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SOIL EXPLORATION AND FOUNDATION REPORT

FOR THE PROPOSED BUILDING

AT

PLOT NO. 176,

NEW NO. 5, OLD NO. 74

F- BLOCK, 2ND STREET

ANNA NAGAR EAST

CHENNAI-600 102

PROJECT NO. TJE/003121/2024

T.J.ENGINEERS

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EXPLORATION REPORT

PROJECT NO. TJE/003121/2024

1.INTRODUCTION:

M/S FIRM FOUNDATIONS & HOUSING PRIVATE LIMITED has proposed to construct a Stilt Floor + Five Floors Building at Plot No. 176, New No. 5, Old No. 74, F-Block, 2nd Street, Anna Nagar East, Chennai-600 102. The work was entrusted to T.J. Engineers by the promoter. The location is shown in Fig No.1. The object of the soil exploration work done is to determine the soil properties of the proposed area and to arrive at a most suitable type of foundation system for the proposed structure.

2.0 SCOPE OF WORK

The Scope of Work includes the following

Boreholes

- Drilling of borehole at the proposed borehole locations as per the direction of the client.
- Collection of disturbed and undisturbed soil samples and carrying out the relevant laboratory test on soils.
- Conducting of standard penetration test (SPT) within the borehole at every 1.50m depth interval or as required.
- Collection of soil sample from bore hole.
- Preparation of geotechnical investigation Report.

3.0. LOCATION & NUMBER OF BORE HOLES

For this purpose one bore hole was bored up to maximum depth of 29.00m below existing ground level. The bore hole location is shown in Fig No.1 and bore log details

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are given in Fig No. 2. The bore hole was terminated in the Very Dense Sandy Gravel-(Slate) layer.

4.0. GEOTECHNICAL INVESTIGATIONS

4.1. Filed Investigations of Boreholes

Rotary drilling boring technique was adopted for boring in this area. The Standard penetration tests were conducted at change of layers and at specified intervals, commencing the test at 1.50m below the existing ground level. The relative density of different soil layers obtained from the N-Values are given in the Fig No. 2. Disturbed and un disturbed samples were collected from all the layers for visual observation, classification tests and strength characteristics of the soil layers.

Standard Penetration Test (SPT)

Standard Penetration Tests were conducted using a split spoon sampler, as per relevant codal provision (IS: 2131 – 1981). The SPT is generally conducted in sandy and completely weathered rock strata till 45 cm penetration with number of blows recorded for every 15 cm penetration. The number of blows required for first 15 cm in neglected. The blows for last 30 cm penetration or refusal 'N' value of 100 whichever is earlier is taken as the 'N' value. In the clayey strata, when driving of sampling tube is not possible, SPT was conducted to know the consistency of the soil strata and to retrieve the disturbed soil sample. The soil samples obtained in the split spoon sampler are carefully packed in polythene bags for testing in the laboratory. The SPT values obtained at every 1.50m interval are given in the bore logs.

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4.2. Grain Size Analysis

Combined sieve and hydrometer analyses were conducted on the various samples collected. The results are given in Table-1. Based on the proportion of the different soil constituents, the soil is classified.

4.3. Laboratory Tests for Borehole samples

The following laboratory tests were conducted on collected Soil Samples.

I. Moisture Content as per IS: 2720 (Part 2)

II. Specific Gravity as per IS: 2720 (Part 2)

III. Sieve Analysis as per IS: 2720 (Part 4)

IV. Hydrometer Analysis as per IS: 2720 (Part 4)

V. Liquid Limit as per IS: 2720 (Part 5)

VI. Plastic Limit as per IS: 2720 (Part 5)

VII. Swelling Index as per IS: 2720 (Part 40)

5.0. BORE LOG DATA

The Summary of bore hole log data for BH-01 is given in Fig-2. Bore hole location is given in Fig.1.

6.0. LABORATORY TEST RESULTS

The laboratory test results of boreholes samples are presented in Table-1 and Table-2.

7.0. GROUND WATER TABLE

The ground water table was encountered at the **depth of 2.50m**, below the existing ground level at the time of soil exploration.

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8.0. SUB SOIL PROFILE

From the visual identification from field test results, it is concluding that the sub soil is basically made-up of four distinctive layers.

i. Filled Up Soil 0.00m to 1.00m

ii. Soft to Medium Stiff Sandy Silty Clay, 1.00m to 5.70m SPT's N= 4-6

iii. Loose to Medium Dense Silty Sand, 5.70m to 8.50m SPT's N= 9-12

iv. Medium Dense to Dense Silty Claycy Sand, 8.50m to 19.20m SPT's N= 13-30

v. Very Stiff to Very Hard Sandy Silty Clay, 19.20m to 27.30m SPT's N= 18-68

vi. Very Dense Sandy Gravel-(Slate), 27.30 to 29.00m SPT's N= >100

The soil profile details are presented in the Bore logs, in Fig. 2.

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9.0 FOUNDATION ANALYSIS

From the bore log data from 0.00m to 1.00m Filled Up Soil layer is present. From 1.00m to 5.70m soft to medium stiff Sandy Silty Clay layer is present, this layer has got swelling character. From 5.70m to 8.50m loose to medium dense Silty Sand layers are present. From 8.50m to 19.20m medium dense to dense Silty Clayey Sand layers are present. From 19.20m to 27.30m very stiff to very hard Sandy Silty Clay layer is present, this layer also has got swelling character. Below 27.30m very dense Sandy Gravel-(Slate) layer is seen, this layer is fair to rest pile foundation for heavy loaded structure.

The layer up to 18.00m is the critical zone for open foundation system. Within the critical zone soft to stiff Silty Clayey and loose to medium dense Sandy layers are present, and the Clayey layer has got swelling character. For light loaded structure with column positions are symmetrical and short span, open foundation of **Isolated Footing Foundation** can be adopted. For light loaded structure with column positions are un symmetrical long span sensitive for differential settlement, open foundation of **Continues Strip Raft Footing** or **Raft Foundation** can be adopted. The open foundation can be placed at the minimum **depth of 2.10m** below the existing ground level. The existing ground level was 0.15m higher than the road level at the time of soil investigation.

For heavy loaded structure, if the SBC is not sufficient for the expected loading intensity, it is advisable to provide deep foundation of pile foundations. The pile foundation can be Bored Cast in situ pile. The pile foundation should be terminated at the minimum **depth of 29.00m (Including Anchorage Depth)** below existing ground level.

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The pile should be anchored into the very dense Sandy Gravel-(Slate) layer for minimum of 1.00m depth.

9.1. COMPUTATION OF THE SAFE BEARING CAPACITY AT 2.10m DEPTH

Based on the standard penetration test value the ultimate net bearing capacity (q_u) could be calculated from the following formula.

$q_u = 1.2\ C\ Nc + \gamma\ D_f\ N_q$

The minimum observed N-Value is taken as 5 from Fig. 2.

The corresponding bearing capacity factors are,

$Nc = 5.7$

$N_q = 1$

Where,

C = Un drained shear strength = 2.92 t/m^2

γ = Unit weight of the soil = 1.50 t/m^3

γ' = Submerged unit weight of the soil = 0.50 t/m^3

D_f = Depth of footing = 2.10 m

D_w = Depth of water table = 2.50 m

Substitute all the above values in the formula,

$q_u = 1.2 \times 2.92 \times 5.7 + 1.50 \times 2.10 \times 1$

$= 19.972 + 3.15 = 23.122$ t/m^2

Safe bearing capacity could be considered with a factor of safety of 2.5

Hence, safe bearing capacity $q_s = 23.122/2.50 = 9.249$ t/m^2. Say 9.50 t/m^2.

Therefore, safe bearing capacity of the soil at 2.10m is 9.50 t/m^2

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9.2. SETTLEMENT ANALYSIS FOR THE INTENSITY OF 9.50 t/m ^{2}

LAYER -1, SANDY SILTY CLAY

The Consolidation Settlement of the Clay layer can be calculated using the following formula.

$$S_1 = (C_c / 1 + e_0) H \quad \text{Log} (\sigma'_0 + \Delta\sigma / \sigma'_0)$$

Where

C_c = Coefficient of compression index
= 0.35

e_0 = The initial void ratio
= 1.80

H =The thickness of the compressible clay layer
= 15.90m

σ'_0 = The original effective over burden pressure at the centre of the clay layer
= 7.525 t/m^2

$\Delta\sigma$ = The stress increases at the centre of the clay layer due to foundation loads (or) pressure
= 0.077 t/m^2

S_2 = (0.35 /1+1.80) 15.90 Log (7.525 + 0.077 /7.525)
= 0.125 x 15.90 x 4.421
= 0.8.787m x 10^{-3}
= 8.78mm

TOTAL SETTLEMENT

= 8.78mm < 50mm

The maximum allowable settlement as per IS: 1904-1986 for R.C.C structure with Isolated footing foundation is 50mm. **The settlement is within the permissible limit. Hence it is Safe.**

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9.3. LOAD CARRYING CAPACITY OF THE CONVENTIONAL PILE

Based on the standard penetration test value the ultimate load carrying capacity (q_u) could be calculated from the following formula.

$$\mathbf{Qu} = \mathbf{Qb} + \mathbf{Qs}$$

Qs = Ultimate unit skin friction on an individual layer

$$= Ks\ \sigma'_{vo} \tan\delta\ \pi\ D\ L$$

Where

Ks = Co-efficient of horizontal soil stress = 0.471

σ'_{vo} = average effective overburden pressure = 13.75 t/m^2

δ = angle of wall friction = 32

D = Dia meter of pile = 0.40m

L = Length of individual layer = 1.00m

= 0.471 x 13.75 x 0.624 x 3.14 x 0.40 x 1.00

= 5.075 t

$q_b = Nq\ \sigma'_{vo}\ Ab$

where

Nq = Bearing Capacity Factor = 90

σ'_{vo} = effective overburden pressure at the toe = 14.00 t/m^2

Ab = Cross sectional area at the base

D = Dia of Pile = 0.40m

= 90 x 14.00 x 3.14 x 0.40^2 /4

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= 158.256 t

Qu = Qb + Qs

= 158.256 + 5.075 = 163.331 t

Q safe = Qu/F.S = 163.331/2.5 = 65.332 t Say 65.00 t

The safe load carrying capacity for five different diameter of piles for the **depth of 29.00m** are worked and are given below.

Dia of Pile	Depth of Pile	Safe Load (Tones)
400mm	29.00m	65
450mm	29.00m	82
500mm	29.00m	101
600mm	29.00m	145
750mm	29.00m	226

The above safe loads are provisional and shall be confirmed by conducting pile load test as per the guide line laid down in IS: 2911 (Part: IV).

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10.0. CONCLUSIONS

1. Soil in the shallow depth is fair to adopt open foundation system for light loaded structure.
2. For light loaded structure with column positions are symmetrical and short span, open foundation of **Isolated Footing Foundation** can be adopted. For light loaded structure with column positions are un symmetrical long span sensitive for differential settlement, open foundation of **Continues Strip Raft Footing** or **Raft Foundation** can be adopted.
3. The open foundation can be placed at the minimum **depth of 2.10m** below the existing ground level. The existing ground level was 0.15m higher than the road level at the time of soil investigation.
4. The **Safe Bearing Capacity of the soil at 2.10m depth is 9.50 t/m ^{2}.**
5. All the foundation should rest on 100 mm thick river sand or M Sand and 100mm thick 1:4:8 concrete mat.
6. The foundation bed should be well compacted by ramming before laying PCC.
7. The foundation should rest on the natural undisturbed strata.
8. The sandy Silty Clay layer has got swelling character. **If Isolated footing provided** it is advisable to make the structure as rigid as possible by providing two layers of **grade beam** one at the top of the footing and another one at plinth level, **continues sill slab** and **continues lintel beam** connecting monolithically with column.
9. **For heavy loaded structure,** if the SBC is not sufficient for the expected loading intensity it is advisable to provide **deep foundation of pile.** The pile foundation can be **Bored Cast in situ pile**. The pile foundation can be terminated at the minimum

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depth of **29.00m (Including Anchorage Depth)** below existing ground level, existing ground level at the time of soil investigation.

10. The safe load carrying capacity for five different diameter of piles for the **depth of 29.00m** are worked and are given below.

Dia of Pile	Depth of Pile	Safe Load (Tones)
400mm	**29.00m**	**65**
450mm	**29.00m**	**82**
500mm	**29.00m**	**101**
600mm	**29.00m**	**145**
750mm	**29.00m**	**226**

The above safe loads are provisional and shall be confirmed by conducting pile load test as per the guide line laid down in IS: 2911 (Part: IV)

11. The **pile should be anchored** in to the very dense **Sandy Gravel-(Slate) layer** for **minimum 1.00m depth**.

12. The pile boring should be done with **Percussion** drilling or **Hydraulic** Rotary Drilling with DMC method.

13. Proper precaution should be taken while boring the pile against sliding of bore hole, by maintaining the proper dense bentonite slurry or providing temporary casing or permanent casing and pile concreting should be done as soon as boring is over.

14. The bore hole should be flushed properly before laying concrete. It has to be ensured by comparing the depth of pile bore hole and Tremie Pipe. The depth of Tremie Pipe lowered can be 300mm less than borehole depth. If the gap between bore hole

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bottom and Tremie Pipe bottom is more than 300mm, there is a possibility of slush deposit in the bore hole.

15. For foundation design stress due to any eccentricity and horizontal force should be considered and stability should be checked.
16. It is advisable not to mix deep foundation and shallow foundation in same building. Combined Raft cum Pile can be adopted.
17. All suggested foundation recommendations and precautions should be adopted while undertaking the design aspects and construction activities.

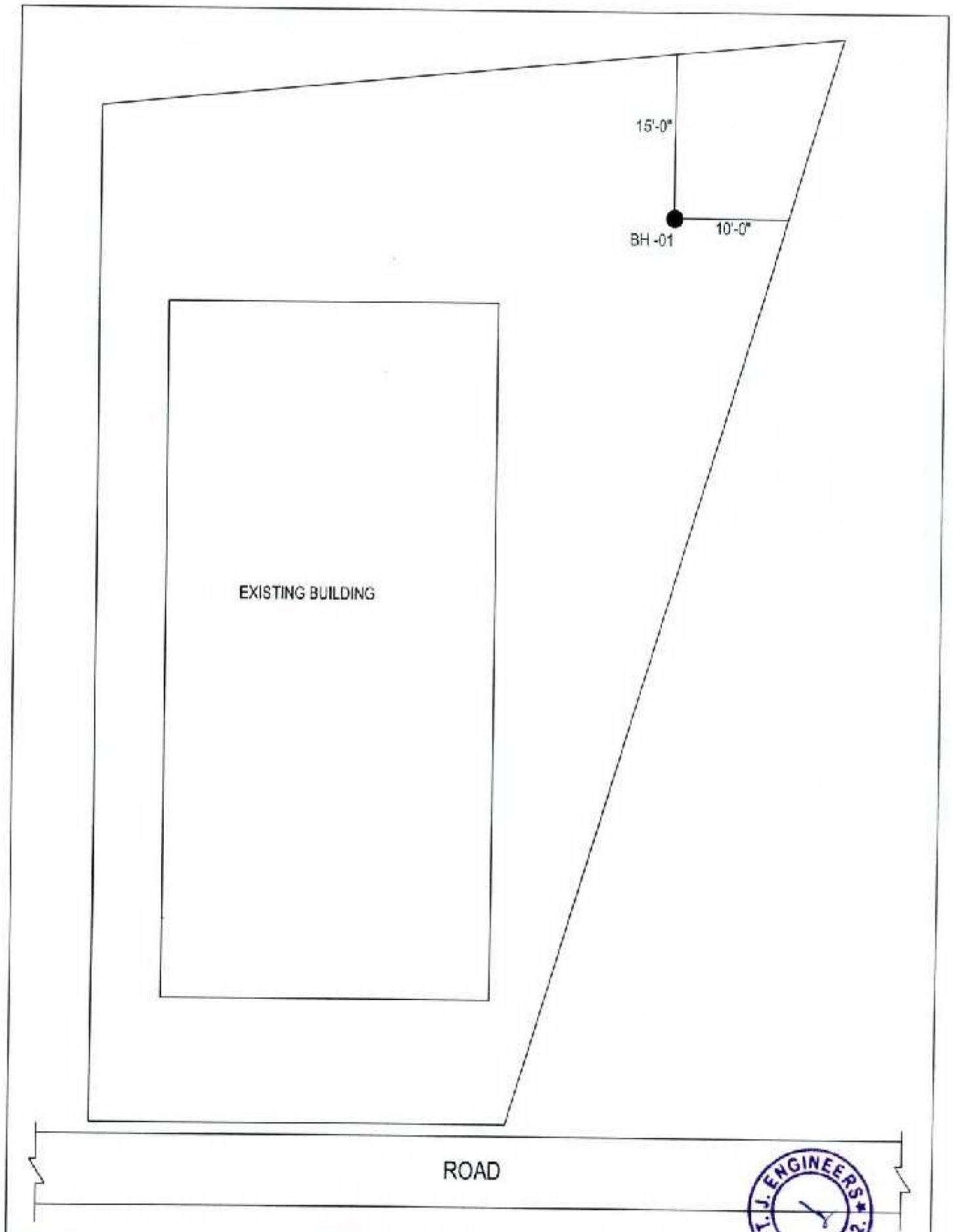
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For T.J. Engineers

07 – 02 – 2024

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DTCP Reg. No. CGLRON/RGTE/2019/07/010

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CLIENT:-	PROJECT:-		
M/S FIRM FOUNDATIONS & HOUSING PRIVATE LIMITED CHENNAI	PROPOSED BUILDING AT PLOT NO. 176, NEW NO. 5, OLD NO. 74, F- BLOCK, 2ND STREET, ANNA NAGAR EAST, CHENNAI-600 102.	SITE PLAN FIG.1	T.J. ENGINEERS

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BORE LOG

PROJECT : Proposed Building at Plot No. 176, New No. 8, Old No. 74, F- Block, 2nd Street, Anna Nagar East, Chennai-600 102.

BORE HOLE NO : B.H.01

TYPE OF BORING : Rotary Drilling

DATE OF COMMENCEMENT : 29 - 01 - 2024

DATE OF COMPLETION : 30 - 01 - 2024

G.W.L : 2.50m

Depth below G.L	Soil profile	Description of soil	Thickness of layer	Depth at which samples are collected		Standard penetration test are			Graphical representation of penetration resistance
				D.S	U.D.S	Depth at which test is conducted	N-Value	Relative density/ Consistency	10 20 30 40 50
0.00		Filled Up Soil	1.00						
1.00				1.00					
						1.50	5	Medium Stiff	
2.00									
3.00		Sandy Silty Clay-SSLC1	4.70			3.00	4	Soft	
		(Brownish Gray)							
4.00						4.50	5	Medium Stiff	
5.00				5.70					
						6.00	5	Loose	
		Silty Sand-SLS1	2.80						
7.00		(Whitish Yellowish Brown)				7.50	12	Medium Dense	
8.00				8.50					
9.00						9.00	13	Medium Dense	
10.00						10.50	15	Medium Dense	
11.00									
12.00						12.00	17	Medium Dense	
		Silty Clayey Sand-SLCS1	10.70						
13.00		(Whitish Gray)				13.50	22	Medium Dense	
14.00									
15.00						15.00	25	Medium Dense	
16.00						16.00	27	Medium Dense	

Remark: All Dimensions in meters

End of Boring

FIG: 2

cont....

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BORE LOG

PROJECT: Proposed Building at Plot No. 176, New No. 5, Old No. 74, F- Block, 3rd Street, Anna Nagar East, Chennai-600 102.

BORE HOLE NO: B.H:01

TYPE OF BORING: Rotary Drilling

DATE OF COMMENCEMENT: 29 - 01 - 2024

DATE OF COMPLETION: 30 - 01 - 2024

G.W.L: 2.50m

Depth below G.L	Soil profile	Description of soil	Thickness of layer	Depth at which samples are collected		Standard penetration test data			Graphical representation of penetration resistance
				D.S	U.D.S	Depth at which test is conducted	N-Value	Relative density/ Consistency	10 20 30 40 50
17.00		**Silty Clayey Sand-SLCS1** **(Whitish Gray)**	10.70			18.00	30	Dense	
18.00				19.20					
20.00						20.00	19	Very Stiff	
21.00						21.50	32	Hard	
23.00		**Sandy Silty Clay-SSLC2** **(Yellowish Brown Whitish Gray)**	8.10			23.00	36	Hard	
24.00									
25.00						25.00	51	Very Hard	
26.00						26.50	56	Very Hard	
27.00				27.30					
28.00		**Sandy Gravel-SG1** **(Slate)** **(Brownish Gray)**				28.00	>100	Very Dense	
29.00						28.30	>100	Very Dense	
30.00									

Remark: All Dimensions in meters

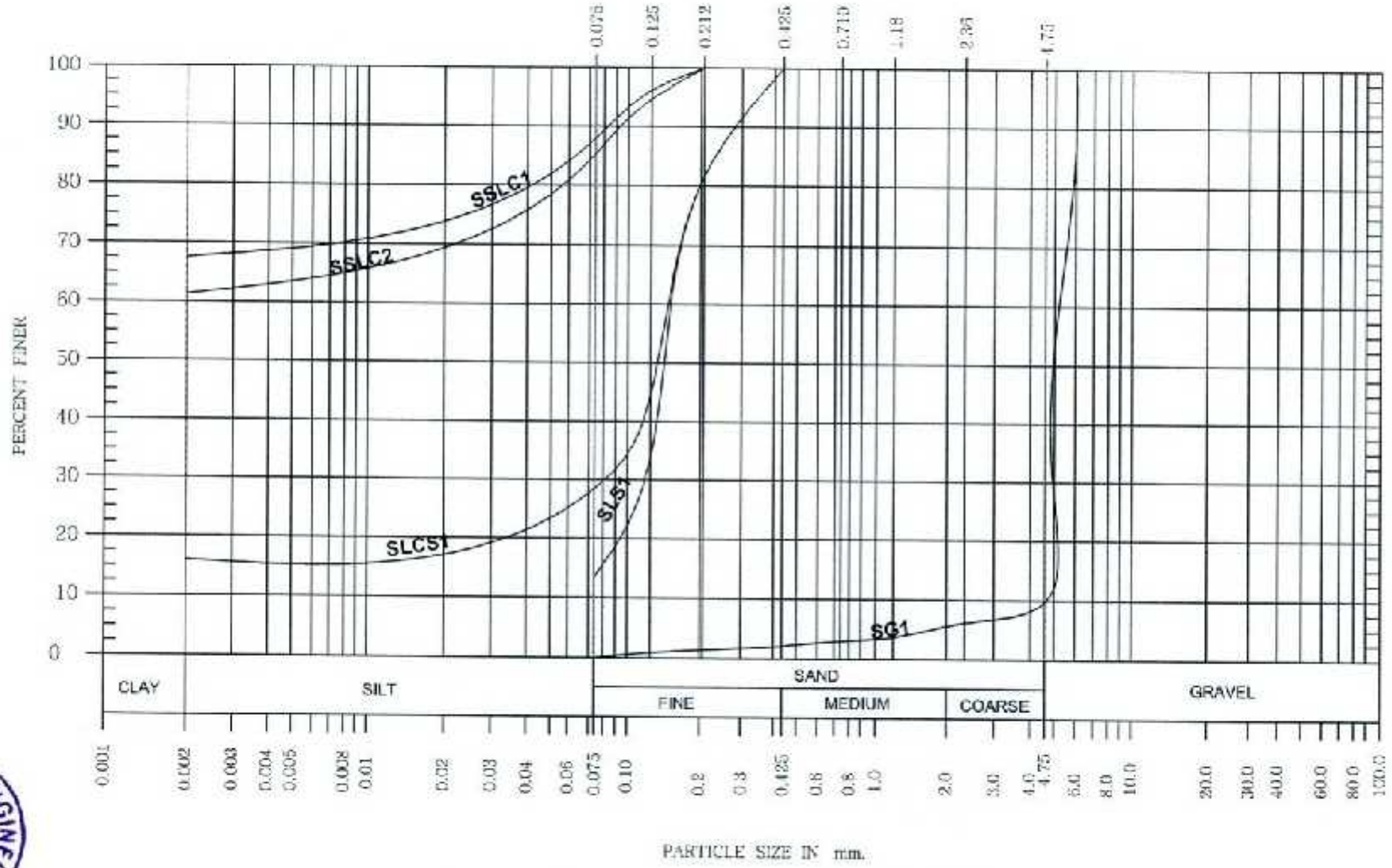
End of Boring

FIG: 2

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Project: Proposed Building at Plot No. 176, New No. 5, Old No. 74, F- Block, 2nd Street, Anna Nagar East, Chennai-600 102.



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FIG. 3 GRAIN SIZE DISTRIBUTION CURVE-BH-01

LABORATARY TEST RESULTS

TABLE-1

B.H No	Layer thickness	Soil classification	Depth of sample collected		SP. gravity	%of free swell	Grain size distribution				Remarks
	m		DS / SPT m	UDS m			Clay %	Silt %	Sand %	Gravel %	
1	0.00 - 1.00	Filled Up Soil	–	–	–	–	–	–	–	–	–
	1.00 - 5.70	Sandy Silty Clay-SSLC1	1.50	–	2.66	36	67	21	12	0	–
	5.70 - 8.50	Silty Sand-SLS1	6.00	–	2.63	–	0	14	86	0	–
	8.50 - 19.20	Silty Clayey Sand-SLCS1	9.00	–	2.65	–	16	12	72	0	–
	19.20 - 27.30	Sandy Silty Clay-SSLC2	20.00	–	2.66	34	62	24	14	0	–
	27.30 - 29.00	Sandy Gravel-(Slate)	29.00	–	2.63	–	0	0	9	91	–

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LABORATARY TEST RESULTS

TABLE -2

B.H No	Layer thickness	Soil classification	Depth of sample collected		LL	PL	Bulk density	Consolidation Parameters		Shear Strength Parmeters		Remarks
	m		DS / SPT m	UDS m	%	%	t/m³	e_o	Cc	Cu t/m²	Ø degree	
1	0.00 - 1.00	Filled Up Soil	–	–	–	–	–	–	–	–	–	–
	1.00 - 5.70	Sandy Silty Clay-SSLC1	1.50	–	66	26	1.50	1.80	0.35	2.92	–	–
	5.70 - 8.50	Silty Sand-SLS1	6.00	–	–	–	1.53	–	–	–	30	–
	8.50 - 19.20	Silty Clayey Sand-SLCS1	9.00	–	–	–	1.56	–	–	–	36.00	–
	19.20 - 27.30	Sandy Silty Clay-SSLC2	20.00	–	59	23	1.55	1.30	0.25	12.10	–	–
	27.30 - 29.00	Sandy Gravel-(Slate)	29.00	–	–	–	1.60	–	–	–	40	–

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