IDENTIFICATION NUME	:	GMC/0224/823
REPORT ISSUED TO	:	M/s URBANDO HOUSING LLP	TEST REPORT NUMBER	:	GT-2737
DISCIPLINE/GROUP	:	MECHANICAL / SOIL AND ROCK	SAMPLE RECEIPT DATE	:	12/02/2024
SAMPLE DESCRIPTION	:	CLAY AND SOIL	PERIOD OF TESTING	:	14/02/2024 to 21/02/2024
SAMPLE CONDITION	:	SATISFACTORY	REPORT ISSUE DATE	:	27/02/2024
TEST METHOD	:	BUREAU OF INDIAN STANDARDS	NO. OF PAGES	:	One

TABLE-2.4 LABORATORY CLASSIFICATION OF SOIL SAMPLES FROM BH-04

Sampling Depth (m)	"N" Value	Type of Sample	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)	SHRINKAGE LIMIT (%) AS PER IS 2720 (P-VI) - 1972, RA-2011	FREE SWELL INDEX (%) AS PER IS 2720 (P-XL) - 1977, RA-2011	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						DIRECT SHEAR TEST IS 2720 PART 13:1986 (RA 2016)		Uniformity Co-Efficient $C_U=D_{60}/D_{10}$	Co-Efficient of Curvature $C_c=D_{30}^2/(D_{10}xD_{60})$	Consistancy	Relative Density	IS-Notation		
										Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	Cohesion (kg/cm²)	ϕ (Degrees)					Fine Grain Soils	Gravely Soils	Sandy Soils
0.5	3	SPT	14	24	No Plasticity			9	-	0.0	4.6	30.7	25.7	39.0		-	-	-	-	-	V.Loose	-	-	SM
1.25	-	UDS	30	104	27	77	-	167	2.52	4.3	3.1	7.5	11.7	56.4	17.0	-	-	-	-	-	-	CH	-	-
2.0	7	SPT	36	115	27	88	-	217	-	0.0	3.3	9.4	10.4	76.9		-	-	-	-	M.Stiff	-	CH	-	-
3.0	31	SPT	24	37	22	15	24.4	45	-	8.3	10.1	24.5	15.5	41.6		-	-	-	-	-	Dense	Disintegrated Rock/ Residual Soil		
4.0	57	SPT	26	45	22	23	21.6	54	-	9.6	10.5	26.4	15.9	37.7		-	-	-	-	-	V.Dense			
5.0	>100	DS	Test Not Applicable/No Plasticity							44.9	28.0	20.8	3.3	3.1		-	-	-	-	-	V.Dense	Completely to Highly Weathered Rock		
6.0	-	DS								38.3	31.9	23.8	3.6	2.4		-	-	-	-	-	V.Dense			
7.5	-	DS								70.9	13.6	13.0	1.6	0.9		-	-	-	-	-	V.Dense			
9.0	-	DS								7.2	25.8	53.3	11.9	1.8		-	-	-	-	-	V.Dense			

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LABORATORY TEST REPORT

GEOMARINE CONSULTANTS PVT LTD- TESTING LABORATORY

NO.11 2nd MAIN ROAD, KANNAPA NAGAR, CHENNAI-600041

ULR NO.	:	TC114102400000433F	SAMPLE IDENTIFICATION NUME	:	GMC/0224/823
REPORT ISSUED TO	:	M/s URBANDO HOUSING LLP	TEST REPORT NUMBER	:	GT-2737
DISCIPLINE/GROUP	:	MECHANICAL / SOIL AND ROCK	SAMPLE RECEIPT DATE	:	12/02/2024
SAMPLE DESCRIPTION	:	CLAY AND SOIL	PERIOD OF TESTING	:	14/02/2024 to 21/02/2024
SAMPLE CONDITION	:	SATISFACTORY	REPORT ISSUE DATE	:	27/02/2024
TEST METHOD	:	BUREAU OF INDIAN STANDARDS	NO. OF PAGES	:	One

TABLE-2.5 LABORATORY CLASSIFICATION OF SOIL SAMPLES FROM BH-05

Sampling Depth (m)	"N" Value	Type of Sample	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)	SHRINKAGE LIMIT (%) AS PER IS 2720 (P-VI) - 1972, RA-2011	FREE SWELL INDEX (%) AS PER IS 2720 (P-XL) - 1977, RA-2011	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						DIRECT SHEAR TEST IS 2720 PART 13:1986 (RA 2016)		Uniformity Co-Efficient $C_U=D_{60}/D_{10}$	Co-Efficient of Curvature $C_c=D_{30}^2/(D_{10}xD_{60})$	Consistancy	Relative Density	IS-Notation		
										Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	Cohesion (kg/cm²)	ϕ (Degrees)					Fine Grain Soils	Gravely Soils	Sandy Soils
0.5	7	SPT	Sample Failed																					
1.25	4	SPT	28	72	21	51	-	170	-	-	-	-	-	87.0	13.0	-	-	-	-	Soft	-	CH	-	-
2.0	-	UDS	38	138	31	107	-	325	2.51	6.2	2.1	12.7	14.8	47.7	16.5	-	-	-	-	-	-	CH	-	-
3.0	36	SPT	25	63	23	39	25.3	117	-	0.0	7.4	26.8	20.9	44.9		-	-	-	-	-	Dense	Disintegrated Rock/ Residual Soil		
4.0	>100	SPT	29	59	25	33	21.1	92	-	0.0	2.7	10.9	19.6	66.9		-	-	-	-	Hard	-			
5.0	>100	SPT	21	Little/No Plasticity				8.3	-	10.8	4.9	18.8	19.0	46.5		-	-	-	-	-	V.Dense			
6.0	>100	DS	Test Not Applicable/No Plasticity							73.0	18.1	6.7	2.2	0.0		-	-	-	-	-	V.Dense	Completely to Highly Weathered Rock		
7.5	-	DS								24.4	23.3	46.7	4.4	1.1		-	-	-	-	-	V.Dense			
9.0	-	DS								17.1	24.0	51.7	6.3	0.9		-	-	-	-	-	V.Dense			
10.5	-	DS								2.8	17.3	60.0	17.5	2.4		-	-	-	-	-	V.Dense			

** END OF REPORT**

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

TC-11410

TABLE 2.7 RESULT OF CHEMICAL TEST ON WATER

URL NO	:TC114102400000431F	SAMPLE SOURCE	:CUSTOMER SUPPLIED
DISCIPLINE/GROUP	:CHEMICAL - WATER	SAMPLE ID	:GMC/0224/823
SAMPLE DESCRIPTION	:GROUND WATER	REPORT NUMBER	:GT-2737
SAMPLE CONDITION	:SATISFACTORY	RECEIVED DATE	:16/02/2024
TEST METHOD	:AS PER BIS	TEST PERIOD	:17/02/2024
NO. OF PAGES	:1 Of 1	ISSUE OF REPORT	:27/02/2024
REPORT ISSUED TO	:M/s URBANDO HOUSING LLP		

S.NO.	SAMPLE REFERENCE	WATER			
		DEPTH OF SAMPLE (m)	pH AS PER IS 3025 (P-XI) - 2022	SULPHATES (mg/l) AS PER APHA 23rd Edn.2017-4500	CHLORIDES (mg/l) AS PER IS 3025(P-XXXII) - 1988, RA-2019
1.0	BH-01	2.90	7.9	341.8	896.9
2.0	BH-02	1.80	8.0	387.6	1558.9
3.0	BH-03	1.60	7.9	393.1	1547.5
4.0	BH-04	2.75	7.9	292.4	490.8
5.0	BH-05	3.20	7.8	341.9	841.4

** END OF REPORT**

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A. VINOTH
(Technical Manager)

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

TC-11410

TABLE 2.8 RESULT OF CHEMICAL TEST ON SOIL

URL NO	:TC114102400000432F	SAMPLE SOURCE	:CUSTOMER SUPPLIED
DISCIPLINE/GROUP	:CHEMICAL-SOIL AND ROCK	SAMPLE ID	:GMC/0224/823
SAMPLE DESCRIPTION	:SOIL	REPORT NUMBER	:GT-2737
SAMPLE CONDITION	:SATISFACTORY	RECEIVED DATE	:16/02/2024
TEST METHOD	:AS PER BIS	TEST PERIOD	:17/02/2024
NO. OF PAGES	:1 Of 1	ISSUE OF REPORT	:27/02/2024
REPORT ISSUED TO	:M/s URBANDO HOUSING LLP		

S.NO.	SAMPLE REFERENCE	SOIL (2:1)	
		DEPTH OF SAMPLE (m)	pH AS PER IS 2720 (P-XXVI) - 1987
1.0	BH-01	2.00	7.64
2.0	BH-02	2.00	7.65
3.0	BH-03	3.00	7.72
4.0	BH-04	2.00	7.74
5.0	BH-05	4.00	7.73

** END OF REPORT**

Authorised Signatory
A. VINOTH
(Technical Manager)

Terms and Conditions

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

(2) The tested sample will not be retained for more than 30 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

GEOMARINE
THE SPIRIT OF ENGINEERING
Phone No.: 044-24480305

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

TABLE 2.9 RESULT OF CHEMICAL TEST ON SOIL

		SAMPLE SOURCE	:CUSTOMER SUPPLIED
DISCIPLINE/GROUP	:CHEMICAL-SOIL AND ROCK	SAMPLE ID	:GMC/0224/823
SAMPLE DESCRIPTION	:SOIL	REPORT NUMBER	:GT-2737
SAMPLE CONDITION	:SATISFACTORY	RECEIVED DATE	:16/02/2024
TEST METHOD	:AS PER BIS	TEST PERIOD	:17/02/2024
NO. OF PAGES	:1 Of 1	ISSUE OF REPORT	:27/02/2024
REPORT ISSUED TO	:M/s URBANDO HOUSING LLP		

S.NO.	SAMPLE REFERENCE	SOIL (2:1)		
		DEPTH OF SAMPLE (m)	SULPHATES (mg/l) AS PER APHA 23rd Edn.2017-4500	CHLORIDES (mg/l) AS PER IS 3025(P-XXXII) - 1988, RA-2019
1.0	BH-01	2.00	35.9	76.6
2.0	BH-02	2.00	36.4	35.9
3.0	BH-03	3.00	33.4	32.6
4.0	BH-04	2.00	35.0	76.6
5.0	BH-05	4.00	28.6	45.7

** END OF REPORT**

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CHAPTER-3

GEOLOGY & SUB-SURFACE STRATIFICATION

3.0 PREAMBLE:

Geotechnical investigation carried out at a specific site provides location specific sub surface 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.

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	1.30	1.30	Filled Up	Grey Brown	3	Very Loose	-	13	-	20
2.0	1.30	3.00	1.70	Silty Clay	Grey	7	-	Medium Stiff	16	47	-
3.0	3.00	4.00	1.00	Residual Soil	Brown, Grey Brown	29	Medium Dense	-	19	-	36
4.0	4.00	6.60	2.60	Completely Weathered Rock	Grey Brown	>100	Very Dense	-	21	-	43
5.0	6.60	7.60	1.00	Completely Weathered Rock	Greyish Brown	CRR = 10%, RQD = 0%					
6.0	7.60	12.00	4.40	Highly Weathered Rock	Grey, Grey Brown	CRR = 21%,21% & 23%, RQD = 0%					
7.0	12.00	15.00	3.00	Moderately Weathered Rock	Grey, Grey Brown	CRR = 33% & 42%, RQD = 0% & 8%					

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							(C_u) kPa	(ϕ) Deg.
1.0	0.00	1.25	1.25	Filled Up	-	3	Very Loose	-	13	-	20
2.0	1.25	3.00	1.75	Clayey Silty Sand	Grey	15	Medium Dense	-	17.5	-	32
3.0	3.00	5.00	2.00	Residual Soil	Grey Brown	>100	Very Dense	-	21	-	43
4.0	5.00	9.00	4.00	Completely Weathered Rock	Grey	>100	Very Dense	-	21	-	43
5.0	9.00	15.00	6.00	Highly Weathered Rock	Grey, Grey Brown	CRR = 9%,0%, 5% & 10%, 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							(C_u) kPa	(ϕ) Deg.
1.0	0.00	3.00	3.00	Sandy Silty Clay	Grey	7	-	Medium Stiff	16	47	-
2.0	3.00	4.00	1.00	Clayey Silty Sand	Brown	14	Medium Dense	-	17	-	31
3.0	4.00	6.00	2.00	Residual Soil	Brown	>100	Very Dense	-	21	-	43
4.0	6.00	10.50	4.50	Completely Weathered Rock	Grey	>100	Very Dense	-	21	-	43
5.0	10.50	15.00	4.50	Highly Weathered Rock	Brown, Grey Brown	CRR = 4%,5%, & 12%, RQD = 0%					
6.0	15.00	16.50	1.50	Moderately Weathered Rock	Grey, Brown Grey	CRR = 29%, RQD = 0%					

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/m³	Shear Parameters	
	Top BGL	Bottom BGL	Thickness							(C_u) kPa	(ϕ) Deg.
1.0	0.00	1.25	1.25	Silty Sand	Grey	3	Very Loose	-	13	-	20
2.0	1.25	3.00	1.75	Silty Clay	Grey, Brown Grey	7	-	Medium Stiff	16	47	-
3.0	3.00	5.00	2.00	Residual Soil	Brown	44	Dense	-	20	-	40
4.0	5.00	9.00	4.00	Completely Weathered Rock	Grey	>100	Very Dense	-	21	-	43
5.0	9.00	15.00	6.00	Highly Weathered Rock	Grey, Grey Brown	CRR = 8%,12%, 13% & 19%, RQD = 0%					

REFERENCE BORE HOLE					BH-05	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							(C_u) kPa	(ϕ) Deg.
1.0	0.00	3.00	3.00	Silty Clay	Grey, Brown Grey	6	-	Medium Stiff	15.5	40	-
2.0	3.00	4.00	1.00	Residual Soil	Brown, Off-white	36	Dense	-	19.5	-	38
3.0	4.00	6.00	2.00	Residual Soil	Brown, Grey Brown	>100	Very Dense	-	21	-	43
4.0	6.00	10.50	4.50	Completely Weathered Rock	Grey	>100	Very Dense	-	21	-	43
5.0	10.50	13.50	3.00	Highly Weathered Rock	Grey, Brown Grey	CRR = 9% & 4%, RQD = 0%					
6.0	13.50	16.50	3.00	Moderately Weathered Rock	Grey, Brown Grey	CRR = 35% & 47%, RQD = 0% & 9%					

FOUNDATION SYSTEM

CHAPTER-4

FOUNDATION SYSTEM

4.0 PREAMBLE:

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

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

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

4.1 PROPOSED STRUCTURES:

An understanding of the proposed construction and the order of loads on the foundations is needed for choosing the appropriate foundation system. In the present case, the proposed structure is configured with stilt and eleven upper floors, and is meant for residential use. For this kind of structure, the column loads could vary between 3500 kN to 5000 kN.

The above-mentioned loads have no bearing on the design of either sub or super structures and are mentioned just to provide an insight to choose an appropriate foundation system with respect to subsoil conditions.

4.2 SUB SOIL STRATIFICATION:

The sub soil in the project location consists of:

Layer-I	0.0m to 3.0m	Medium Stiff & Soft, Silty Clay (Filling of 1.0m Approx thickness using Debris & Soil)
Layer-II	3.0m to 4.0m	Medium Dense & Dense, Clayey Sand/Residual Soil
Layer-III	4.0m to 5.0m/6.0m	Very Dense, Residual Soil- Grade W5 Rock
Layer-IV	5m/6m to 6m/7.5m/9m	Very Dense, Grade W5/W4, Completely to Highly Weathered Rock
Layer-V	9.0m to 15.0m/16.5m	Highly Weathered to Moderately Weathered Rock Formation, Grade W4/W3 Rock

4.3 FOUNDATION SYSTEM:

4.3.1 OPTION-I (ISOLATED COLUMN FOOTING)

In case of shallow foundation is adopted, adopt isolated column footing located at a depth of 3.5m below the existing ground level. The isolated column footing shall be placed over a well compacted layer of Granular Sub Base (GSB)/ Hill Earth.

Table 4.1 presents the allowable net safe bearing pressure for different sizes of footings. In the present case, the overall depth of foundation excavation is 3.5m below the existing ground level.

Typical computation is presented in the Annexure-I

TABLE-4.1 RECOMMENDED ALLOWABLE SAFE BEARING PRESSURE							
S.No.	REFERENCE BOREHOLE (m)	DEPTH OF FOUNDATION EXCAVATION BELOW EGL (m)	THICKNESS OF SOIL REPLACEMENT (m)	SHAPE OF FOUNDATION	SIZE OF FOOTING (m x m)	RECOMMENDED ALLOWABLE NET SAFE BEARING PRESSURE (kPa)	ELASTIC SETTLEMENT (mm)
1.0	BH-03	3.50	0.3 - 0.6	Isolated Column Footing	1.0 x 1.0	400	1.38
					2.0 x 2.0	500	4.14
					3.0 x 3.0	600	6.22
					4.0 x 4.0	600	8.29
					5.0 x 5.0	600	10.36

NOTE:

- ***The formation experiences slushy condition in the presence of water. Hence, adopt ground water lowering system of short boreholes taken to a depth of 5.0m below the existing ground level along the periphery of the plan boundary with a spacing of 10m c/c and provide a minimum of 300mm to a maximum of 600mm Granular Sub Base (GSB)/ Hill Earth layer depending on the local variation.***
- ***Formation of slush shall not be construed as weak bearing strata and the same shall be removed before laying the GSB/ Hill Earth layer.***

4.3.2 OPTION-II (PILE FOUNDATION SYSTEM)

Alternate to shallow foundation system, pile foundation taken to a depth of 8.0m below the existing ground level can be adopted.

The piles can be installed by drilling with direct mud circulation technique *(Bored Cast Insitu Piles)* and the provisional safe load carrying capacity of bored cast insitu piles taken to a depth of 8.0m below the existing ground level in compression, tension and lateral for different diameters is worked out as per IS 2911-Part-I-Section-2 and are presented in Table-4.2.

Typical computations are presented in Annexure-I.

TABLE: - 4.2 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
1.0	BH-01 to BH-05	8.0	1.0	7.00	450	900	600	40
2.0					500	1200	700	45
3.0					600	1600	800	50
4.0					750	2100	900	65
5.0					800	2500	1000	70
6.0					900	3000	1200	80

NOTE:

In the present drilling technology do not adopt tractor mounted drill rigs. Adopt hydraulic drill rigs with minimum torque of 180 N-m.

RECOMMENDATIONS

CHAPTER-5

RECOMMENDATIONS

5.1 RECOMMENDATION FOR OPEN FOUNDATION:

- In case of isolated column footing is adopted, open foundation system is feasible.
- Adopt isolated footing over a well compacted layer of Granular Sub Base (GSB) or Hill Earth. The Thickness of the granular sub base (GSB) or hill earth shall vary between 300mm to 600mm depending on the lateral variation.
- Table 4.1 presents the recommended allowable net safe bearing pressure for different sizes of the footing.

5.2 RECOMMENDATION FOR PILE FOUNDATIONS:

- In case of shallow foundation is not feasible, pile foundation can be adopted. In the present site Bored Cast in situ piles are recommended as the suitable foundation system.
- The allowable safe load carrying capacities of different diameters of piles as given in Table-4.2 can be adopted as provisional design loads, as the load carrying capacity of piles is 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 concreting can be done.

2.1 CONSTRUCTION METHOD STATEMENT OF PILE FOUNDATION:

- For the bored cast in situ piles, a guide casing of suitable length can be adopted
- The mud used shall be made out of sodium bentonite with minimum frees swell index of more than 300% and liquid limit more than 100%. The silt content in bentonite shall not more than 5%.

The mud was prepared using sodium bentonite with a density of 1.10 to 1.15 g/cc.

5.3 GENERAL RECOMMENDATIONS:

- The present project site falls in seismic zone-III as per IS 1893-P-I
- The excavated earth is not suitable for backfilling.
- The chlorides content in ground water is higher than the permissible limit of 500 mg/l as per IS 456 Table 1.0.
- However, the chlorides content in soil- water extract is lesser than the permissible limit of 500 mg/l as per IS 456 Table 1.0.
- The sulphate content in ground water is within the permissible limit of 400 mg/l except at one location, as per IS 456 Table 1.0. However, the sulphate content in soil-water extract is less than the permissible limit. Hence, corresponding to the sulphate content in 2:1 Water-Soil extract and ground water use Table: 4.0 of IS 456 for minimum cement content and maximum water cement ratio.

On behalf of CMDA MSB Panel the Geotechnical Investigation Report is Generally reviewed.

Superintending Engineer, P.W.D.,
Planning and Designs Circle,
Chepauk, Chennai-5.

AUTHORISED SIGNATORY

DR. C. V. PRASAD
GEOMARINE CONSULTANTS PRIVATE LIMITED

ANNEXURE-I

GEOMARINE

TYPICAL BEARING CAPACITY COMPUTATIONS FOR SHALLOW FOUNDATION

1.0 COMPUTATION OF BEARING CAPACITY AS PER IS:6403

Ref. BH-03

1.1 Geometrical Data :

Shape of the Foundation	Square
Depth of Foundation Below E.G.L"Df" (m)	2.90
Thickness of soil replacement (m)	0.60
Total Depth of Foundation (m)	3.50
Breadth"B" (m)	1.00
Length"L" (m)	1.00
L/B	1.00
Inclination of Vertical Load with the Vertical (a)	0.00
Thickness of Fill (m)	0.00

1.2 Soil Data :

Type of Effective Bearing Strata :	Clayey Sand/ Disintegrated Rock
Average SPT"N" of the bearing stratum:	57.00
Design SPT N Value of the Bearing Stratum:	30.00
Type of Shear Failure:	General
Angle of Shearing Resistance	36.00

1.3 Design Parameters:

Bulk Density of Soil above the foundation depth (γ_{bulk})	18.00
Water Table Correction Factor (w')	0.50
Effective Overburden pressure at foundation level including the thickness of fill (q)	28.00
Bearing Capacity Factors:	
N_c =	N/A
N_q =	39.48
N_g =	60.31
Shape Factors:	
S_c =	-
S_q =	1.20
S_g =	0.80
Depth Factors :	
D_c =	-
D_q =	1.05
D_g =	1.05
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' 1579.39 kPa

(g should be read as gama)

1.5 Safe Bearing Capacity (Qsafe) :

Factor of Safety (F.S.) :	2.50	
Qsafe :	632	kPa
Say Q_{safe}	**400**	**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	400.00 kPa
Poission's Ratio (μ)	0.30
Modulus of Elasticity (E_s)(Ref. Joseph E Bowels,1996,page316,Table5.6, Japanese design standards)	
Modulus of Elasticity (E_s)	148200
Size of footing considered for maximum settlement(m)	1.00
Influence factor:	0.95
Rigidity Factor:	0.80
Depth Factor:	0.74
Elastic Settlement (DH_i)	1.38 mm
	<50mm

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ESTIMATION OF SAFE LOAD CARRYING CAPACITY OF BORED CAST-INSITU PILES

Type of Pile	Bored	Diameter of Pile			Length of Pile From Natural Ground Level (m)	8.0	As Per IS:2911-(P-I,S-2)-2010
Reference Bore Hole	BH-01	500	mm	Surcharge Pressure	0	kPa	

Layer No.	Layer Thk. (m) Top Below N.G.L	Bottom Below N.G.L	Thickness	Type of Strata	Ave. SPT	(γ) kN/m³ of Layer	(γ) kN/m³ Ave. upto Layer	Shear Parameters (C_u) kPa	Shear Parameters (ϕ) Deg.	Effective Overburden Pressure (kPa) At top of Layer	At Bot. of Layer	At Mid. of Layer	Adhesion Factor (α)	Earth Pressure Coefficient (k)	Skin Friction (Q_f) kN		
1.0	0.0	1.0	1.0	Cut-Off Level													
2.0	1.0	3.0	2.0	Silty Clay	7	16.0	16.0	47	-	0.0	12.0	6.0	0.9	-	qf	2	132.9
3.0	3.0	4.0	1.0	Clayey Sand	14	17.0	16.5	-	31	12.0	19.0	15.5	-	1.1	qf	3	15.6

Summation of Positive Skin Resitance (kN)	Q_f=	148.53
Summation of Negative Skin Resistance (kN)	-Qf=	0.00
Safe Positive Skin Friction for Vertical Load Load Carrying Capacity (kN) (Q_f/2.5)	Q_{sf}=	59.41
Safe Positive Skin Friction for Pull Out Capacity (kN) (Q_f/3)	Q_{spf}=	49.51

COMPUTATION OF ROCK SOCKET CAPACITY, IS 2911 (PART 1/SEC 2):2010, ANNEX-B, B-8

Type of Strata:	Disintegrated Rock
Diameter of the Pile (D):	0.50 m
Shear Strength of Rock in the Socketed Length (Grade-F, Ref Figure-3, Page No. 13, IS 2911/1/2-2010) (Cu_2):"N" Value=50	300 kPa
(Recommended Value as per IS 2911 (Part 1/Sec 2), Annex-B, B-8), α:	0.90 "
Socket Length into the rock (L):	2.00
Factor of Safety, as per IS 2911 (Part 1/Sec 2), Annex B-8 (F_s):	3.00
Safe Socketing Capacity (QSoc= $Cu_2\alpha\pi DL/Fs$):	283 kN
Type of Strata:	Completely/Highly Weathered Rock
Diameter of the Pile (D):	0.50 m
Shear Strength of Rock in the Socketed Length (Grade-D, Ref Figure-3, Page No. 13, IS 2911/1/2-2010) (Cu_2):"N" Value=100 (Adopted Grade-E for the Design)	700 kPa
(Recommended Value as per IS 2911 (Part 1/Sec 2), Annex-B, B-8), α:	0.90 "
Socket Length into the rock (L):	2.00
Factor of Safety, as per IS 2911 (Part 1/Sec 2), Annex B-8 (F_s):	3.00
Safe Socketing Capacity (QSoc= $Cu_2\alpha\pi DL/Fs$):	660 kN

COMPUTATION OF END BEARING RESISTANCE, IS 2911 (PART 1/SEC 2):2010, ANNEX-B, B-8

Type of Strata:	Completely/Highly Weathered Rock
Diameter of the Pile (D):	0.50 m
Shear Strength of Rock below Pile Base (Grade-D, Ref Figure-3, Page No. 13, IS 2911/1/2-2010) (Cu1):"N" Value=80 (Adopted Grade-E for the Design)	700 kPa
Bearing Capacity Factor (Nc), Ref B-8, Page No.13, IS 2911/1/2-2010:	9.00 "
Cross Sectional Area of Pile Toe (A_p):	0.20
Factor of Safety, as per IS 2911 (Part 1/Sec 2), Annex B-8 (F_s):	3.00
Safe End Bearing Capacity ($Q_{End}=C_{u1}N_cA_p/F_s$):	412 kN
Self Weight of Pile (P_{SW}):	23.86 kN
Allowable Vertical Load Carrying Capacity (Q_{AV}):	**1414 kN**
Allowable Pull Out Capacity (Q_{AP}):	**1016 kN**

Where

Cu=Undrained Shear Strength of Clay
ϕ=Angle of Shearing Resistance
N_c=Bearing Capacity Factor = 9
K=Coef. Earth Pressure at Rest
q_i=Effecitve Overburden Pressure at middle of Layer
N_q=Bearing Capacity Factor, Ref. Fig.1 of IS: Code Referred above
d=Dia. Of Pile
α=Adhesion Factor
T_i=Thickness of Layer

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

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LATERAL LOAD CARRYING CAPACITY OF BORED CAST- SITU PILES

1.0 Geometrical Data

Type of Pile Head Considered		Fixed	
Diameter of Pile (d)	:	0.50	m
Free standing Length of Pile (e)	:	0	m
Length of Pile below E.G.L (Le)	:	13.0	m
Cut-Off Level From E.G.L	:	1.0	
Length of Pile below Cut-Off Level (Le)	:	12.0	m
Grade of Concrete (M)	:	30	MN/m^2
Young's Modulus of Concrete (E)	:	27386128	kN/m^2
Momemnt of Inertia (I)	:	0.003068	m^4

2.0 Determination of Depth of Fixity

Type of Soil Strata	:	Clay	
Ground Water Condition	:	Submerged	
Design SPT "N" Value	:	7	
K=((k1/1.5)*(0.3/B))			
(n can be read as h in the above and below equation in case of Sand)			
K1=	:	18000	kN/m^3
K=	:	7200	kN/m^4
R=	:	2.20	m
L1/R	:	0.00	
Lf/R	:	2.20	
Depth of Fixity below Cut off (z_f)	:	4.84	m

3.0 Determincation of Lateral Load and Moment Carrying Capacity for 0.005 m Lateral Deflection:

Allowable Lateral Deflection (Y)	:	0.005	m
Lateral Load Carrying Capacity (H)= Y*12EI/(e+zf)^3	:	45	kN
Recommended Design Lateral Load carrying Capacity	:	**45**	**kN**
Fixed End Moment, $M_F=H(e+z_f)/2$		108	
Reduction Factor (L_1/T)	:	0.67	m
Actual Moment (Fixed End Moment/Reduction Factor), M_F		**72**	kN-m

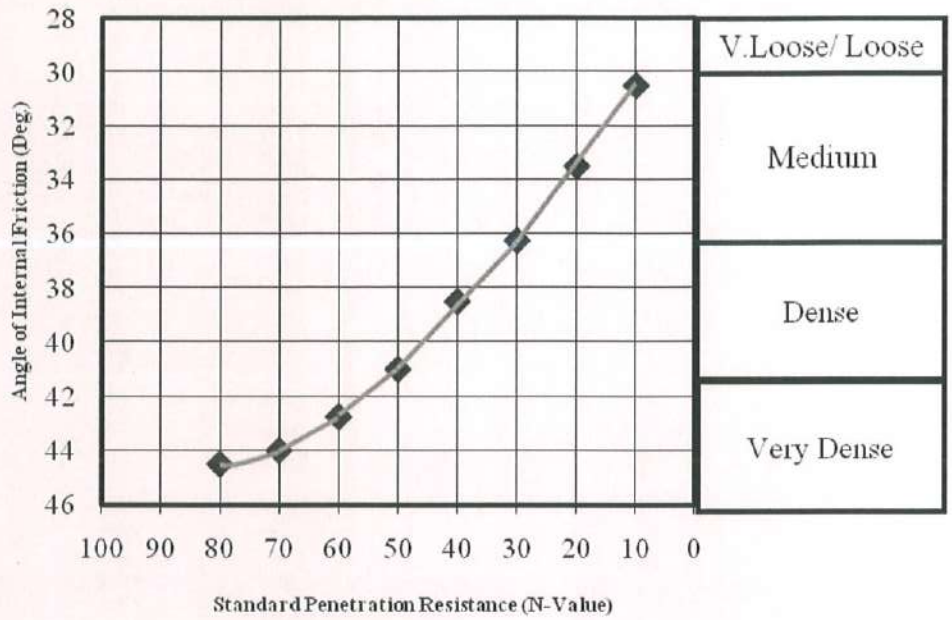


FIG. A1 Relation Ship between Angle of Internal Friction & N-value (Reproduced from IS:6403-1981)

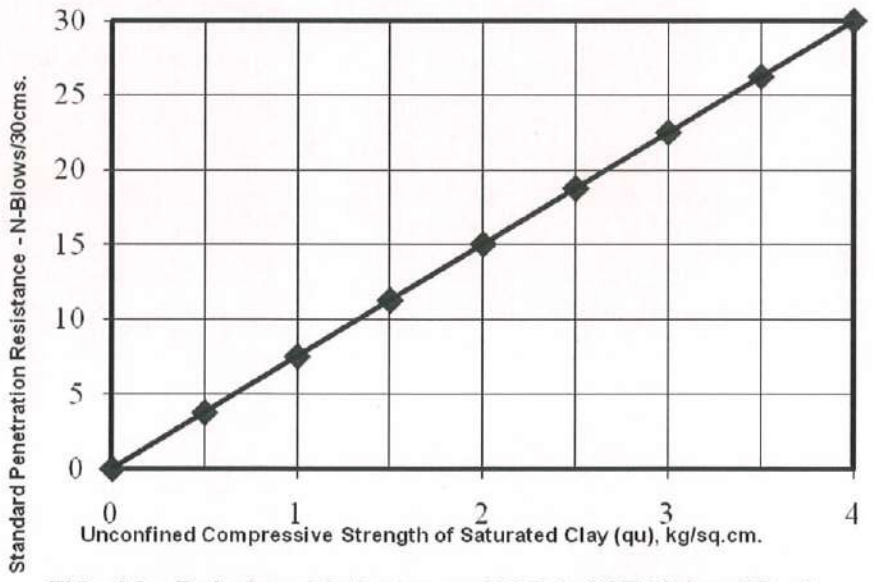


FIG. A2 : Relationship between UCC & SPT-Value (N) of Saturated Clay (AfterTerzhagi & Peck, 1948)

ANNEXURE-II

CONSOLIDATION TEST GRAPH

GEOMARINE
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Phone No.: 044-24480305

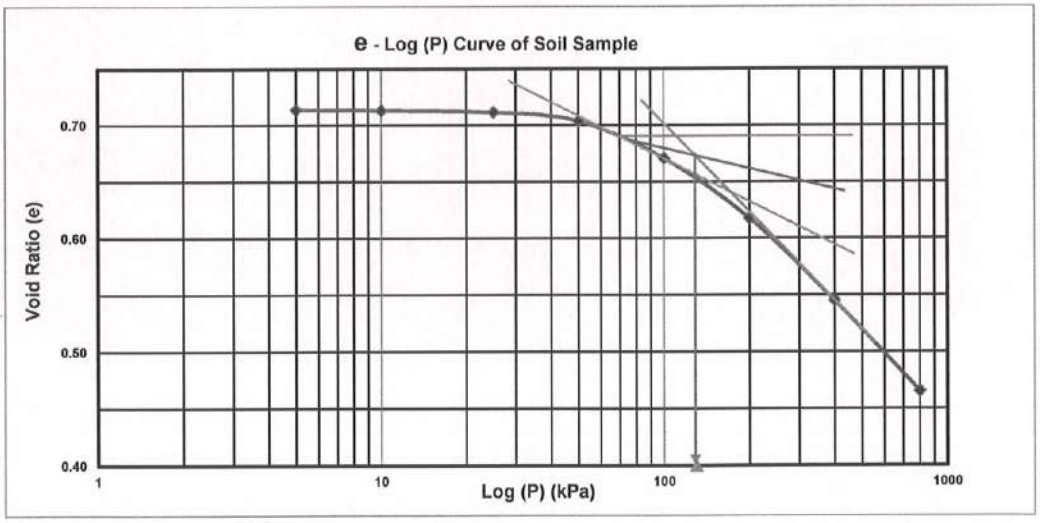
LABORATORY TEST REPORT
GEOMARINE CONSULTANTS PVT LTD- GEOTECHNICAL LABORATORY
NO.11 2nd MAIN ROAD, KANNAPA NAGAR EXTN,
KOTTIVAKKAM, CHENNAI

TC-11410

CONSOLIDATION TEST AS PER IS 2720-Part-15 : 1965 (RA 2021)

ULR NO	:	TC114102400000433F	SAMPLE SOURCE	:	CUSTOMER SUPPLIED
REPORT ISSUED TO	:	M/s URBANDO HOUSING LLP	SAMPLE IDENTIFICATION NUMBER	:	GMC/0224/823
DISCIPLINE/GROUP	:	MECHANICAL/SOIL AND ROCK	TEST REPORT NUMBER	:	GT-2737
SAMPLE DESCRIPTION	:	SOIL	SAMPLE RECEIPT DATE	:	12/02/2024
SAMPLE CONDITION	:	SATISFACTORY	PERIOD OF TESTING	:	14/02/2024 to 22/02/2024
TEST METHOD	:	BUREAU OF INDIAN STANDARDS	REPORT ISSUE DATE	:	27/02/2024
BORE HOLE NUMBER	:	BH-01	NO. OF PAGES	:	ONE
DEPTH OF SAMPLE,m	:	3.00			

BEFORE TEST		AFTER TEST	
Diameter of consolidation ring, mm	60	Mass of the consolidation ring + Sample, g	239.72
Height of consolidation ring, mm	20	Mass of sample, g	104.28
Mass of consolidation ring, g	135.44	Dry Mass, g	82.79
Mass of consolidation ring + sample, g	242.23	Specific Gravity	2.51
Mass of sample, g	106.79	Height of Solids, mm	11.67
Bulk Unit weight, kN/m3	18.5	Dry Unit Weight, kN/m3	14.7
INITIAL MOISTURE CONTENT OF SAMPLE		**FINAL MOISTURE CONTENT OF SAMPLE**	
Can No	A1	Can No	A1
Mass of can, g	7.32	Mass of can, g	44.1
Can + Wet mass, g	22.53	Can + Wet mass, g	148.47
Can + Dry mass, g	19.22	Can + Dry mass, g	126.89
Initial Moisture Content, %	27.8	Initial Moisture Content, %	26.07



Results :

Natural Moisture Content	28
Initial Void Ratio	0.714
Pre Consolidation Pressure	130
Compression Index	0.265

** END OF REPORT**

Authorised Signatory

A. VINOTH
(Technical Manager)

Terms and Conditions

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(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

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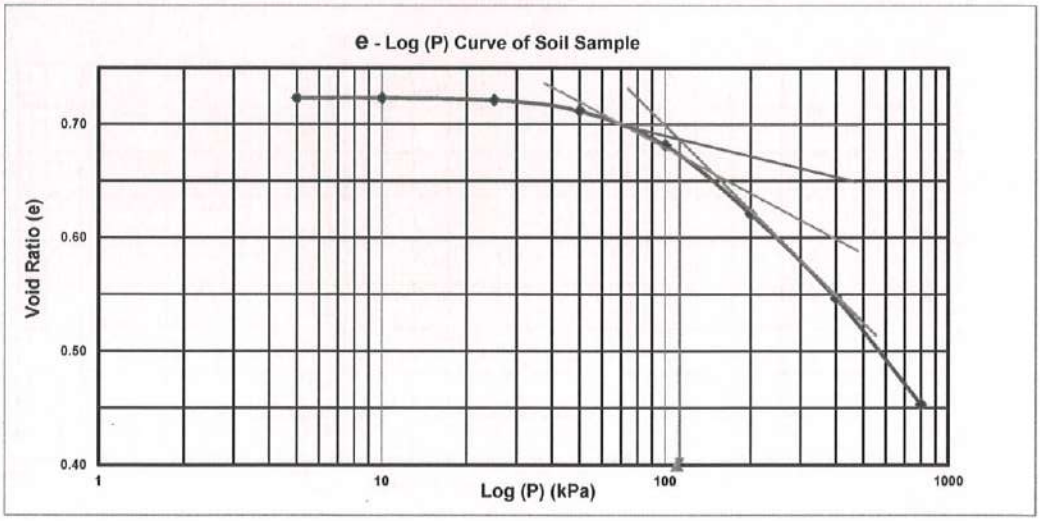
LABORATORY TEST REPORT
GEOMARINE CONSULTANTS PVT LTD- GEOTECHNICAL LABORATORY
NO.11 2nd MAIN ROAD, KANNAPA NAGAR EXTN,
KOTTIVAKKAM, CHENNAI

TC-11410

CONSOLIDATION TEST AS PER IS 2720-Part-15 : 1965 (RA 2021)

ULR NO	:	TC114102400000433F	SAMPLE SOURCE	:	CUSTOMER SUPPLIED
REPORT ISSUED TO	:	M/s URBANDO HOUSING LLP	SAMPLE IDENTIFICATION NUMBER	:	GMC/0224/823
DISCIPLINE/GROUP	:	MECHANICAL/SOIL AND ROCK	TEST REPORT NUMBER	:	GT-2737
SAMPLE DESCRIPTION	:	SOIL	SAMPLE RECEIPT DATE	:	16/02/2024
SAMPLE CONDITION	:	SATISFACTORY	PERIOD OF TESTING	:	19/02/2024 to 27/02/2024
TEST METHOD	:	BUREAU OF INDIAN STANDARDS	REPORT ISSUE DATE	:	27/02/2024
BORE HOLE NUMBER	:	BH-03	NO. OF PAGES	:	ONE
DEPTH OF SAMPLE,m	:	3.00			

BEFORE TEST		AFTER TEST	
Diameter of consolidation ring, mm	60	Mass of the consolidation ring + Sample, g	282.21
Height of consolidation ring, mm	20	Mass of sample, g	147.37
Mass of consolidation ring, g	134.84	Dry Mass, g	82.65
Mass of consolidation ring + sample, g	241.29	Specific Gravity	2.52
Mass of sample, g	106.45	Height of Solids, mm	11.61
Bulk Unit weight, kN/m3	18.5	Dry Unit Weight, kN/m3	14.5
INITIAL MOISTURE CONTENT OF SAMPLE		**FINAL MOISTURE CONTENT OF SAMPLE**	
Can No	A1	Can No	A1
Mass of can, g	7.12	Mass of can, g	40.88
Can + Wet mass, g	30.43	Can + Wet mass, g	146.31
Can + Dry mass, g	27.18	Can + Dry mass, g	123.53
Initial Moisture Content, %	16.2	Initial Moisture Content, %	27.56



Results :

Natural Moisture Content	16
Initial Void Ratio	0.723
Pre Consolidation Pressure	110
Compression Index	0.311

** END OF REPORT**

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(Technical Manager)

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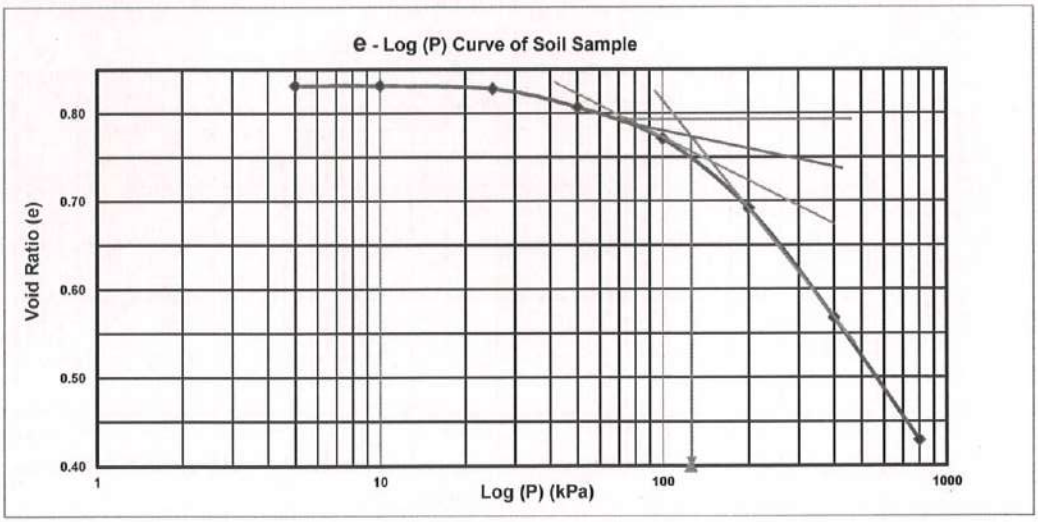
LABORATORY TEST REPORT
GEOMARINE CONSULTANTS PVT LTD- GEOTECHNICAL LABORATORY
NO.11 2nd MAIN ROAD, KANNAPA NAGAR EXTN,
KOTTIVAKKAM, CHENNAI

TC-11410

CONSOLIDATION TEST AS PER IS 2720-Part-15 : 1965 (RA 2021)

ULR NO	:	TC114102400000433F	SAMPLE SOURCE	:	CUSTOMER SUPPLIED
REPORT ISSUED TO	:	M/s URBANDO HOUSING LLP	SAMPLE IDENTIFICATION NUMBER	:	GMC/0224/823
DISCIPLINE/GROUP	:	MECHANICAL/SOIL AND ROCK	TEST REPORT NUMBER	:	GT-2737
SAMPLE DESCRIPTION	:	SOIL	SAMPLE RECEIPT DATE	:	12/02/2024
SAMPLE CONDITION	:	SATISFACTORY	PERIOD OF TESTING	:	14/02/2024 to 22/02/2024
TEST METHOD	:	BUREAU OF INDIAN STANDARDS	REPORT ISSUE DATE	:	27/02/2024
BORE HOLE NUMBER	:	BH-04	NO. OF PAGES	:	ONE
DEPTH OF SAMPLE,m	:	1.25			

BEFORE TEST		AFTER TEST	
Diameter of consolidation ring, mm	60	Mass of the consolidation ring + Sample, g	233.26
Height of consolidation ring, mm	20	Mass of sample, g	95.1
Mass of consolidation ring, g	138.16	Dry Mass, g	77.77
Mass of consolidation ring + sample, g	242.86	Specific Gravity	2.52
Mass of sample, g	104.7	Height of Solids, mm	10.92
Bulk Unit weight, kN/m3	18.2	Dry Unit Weight, kN/m3	14.8
INITIAL MOISTURE CONTENT OF SAMPLE		**FINAL MOISTURE CONTENT OF SAMPLE**	
Can No	A1	Can No	A1
Mass of can, g	6.76	Mass of can, g	42.14
Can + Wet mass, g	21.17	Can + Wet mass, g	137.54
Can + Dry mass, g	17.18	Can + Dry mass, g	119.91
Initial Moisture Content, %	38.3	Initial Moisture Content, %	22.67



Results :

Natural Moisture Content	38
Initial Void Ratio	0.831
Pre Consolidation Pressure	125
Compression Index	0.459

** END OF REPORT**

Authorised Signatory

A. VINOTH
(Technical Manager)

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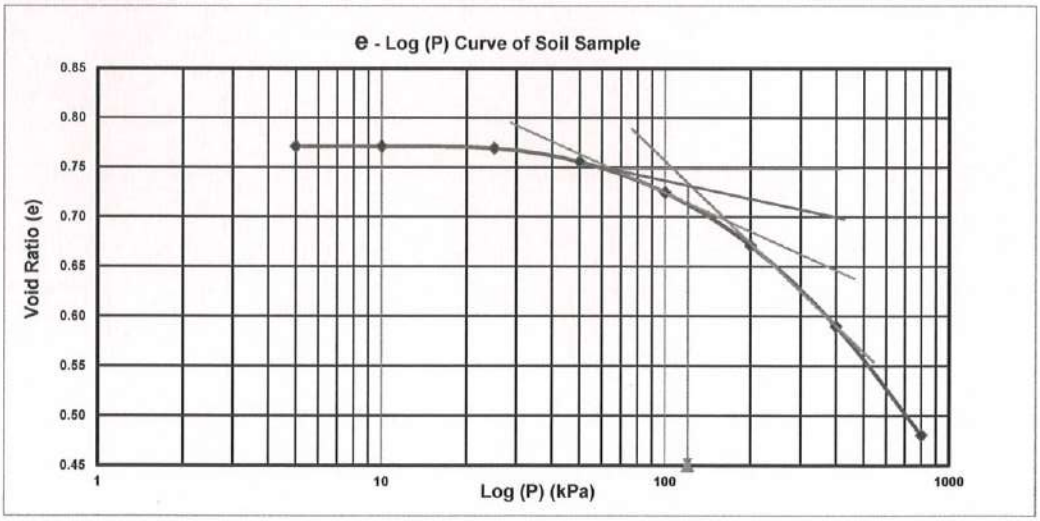
LABORATORY TEST REPORT
GEOMARINE CONSULTANTS PVT LTD- GEOTECHNICAL LABORATORY
NO.11 2nd MAIN ROAD, KANNAPA NAGAR EXTN,
KOTTIVAKKAM, CHENNAI

TC-11410

CONSOLIDATION TEST AS PER IS 2720-Part-15 : 1965 (RA 2021)

ULR NO	:	TC114102400000433F	SAMPLE SOURCE	:	CUSTOMER SUPPLIED
REPORT ISSUED TO	:	M/s URBANDO HOUSING LLP	SAMPLE IDENTIFICATION NUMBER	:	GMC/0224/823
DISCIPLINE/GROUP	:	MECHANICAL/SOIL AND ROCK	TEST REPORT NUMBER	:	GT-2737
SAMPLE DESCRIPTION	:	SOIL	SAMPLE RECEIPT DATE	:	12/02/2024
SAMPLE CONDITION	:	SATISFACTORY	PERIOD OF TESTING	:	14/02/2024 to 22/02/2024
TEST METHOD	:	BUREAU OF INDIAN STANDARDS	REPORT ISSUE DATE	:	27/02/2024
BORE HOLE NUMBER	:	BH-05	NO. OF PAGES	:	ONE
DEPTH OF SAMPLE,m	:	2.00			

BEFORE TEST		AFTER TEST	
Diameter of consolidation ring, mm	60	Mass of the consolidation ring + Sample, g	235.73
Height of consolidation ring, mm	20	Mass of sample, g	101.13
Mass of consolidation ring, g	134.6	Dry Mass, g	80.11
Mass of consolidation ring + sample, g	239.2	Specific Gravity	2.51
Mass of sample, g	104.6	Height of Solids, mm	11.29
Bulk Unit weight, kN/m3	18.2	Dry Unit Weight, kN/m3	14.3
INITIAL MOISTURE CONTENT OF SAMPLE		**FINAL MOISTURE CONTENT OF SAMPLE**	
Can No	A1	Can No	A1
Mass of can, g	6.22	Mass of can, g	43.99
Can + Wet mass, g	28.04	Can + Wet mass, g	145.52
Can + Dry mass, g	21.99	Can + Dry mass, g	124.1
Initial Moisture Content, %	38.4	Initial Moisture Content, %	26.74



Results :

Natural Moisture Content	38
Initial Void Ratio	0.771
Pre Consolidation Pressure	120
Compression Index	0.362

** END OF REPORT**

Authorised Signatory

A. VINOTH
(Technical Manager)

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ANNEXURE-III

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No. BH-01
PAGE No. 01
DIA OF BORE HOLE 150mm → 100mm

PROJECT NAME: URBANDO
LOCATION: Perumbakkam | MACHINE No.: CR-02 | CHAINAGE (m):
STRUCTURE: | DRILLING METHOD: Rotary | CO-ORDINATES: N
JOB CODE: | FLUSHING MEDIUM: Bentonite | E

BORE START DATE: 10/02/2024
BORE END DATE: 12/02/2024
TOTAL DRILLING DAYS: 02

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	Layer Data: Depth (m)	Layer Data: Geotechnical Description
1	10/02	9	27	SC			0	1	2	3	0.50 mts	01	SS		Soft, Greyish, Sandy clay with filled up material.
		9	27												
	10/02	9	39	SC			—	—	—	20	1.25 mts	02	UDS		UNDISTURBED SAMPLE
		9	40												
2	10/02	9	58	SC			2	3	4	7	2.00 mts	03	SS		Medium stiff, Greyish, Sandy silty clay.
		10	00												
3	10/02	10	14	SC			10	12	17	29	3.00 mts	04	SS		Medium dense, Brownish, residual soil with rock Particles.
		10	15												
4	10/02	10	31	SC			12	23	10cm / 40blks	N>100	4.00 mts	05	SS		Very dense, Greyish Brown, residual soil with rock particles.
		10	33												
5	10/02	10	48	SC			40	34	3cm / 3blks	N>100	5.00 mts	06	SS		Very dense, Brownish, residual soil with rock particles
		10	50												
6	10/02	11	07	SC			Hammer rebound			N>100	6.00 mts	07	WS		Very weak, Brownish, Highly to Completely weathered rock.
		11	09												
7															
8	10/02	11	24	DB	10	0					7.50 mts	08	CS		Weak to moderately strong Brownish, partially weathered rock.
		12	32												
9	10/02	13	12	DB	21	0					9.00 mts	09	CS		moderately weak to Strong Brownish greyish, partially fractured rock.
		14	35												
0															

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
SIGNATURE
DATE
CLIENT IN-CHARGE

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

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No. 01
PAGE No. 2

PROJECT NAME	URBANDO					DIA OF BORE HOLE	150mm / 100mm
LOCATION	Perumbakkam	MACHINE No.	CR-02	CHAINAGE (m)		BORE START DATE	10/02/2024
STRUCTURE		DRILLING METHOD	Rotary	CO-ORDINATES	N	BORE END DATE	12/02/2024
JOB CODE		FLUSHING MEDIUM	Bentonite		E	TOTAL DRILLING DAYS	02

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	Layer Data: Depth (m)	Geotechnical Description
1	10/02	14	52	DB	21	0					10.50 mts	10	CS		moderately strong to strong Brownish grey, Partially weathered rock.
		15	27												
2	10/02	15	45	DB	23	0					12.00 mts	11	CS		Weak to moderately strong, Greyish brown, Partially weathered rock.
		16	17												
3															
4	12/02	09	18	DB	33	0					13.50 mts	12	CS		Moderately strong to strong, Brownish grey, Partially weathered Hard rock.
		11	02												
5	12/02	11	32	DB	42	8					15.00 mts	13	CS		Strong to very strong, Brownish grey, partially weathered hard rock.
		12	48												
6															Bore hole terminated at 15.00 mts
7															
8															
9															
0															

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	Susi	PROJECT SITE DETAILS	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	Susi	GROUND LEVEL (m)	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	12/02/2024	WATER TABLE (m)	
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE		CASING DEPTH (m)	

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No. 02
PAGE No. 01
DIA OF BORE HOLE 150mm ~ / 100mm

PROJECT NAME	URBANDO					BORE START DATE	14/02/2024
LOCATION	Perumbakkam	MACHINE No.	CR-08	CHAINAGE (m)		BORE END DATE	15/02/2024
STRUCTURE		DRILLING METHOD	Rotary	CO-ORDINATES	N	TOTAL DRILLING DAYS	2
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: 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)	Geotechnical Description
0	14/02	11	02	SC			1	1	2	3	0.50 mts	01	SS		Soft, Greyish, Sandy clay with filling materials.
1		11	02												
	14/02	11	21	SC			-	-	-	19	1.025 mts	02	UDS		UNDISTURBED SAMPLE
		11	22												
2	14/02	12	01	SC			4	6	9	15	2.00 mts	03	SS		Stiff, Greyish, Sandy clay with rock particles.
		12	02												
3	14/02	12	17	SC			24	11cm / 40blks		N>100	3.00 mts	04	SS		Very dense, Brownish, Sand with ~~rock~~ weathered rock.
		12	20												
4	14/02	12	40	SC			9cm / 50blk			N>100	4.00 mts	05	SS		very dense, Brownish, Highly weathered rock.
		12	43												
5	14/02	13	09	SC			Hammer Rebound			N>100	5.00 mts	06	WS		very dense, Brownish, Highly weathered rock.
		14	00												
6	14/02	14	22	DB	0	0					6.00 mts	07	WS	W	Weak, Brownish, Highly weathered rock.
		15	18												
7															
8	14/02	15	34	DB	0	0					7.50 mts	08	WS		very weak, Brownish, Highly weathered rock.
		16	39												
9															
	14/02	16	53	DB	0	0					9.00 mts	09	WS		very weak, Brownish, Highly to Completely weathered rock.
0		17	50												

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: Sasi
SIGNATURE:
DATE: 14/02/2024
CLIENT IN-CHARGE:

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

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.	02
PAGE No.	2
DIA OF BORE HOLE	150mm ✓ / 100mm
BORE START DATE	14/02/2024
BORE END DATE	15/02/2024
TOTAL DRILLING DAYS	2

PROJECT NAME	URBANDO						
LOCATION	PERUMBAKKAM	MACHINE No.	CR-08	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: 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	15/02/2024	9	38	DB	9%	0%					10.50	10	CS		Weak, Brownish and greyish, Highly weathered Rock
		10	19												
2		10	45	DB	0%	0%					12.00	11	WS		Brownish, Completely weathered Rock
		11	20												
3		11	34	DB	5%	0%					13.50	12	CS		Weak, Greyish Mix Brownish Highly weathered Rock.
		12	29												
4															
5		12	44	DB	10%	0%					15.00	13	CS		weak, Greyish Mix Brownish Highly weathered Rock.
		1	39												
6															
					Bore Terminate at 15.00 m depth.										
7															
8															
9															
0															

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	R. Kuppalakannan	PROJECT SITE DETAILS	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	R. G	GROUND LEVEL (m)	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	15/02/2024	WATER TABLE (m)	
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE		CASING DEPTH (m)	

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.	03
PAGE No.	01
DIA OF BORE HOLE	150mm / 100mm — 1
BORE START DATE	12/02/2024
BORE END DATE	14/02/2024
TOTAL DRILLING DAYS	03

PROJECT NAME	URBANDO						
LOCATION	PERUMBAKKAM	MACHINE No.	CR-02	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: R.Q.D %	SPT Details: Blows/cm. 0-15	15-30	30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	Layer Data: Depth (m)	Geotechnical Description
0	12/02	12	52	SC											
		12	52				1	3	3	6	0.50 mts	01	SS		Medium stiff, Greyish, Sandy clay.
1	12/02	13	02	SC											
		13	03				2	3	4	(7)	1.25 mts	02	SS		Medium stiff, Greyish, Sandy clay.
2	12/02	14	12	SC									UDS		
		14	15				-	-	-	35	2.00 mts	03	SS		UNDISTURBED SAMPLE
3	12/02	14	26	SC											
		14	27				5	5	9	14	3.00 mts	04	SS		Medium dense, Brownish, Sand with rock particles
4	12/02	14	43	SC			12cm								
		14	45				40blc			N>100	4.00 mts	05	SS		Very dense, Brownish, Sand with rock particles.
5	12/02	15	02	SC			10cm								
		15	04				40blc			N>100	5.00 mts	06	WS		very weak, Brownish, Highly to Completely weathered rock.
6	12/02	15	17	SC			HAMMER								
		15	19				REBOUND			N>100	6.00 mts	07	WS		very weak, Brownish, Highly to Completely weathered rock.
7															
8	12/02	15	34	DB	0	0					7.50 mts	08	WS		very weak, Brownish, Highly to completely weathered rock.
		16	18												
9	12/02	16	39	DB	0	0									
		17	12								9.00 mts	09	WS		Very weak, Brownish, Highly to completely weathered rock.
0															

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE	

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

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.	03
PAGE No.	02
DIA OF BORE HOLE	150mm / 100mm
BORE START DATE	12/02/2024
BORE END DATE	14/02/2024
TOTAL DRILLING DAYS	03

PROJECT NAME	URBANDO						
LOCATION	PERUMBAKKAM	MACHINE No.	CR-02	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: 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	12/02	17	21	DB	0	0					10.50 mts	10	WS		Very weak, Brownish, Highly to completely weathered rock.
		18	18												
2	13/02	15	32	DB	4	0					12.00 mts	11	CS		Weak, Brownish, Highly weathered rock.
		16	23												
3	13/02	16	52	DB	5	0					13.50 mts	12	CS		Weak, Brownish, Highly weathered rock.
4		17	49												
5	14/02	08	50	DB	12	0					15.00 mts	13	CS		Weak to moderately strong, slightly weathered rock.
		09	47												
6															
7	14/02	10	23	DB	29	0					16.50 mts	14	CS		Moderately strong to strong, Brownish Grey, Slightly weathered Hard rock.
		11	38												
8															
				BORE HOLE TERMINATED AT											16.50 mts
9															
0															

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	SUST L	PROJECT SITE DETAILS	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	SUST L	GROUND LEVEL (m)	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	14/02/2024	WATER TABLE (m)	
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE		CASING DEPTH (m)	

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.	04
PAGE No.	01
DIA OF BORE HOLE	150mm / 100mm
BORE START DATE	12/02/2024
BORE END DATE	13/02/2024
TOTAL DRILLING DAYS	02

PROJECT NAME	URBANDO						
LOCATION	PERUMBAKKAM	MACHINE No.	CR-08	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: 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)	Geotechnical Description
1	12/02	09	25	SC			0	1	2	3	0.50 mts	01	SS		Greyish, Soft, Sandy clay.
		09	25												
	12/02	11	00	SC			–	–	–	19	1.25 mts	02	UDS		UNDISTURBED SAMPLE
		11	03												
2	12/02	11	14	SC			2	3	4	7	2.00 mts	03	SS		Medium stiff, Greyish, Sandy Silty Clay.
		11	14												
3	12/02	11	25	SC			8	12	19	31	3.00 mts	04	SS		Brownish, Dense, Highly weathered rock mixed with clay.
		11	26												
4	12/02	11	38	SC			13	21	36	57	4.00 mts	05	SS		Very dense, Brownish, Highly weathered rock.
		11	39												
5	12/02	12	02	SC			Hammer rebound			N>100	5.00 mts	06	WS		Very dense, Brownish, Highly to Completely weathered rock.
		12	05												
6	12/02	12	24	DB	0	0					6.00 mts	07	WS		Very weak, Brownish, Highly to Completely weathered rock.
		12	58												
7	12/02	14	12	DB	0	0					7.50 mts	08	WS		Very weak, Brownish, Highly to Completely weathered rock.
8		15	23												
9	12/02	15	48	DB	0	0					9.00 mts	09	WS		Very weak, Brownish, Highly to Completely weathered rock.
		16	57												
0															

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

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.	04
PAGE No.	02
DIA OF BORE HOLE	150mm ✓ / 100mm
BORE START DATE	12/02/2024
BORE END DATE	13/02/2024
TOTAL DRILLING DAYS	02

PROJECT NAME	URBANDO						
LOCATION	PERUMBAKKAM	MACHINE No.	CR-08	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: 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	12/02	17	28	DB	8	0					10.50 mts	10	CS		very weak, Brownish, Highly weathered rock.
		18	41												
2	13/02	09	32	DB	12	0					12.00 mts	11	CS		Weak, Brownish, Highly weathered rock.
		10	52												
3															
4	13/02	11	38	DB	13	0					13.50 mts	12	CS		Weak, Whitish brown, Highly weathered rock.
		12	52												
5	13/02	13	12	DB	19	0					15.00 mts	13	CS		Weak to strong, Brownish grey, partially weathered hard rock.
		15	21												
6															
7															
8															Bore hole terminated at 15.00mts
9															
0															

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

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.	05
PAGE No.	01
DIA OF BORE HOLE	150mm ✓ / 100mm
BORE START DATE	09/02/2024
BORE END DATE	10/02/2024
TOTAL DRILLING DAYS	02

PROJECT NAME	URBANDO						
LOCATION	PERUMBAKKAM	MACHINE No.	CR-08	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: 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)	Geotechnical Description
0	09/02	10	58	SC			2	3	4	7	0.50 mts	01	SS		SAMPLE SLIPPED
		10	58												
1	09/02	11	10	SC			1	1	3	4	1.25 mts	02	SS		Soft, Greyish, Sandy silty clay.
		11	10												
2	09/02	11	27	SC			–	–	–	25	2.00 mts	03	UDS		UNDISTURBED SAMPLE
		11	29												
3	09/02	11	43	SC			10	15	21	36	3.00 mts	04	SS		Dense, whitish brown, Sand with gravels
		11	44												
4	09/02	12	00	SC			19	13cm / 40blows	–	N>100	4.00 mts	05	SS		Very dense, Brownish, clay and residual soil.
		12	03												
5	09/02	12	20	SC			15cm / 50blows	–	–	N>100	5.00 mts	06	SS		Very dense, Greyish brown, residual soil mixed with clay and rock particles.
		12	23												
6	09/02	12	34	SC			Hammer rebound			N>100	6.00 mts	07	US		Very dense, Brownish, Highly to completely weathered rock.
		12	36												
7	09/02	13	09	DB	0	0					7.50 mts	08	WS		Very weak, Brownish, Highly to completely weathered rock.
		13	40												
8	09/02	14	52	DB	0	0					9.00 mts	09	WS		Very weak, Brownish, Highly to completely weathered rock.
		15	30												
9	09/02	16	04	DB	0	0					10.50 mts	10	WS		Weak, Brownish grey, Highly weathered rock.
		17	12												
10															

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	Susil	PROJECT SITE DETAILS	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	Susil	GROUND LEVEL (m)	
UDS - Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	09/02/2024	WATER TABLE (m)	
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE		CASING DEPTH (m)	

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

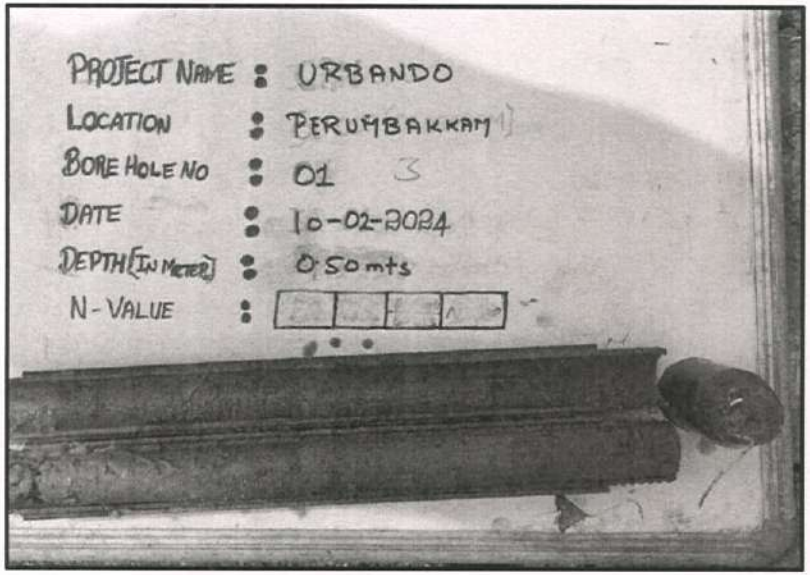
BORE HOLE No. 05
PAGE No. 02

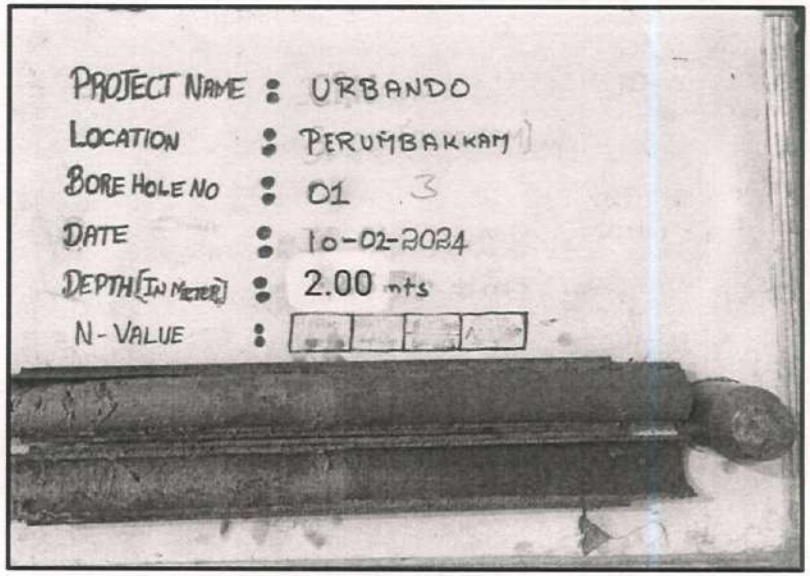
PROJECT NAME	URBANDO					DIA OF BORE HOLE	150mm 1 / 100mm
LOCATION	Perumbakkam	MACHINE No.	MR-08	CHAINAGE (m)		BORE START DATE	09/02/2024
STRUCTURE		DRILLING METHOD	Rotary	CO-ORDINATES	N	BORE END DATE	10/02/2024
JOB CODE		FLUSHING MEDIUM	Bentonite		E	TOTAL DRILLING DAYS	02

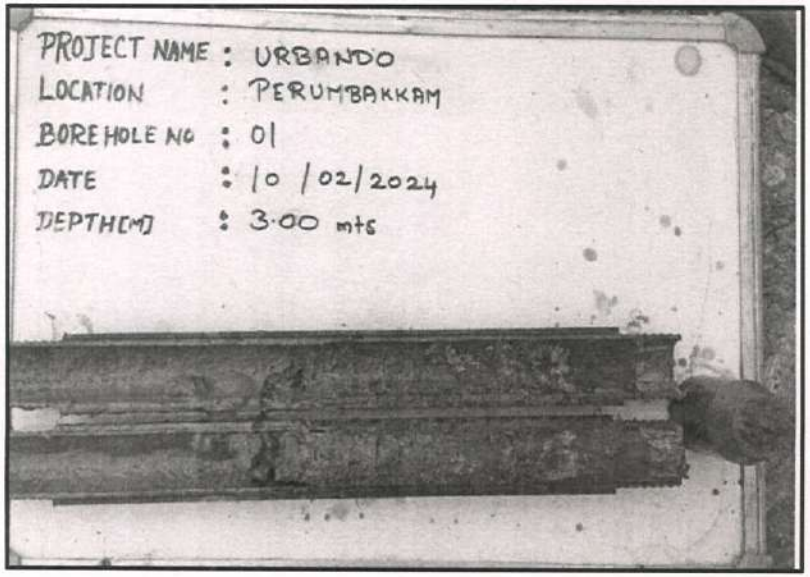
Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Layer Data: Depth (m)	Layer Data: Geotechnical Description
2	09/02	17	32	DB	9	0					12.00 mts	11	CS		Weak, Brownish, Highly weathered rock.
		18	24												
4	10/02	8	50	DB	4	0					13.50 mts	12	CS		Weak, Brownish, Highly weathered rock.
		9	45												
5	10/02	10	02	DB	35	0					15.00 mts	13	CS		Moderately weak to strong, Brownish to greyish, weathered rock to moderately hard rock.
		10	54												
7	10/02	11	22	DB	47	9					16.50 mts	14	CS		Moderately strong to Strong, Greyish, moderately weathered hard rock.
		12	48												
8															BORE HOLE TERMINATED AT 16.50 mts

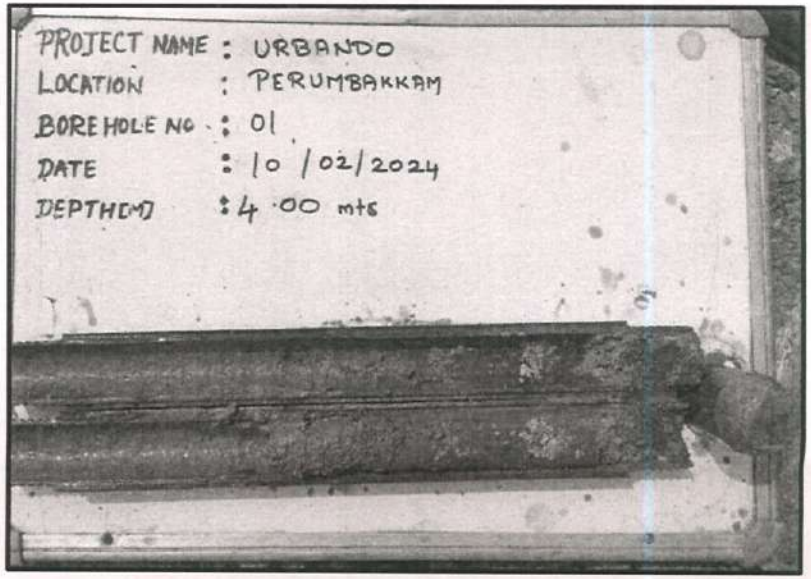
CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	Susi	PROJECT SITE DETAILS	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE		GROUND LEVEL (m)	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	10/02/2024	WATER TABLE (m)	
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE		CASING DEPTH (m)	

GEO MARINE
THE SPIRIT OF ENGINEERING

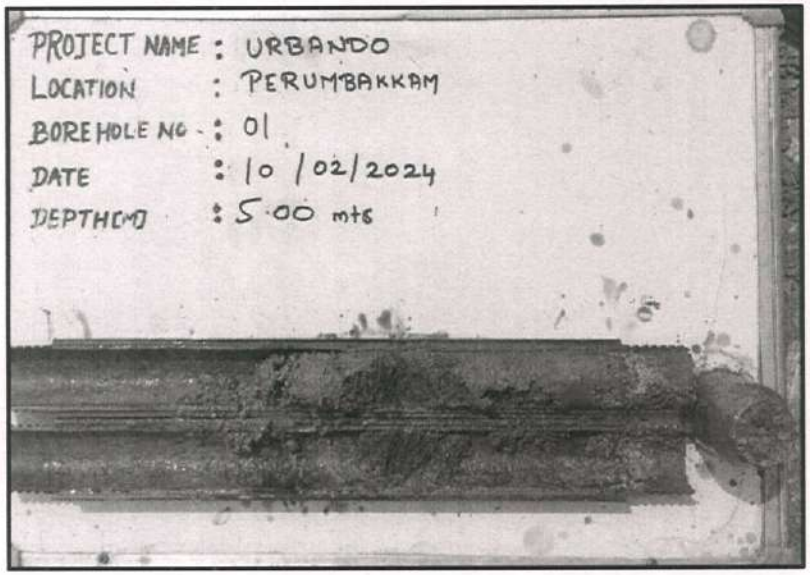


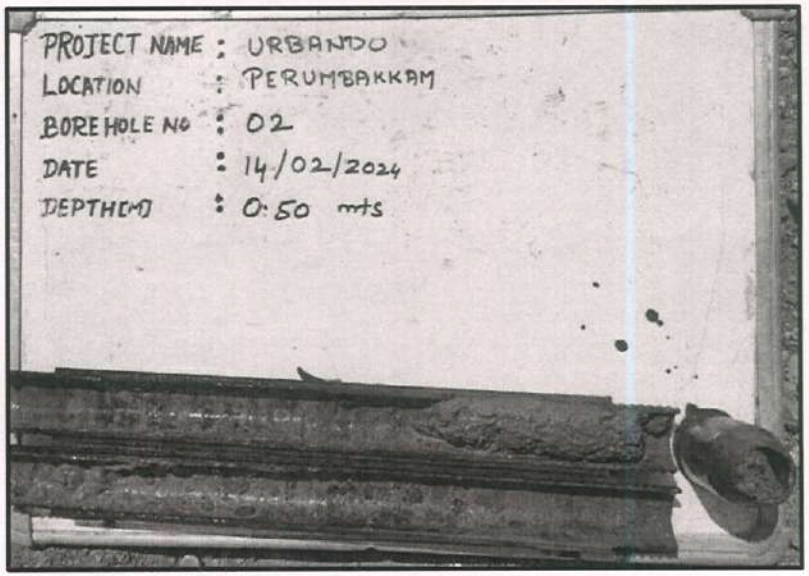


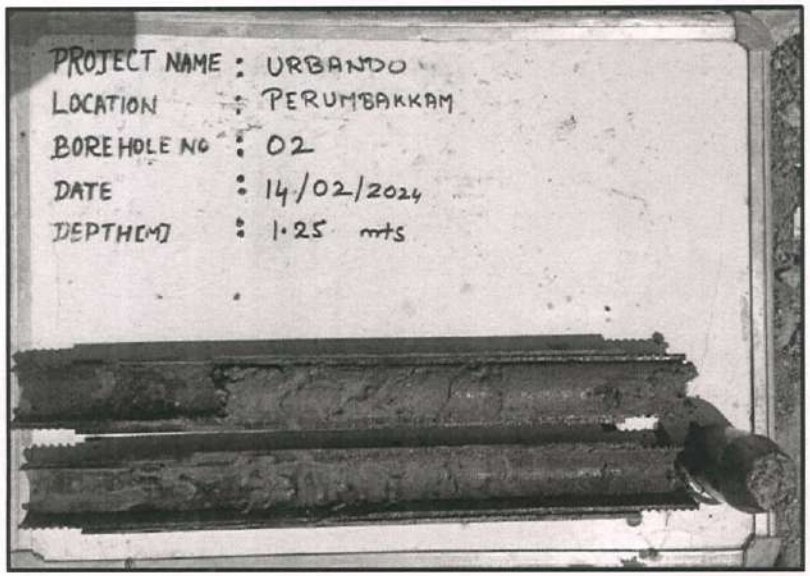


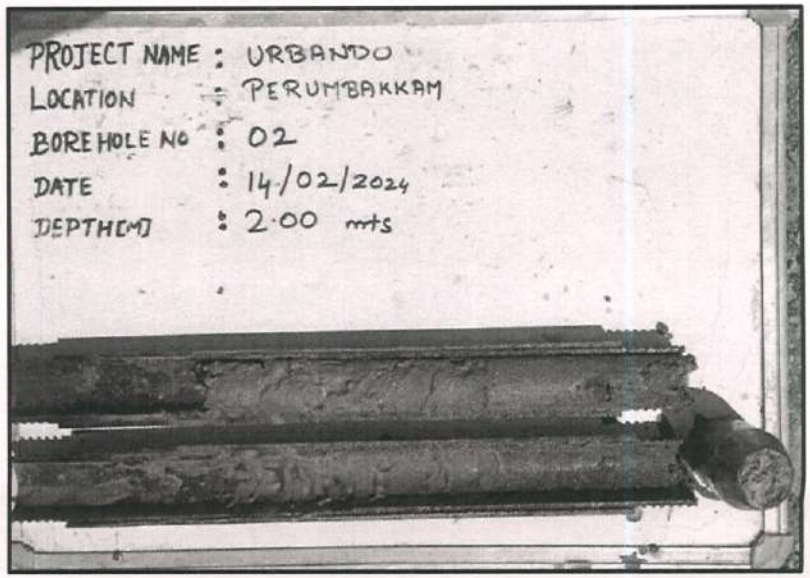


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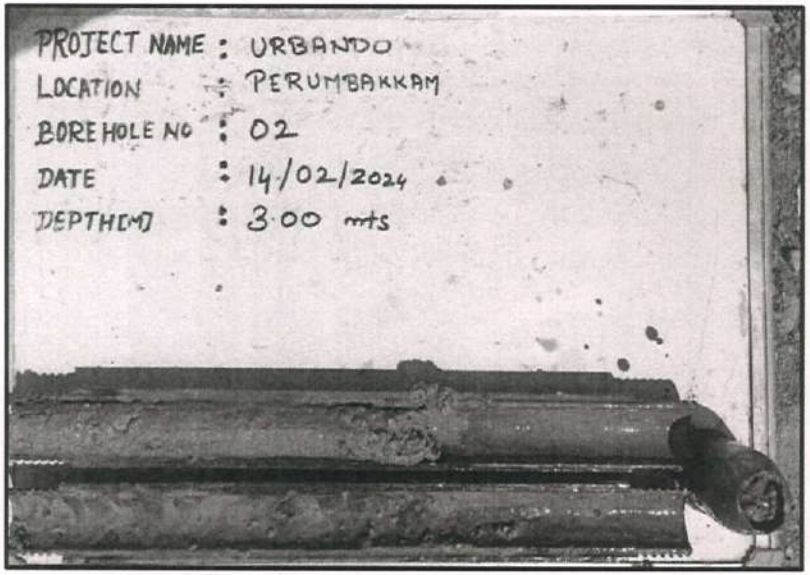


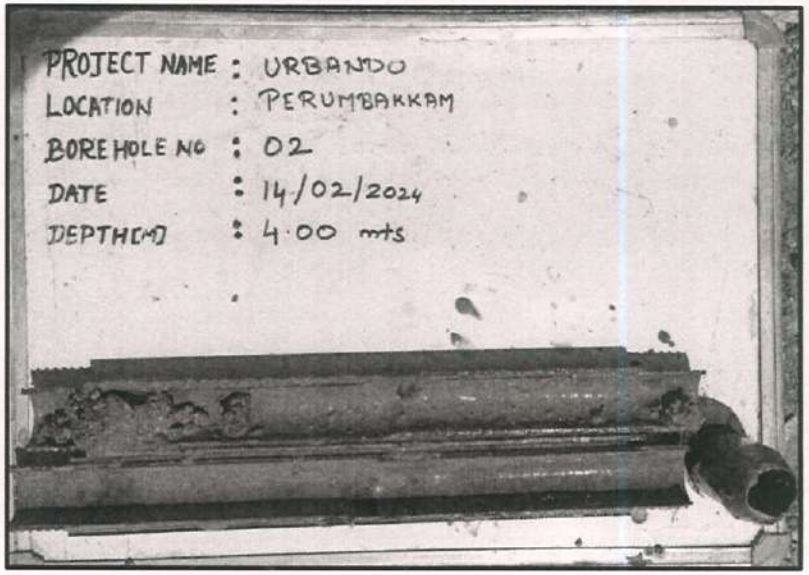




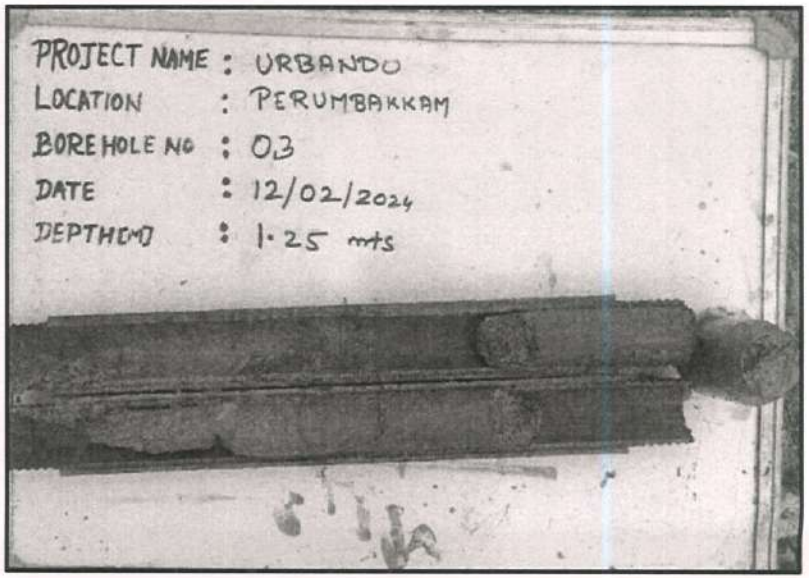


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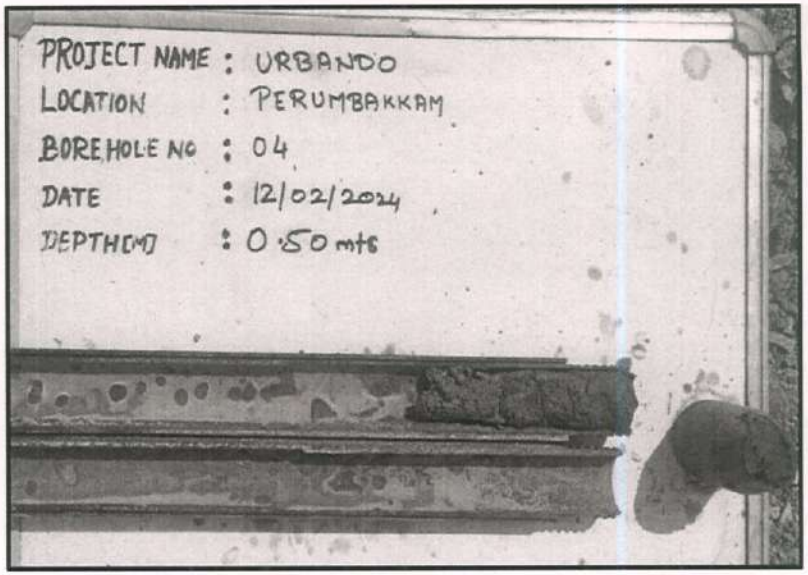


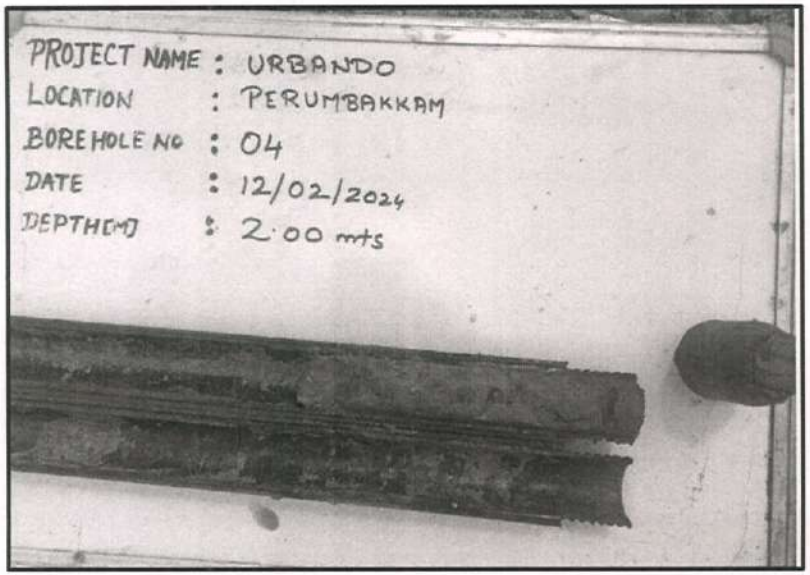


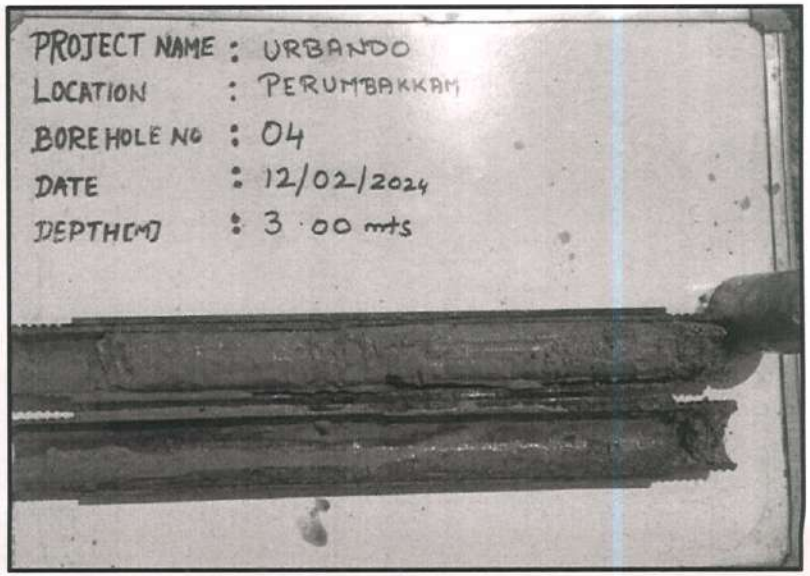


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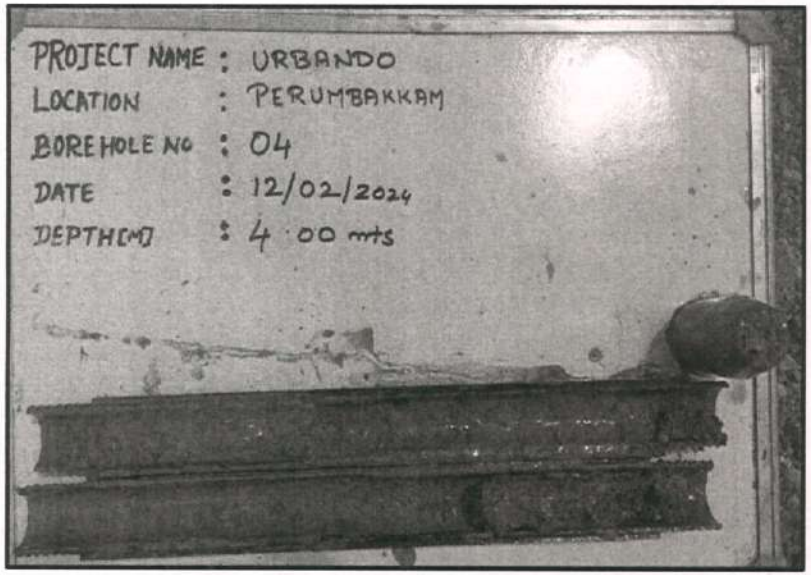


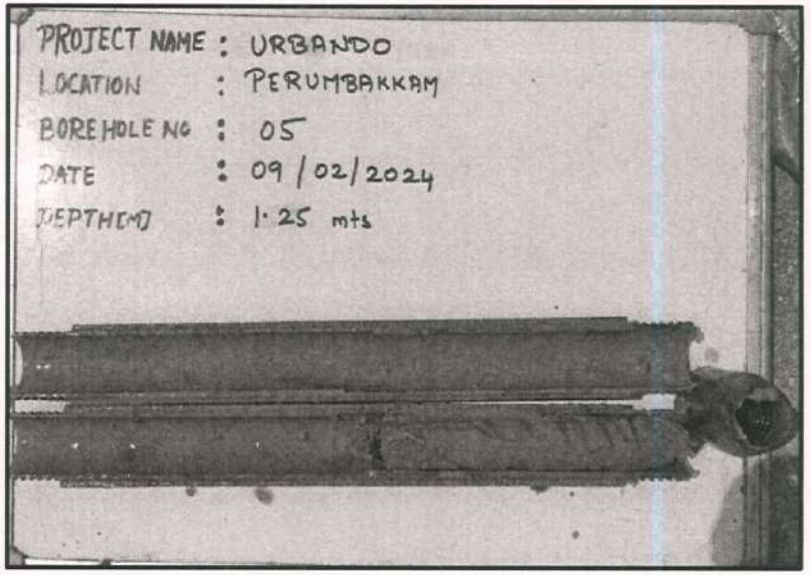


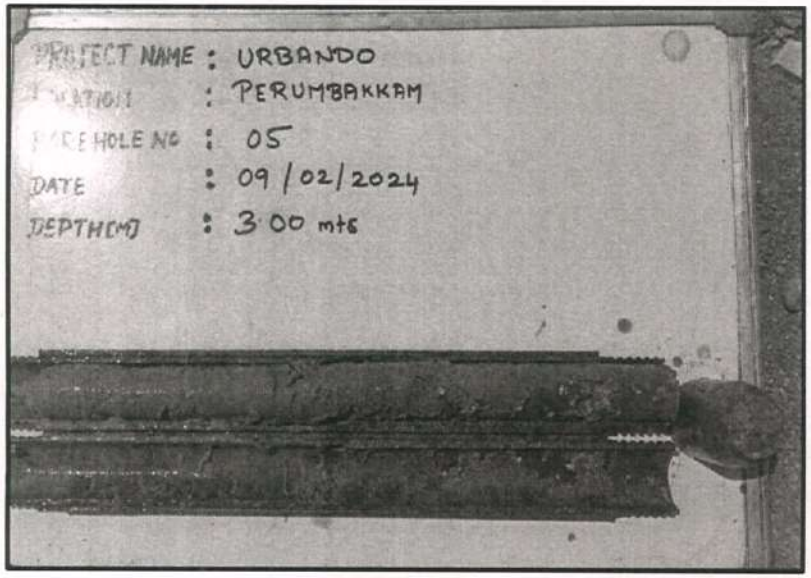


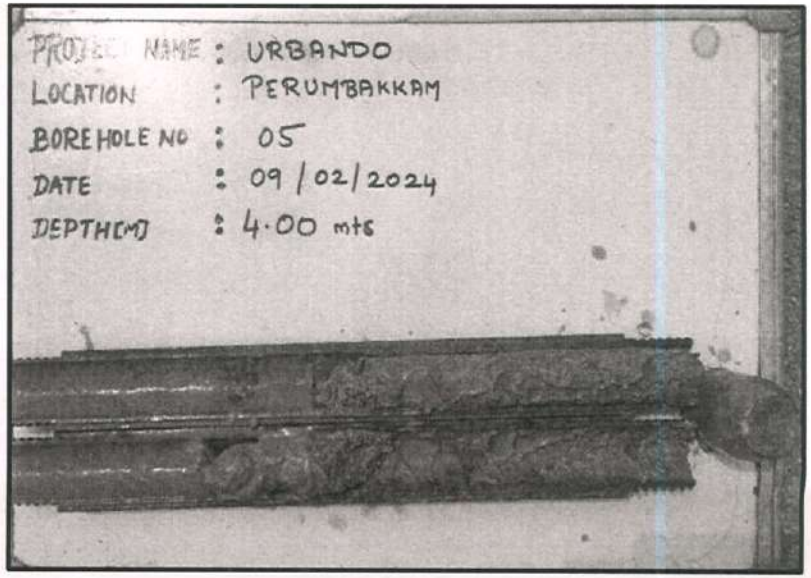


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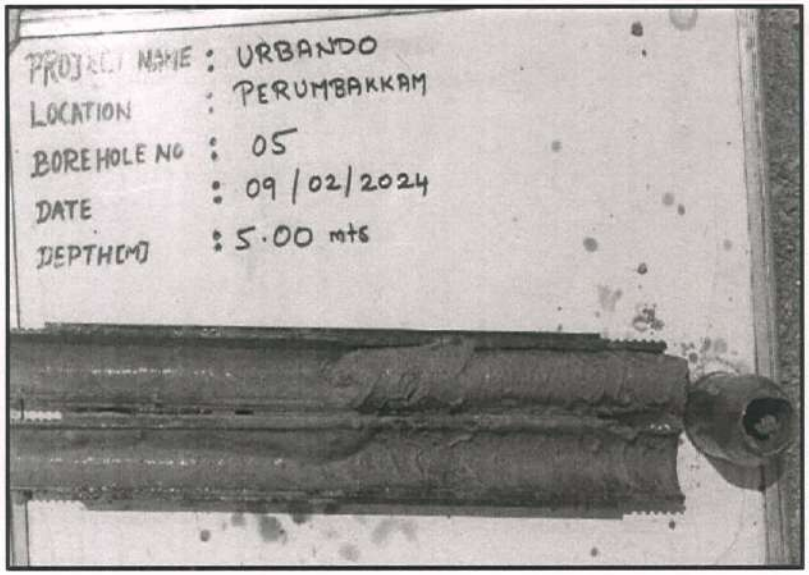








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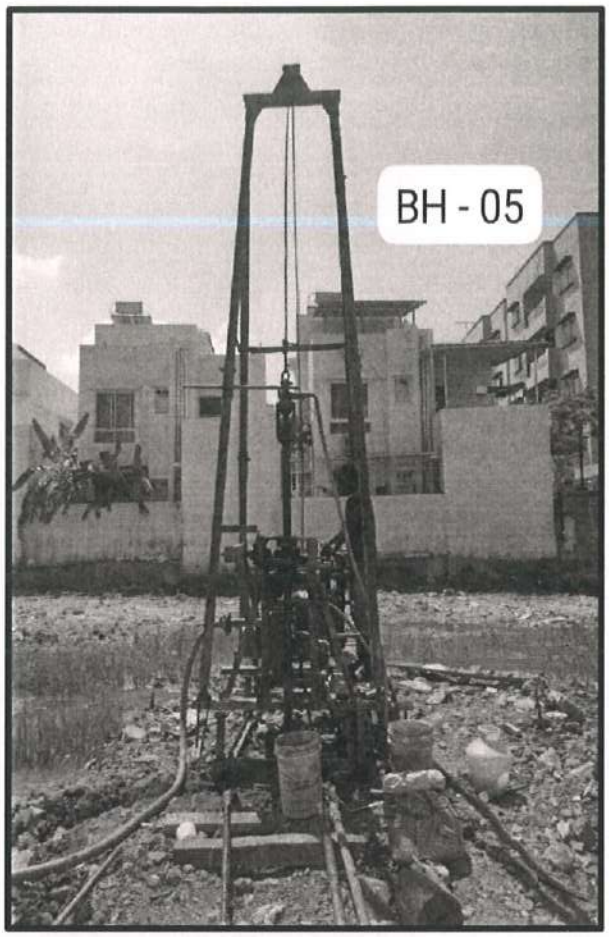


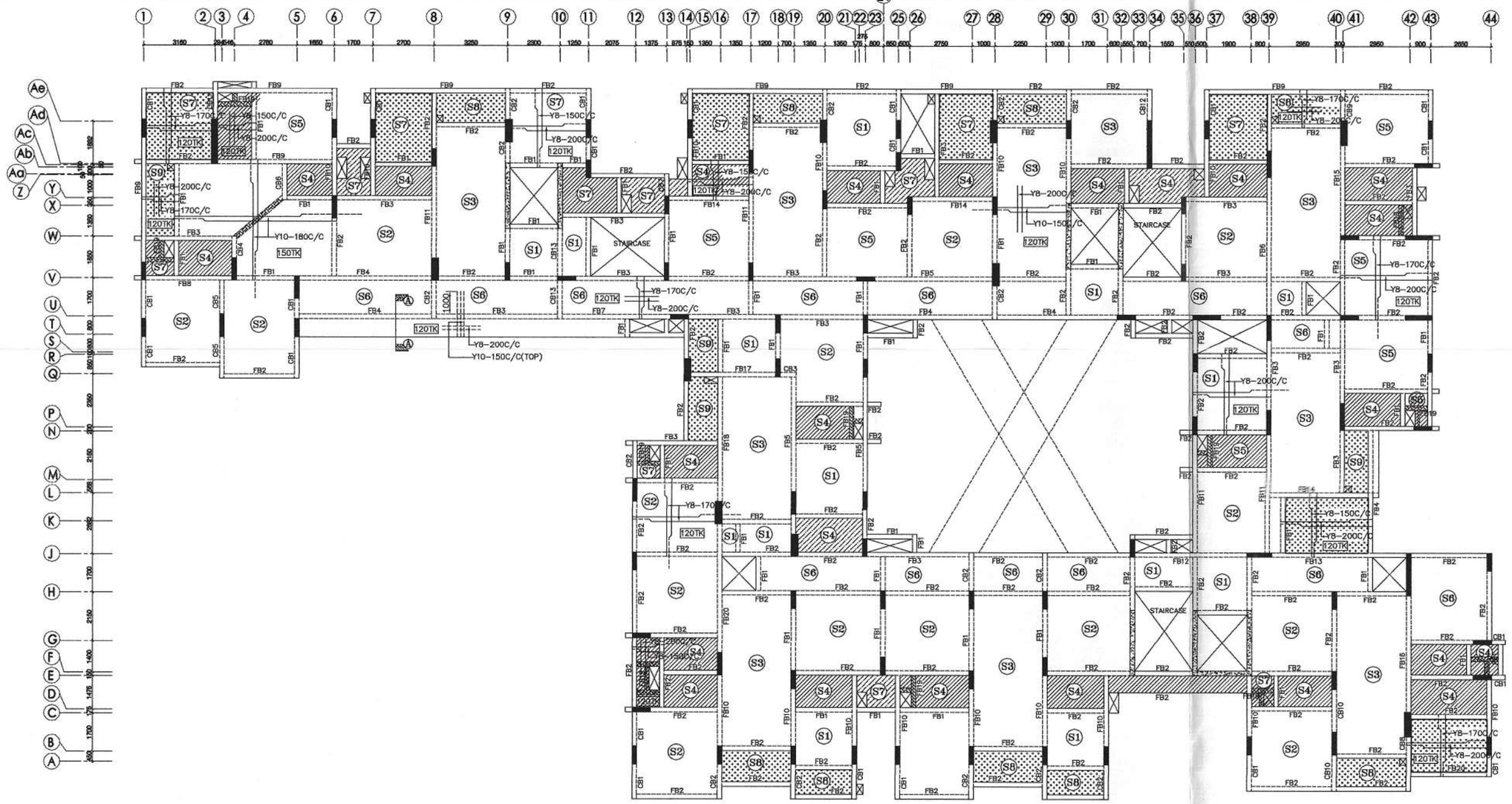

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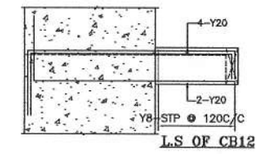

BH - 02


BH - 03

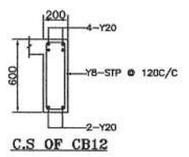

BH - 04


BH - 05

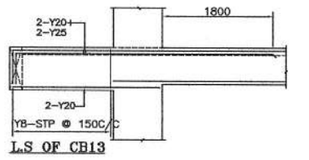




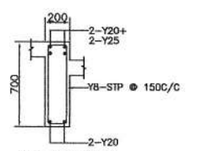
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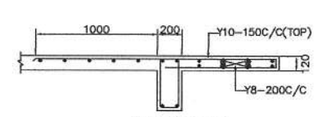
C.S OF CB12



L.S OF CB13

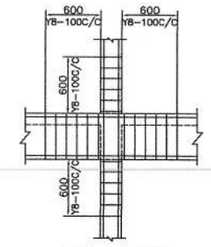


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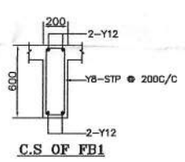


SECTION A A
(TYPICAL)

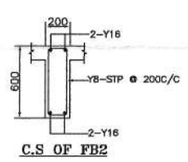
= 100mm SUNKEN (TOILET)
= 150mm SUNKEN (BALCONY & WASH)
= 300mm SUNKEN (OPEN TERRACE)



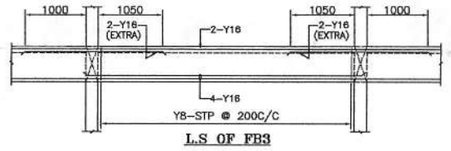
TYP. SEC. FOR
STP. DETAILS



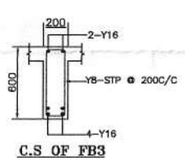
C.S OF FB1



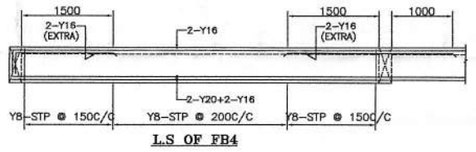
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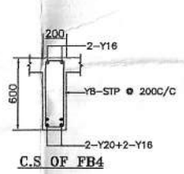
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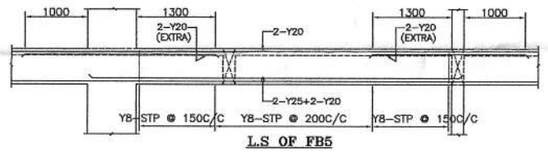
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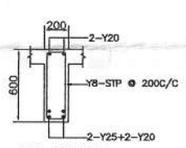
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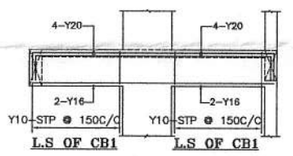
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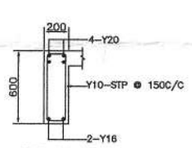
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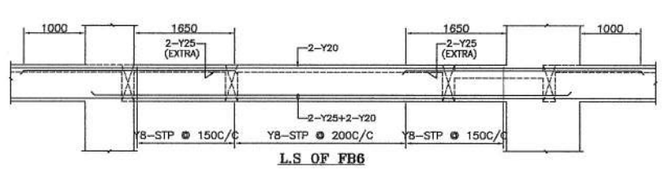
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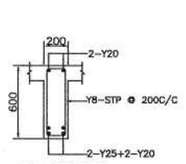
L.S OF CB1



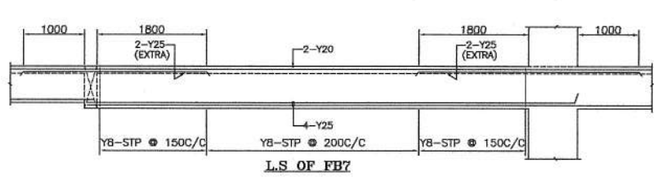
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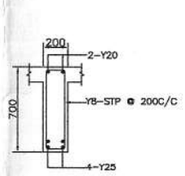
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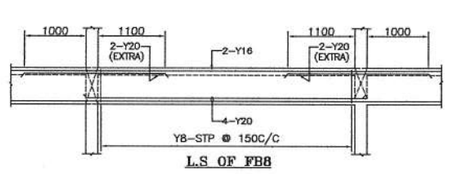
C.S OF FB6



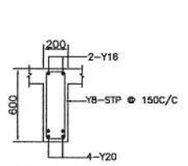
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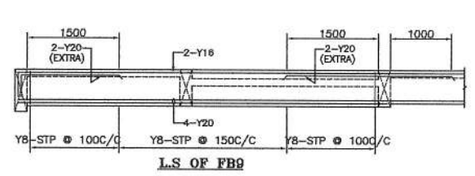
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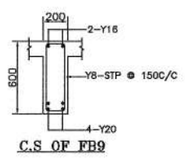
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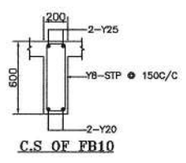
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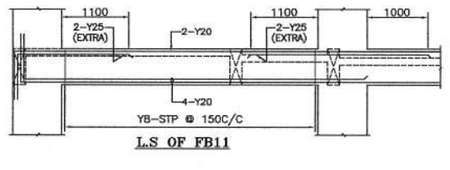
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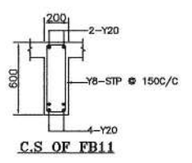
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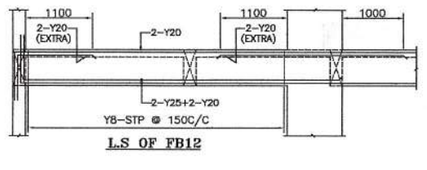
C.S OF FB10



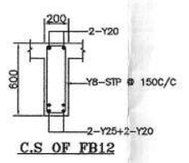
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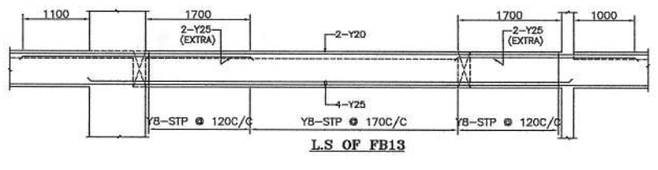
C.S OF FB11



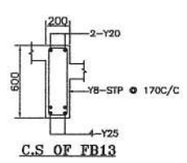
L.S OF FB12



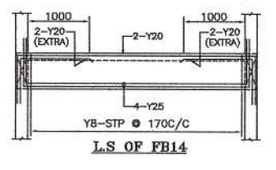
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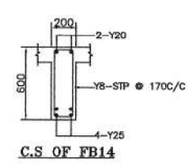
L.S OF FB13



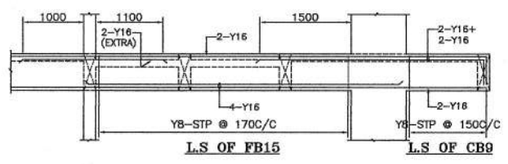
C.S OF FB13



L.S OF FB14

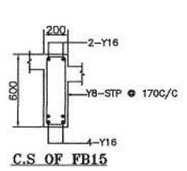


C.S OF FB14

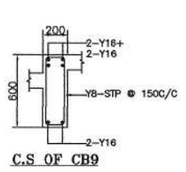


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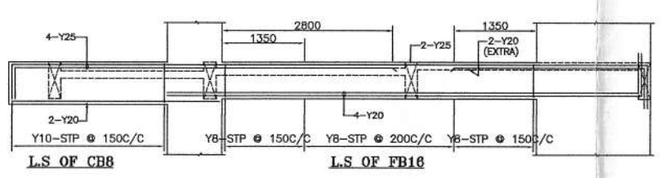
L.S OF CB9



C.S OF FB15

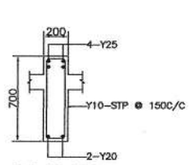


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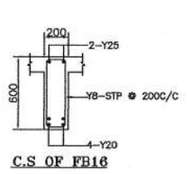


L.S OF CB8

L.S OF FB16



C.S OF CB8



C.S OF FB16

L.S OF FB17

L.S OF CB3

C.S OF FB17

C.S OF CB3

L.S OF FB18

C.S OF FB18

C.S OF FB19

L.S OF FB19

C.S OF FB19

L.S OF CB2

C.S OF CB2

L.S OF CB4

C.S OF CB4

L.S OF CB5

C.S OF CB5

L.S OF CB6

C.S OF CB6

L.S OF CB7

C.S OF CB7

L.S OF CB10

L.S OF CB10

C.S OF CB10

L.S OF CB11

C.S OF CB11

RJND	DATE	DESCRIPTION

Notes:-

1. This drawing should be read along with architectural drawings.
2. Grade of R.C.C. items shall be M40 for column & M30 for all other R.C.C works
3. Y Denotes TOR50 Steel confirming to I.S. 1786 – 1985. Grade – Fe 500
4. Clear cover to the main steel
   50 for Footings , Raft Slabs & Raft Beams.
   40 for Columns.
   25 for Lintel & Beams.
   15 for Sunshade & Slab.
5. Lap length shall be 50 d (Max. dia) for all bars.
6. —— Bottom Reinforcement
7. ----- Top Reinforcement
8. Provide Continuous Chairs to keep the top Reinforcement in position
9. Provide Y 8 ct 200 cs Distribution steel for all top Reinforcement.
10. Spacer Bar to be Provided in Between Two Layers Of Reinforcement of Same Dia at Every 1000 C/ C.
11. Not more than 40% of Reinforcement shall be Lapped at any particular junction.
12. Cantilever props should not be released until the roof is concreted.
13. Foundation is designed for SBR plus Eleven upper floor only.
14. For Earthquake analysis Zone III is taken as per IS : 1893-2016 code.
15. Removal of formworks :
   i) For Slabs :
   a. Slabs spanning upto 4.5 m (15'-0") – 7 days
   b. Slabs spanning over 4.5 m (15'-0") – 14 days
   ii) For Beams and Arches :
   c. Beams and Arches spanning upto 6 m (20'-0") –14days
   d. Beams and Arches spanning over 6 m (20'-0") –21days

PROJECT

PROPOSED RESIDENTIAL BUILDING AT GNADHI NAGAR,3RD CROSS STREET, PERUMBAKKAM, CHENNAI-100. COMPRISED IN OLD S.NO: 310/2A3, 310/2B, 310/3, 311/1 & 311/1B, AS PER PATTA NO:5076, 3753, 20114 & 20082, NEW S.NO:310/2A3A, 310/2B1, 310/3B, 311/1A, 311/1B1 & 311/1B2 OF PERUMBAKKAM VILLAGE, TAMBARAM TALUK, CHENGALPATTU DISTRICT WITHIN THE LIMIT OF ST.THOMAS MOUNT PANCHAYAT UNION.

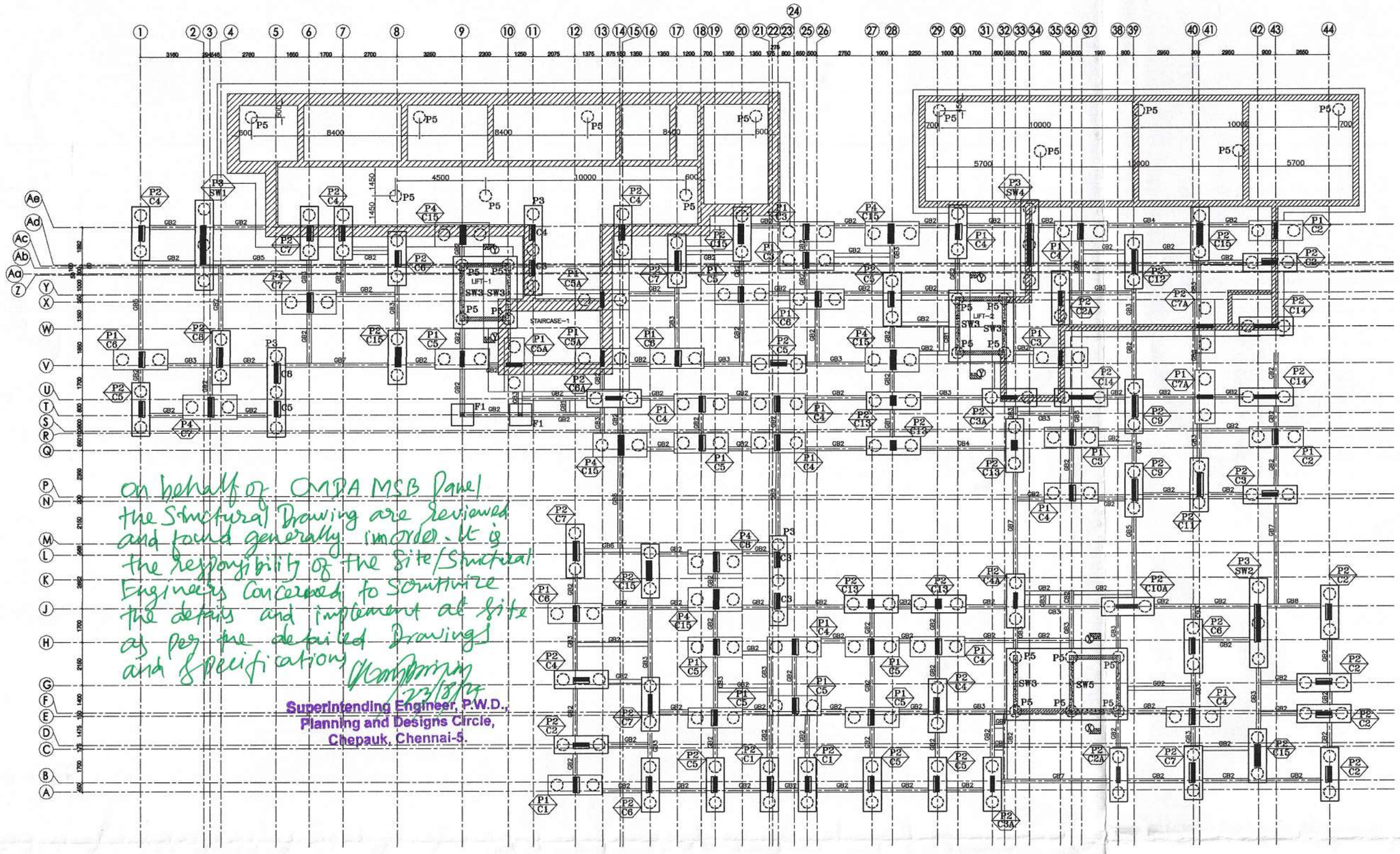
TYPICAL FLOOR SLAB DETAIL

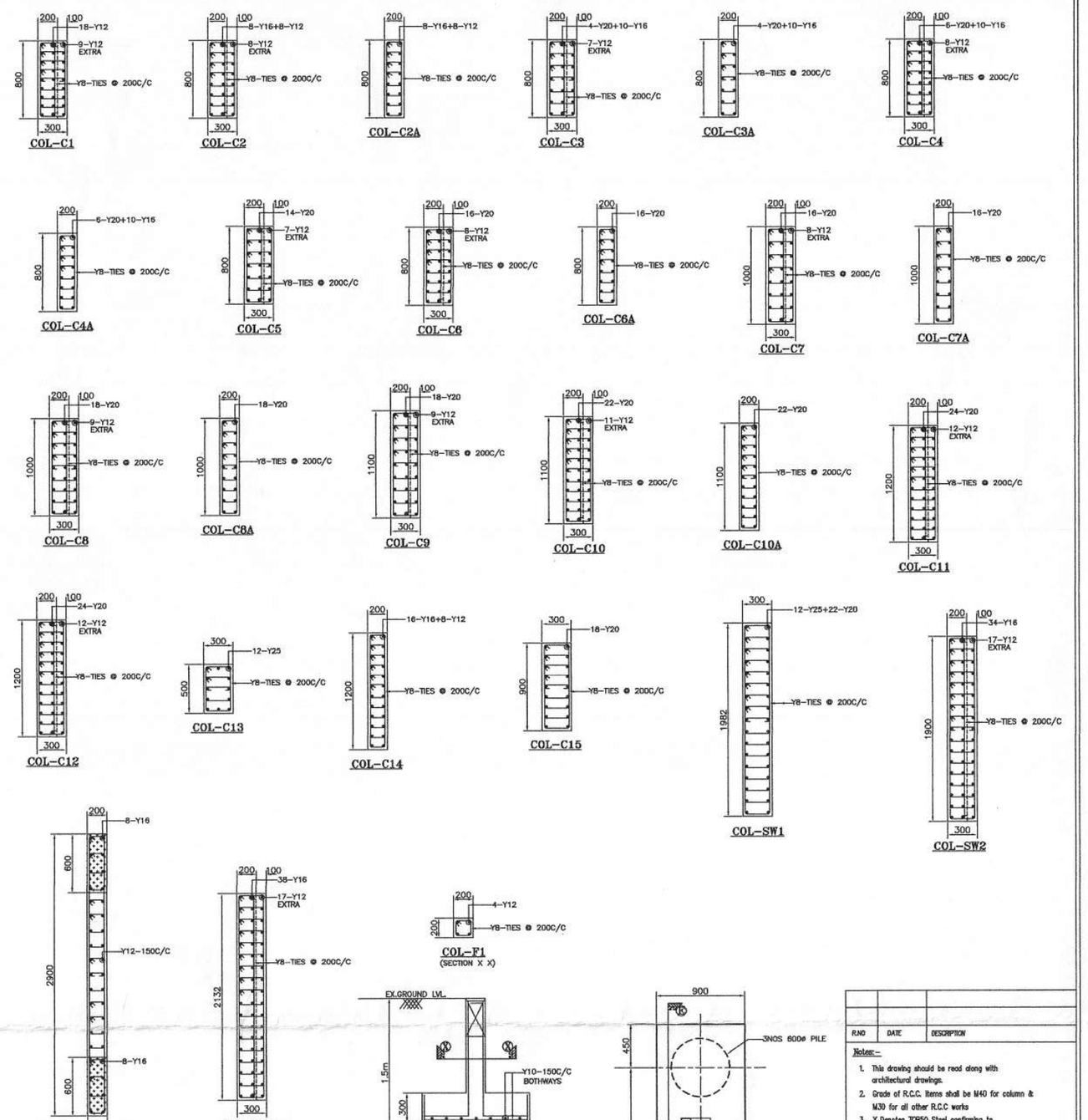
DESIGNED	KANNAN	SCALE	1 : 100
DRAWN	RAJA	DATE	27-07-2024

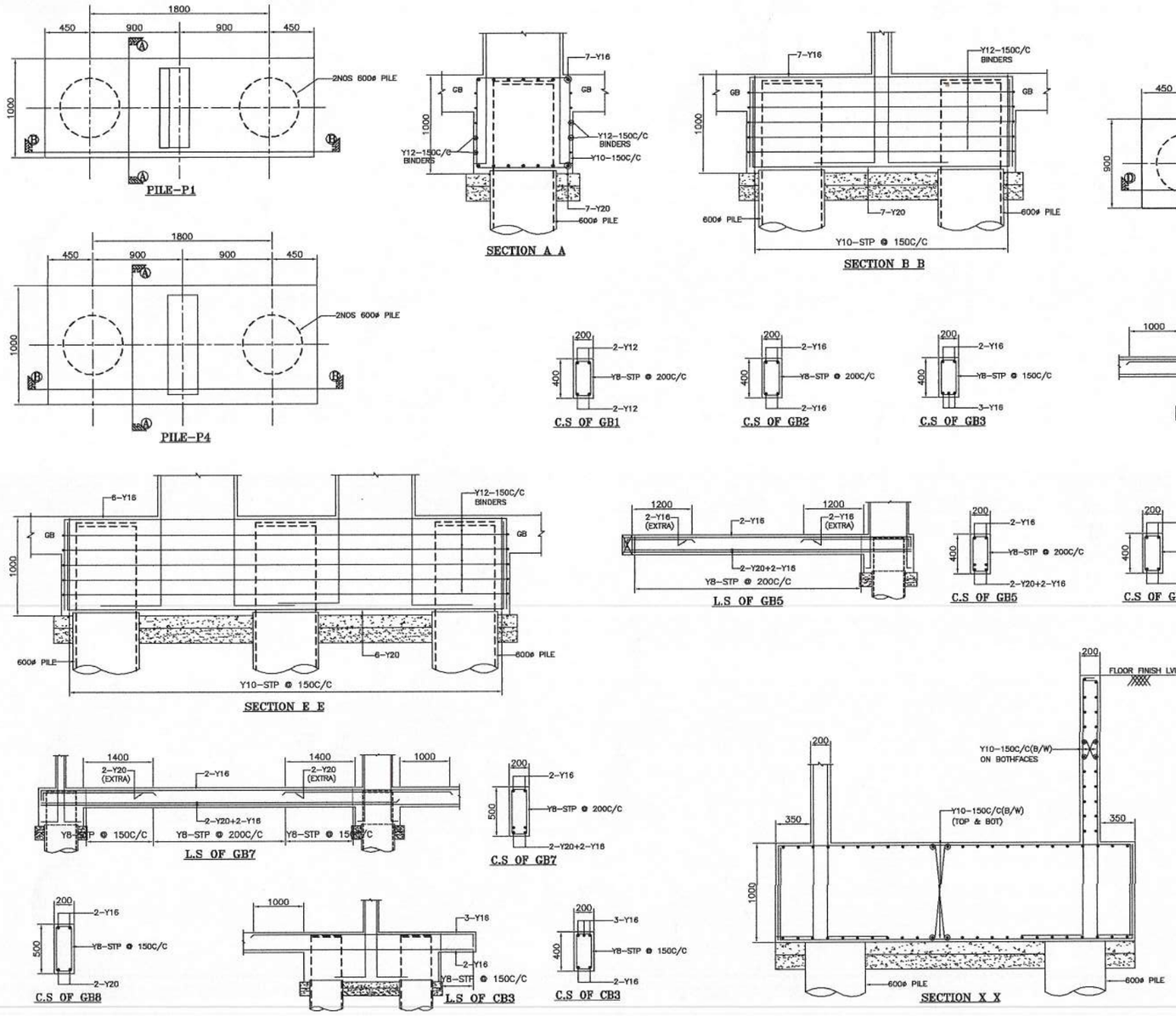
STRUCTURAL CONSULTANTS:

C.KANNAN, B.E., M.E. (Structure)
Structural Engineer,
CMDA Reg No: SE/I/2024/2/0047
DOOR NO:21, PLOT NO:21, 4th Main Road,
FLAT NO:2B, "UTOPIA APARTMENTS", Gandhi Nagar, Chennai-600 020.
2nd FLOOR, 4th MAIN ROAD,
INDIRA NAGAR, CHENNAI-20.
MOBILE NO: 098412 49815.
E-MAIL:kannankala2007@gmail.com

FILE NAME : [I:\CHITRA\corporation\URBANDO-PERUMBAKKAM







Notes:-

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10. Spacer Bar to be Provided in Between Two Layers Of Reinforcement of Same Dia at Every 1000 C/ C.
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    - a. Slabs spanning upto 4.5 m (15'-0") – 7 days
    - b. Slabs spanning over 4.5 m (15'-0") – 14 days
    - ii) For Beams and Arches :
    - c. Beams and Arches spanning upto 6 m (20'-0") –14days
    - d. Beams and Arches spanning over 6 m (20'-0") –21days

R.NO	DATE	DESCRIPTION

PROJECT

PROPOSED RESIDENTIAL BUILDING AT GNADHI NAGAR,3RD CROSS STREET, PERUMBAKKAM, CHENNAI-100. COMPRISED IN OLD S.NO: 310/2A3, 310/2B, 310/3, 311/1 & 311/1B, AS PER PATTA NO:5076, 3753, 20114 & 20082, NEW S.NO:310/2A3A, 310/2B1, 310/3B, 311/1A, 311/1B1 & 311/1B2 OF PERUMBAKKAM VILLAGE, TAMBARAM TALUK, CHENGALPATTU DISTRICT WITHIN THE LIMIT OF ST.THOMAS MOUNT PANCHAYAT UNION.

PILE FOUNDATION DETAIL

DESIGNED	KANNAN	SCALE	1 : 100
DRAWN	KANNAN	DATE	27-07-2024

STRUCTURAL CONSULTANTS:

C.KANNAN, B.E., M.E. (Structure)
Structural Engineer,
CMDA Reg. No: SE/I/2024/2/0047
No: 21, 4th Main Road,
Gandhi Nagar, Chennai-600 020.

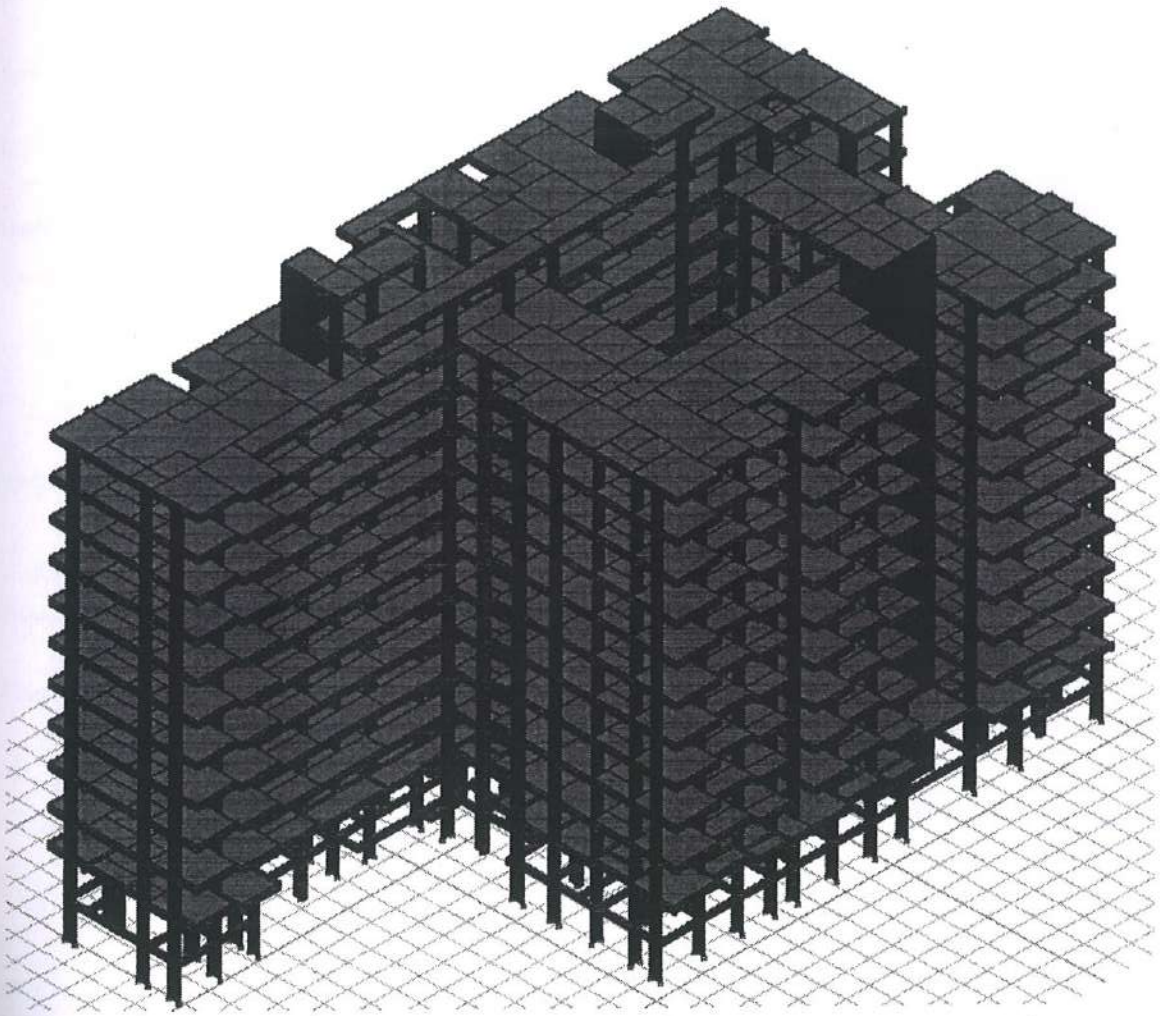
C.KANNAN B.E., M.E(STRUCTURAL)
DOOR NO:21, "UDAYA APARTMENTS",
2nd FLOOR, 4th MAIN ROAD,
INDIRA NAGAR, CHENNAI-20.
MOBILE NO: 9884121 48816,
E-MAIL:kannanskk2007@gmail.com

FILE NAME : [G:/CHENNAI/corporation/URBANDC-PERUMBAKKAM

PROPOSED RESIDENTIAL BUILDING AT GANDHI NAGAR, 3rd CROSS STREET, PERUMBAKKAM, and CHENNAI-100. COMPRISED IN OLD S.NO: 310/2A3, 310/2B, 310/3, 311/1 & 311/1B, AS PER PATTA NO: 5076, 3753, 20114 & 20082, NEW S.NO:310/2A3A, 310/2B1, 310/3B, 311/1A, 311/1B1 & 311/1B2 OF PERUMBAKKAM VILLAGE, TAMBARAM TALUK, CHENGALPATTU DISTRICT WITHIN THE LIMIT OF ST.THOMAS MOUNT PANCHAYAT UNION.

RESIDENTIAL BUILDING - Structural Design Report

AUGUST -2024



STRUCTURAL CONSULTANT

C.KANNAN B.E., M.E (STRUCTURE)
INDIRA NAGAR, CHENNAI-20.

C. KANNAN, B.E., M.E, (Structure)
Structural Engineer,
CMDA Reg. No: SE/I/2024/2/0047
Door No: 21, 4th Main Road,
Indira Nagar, Chennai-600 020.

1.1 FOREWORD

1.1.1 - Description of Project

M/s.Urbando Housing LLP, Chennai is developing a High rise residential building (Stilt + 10 upper floors) at Perubakkam , Chennai. This project is designed to provide a generous and comfortable habitat, complete with facilities that cater to a relaxed and convenient lifestyle. The project construction is carried out as RCC framed structure with Shear wall and RCC Slab system. The building is designed with accessibility in mind as well as earthquake-resistant construction to ensure the well-being of occupants.

1.1.2 – Objective of the Report

The objective of this report is to provide and furnish complete details related to Project and structural analysis and design considerations.

1.1.2 – Scope of the Report

The Structural Report covers the complete Structural Elements design considerations for analysis of lateralloads & gravity loads.

1.2 CODES, STANDARDS AND REFERENCES

Statutory Requirements:

The design of structural and other building services will comply with the following requirements:

- National Building Code The Building Regulations
- The Environmental Protection Act in liaison with the Environmental Agency.
- Fire prevention and detection in compliance with the local Fire Regulation.

DESIGN STANDARDS:

Specific applicable codes and standards will be identified and adopted in the design philosophies as appropriate to the structural elements. The latest editions of the Codes and Standards will be used indesigns. All design work shall be based on Indian Standards and Codes with latest revision, with amendments if any, as on date.

Loads:

IS: 875 -2015	-	Code of Practice for design loads (other than earthquake) for Buildings & structure (All parts)
IS: 1893-2016	-	Criteria for earthquake resistant design of structure

Foundations:

IS: 1080-1985(2016)	-	Code of Practice for design and construction of shallow foundations on soils(other than raft, ring and shell)
IS: 1904-1986(2015)	-	Code of Practice for design and construction of foundations in soils general requirement
IS: 2911-1980(2013)	-	Code of Practice for design and construction of pile foundations (All parts)
IS: 2950-1981(2013)	-	Code of Practice for design and construction of raft foundations
IS: 2974-1998(2013/2015)	-	Code of Practice for design and construction of machine Foundations(All parts)
IS: 8009-1976/1980(2013/2015)	-	Code of Practice for calculation of settlement of foundations (All parts)

RCC:

IS: 456 -2000(2016)	-	Code of Practice for plain and reinforced concrete
IS: 458 -1988	-	Specification for precast concrete pipes
IS: 3370-2009	-	Code of Practice for concrete structures for the storage of liquids:(All parts)
IS: 4326-2013	-	Code of Practice for earthquake resistant design and construction of building
IS: 5525-1969(2013)	-	Recommendation for detailing of reinforced concrete works
IS: 1786-2008	-	Code of Practice for design and construction of machine Foundations(All parts)
IS: 5525-1969(2013)	-	Specification for high strength deformed steel bars and wires for concrete reinforcement
IS: 1786-2008	-	Recommended guidelines for concrete mix design
IS: 10262-2009	-	Criteria for earthquake resistant design of structures (General provisions and building).
IS: 1893 (Part-1)-2016	-	Criteria for structural safety of Tall Concrete buildings
IS: 16700 – 2017	-	Ductile design and Detailing of Reinforced concrete structures subjected to Seismic forces – Code of practice
IS: 13920 – 2016	-	Ductile design and Detailing of Reinforced concrete structures subjected to Seismic forces – Code of practice
IS: 1343 – 1980	-	Code of practice for Prestressed concrete

Miscellaneous:

IS: 432(part 2)-1995	-	Specification for mild steel and medium tensile steel bars and hard-drawnsteel wire for concrete reinforcement
IS: 6313(part II)-2001	-	Standards for anti-termite treatment
IS: 1905-1998	-	Code of Practice for structural use of unreinforced masonry
IS: 3067-1995	-	Code of Practice for general design details and preparatory works for damp proofing and water proofing of buildings
SP: 6 -1998	-	Handbook for structural engineers (all parts)
SP: 7 -2005	-	National Building Code of India
SP: 16-1999	-	Design Aids for reinforced concrete to IS:456-1978
SP: 22-1982	-	Explanatory handbook on codes for earthquake engineering (IS:1982-1975and IS:4326-1976)
SP: 24-1983	-	Explanatory handbook on Indian Standard code of Practice for plain andreinforced concrete
SP: 34-1987	-	Handbook of concrete reinforcement and detailing (SCIP)

Material:

IS: 269 -2015	-	Specification for Ordinary, rapid hardening and low heat Portland cement'
.IS: 455 -1995	-	Specification for Portland blast furnace slag cement.
IS: 1489-1991	-	Specification for Portland pozzolana cement
IS: 4031-1991	-	Method of physical tests for Portland cement.
IS: 383 - 2016	-	Specification for coarse and fine aggregates from natural sources for concrete.
IS: 516 – 1999	-	Method of test for strength of concrete
IS: 1199-1999	-	Method of sampling and analysis of concrete.
IS: 1566-2000	-	Specification for plain hard drawn steel wire fabric for concrete reinforcement
IS: 4990-1998	-	Specification for plywood for concrete shuttering works.
IS: 2645-1999	-	Specification for integral cement water proofing compounds.

1.3 DESCRIPTION OF STRUCTURE

1.3.1 Building Description

The Development consists of the following:

a. Residential building floor covered with RCC roofing.

The usages of individual floors are as given below:

Floors	Details
Main Residential Building	Space for living Purpose

1.3.2 Structural Arrangement:

The Structural System for the residential buildings comprises of RCC column and beam and slab.

S.No.	Description	Details
1.	Column Grids	3.60 m x 2.10 m (Varies for some grids)
2.	Structural System	RCC Shear Wall & Column
3.	Slab Thickness RCC Slab	Min. 120mm (Varies on span)
4.	Foundation	Pile Foundation
5.	Column	As per design
6.	Beams	As per design

1.4 DESIGN APPROACH

1.4.1 – Design Life.

The design life of the building is assumed as 50 years. This requirement is applicable only for concrete works and not applicable to replaceable finishing materials, water proofing membrane and thermal insulations (if any). Hence periodic maintenance / refurbishment are required for all replaceable material for longer life.

1.4.2 – Material Properties.

Materials specified will conform to the latest edition of the relevant Indian Standard or other accepted standard. Specifications for materials will include sampling and testing as stipulated in the design standards. Detailed material specifications will be included in the Technical Specification.

Concrete:

All structural concrete shall have cube crushing strength of 40 N/sq.mm (M35) at 28 days.Plain cement concrete shall have cube crushing strength of 10 N/sq.mm (M10) at 28 days.

Concrete Mix:

Concrete Item	Grade
Pile Foundation	M30
Columns	M40
Slabs & Beams	M30

Reinforcement steel:

- All reinforcement shall confirm to IS: 1786 – 1985 having minimum yield strength of 500 N/sq.mm.Corrosion resistant steel is not required.

1.4.3 – Design loads

Dead loads:

Dead load shall include weight of all structural and Architectural components. Self-weight of the materials shall be calculated on the basis of unit weights given in IS: 875.

- Floor finish of 75 mm thickness : 75 kg/sqm
- Self-weight of Plain concrete : 2400 kg/cum (24 kN/cum)
- Self-weight of RCC : 2500 kg/cum (25 kN/cum)
- Aerocon block masonry : 700 kg/cum (7 kN/cum) [For walls]
  (With additional 15mm thick plastering on external surface and 12mm plastering on internal wallsurfaces)
- Soil (Dry) : 1800 kg/cum (18 kN/cum)
- Soil (Wet : 2000 kg/cum (20 kN/cum)
- Water : 1000 kg/cum (10 kN/cum)
- Masonry with plastering : 2200 kg/cum (22 kN/cum)
- Wall loads : As per actuals

Live loads:

The superimposed loads shall be calculated in accordance with IS: 875(Part-2) based on Occupancy Classification. For multiple occupancies of use in the building shall be referred with the other appropriate comparable occupancy classification as per Table.1 of IS 875(Part-2)-1987.

Following live loads are considered while designing the structural elements apart from the dead loads asper codes.

Floor Live loads:

- Living Area : 200 kg/sqm (2.0 kN/sqm)
- Stairs : 300 kg/sqm (3.0kN/sqm)
- Corridors / Balcony : 300 kg/sqm (3.0kN/sqm)
- Toilets : 200 kg/sqm (2.0kN/sqm)
- Terrace with Access : 200 kg/sqm (2.0kN/sqm)
- Electrical rooms : 400 kg/sqm (4.0kN/sqm)

Sunken Details:

- Toilet : 250mm

Wind Loads

The Wind pressure shall be calculated in accordance with IS: 875 (Part-3):2015.Chennai has a high wind speed of 50m/s.

Basic Wind Speed V_b : 50 m/s

Risk Coefficient k_1 : 1.00 (k_1 corresponds to 50 years Mean Probable Design Life of Structure)

Terrain, height, structure size factor k_2 : To suit the height of the structure for terrain category 2

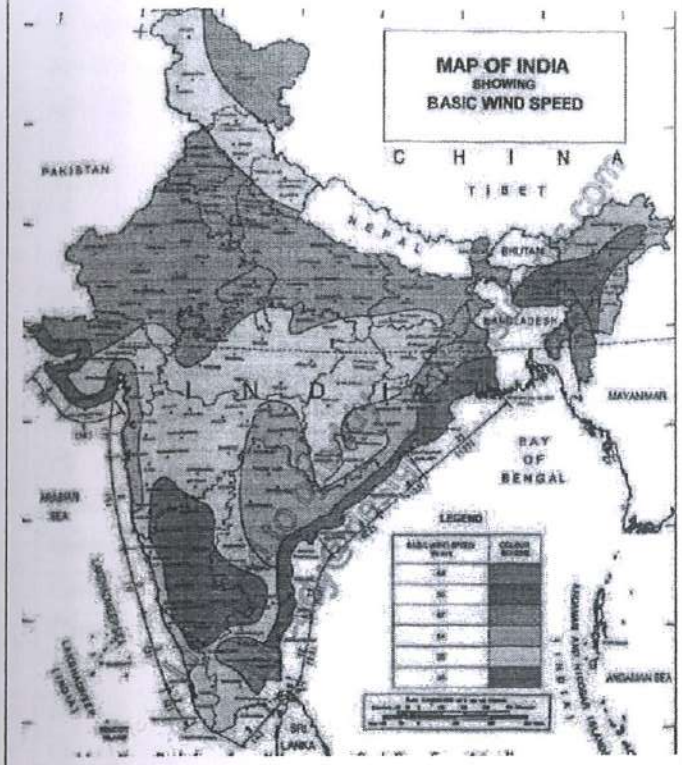
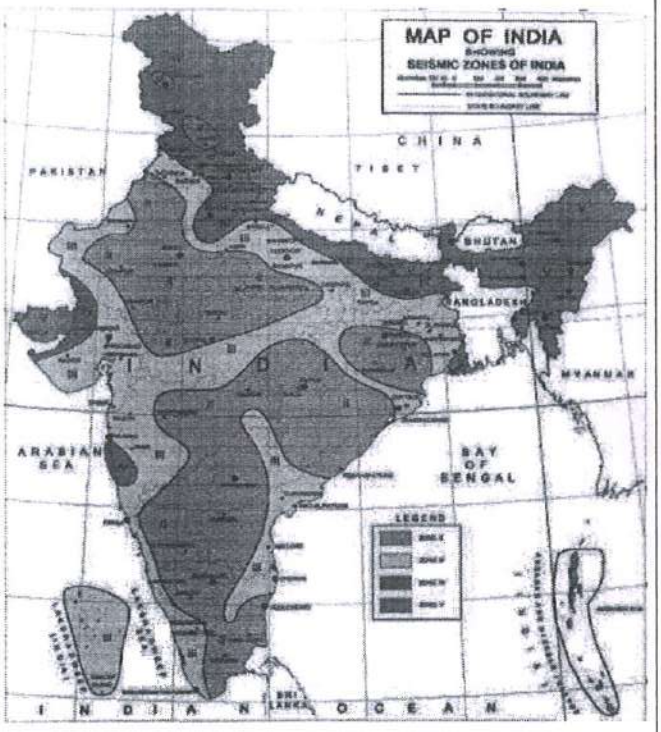
Topography factor k_3 : 1.0

Importance factor for cyclonic region k_4 : 1.00

The external and internal pressure co-efficient shall be as per respective clauses of IS: 875 (Part 3):2015 Design

Wind speed V_z : $V_b \times k_1 \times k_2 \times k_3 \times k_4$

Design Wind Pressure, P_z : $0.6V_z^2$

Map showing basic wind speed	Map showing seismic zones
	
Basic wind speed in m/s (based on 50-year return period)	Seismic zones of India

Seismic Forces:

Chennai falls under seismic zone III as per IS 1893-2016 (Part 1) (Sixth Revision) and has the following factors to be considered for designs. Ductile detailing is required. (Please refer attached map above)

Seismic Zone	: III
Seismic Zone factor, Z	: 0.16 (As per Table 3; IS: 1893-2016)
Design horizontal seismic coefficient (Ah)	: $(Z/2)*(S_a/g)*(I/R)$
I -Importance factor	: 1.2 (Ref Table 8; IS: 1893-2016)
Response reduction Factor	: 4
Soil type	: Type -1
Damping Ratio for RCC	: 5 %

Sa/g – Average response acceleration coefficient for soil sites as per Fig.2 of IS: 1893-2016 and it is arrivedbased on appropriate fundamental natural period of structure as per Cl 7.6.2 (b)

Design horizontal seismic coefficient (A_h)	: $(Z/2)*(S_a/g)*(I/R)$
	: $(0.16/2)*(1.2/4) * (S_a/g)$
A_h	: $0.024 * (S_a/g)$
Design seismic base shear, V_b	: $A_h * w$ where, w - seismic weight of building
Effect of infill panels	: Not considered in the analysis

Table No : 03

Seismic Zone Factor Z

(Clause 6.4.2)

Seismic Zone	II	III	IV	V
Seismic Intensity	Low	Moderate	Severe	Very Severe
Z	0.10	0.16	0.24	0.36

Temperature Loads:

The effect of temperature will be considered wherever applicable in accordance with relevant Indian Codes. Minimum & maximum temperatures considered are as shown in the table below. Same will be used for the analysis & design. The coefficient for thermal expansion and contraction will be in accordance with IS: 456 and IS: 800 for concrete and steel respectively.

Station Name	Month	Period	No. of Years	Mean Temperature in Degree C		Mean rainfall in mm
				Maximum	Minimum	
Chennai (Minambakkam)	January	1901-2000	100	28.8	20.4	35.3
Chennai (Minambakkam)	February	1901-2000	100	30.5	21.1	13.0
Chennai (Minambakkam)	March	1901-2000	100	32.6	23.0	14.5
Chennai (Minambakkam)	April	1901-2000	100	34.7	25.8	15.9
Chennai (Minambakkam)	May	1901-2000	100	37.4	27.6	42.4
Chennai (Minambakkam)	June	1901-2000	100	37.3	27.4	53.9
Chennai (Minambakkam)	July	1901-2000	100	35.3	26.1	99.6
Chennai (Minambakkam)	August	1901-2000	100	34.5	25.5	129.9
Chennai (Minambakkam)	September	1901-2000	100	33.9	25.2	123.5
Chennai (Minambakkam)	October	1901-2000	100	31.8	24.2	284.6
Chennai (Minambakkam)	November	1901-2000	100	29.4	22.6	353.0
Chennai (Minambakkam)	December	1901-2000	100	28.4	21.2	146.3

[Source: National Data Centre: ndc@imdpune.gov.inDGM (Sectt.): dgm.hq@imd.gov.in]

Considering the average **daily** maximum temperature as 34 degrees and minimum as 24 degrees, the variation in temperature for analysis is considered as **10 degrees.** [Source https://www.wunderground.com/history/airport/VOMM/2016/1/4/CustomHistory.html?dayend=5&monthend=2&yearend=2017&req_city=&req_state=&req_statename=&reqdb.zip=&reqdb.magic=&reqdb.wmo=]

Temperature and shrinkage effect:

Horizontal floor displacement due to differential temperatures and shrinkage is of importance in long concrete buildings. It can be taken care of by either providing expansion joints at an appropriate spacing or designing structural members for the additional moments caused by the temperature and shrinkage effects. Pour strips at suitable locations shall also be considered where required.

Exceptional Loads:

Loads due to the following catastrophe scenarios are not considered in the design:

- Exceptional loads due to terrorist attacks (Explosions)
- Accidental loads (Falling of aircraft on the building)
- Accidental collision of vehicles on the façade of the building

On behalf of CMDA MSB Panel the Structural design Calculations are Generally reviewed.

Superintending Engineer, P.W.D.,
Planning and Designs Circle,
Chepauk, Chennai-5.

1.4.4 Durability Considerations:

Environmental conditions, Corrosion and Fire protection for concrete and structural steel

- Environment : Moderate
- Exposure conditions : Concrete surfaces exposed to moderate environment
- Minimum grade of Concrete : Moderate Exposure – M25

Table 5 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal Maximum Size

(Clauses 6.1.2, 8.2.4.1 *and* 9.1.2*)*

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
i)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	–	300	0.55	M 20
iii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

NOTES

1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in 5.2. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.

2 Minimum grade for plain concrete under mild exposure condition is not specified.

1.4.5 Fire Rating

Thickness of the structural elements as per table 15, 16 & 16A clause 26.4 of IS 456-2000.

Fire Resistance h	*Minimum Beam Width b*	*Rib Width of Slabs b_w*	*Minimum Thickness of Floors D*	*Column Dimension (b or D)*			*Minimum Wall Thickness*		
				Fully Exposed	50% Exposed	One Face Exposed	$p<0.4\%$	$0.4\%\leq p\leq 1\%$	$p>1\%$
	mm	mm	mm	mm	mm	mm	mm	mm	mm
0.5	200	125	75	150	125	100	150	100	100
1	200	125	95	200	160	120	150	120	100
1.5	200	125	110	250	200	140	175	140	100
2	200	125	125	300	200	160	–	160	100
3	240	150	150	400	300	200	–	200	150
4	280	175	170	450	350	240	–	240	180

NOTES

1 These minimum dimensions relate specifically to the covers given in Table 16A.

2 p is the percentage of steel reinforcement.

FIG. 1 MINIMUM DIMENSIONS OF REINFORCED CONCRETE MEMBERS FOR FIRE RESISTANCE

Nominal covers for 2 hr. fire resistance:

Nominal Cover						
Beams		Slabs		Ribs		Columns
Simply supported	Continuous	Simply supported	Continuous	Simply supported	Continuous	
mm	mm	mm	mm	mm	mm	mm
40	30	35	25	45	35	40

1.5 ANALYSIS METHODOLOGY:

This structure has a physical interface with almost all the disciplines like geotechnical works, MEP services,etc. The structure proposed is of cast in-situ concrete construction with columns suitably placed. The vertical loads including the dead and super imposed loads are transferred to the soil through columns and foundation. Foundations are sized with consideration to the safe bearing capacity of soil at the level of transfer of load recommended by specialist soil investigation consultants.

1.5.1 Assumptions:

- The structure is idealized as 3D space frame and analyzed using ETABS software package for both vertical and lateral loads.
- The structure is analyzed for specific loads like dead load, live load, wind, and seismic loads and forthe load combinations as given in the relevant codes.
- The foundation is represented in analysis model using fixed end conditions.

1.5.2 Mathematical model

Mass Modelling:

Mass Source as per IS: 1893_2016 is considered as follows.

Mass source = DL+SDL+ 0. 5LLWhere DL - Dead Load;

SDL – Super Imposed Dead Load;LL - Live Load

1.5.3 Static Analysis:

The following Static loads cases are considered in the analysis.

DL - Dead Load which includes self-weight of the structure.

SDL – Super Imposed Dead Load, including load due to finishes, wall Loads, Soil filling loads etc.

LL - Live Load

1.6 LOAD COMBINATIONS:

Load combinations Used for Strength, Serviceability are tabulated below:

Load Combination	Limit State of Collapse			Limit State of Serviceability		
	DL+SDL	*LL*	*WL/EL/TL*	*DL+SDL*	*LL*	*WL/EL/TL*
DL + LL	1.5	1.5	—	1	1	—
DL + WL	1.5 or 0.9*	—	1.5	1	—	1
DL + EL	1.5 or 0.9*	—	1.5	1	—	1
DL + TL	1.5	—	1.5	1	—	1
DL+LL+WL	1.2	1.2	1.2	1	0.8	0.8
DL+LL+EL	1.2	1.2	1.2	1	0.8	0.8
DL+LL+TL	1.2	1.2	1.2	1	1	1
DL+WL+TL	1.2	—	1.2	1	—	1
DL+EL+TL	1.2	—	1.2	1	—	1
DL+LL+EL+TL	1.2	1.2	1.2	1	1	1

Response spectrum combinations:

- 1.2[DL+LL+(SPECX+0.3 SPECY+0.3 SPECZ)]
- 1.2[DL+LL+(SPECY+0.3 SPECX+0.3 SPECZ)]
- 1.5[DL+(SPECX+0.3 SPECY+0.3 SPECZ)]
- 1.5[DL+(SPECY+0.3 SPECX+0.3 SPECZ)]
- 0.9DL+1.5(SPECX+0.3 SPECY+0.3 SPECZ)]
- 0.9DL+1.5(SPECY+0.3 SPECX+0.3 SPECZ)]

The various loads are combined in accordance with the stipulations in IS: 875 (Part 5)-1987; whichever combination produces the most unfavorable effect in the building foundation or structural member concerned may be adopted.

*This value is to be considered when stability against overturning and stress reversal is critical where DL/LL/WL/EL denotes,DL - Dead Load; LL - Live Load; TL - Temperature Load; WL - Wind Load;EL - Earthquake Load , SPEC- Response spectrum Wind load and earthquake loads are considered for both x & y directions. Whenever imposed load is combined with earthquake load, the appropriate part of imposed load as specified in IS: 1893-2016 / Clause 7.3.3 of seismic code will be used both for evaluating earthquake effect and for combined load effects usedin such combination. Serviceability loads combinations with suitable live load reduction factor as per IS: 875(Part-2) will be used for foundation design.

1.7 DESIGN METHODOLOGY:

- All R.C.C structures shall be designed according to the Limit State Method as specified in IS: 456 – 2000.
- Forces and moments from the 3D analysis output for the worst combinations are used for the design of the structure.
- The foundations are designed for critical load combination.
- The structure is analyzed for specific loads like dead load, live load, wind and seismic loads and for the load combinations as given in the relevant codes.
- The slab is analyzed as two-way and one way slabs.
- Design of special members like retaining wall, water tanks will be done in accordance with the relevant IS Codes.

1.8 ACCEPTANCE CRITERIA:

1.8.1 Deflection Limits:

For Reinforced concrete works:

- Limiting values of deflection (Short and Long term) as per clause 35.3 of IS: 456-2000 is followed in the design.
- Limiting value for long term deflection is considered as span/250 and for the long term deflection after erection of partitions & finishes is considered as span/350 or 20mm whichever less as per IS 456 – 2000.

1.8.2 Cracking Limits:

- Limiting values of crack width as per clause 35.3 of IS: 456-2000 is followed in the design.In general for slabs and beams, the crack width is limited to 0.3mm.
- For water retaining structures, crack width is limited to 0.2mm.

1.8.3 Soil data:

Foundations are designed based on Geo Technical investigation report and will dissipate all the vertical and horizontal loads safely to the soil below. The soil investigation report recommends pile foundation system.

1.9 DETAILING REQUIREMENTS:

RC walls, which are considered as lateral load resisting elements are detailed as ductile RC walls along with perimeter SMRFs (both columns and beams). Rest of the columns and beams are detailed as per normal detailing requirement. Detailing for all structural members shall be in accordance with IS: 456 & SP: 34.

IS 1893:2016 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern EQ +X according to IS 1893:2016, as calculated by ETABS.

Direction and Eccentricity

Direction = X + Eccentricity Y

Eccentricity Ratio = 5% for all diaphragms

Structural Period

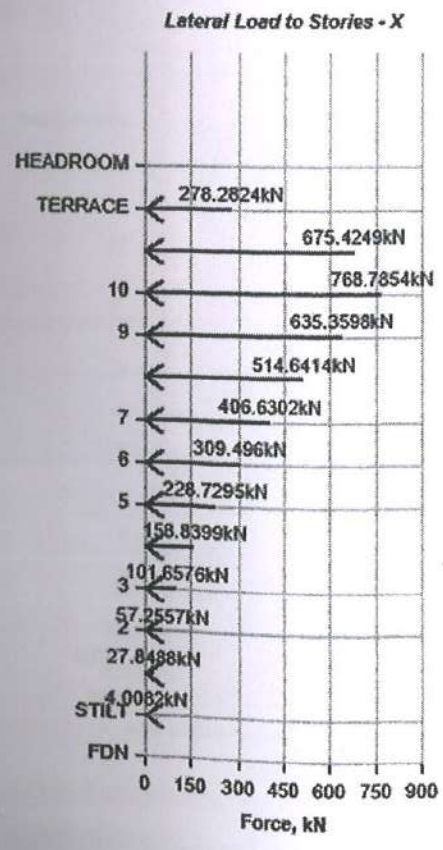
Period Calculation Method = User Specified

User Period		T=1.231 sec
Factors and Coefficients		
Seismic Zone Factor, Z [IS Table 3]		Z = 0.16
Response Reduction Factor, R [IS Table 9]		R = 4
Importance Factor, I [IS Table 8]		I = 1.2
Site Type [IS Table 1] = II		
Seismic Response		
Spectral Acceleration Coefficient, S_a/g [IS 6.4.2]	$\frac{S_a}{g} = \frac{1.36}{T}$	$\frac{S_a}{g} = 1.104793$
Equivalent Lateral Forces		
Seismic Coefficient, A_h [IS 6.4.2]	$A_h = \frac{ZI\frac{S_a}{g}}{2R}$	

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
X + Ecc. Y	1.231	157154.6443	4166.9599

Applied Story Forces



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
HEADROOM	42	0	0
TERRACE	39	278.2824	0
11	36	675.4249	0
10	33	768.7854	0
9	30	635.3598	0
8	27	514.6414	0
7	24	406.6302	0
6	21	309.496	0
5	18	228.7295	0
4	15	158.8399	0
3	12	101.6576	0
2	9	57.2557	0
1	6	27.8488	0
STILT	3	4.0082	0
FDN	0	0	0

IS 1893:2016 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern EQ +Y according to IS 1893:2016, as calculated by ETABS.

Direction and Eccentricity

Direction = Y + Eccentricity X

Eccentricity Ratio = 5% for all diaphragms

Structural Period

Period Calculation Method = User Specified

User Period — T=0.568 sec

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 3] — $Z = 0.16$

Response Reduction Factor, R [IS Table 9] — $R = 4$

Importance Factor, I [IS Table 8] — $I = 1.2$

Site Type [IS Table 1] = II

Seismic Response

Spectral Acceleration Coefficient, S_a/g [IS 6.4.2] — $\frac{S_a}{g} = \frac{1.36}{T}$ — $\frac{S_a}{g} = 2.394366$

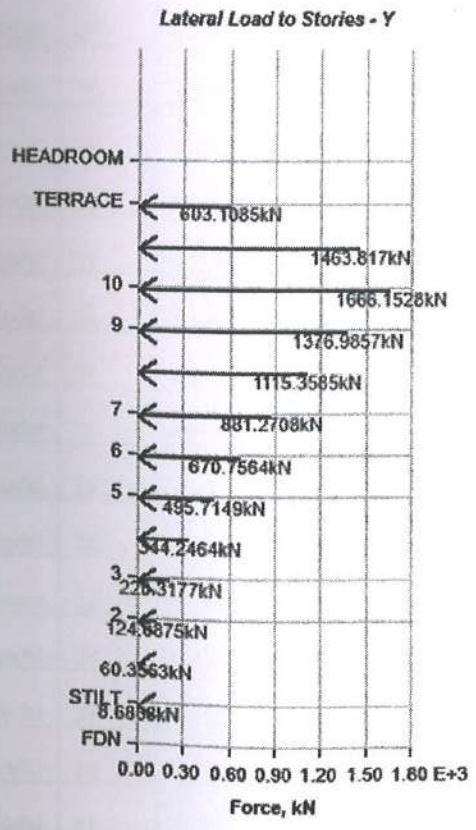
Equivalent Lateral Forces

Seismic Coefficient, A_h [IS 6.4.2] — $A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
Y + Ecc. X	0.568	157154.6443	9030.8584

Applied Story Forces



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
HEADROOM	42	0	0
TERRACE	39	0	603.1085
11	36	0	1463.817
10	33	0	1666.1528
9	30	0	1376.9857
8	27	0	1115.3585
7	24	0	881.2708
6	21	0	670.7564
5	18	0	495.7149
4	15	0	344.2464
3	12	0	220.3177
2	9	0	124.0875
1	6	0	60.3553
STILT	3	0	8.6868
FDN	0	0	0

MODAL PARTICIPATING MASS RATIOS

Case	Mode	Period	UX	UY	UZ	Sum UX	Sum UY	Sum UZ	RX	RY	RZ	Sum RX	Sum RY	Sum RZ
		sec												
Modal	1	2.340	0.520	0.000	0.000	0.522	0.000	0.000	0.000	0.060	0.225	0.000	0.060	0.225
Modal	2	1.678	0.029	0.633	0.000	0.551	0.633	0.000	0.144	0.003	0.057	0.144	0.064	0.283
Modal	3	1.634	0.173	0.092	0.000	0.724	0.725	0.000	0.018	0.022	0.449	0.161	0.086	0.732
Modal	4	0.669	0.100	0.000	0.000	0.823	0.725	0.000	0.000	0.086	0.038	0.161	0.172	0.770
Modal	5	0.455	0.000	0.145	0.000	0.823	0.869	0.000	0.223	0.000	0.001	0.385	0.172	0.770
Modal	6	0.414	0.057	0.000	0.000	0.880	0.870	0.000	0.001	0.036	0.106	0.385	0.208	0.877
Modal	7	0.368	0.023	0.000	0.000	0.903	0.870	0.000	0.000	0.014	0.013	0.385	0.221	0.889
Modal	8	0.353	0.010	0.001	0.000	0.913	0.870	0.000	0.001	0.005	0.000	0.386	0.227	0.890
Modal	9	0.344	0.000	0.000	0.000	0.914	0.871	0.000	0.000	0.000	0.000	0.386	0.227	0.890
Modal	10	0.286	0.004	0.000	0.000	0.918	0.871	0.000	0.000	0.001	0.002	0.386	0.228	0.892
Modal	11	0.265	0.000	0.000	0.007	0.918	0.871	0.007	0.007	0.011	0.000	0.393	0.239	0.892
Modal	12	0.262	0.001	0.000	0.000	0.918	0.871	0.007	0.000	0.000	0.000	0.393	0.240	0.892
Modal	13	0.262	0.006	0.000	0.000	0.925	0.871	0.007	0.000	0.006	0.003	0.393	0.245	0.895
Modal	14	0.262	0.000	0.000	0.000	0.925	0.871	0.007	0.000	0.000	0.000	0.393	0.246	0.895
Modal	15	0.261	0.001	0.000	0.000	0.925	0.871	0.008	0.000	0.001	0.000	0.393	0.247	0.895
Modal	16	0.261	0.000	0.000	0.000	0.925	0.871	0.008	0.000	0.000	0.000	0.393	0.247	0.895
Modal	17	0.260	0.000	0.000	0.000	0.926	0.871	0.008	0.000	0.001	0.000	0.394	0.247	0.895
Modal	18	0.260	0.000	0.000	0.000	0.926	0.871	0.008	0.000	0.000	0.000	0.394	0.247	0.895
Modal	19	0.259	0.000	0.000	0.000	0.926	0.871	0.008	0.001	0.000	0.000	0.395	0.247	0.895
Modal	20	0.259	0.000	0.000	0.000	0.926	0.871	0.008	0.000	0.001	0.000	0.395	0.248	0.895
Modal	21	0.257	0.007	0.000	0.000	0.933	0.871	0.008	0.000	0.006	0.002	0.395	0.254	0.897
Modal	22	0.220	0.002	0.042	0.000	0.935	0.913	0.008	0.041	0.002	0.003	0.436	0.256	0.901
Modal	23	0.216	0.005	0.003	0.000	0.940	0.916	0.008	0.003	0.003	0.010	0.439	0.259	0.911
Modal	24	0.215	0.001	0.004	0.000	0.941	0.920	0.008	0.003	0.001	0.007	0.442	0.260	0.918
Modal	25	0.201	0.000	0.000	0.001	0.941	0.920	0.009	0.001	0.000	0.000	0.443	0.260	0.918
Modal	26	0.201	0.010	0.000	0.000	0.951	0.920	0.009	0.000	0.009	0.005	0.443	0.270	0.923
Modal	27	0.194	0.000	0.000	0.000	0.951	0.920	0.009	0.000	0.000	0.000	0.443	0.270	0.923
Modal	28	0.189	0.000	0.000	0.000	0.951	0.920	0.009	0.000	0.000	0.000	0.444	0.270	0.923
Modal	29	0.186	0.006	0.001	0.001	0.957	0.921	0.009	0.001	0.005	0.013	0.444	0.275	0.936
Modal	30	0.182	0.000	0.000	0.013	0.957	0.921	0.022	0.001	0.000	0.000	0.445	0.275	0.936
Modal	31	0.175	0.000	0.000	0.003	0.957	0.921	0.025	0.000	0.000	0.000	0.445	0.275	0.936
Modal	32	0.172	0.000	0.000	0.000	0.957	0.921	0.026	0.000	0.000	0.000	0.445	0.275	0.936

Modal	33	0.172	0.000	0.000	0.000	0.957	0.921	0.026	0.000	0.000	0.000	0.445	0.275	0.936
Modal	34	0.172	0.000	0.000	0.000	0.957	0.921	0.026	0.000	0.000	0.000	0.445	0.275	0.936
Modal	35	0.171	0.000	0.000	0.000	0.957	0.921	0.026	0.000	0.000	0.000	0.445	0.275	0.936
Modal	36	0.171	0.000	0.000	0.000	0.957	0.921	0.026	0.000	0.000	0.000	0.446	0.275	0.936

STORY DRIFT

Story	Output Case	Direction	Drift	X	Y	Z
				m	m	m
TERRACE	EQ +X	X	0.00167	43.6352	11.525	39
11	EQ +X	X	0.001783	0	31.225	36
10	EQ +X	X	0.002171	0	31.225	33
9	EQ +X	X	0.002421	0	31.225	30
8	EQ +X	X	0.002587	0	31.225	27
7	EQ +X	X	0.002691	0	31.225	24
6	EQ +X	X	0.002745	56.7352	31.225	21
5	EQ +X	X	0.002721	56.7352	31.225	18
4	EQ +X	X	0.002628	56.7352	31.225	15
3	EQ +X	X	0.00246	56.7352	31.225	12
2	EQ +X	X	0.002174	56.7352	31.225	9
1	EQ +X	X	0.001596	55.9352	27.975	6
STILT	EQ +X	X	0.000886	19.6102	27.475	3
TERRACE	EQ +Y	Y	0.002602	48.6353	10.725	39
11	EQ +Y	Y	0.002759	56.7352	16.325	36
10	EQ +Y	Y	0.003083	59.3852	5.325	33
9	EQ +Y	Y	0.00339	59.3853	2.7749	30
8	EQ +Y	Y	0.003618	59.3853	2.7749	27
7	EQ +Y	Y	0.003772	59.3853	2.7749	24
6	EQ +Y	Y	0.003836	59.3853	2.7749	21
5	EQ +Y	Y	0.003791	59.3852	9.925	18
4	EQ +Y	Y	0.00361	59.3852	6.875	15
3	EQ +Y	Y	0.003269	59.3852	9.925	12
2	EQ +Y	Y	0.002729	59.3852	6.875	9
1	EQ +Y	Y	0.001953	59.3853	2.7749	6
STILT	EQ +Y	Y	0.000798	55.5352	24.775	3
TERRACE	RSA-X	X	0.000574	56.7352	31.225	39
11	RSA-X	X	0.000689	56.7352	31.225	36
10	RSA-X	X	0.000819	0	31.225	33
9	RSA-X	X	0.000903	56.7352	31.225	30
8	RSA-X	X	0.000957	56.7352	31.225	27
7	RSA-X	X	0.000985	56.7352	31.225	24
6	RSA-X	X	0.000997	56.7352	31.225	21
5	RSA-X	X	0.000997	56.7352	31.225	18
4	RSA-X	X	0.000989	56.7352	31.225	15
3	RSA-X	X	0.000967	56.7352	31.225	12
2	RSA-X	X	0.000902	56.7352	31.225	9
1	RSA-X	X	0.000675	55.9352	27.975	6
STILT	RSA-X	X	0.000387	19.6102	27.475	3
TERRACE	RSA-Y	Y	0.000614	49.7354	10.725	39
11	RSA-Y	Y	0.000702	0.000000612	20.425	36
10	RSA-Y	Y	0.000762	0	29.0571	33
9	RSA-Y	Y	0.000815	6.112E-07	21.225	30

8	RSA-Y	Y	0.000856	0	29.0571	27
7	RSA-Y	Y	0.000883	6.112E-07	21.225	24
6	RSA-Y	Y	0.000898	0	22.925	21
5	RSA-Y	Y	0.000899	6.112E-07	21.225	18
4	RSA-Y	Y	0.000883	0	22.925	15
3	RSA-Y	Y	0.000839	6.112E-07	21.225	12
2	RSA-Y	Y	0.000743	0	31.225	9
1	RSA-Y	Y	0.000564	6.112E-07	21.225	6
STILT	RSA-Y	Y	0.000354	23.1352	21.225	3

STORY MAX OVER AVG DISPLACEMENTS:

Story	Output Case	Case Type	Direction	Maximum	Average	Ratio
				mm	mm	
TERRACE	EQ +X	LinStatic	X	82.041	69.701	1.177
11	EQ +X	LinStatic	X	78.075	62.995	1.239
10	EQ +X	LinStatic	X	72.989	58.318	1.252
9	EQ +X	LinStatic	X	66.876	52.900	1.264
8	EQ +X	LinStatic	X	59.876	46.956	1.275
7	EQ +X	LinStatic	X	52.294	40.685	1.285
6	EQ +X	LinStatic	X	44.366	34.239	1.296
5	EQ +X	LinStatic	X	36.286	27.772	1.307
4	EQ +X	LinStatic	X	28.286	21.456	1.318
3	EQ +X	LinStatic	X	20.568	15.459	1.330
2	EQ +X	LinStatic	X	13.356	9.970	1.340
1	EQ +X	LinStatic	X	6.985	5.213	1.340
TERRACE	EQ +Y	LinStatic	Y	114.427	91.729	1.247
11	EQ +Y	LinStatic	Y	109.651	79.073	1.387
10	EQ +Y	LinStatic	Y	101.427	73.100	1.388
9	EQ +Y	LinStatic	Y	92.182	66.470	1.387
8	EQ +Y	LinStatic	Y	82.014	59.212	1.385
7	EQ +Y	LinStatic	Y	71.160	51.455	1.383
6	EQ +Y	LinStatic	Y	59.846	43.351	1.380
5	EQ +Y	LinStatic	Y	48.338	35.091	1.378
4	EQ +Y	LinStatic	Y	36.968	26.909	1.374
3	EQ +Y	LinStatic	Y	26.140	19.093	1.369
2	EQ +Y	LinStatic	Y	16.338	11.982	1.364
1	EQ +Y	LinStatic	Y	8.156	6.006	1.358
TERRACE	RSA-X	LinRespSpec	X	29.020	23.702	1.224
11	RSA-X	LinRespSpec	X	27.591	22.167	1.245
10	RSA-X	LinRespSpec	X	25.864	20.556	1.258
9	RSA-X	LinRespSpec	X	23.840	18.732	1.273
8	RSA-X	LinRespSpec	X	21.566	16.763	1.286
7	RSA-X	LinRespSpec	X	19.121	14.701	1.301
6	RSA-X	LinRespSpec	X	16.554	12.575	1.316
5	RSA-X	LinRespSpec	X	13.888	10.413	1.334
4	RSA-X	LinRespSpec	X	11.156	8.248	1.353
3	RSA-X	LinRespSpec	X	8.386	6.115	1.371
2	RSA-X	LinRespSpec	X	5.629	4.063	1.385
1	RSA-X	LinRespSpec	X	3.029	2.184	1.387
TERRACE	RSA-Y	LinRespSpec	Y	25.845	22.922	1.128
11	RSA-Y	LinRespSpec	Y	26.304	22.499	1.169
10	RSA-Y	LinRespSpec	Y	24.306	20.808	1.168
9	RSA-Y	LinRespSpec	Y	22.162	18.990	1.167
8	RSA-Y	LinRespSpec	Y	19.877	17.036	1.167
7	RSA-Y	LinRespSpec	Y	17.464	14.965	1.167
6	RSA-Y	LinRespSpec	Y	14.948	12.799	1.168

5	RSA-Y	LinRespSpec	Y	12.355	10.564	1.170
4	RSA-Y	LinRespSpec	Y	9.722	8.298	1.172
3	RSA-Y	LinRespSpec	Y	7.108	6.053	1.174
2	RSA-Y	LinRespSpec	Y	4.607	3.915	1.177
1	RSA-Y	LinRespSpec	Y	2.385	2.022	1.179

STORY STIFFNESS:

Story	Output Case	Case Type	Shear X	Drift X	Stiff X	Shear Y	Drift Y	Stiff Y
			kN	mm	kN/m	kN	mm	kN/m
HEADROOM	EQ +X	LinStatic	1.248	2.184	571.107	0.069	0.662	0.000
TERRACE	EQ +X	LinStatic	286.282	4.225	67759.713	0.368	0.522	0.000
11	EQ +X	LinStatic	979.823	4.740	206697.667	0.561	1.215	0.000
10	EQ +X	LinStatic	1773.080	5.560	318890.950	0.543	1.330	0.000
9	EQ +X	LinStatic	2432.876	6.042	402638.183	0.544	1.454	0.000
8	EQ +X	LinStatic	2971.642	6.321	470122.533	0.554	1.601	0.000
7	EQ +X	LinStatic	3401.812	6.467	526024.134	0.568	1.734	0.000
6	EQ +X	LinStatic	3733.814	6.471	576997.217	0.565	1.850	0.000
5	EQ +X	LinStatic	3984.015	6.318	630546.476	0.565	1.927	0.000
4	EQ +X	LinStatic	4162.784	6.000	693822.275	0.549	1.932	0.000
3	EQ +X	LinStatic	4282.408	5.493	779574.810	0.508	1.836	0.000
2	EQ +X	LinStatic	4355.140	4.756	915689.399	0.436	1.624	0.000
1	EQ +X	LinStatic	4396.296	3.509	1252751.777	0.420	1.254	0.000
STILT	EQ +X	LinStatic	4405.371	1.889	2331543.523	0.409	0.521	0.000
HEADROOM	EQ +Y	LinStatic	0.202	0.150	1343.180	1.439	5.402	266.466
TERRACE	EQ +Y	LinStatic	1.305	0.434	0.000	612.916	6.187	99066.187
11	EQ +Y	LinStatic	2.974	0.848	0.000	2099.759	6.013	349220.549
10	EQ +Y	LinStatic	5.058	0.798	0.000	3797.051	6.643	571563.033
9	EQ +Y	LinStatic	7.257	0.885	0.000	5205.182	7.276	715414.816
8	EQ +Y	LinStatic	9.532	0.979	0.000	6351.384	7.777	816641.985
7	EQ +Y	LinStatic	11.839	1.043	0.000	7262.827	8.123	894083.394
6	EQ +Y	LinStatic	14.102	1.080	0.000	7962.473	8.279	961711.419
5	EQ +Y	LinStatic	16.336	1.078	0.000	8485.659	8.200	1034853.824
4	EQ +Y	LinStatic	18.449	1.059	0.000	8855.203	7.833	1130433.572
3	EQ +Y	LinStatic	20.367	0.969	0.000	9097.974	7.125	1276829.204
2	EQ +Y	LinStatic	21.985	0.812	0.000	9240.884	5.993	1541903.911
1	EQ +Y	LinStatic	23.270	0.517	0.000	9316.832	4.307	2163264.851
STILT	EQ +Y	LinStatic	23.669	0.225	0.000	9330.748	1.743	5352919.197

STORY FORCES:

Story	Output Case	Case Type	P	VX	VY	T	MX	MY
TERRACE	RSA-X	LinRespSpec	3.920	197.425	32.837	6526.981	160.793	698.328
TERRACE	RSA-Y	LinRespSpec	1.798	15.042	266.342	10208.711	1039.820	174.759
TERRACE	EQ +X	LinStatic	0.000	-286.282	0.368	7262.138	-0.898	-862.588
TERRACE	EQ +Y	LinStatic	0.000	1.305	-612.916	-24771.633	1843.066	4.519
11	RSA-X	LinRespSpec	7.064	449.204	54.542	14662.771	374.761	1994.222
11	RSA-Y	LinRespSpec	5.658	37.934	700.758	26384.771	3380.566	380.188
11	EQ +X	LinStatic	0.000	-979.823	0.561	21090.159	-2.579	-3802.058
11	EQ +Y	LinStatic	0.000	2.974	-2099.759	-80563.934	8142.342	13.439
10	RSA-X	LinRespSpec	9.176	700.086	67.985	21618.973	579.209	4045.244
10	RSA-Y	LinRespSpec	9.593	65.637	1109.378	41152.700	6943.867	619.536
10	EQ +X	LinStatic	0.000	-1773.080	0.543	36243.795	-4.208	-9121.299
10	EQ +Y	LinStatic	0.000	5.058	-3797.051	-142931.08	19533.495	28.612
9	RSA-X	LinRespSpec	11.298	881.319	79.639	25853.756	793.884	6576.939
9	RSA-Y	LinRespSpec	12.909	84.806	1374.986	50590.515	11167.983	864.340
9	EQ +X	LinStatic	0.000	-2432.876	0.544	48871.236	-5.839	-16419.928
9	EQ +Y	LinStatic	0.000	7.257	-5205.182	-194688.38	35149.041	50.384
8	RSA-X	LinRespSpec	12.935	1004.563	93.034	28397.175	1019.234	9411.051
8	RSA-Y	LinRespSpec	14.633	98.171	1553.169	56827.360	15709.454	1092.806
8	EQ +X	LinStatic	0.000	-2971.642	0.554	59206.666	-7.502	-25334.854
8	EQ +Y	LinStatic	0.000	9.532	-6351.384	-236833.94	54203.192	78.979
7	RSA-X	LinRespSpec	14.272	1088.985	108.957	30314.827	1275.100	12413.539
7	RSA-Y	LinRespSpec	14.722	113.582	1695.848	61928.369	20399.655	1331.820
7	EQ +X	LinStatic	0.000	-3401.812	0.568	67479.788	-9.205	-35540.290
7	EQ +Y	LinStatic	0.000	11.839	-7262.827	-270345.10	75991.673	114.495
6	RSA-X	LinRespSpec	15.319	1158.209	124.298	32229.299	1578.782	15493.403
6	RSA-Y	LinRespSpec	13.903	130.930	1834.714	67077.597	25202.858	1616.924
6	EQ +X	LinStatic	0.000	-3733.814	0.565	73876.509	-10.901	-46741.731
6	EQ +Y	LinStatic	0.000	14.102	-7962.473	-296074.06	99879.092	156.801
5	RSA-X	LinRespSpec	16.271	1244.598	136.468	34730.728	1934.143	18625.363
5	RSA-Y	LinRespSpec	13.462	142.938	1990.946	72891.853	30166.802	1966.550
5	EQ +X	LinStatic	0.000	-3984.015	0.565	78738.149	-12.597	-58693.776
5	EQ +Y	LinStatic	0.000	16.336	-8485.659	-315348.91	125336.069	205.809
4	RSA-X	LinRespSpec	17.861	1365.358	145.201	38028.211	2332.809	21866.979
4	RSA-Y	LinRespSpec	13.824	148.684	2175.314	79624.435	35395.102	2371.851
4	EQ +X	LinStatic	0.000	-4162.784	0.549	82239.758	-14.243	-71182.128
4	EQ +Y	LinStatic	0.000	18.449	-8855.203	-328979.26	151901.679	261.157
3	RSA-X	LinRespSpec	19.833	1513.296	152.283	41706.627	2761.404	25330.338
3	RSA-Y	LinRespSpec	14.373	154.229	2378.467	86935.393	41025.638	2816.221
3	EQ +X	LinStatic	0.000	-4282.408	0.508	84610.736	-15.767	-84029.353
3	EQ +Y	LinStatic	0.000	20.367	-9097.974	-337948.76	179195.602	322.258
2	RSA-X	LinRespSpec	20.864	1671.154	158.631	45256.875	3209.146	29134.833
2	RSA-Y	LinRespSpec	14.825	161.849	2563.243	93510.751	47168.569	3287.507
2	EQ +X	LinStatic	0.000	-4355.140	0.436	86077.797	-17.076	-97094.772
2	EQ +Y	LinStatic	0.000	21.985	-9240.884	-343242.27	206918.253	388.213

1	RSA-X	LinRespSpec	21.133	1812.036	164.034	48152.493	3672.768	33350.983
1	RSA-Y	LinRespSpec	15.272	168.807	2696.901	98267.089	53843.327	3779.232
1	EQ +X	LinStatic	0.000	-4396.296	0.420	86924.051	-18.337	-110283.66
1	EQ +Y	LinStatic	0.000	23.270	-9316.832	-346095.64	234868.750	458.024
STILT	RSA-X	LinRespSpec	20.220	1850.666	165.157	48817.063	4141.004	37913.697
STILT	RSA-Y	LinRespSpec	16.175	170.763	2724.795	99157.541	60876.697	4269.868
STILT	EQ +X	LinStatic	0.000	-4405.371	0.409	87110.911	-19.564	-123499.77
STILT	EQ +Y	LinStatic	0.000	23.669	-9330.748	-346600.46	262860.993	529.030
TERRACE	RSA-X	LinRespSpec	3.920	197.425	32.837	6526.981	160.793	698.328
TERRACE	RSA-Y	LinRespSpec	1.798	15.042	266.342	10208.711	1039.820	174.759
TERRACE	EQ +X	LinStatic	0.000	-286.282	0.368	7262.138	-0.898	-862.588
TERRACE	EQ +Y	LinStatic	0.000	1.305	-612.916	-24771.633	1843.066	4.519
11	RSA-X	LinRespSpec	7.064	449.204	54.542	14662.771	374.761	1994.222
11	RSA-Y	LinRespSpec	5.658	37.934	700.758	26384.771	3380.566	380.188
11	EQ +X	LinStatic	0.000	-979.823	0.561	21090.159	-2.579	-3802.058
11	EQ +Y	LinStatic	0.000	2.974	-2099.759	-80563.934	8142.342	13.439
10	RSA-X	LinRespSpec	9.176	700.086	67.985	21618.973	579.209	4045.244
10	RSA-Y	LinRespSpec	9.593	65.637	1109.378	41152.700	6943.867	619.536
10	EQ +X	LinStatic	0.000	-1773.080	0.543	36243.795	-4.208	-9121.299
10	EQ +Y	LinStatic	0.000	5.058	-3797.051	-142931.08	19533.495	28.612

C. KANNAN, B.E., M.E, (Structure)
Structural Engineer,
CMDA Reg. No: SE/I/2024/2/0047
Door No: 21, 4th Main Road,
Indira Nagar, Chennai - 600 020.

ETABS Shear Wall Design (C1)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW100	21685.2	1725	800	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	21685.2	1325	21685.2	2125	800	200
Bottom	Leg 1	21685.2	1325	21685.2	2125	800	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm^2)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm^2
Top	400	0.0025	0.0614	119 0.9 DL+1.5 WL +Y	711.258	-14.5905	33.4853	160000
Bottom	438	0.0027	0.0614	109 -0.45 SL X+1.5 SL Z+1.5 DL	1856.3854	44.0241	-129.8465	160000

Shear Design

Station Location	ID	Rebar mm^2/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	1302.2763	43.8455	-45.4842	57.6	173.0783
Bottom	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	1320.271	79.456	-45.4842	57.6	173.0783

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	0	112 0.45 SL X+1.5 SL Z+0.9 DL	1210.2573	-4.5768	7.78	8
Top–Right	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	1838.3907	43.8455	13.55	8
Bottom–Left	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	1856.3854	-129.8465	17.69	8
Botttom–Right	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	1856.3854	79.456	15.33	8

ETABS Shear Wall Design (C2)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW18	56735.2	29457.4	800	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	56735.2	29057.4	56735.2	29857.4	800	200
Bottom	Leg 1	56735.2	29057.4	56735.2	29857.4	800	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	454	0.0028	0.0614	109 -0.45 SL X+1.5 SL Z+1.5 DL	1967.1242	49.3978	-64.2594	160000
Bottom	1152	0.0072	0.0614	107 1.5 SL X+-0.45 SL Z+1.5 DL	1915.3087	52.2024	145.5791	160000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1258.8436	12.7225	45.4554	57.6	173.0783
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1276.8383	145.5791	45.4554	83.9525	199.4307

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	1967.1242	-29.5998	13.68	8
Top–Right	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	1967.1242	7.3852	12.64	8
Bottom–Left	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	1985.1189	-103.7089	17.27	8
Botttom–Right	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	1985.1189	135.1314	18.74	8

ETABS Shear Wall Design (C3)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW20	33285.2	28224.9	800	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	33285.2	27824.9	33285.2	28624.9	800	200
Bottom	Leg 1	33285.2	27824.9	33285.2	28624.9	800	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm^2)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm^2
Top	920	0.0058	0.0614	109 -0.45 SL X+1.5 SL Z+1.5 DL	2120.0371	-50.6068	69.6583	160000
Bottom	1573	0.0098	0.0614	109 -0.45 SL X+1.5 SL Z+1.5 DL	2138.0318	51.0117	-152.6054	160000

Shear Design

Station Location	ID	Rebar mm^2/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	1485.2443	69.6583	-73.7738	76.7091	192.1874
Bottom	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	1503.239	75.41	-73.7738	97.07	212.5482

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	2120.0371	-0.5054	13.27	8
Top–Right	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	2120.0371	69.6583	16.52	8
Bottom–Left	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	2138.0318	-152.6054	20.52	8
Botttom–Right	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	2138.0318	75.41	16.9	8

ETABS Shear Wall Design (C4)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW1	0	29457.1	800	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	0	29057.1	0	29857.1	800	200
Bottom	Leg 1	0	29057.1	0	29857.1	800	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	1851	0.0116	0.0614	107 1.5 SL X+-0.45 SL Z+1.5 DL	2270.6495	59.1969	-95.4261	160000
Bottom	2669	0.0167	0.0614	107 1.5 SL X+-0.45 SL Z+1.5 DL	2288.6442	59.6018	191.3202	160000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1964.1375	5.8589	62.0756	103.3415	218.8198
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1982.1321	191.3202	62.0756	120.3662	235.8445

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2270.6495	-95.4261	18.66	8
Top–Right	Leg 1	200	106 1.5 SL X+0.45 SL Z+1.5 DL	2270.6495	5.8589	14.47	8
Bottom–Left	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2288.6442	-107.6208	19.35	8
Botttom–Right	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	2289.871	167.3897	22.16	8

ETABS Shear Wall Design (C5)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW49	6.116E-04	20825	800	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	6.12E-04	20425	6.112E-04	21225	800	200
Bottom	Leg 1	6.12E-04	20425	6.112E-04	21225	800	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	3050	0.0191	0.0614	107 1.5 SL X+-0.45 SL Z+1.5 DL	2663.4602	-65.3441	87.0064	160000
Bottom	4129	0.0258	0.0614	107 1.5 SL X+-0.45 SL Z+1.5 DL	2681.4549	65.749	-231.5503	160000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	955.5017	69.7069	-87.5965	121.4315	236.9097
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	973.4964	129.2975	-87.5965	121.4315	236.9097

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	0	101 1.5 DL+1.5 LL	0	0	0	0
Top–Right	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2663.4602	69.7069	19.91	8
Bottom–Left	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	2681.4549	-231.5503	27.61	8
Botttom–Right	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2681.4549	129.2975	22.82	8

ETABS Shear Wall Design (C6)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW38	0	23325	800	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	0	22925	0	23725	800	200
Bottom	Leg 1	0	22925	0	23725	800	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	2987	0.0187	0.0614	107 1.5 SL X+-0.45 SL Z+1.5 DL	2655.0219	-64.5794	86.7307	160000
Bottom	3742	0.0234	0.0614	107 1.5 SL X+-0.45 SL Z+1.5 DL	2673.0166	64.9843	190.854	160000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1565.6538	9.2503	63.1575	121.4315	236.9097
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1583.6485	190.854	63.1575	121.4315	236.9097

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2655.0219	-23.1231	17.68	8
Top–Right	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2655.0219	9.2503	17.03	8
Bottom–Left	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2673.0166	-184.2601	25.34	8
Botttom–Right	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2673.0166	190.854	25.65	8

ETABS Shear Wall Design (C7)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW24	8410	25975	1000	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	8410	25475	8410	26475	1000	200
Bottom	Leg 1	8410	25475	8410	26475	1000	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	4589	0.0229	0.0589	107 1.5 SL X+-0.45 SL Z+1.5 DL	3507.814	-87.4913	-137.974	200000
Bottom	5499	0.0275	0.0589	107 1.5 SL X+-0.45 SL Z+1.5 DL	3530.3074	87.9974	-287.5054	200000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	2744.5492	96.1776	-86.4159	151.7893	296.1372
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	2767.0425	199.0995	-86.4159	151.7893	296.1372

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	3507.814	-30.3786	18.45	8
Top–Right	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	3507.814	96.1776	20.42	8
Bottom–Left	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	3530.3074	-287.5054	26.28	8
Botttom–Right	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	3530.3074	199.0995	23.62	8

ETABS Shear Wall Design (C8)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW3	4000	23425	1000	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	4000	22925	4000	23925	1000	200
Bottom	Leg 1	4000	22925	4000	23925	1000	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	2845	0.0142	0.0025	107 1.5 SL X+-0.45 SL Z+1.5 DL	3094.8072	76.6892	121.7291	200000
Bottom	3623	0.0181	0.0025	107 1.5 SL X+-0.45 SL Z+1.5 DL	3117.3005	77.1953	-257.554	200000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1964.3929	115.3071	-52.8282	140.642	284.9899
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1986.8862	223.9887	-52.8282	151.7893	296.1372

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	3094.8072	-100.835	18.5	8
Top–Right	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	3094.8072	115.3071	18.93	8
Bottom–Left	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	3117.3005	-257.554	23.31	8
Botttom–Right	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	3117.3005	223.9887	22.31	8

ETABS Shear Wall Design (C9)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW66	49635.2	16675	1100	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	49635.2	16125	49635.2	17225	1100	200
Bottom	Leg 1	49635.2	16125	49635.2	17225	1100	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	3816	0.0173	0.058	101 1.5 DL+1.5 LL	3659.9792	-81.0407	156.1591	220000
Bottom	3903	0.0177	0.058	101 1.5 DL+1.5 LL	3684.7219	81.5974	-157.2148	220000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	2722.0673	108.4706	-63.997	166.9683	325.7509
Bottom	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	2746.81	201.5939	-63.997	166.9683	325.7509

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	3469.0144	-48.7865	16.98	8
Top–Right	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	3469.0144	108.4706	18.46	8
Bottom–Left	Leg 1	400	108 0.45 SL X+1.5 SL Z+1.5 DL	3493.7571	-239.5419	21.82	8
Botttom–Right	Leg 1	400	108 0.45 SL X+1.5 SL Z+1.5 DL	3493.7571	201.5939	20.88	8

ETABS Shear Wall Design (C10)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW77	49185.3	10725	1100.1	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	48635.3	10725	49735.4	10725	1100.1	200
Bottom	Leg 1	48635.3	10725	49735.4	10725	1100.1	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm^2)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm^2
Top	6944	0.0316	0.058	109 -0.45 SL X+1.5 SL Z+1.5 DL	4291.3195	112.9266	183.1117	220021
Bottom	7096	0.0323	0.058	107 1.5 SL X+-0.45 SL Z+1.5 DL	4264.8786	111.0868	-241.5244	220021

Shear Design

Station Location	ID	Rebar mm^2/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	3335.1492	34.8212	69.9078	166.9846	325.7827
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	3359.8943	238.0447	69.9078	166.9846	325.7827

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	400	108 0.45 SL X+1.5 SL Z+1.5 DL	4291.3195	-36.3054	20.4	8
Top–Right	Leg 1	400	108 0.45 SL X+1.5 SL Z+1.5 DL	4291.3195	4.507	19.62	8
Bottom–Left	Leg 1	500	106 1.5 SL X+0.45 SL Z+1.5 DL	4264.8786	-241.5244	25.37	8
Botttom–Right	Leg 1	500	106 1.5 SL X+0.45 SL Z+1.5 DL	4264.8786	238.0447	25.28	8

ETABS Shear Wall Design (C11)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW57	49635.2	20675	1100	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	49635.2	20125	49635.2	21225	1100	200
Bottom	Leg 1	49635.2	20125	49635.2	21225	1100	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm^2)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm^2
Top	4182	0.019	0.058	101 1.5 DL+1.5 LL	3753.6496	-83.849	-160.1557	220000
Bottom	4280	0.0195	0.058	101 1.5 DL+1.5 LL	3778.3923	84.4057	161.2114	220000

Shear Design

Station Location	ID	Rebar mm^2/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	3122.9786	86.8678	47.7351	166.9683	325.7509
Bottom	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	3147.7213	228.3675	47.7351	166.9683	325.7509

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	3451.0205	-81.0581	17.7	8
Top–Right	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	3451.0205	86.8678	17.84	8
Bottom–Left	Leg 1	400	108 0.45 SL X+1.5 SL Z+1.5 DL	3475.7632	-201.8097	20.8	8
Botttom–Right	Leg 1	400	108 0.45 SL X+1.5 SL Z+1.5 DL	3475.7632	228.3675	21.46	8

ETABS Shear Wall Design (C12)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW22	49635.2	28324.9	1200	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	49635.2	27724.9	49635.2	28924.9	1200	200
Bottom	Leg 1	49635.2	27724.9	49635.2	28924.9	1200	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm^2)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm^2
Top	7359	0.0307	0.0573	101 1.5 DL+1.5 LL	4820.8568	110.1283	-221.7594	240000
Bottom	7451	0.031	0.0573	101 1.5 DL+1.5 LL	4847.8488	-110.7356	223.001	240000

Shear Design

Station Location	ID	Rebar mm^2/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	4119.9228	94.431	76.1013	182.1472	355.3646
Bottom	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	4146.9148	321.0455	76.1013	182.1472	355.3646

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	500	106 1.5 SL X+0.45 SL Z+1.5 DL	4243.3339	-160.814	21.03	8
Top–Right	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	4243.3339	83.9035	19.43	8
Bottom–Left	Leg 1	500	106 1.5 SL X+0.45 SL Z+1.5 DL	4270.326	-171.1918	21.36	8
Botttom–Right	Leg 1	500	106 1.5 SL X+0.45 SL Z+1.5 DL	4270.326	305.3563	24.15	8

ETABS Concrete Frame Design (C13)

IS 456:2000 + IS 13920:2016 Column Section Design (Summary)

Column Element Details (Part 1 of 2)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
STILT	C8	3562	C300*900	109 -0.45 SL X+1.5 SL Z+1.5 DL	0	3000	0.6

Column Element Details (Part 2 of 2)

Type
Ductile Frame

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
300	900	60	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

ɣc	ɣs
1.5	1.15

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm²	Rebar % %
3197.4515	63.949	95.2454	63.949	111.9108	2160	0.8

Axial Force and Biaxial Moment Factors

	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	0.688897	2500	38.0982	0	111.9108
Minor Bend(M2)	0.638117	2500	8.0916	0	63.949

Axial Compression Check for Seismic Design per IS 13920:2016 Section 7.1

Limit Compression Factor Unitless	Limit Compression Strength kN	Compression D/C Ratio Unitless	Status
0.4	4320	0.740151	OK

Shear Design for V_{u2} , V_{u3}

	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
Major, V_{u2}	23.2084	178.7402	100.8002	20.0428	332.53
Minor, V_{u3}	40.0849	165.2406	86.4007	40.0849	997.59

Additional Moment Reduction Factor k (IS 39.7.1.1)

A_g cm²	A_{sc} cm²	P_{uz} kN	P_b kN	P_u kN	k Unitless
2700	21.6	5670	2145.8291	3197.4515	0.701597

Additional Moment (IS 39.7.1)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	Yes	0.833	900	1.914	12	No	0
Minor Bending (M_2)	Yes	0.833	300	5.318	12	No	0

ETABS Shear Wall Design (C14)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW59	56135.2	21225	1200	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	55535.2	21225	56735.2	21225	1200	200
Bottom	Leg 1	55535.2	21225	56735.2	21225	1200	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	808	0.0034	0.0573	107 1.5 SL X+-0.45 SL Z+1.5 DL	2902.5528	73.7418	-165.0657	240000
Bottom	2932	0.0122	0.0573	107 1.5 SL X+-0.45 SL Z+1.5 DL	2929.5449	74.3491	483.1373	240000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1954.4745	34.4211	151.7937	90.6161	263.8335
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1981.4666	483.1373	151.7937	158.3608	331.5782

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2902.5528	-165.0657	15.53	8
Top–Right	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2902.5528	34.4211	12.81	8
Bottom–Left	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	2929.5449	-358.5376	19.68	8
Botttom–Right	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	2929.5449	483.1373	22.27	8

ETABS Concrete Frame Design (C15)

IS 456:2000 + IS 13920:2016 Column Section Design (Summary)

Column Element Details (Part 1 of 2)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
1	C5	529	C300X450	111 1.5 SL X+-0.45 SL Z+0.9 DL	2400	3000	1

Column Element Details (Part 2 of 2)

Type
Ductile Frame

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
300	450	60	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

γ_c	γ_s
1.5	1.15

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm²	Rebar % %
152.2991	-15.8048	239.852	3.046	3.046	3729	2.76

Axial Force and Biaxial Moment Factors

	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	0.910446	2400	34.4937	0	3.046
Minor Bend(M2)	1	2400	7.7733	0	3.046

Axial Compression Check for Seismic Design per IS 13920:2016 Section 7.1

Limit Compression Factor Unitless	Limit Compression Strength kN	Compression D/C Ratio Unitless	Status
0.4	2160	0.074871	OK

Shear Design for V_{u2} , V_{u3}

	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
Major, V_{u2}	159.9013	102.6295	57.2719	159.9013	406.93
Minor, V_{u3}	59.8116	97.8465	43.2003	59.8116	498.8

Joint Shear Check/Design

	Joint Shear Force kN	Shear V_{Top} kN	Shear $V_{u,Tot}$ kN	Shear V_c kN	Joint Area cm²	Shear Ratio Unitless
Major Shear, V_{u2}	0	0	335.2523	853.815	1350	0.393
Minor Shear, V_{u3}	0	0	149.326	664.0783	1050	0.225

(1.4) Beam/Column Capacity Ratio

Major Ratio	Minor Ratio
0.934	0.542

Additional Moment Reduction Factor k (IS 39.7.1.1)

A_g cm^2	A_{sc} cm^2	P_{uz} kN	P_b kN	P_u kN	k Unitless
1350	37.3	3828.4899	978.1761	152.2991	1

Additional Moment (IS 39.7.1)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	Yes	0.8	450	4.856	12	No	0
Minor Bending (M_2)	Yes	0.8	300	8	12	No	0

ETABS Concrete Frame Design (FB5)

IS 456:2000 + IS 13920:2016 Beam Section Design (Summary)

Beam Element Details (Part 1 of 2)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
7	B379	2112	B200X500	109 -0.45 SL X+1.5 SL Z+1.5 DL	0	4817.6	1

Beam Element Details (Part 2 of 2)

Type
Ductile Frame

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
200	500	200	0	60	60

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
27386.13	30	1	500	500

Design Code Parameters

γ_c	γ_s
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-143.3329	2.1176	122.5612	8.3608

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-143.3329	4.3597	0	-147.6926

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-147.6926		943	0	943	236
Bottom (-2 Axis)		0	471	0	0	471

Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
170.4505	0	187.3912	58.7922	1180.17

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
2.1176	122.5612	100	400	498.25

ETABS Concrete Frame Design (FB11)

IS 456:2000 + IS 13920:2016 Beam Section Design (Summary)

Beam Element Details (Part 1 of 2)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
7	B312	1028	B200X500	109 -0.45 SL X+1.5 SL Z+1.5 DL	5400	5400	1

Beam Element Details (Part 2 of 2)

Type
Ductile Frame

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
200	500	200	0	60	60

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
27386.13	30	1	500	500

Design Code Parameters

Yc	Ys
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-168.429	2.7517	135.2455	11.3376

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-168.429	5.6652	0	-174.0942

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-174.0942		1117	0	1117	279
Bottom (-2 Axis)		0	559	0	124	559

Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
184.3251	0	206.3383	60.8494	1299.5

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
2.7517	135.2455	100	400	585.7

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ETABS Concrete Frame Design (FB11)

IS 456:2000 + IS 13920:2016 Beam Section Design (Summary)

Beam Element Details (Part 1 of 2)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
7	B312	1028	B200X500	109 -0.45 SL X+1.5 SL Z+1.5 DL	5400	5400	1

Beam Element Details (Part 2 of 2)

Type
Ductile Frame

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
200	500	200	0	60	60

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
27386.13	30	1	500	500

Design Code Parameters

ɣc	ɣs
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-168.429	2.7517	135.2455	11.3376

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-168.429	5.6652	0	-174.0942

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-174.0942		1117	0	1117	279
Bottom (-2 Axis)		0	559	0	124	559

Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
184.3251	0	206.3383	60.8494	1299.5

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
2.7517	135.2455	100	400	585.7

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