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REPORT ON
SOIL INVESTIGATION FOR THE CONSTRUCTION OF 288
TENEMENTS (STILT + 9 FLOORS) FOR TNUHDB AT
THIRUVALLUVAR SALAI, VANNIAPURAM, CHENNAI

CLIENT
THE EXECUTIVE ENGINEER,
DIVISION V,
TAMILNADU URBAN HABITAT DEVELOPMENT BOARD (TNUHDB),
CHENNAI.

CONSULTANTS

Dr. V. B. Maji
Dr. A. Boominathan



GEOTECHNICAL ENGINEERING DIVISION
DEPARTMENT OF CIVIL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY MADRAS
CHENNAI - 600 036

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REPORT ON SOIL INVESTIGATION FOR THE CONSTRUCTION OF MULTISTORIED TENEMENT BUILDINGS FOR TNUHDB AT THIRUVALLUVAR SALAI, VANNIAPURAM, CHENNAI.

1. INTRODUCTION

On a request from the Executive Engineer, Division- V, Tamil Nadu Urban Habitat Development Board (TNUHDB), Chennai, the Geotechnical Engineering Division of Indian Institute of Technology Madras undertook the consultancy for geotechnical Investigation to determine the soil properties and recommend a suitable type of foundations for the construction of 288 multistoried tenements (stilt+9 floors) at Thiruvalluvar Salai, Vanniapuram, Chennai.

The field investigation consists of drilling boreholes, carrying out standard penetration tests in the boreholes, collecting soil samples, and groundwater table observation. The drilling of boreholes at the site was carried out from 18th April 2022 to 28th April 2022 by M/s. Geotechnical Solutions, Chennai under the guidance of the undersigned in the presence of Engineers from Tamil Nadu Urban Habitat Development Board. This report presents the details of the field and laboratory investigations carried out for this project scheme, evaluation of design soil parameters, recommendations on the capacity of soil strata, and the type of foundations to be adopted for the proposed buildings.

2. FIELD INVESTIGATIONS

The investigation program comprises sinking five (5 Nos.) exploratory boreholes at the locations shown in **Figure 1**. These boreholes were advanced up to a maximum depth of about 27 m below the ground level.

Exploratory boreholes were advanced from the existing ground level using rotary drilling techniques supplemented by bentonite mud circulation. Mud circulation was used to stabilize the sides and the bottom of the boreholes, and then to bring the soil cuts to the surface. The use of drilling mud will also help in preventing the disturbance



The bore logs of all boreholes are shown in **Annexure 1**. Field N values at different

depths, the depth, and thickness of different soil layers are presented in these bore logs. **Figure 2** (a, b) shows the pictures taken during the site investigation.



Figure 2 a): Images were taken during site investigation



Figure 2 b): Images were taken during the site investigation

3. LABORATORY INVESTIGATIONS

Grain size analyses on selected samples were conducted on oven-dried samples since accurate dry weights of test specimen prior to washing through 75 micron sieve is necessary in this case. The liquid limit of the soil is determined with the standard Casagrande liquid limit apparatus. The Casagrande grooving tool is used for making a groove in the soil sample. The water content corresponding to 25 blows in the flow curve is taken as the liquid limit of the soil. Air-dried sample passing through IS sieve 425 micron is used for determining the liquid limit and plastic limit of the soil sample. About 15 g of the soil sample is taken for plastic limit determination and is mixed with

a sufficient quantity of water which would enable the soil mass to become plastic enough to be easily shaped into a ball.

Laboratory test results such as determination of natural moisture content, specific gravity, Atterberg's limits, unconfined compression tests, and grain size analysis are presented in **Annexure 2**. **Figure 3** shows the pics of the rock samples collected from the boreholes.



Figure 3: Rock samples collected from site investigation

4. SITE CHARACTERIZATION

The site characterization is carried out on the bore logs obtained from the field and laboratory investigations carried out at the project site.

4.1. Soil Profiling based on Bore logs

In general, the soil profile obtained from the bore logs such as the soil stratification and variation in the layer thickness at the site as follows.

The top layer in the site predominantly consists of filled-up layer up to a depth of 1.4 m from the ground level. It is followed by fine/medium size loose/medium dense sand layers mixed with brick pieces/clay lumps up to a depth of about 2.9m to 5.2m from the ground level. It is followed by dark grey soft silty clay layers mixed with organic patches/mica/sand pockets occurring up to a depth of about 8.3m to 9.6m from the ground level. Below this depth, fine/medium size loose/medium dense sand layers mixed with brick pieces/clay lumps up to a depth of about 14.2m from the ground level. Similarly, alternating layers of soft/medium stiff/stiff clay and loose/medium dense sand are observed up to a depth of about 18.5m to 21.7m from the ground surface. From the depth of 18.5 to 23.4m, a hard clay layer exists. In general, alternate layers of clay and sand exist at the present site. From the depth starting from 21.7m to 25m, weathered shale sediments with a very high penetration resistance are present. A jointed weathered shale layer is encountered at a depth below 24 to 25 m from ground level up to the borehole termination depth as shown in the bore logs. The lateral profile of the investigation site is shown in **Annexure 3**.

4.2. Groundwater Table

During the period of field investigation, the groundwater table was encountered at a depth of 2 to 2.2 m from ground level. The groundwater table may be expected to come at a shallow depth during the monsoon period. However, for the foundation analysis, the ground water table level is considered at the ground level.

4.3. Shear strength

Standard Penetration Test blow counts N is measured at different levels in the borehole. Shear strength parameters for cohesionless soils were selected based on SPT results and grain size distribution analyses. Conventional method of estimating the angle of shearing resistance ϕ corresponding to the corrected SPT N value is adopted. The N values are corrected for overburden and dilatancy as usual before arriving at the angle of friction. For cohesive soils, the shear strength parameters were selected based on SPT results. The N values are not corrected for overburden and dilatancy and suitable values of cohesion are considered. The shear strength of weathered shale layers are selected from Cole and Stroud recommendations as given

in IS: 2911(Part I/ Sec 2) –2010.

4.4. Liquefaction Susceptibility

Liquefaction is a phenomenon in which the soil loses its strength and stiffness due to the shaking which takes place during an earthquake. It can occur in saturated cohesionless soils if earthquake characteristics and soil conditions are favorable. The present site falls in zone 3 as per the seismic zonation map provided in IS 1893-Part I: 2016. According to that, a moderate level earthquake may be expected at the site. The soft clay layers may not liquefy but undergo strain-softening behaviour. Some loose sand layers present at deeper depths may liquefy. In view of that, the pile foundations shall be adopted, and the piles shall be anchored into the hard strata.

5.0. SELECTION OF TYPE OF FOUNDATION AND ESTIMATION OF FOUNDATION CAPACITY

5.1. Selection of Type of Foundation

The subsoil of the site consists of alternate layers of soft/medium stiff clay and loose/medium dense sand layers up to a depth of about 21m from the ground level. Therefore, it is not feasible to adopt shallow foundations because of higher settlement caused by the loose sand/soft clay layers present within the zone of influence. Further, the jointed weathered shale layers are encountered from a depth of 24 to 25 m to the borehole termination depth. Hence considering the anticipated load intensity induced by the proposed buildings and the nature of the soil strata at the site, it is recommended to adopt bored cast-in-situ piles to support the proposed buildings.

5.2. Bored cast-in-situ piles

5.2.1. Safe compression and Uplift Load Capacity of piles

The ultimate end bearing capacity of the bored cast in-situ pile, Q_b is calculated using the following formula as per IS: 2911(Part I/ Sec 2) –2010.

$$Q_b = A_p N_c C_p$$

where,

D = Stem diameter in m.

A_p = Cross sectional area of pile toe in m^2

C_p = Average cohesion at pile tip in kN/m^2

N_c = Bearing capacity factor = 9

The ultimate frictional resistance of the pile in cohesionless soil is calculated using the following formula,

$$Q_{f1} = \sum_i^n K P_{Di} \tan \delta A_{Si}$$

where,

K = Coefficient of earth pressure,

P_{Di} = Effective overburden pressure in kN/m^2 for the i^{th} layer where i varies from 1 to n

δ = Angle of wall friction between pile and soil

A_{Si} = Surface area of pile stem in m^2 in the i^{th} layer where i varies from 1 to n .

The frictional resistance of the cohesive soil, Q_{f2} is calculated using the following equation,

$$Q_{f2} = \alpha C A_s$$

α = Reduction factor

C = Average cohesion throughout the length of the pile in kN/m^2

A_s = Surface area of pile stem in m^2

Negative skin friction is considered for very soft clay and very loose sand layers. The positive skin friction from loose sand and soft clay layers are not considered for the pile capacity calculations. The parameters used to estimate the bearing capacity of the pile were considered based on the corrected SPT N values. The factor of safety of 2.5 is used in the estimation of safe load carrying capacity of the piles.

The uplift capacity of the pile is calculated with a factor of safety of 4 against the positive skin friction. The safe compression and uplift capacity is estimated and the details are presented in **Appendix A**. The bearing stratum for the piles is considered as the weathered shale layer. The safe compression and uplift capacities of piles are calculated based on the soil profile of the boreholes BH1. The estimated pile capacities are presented in **Table 1**.

Table 1: Safe compression and uplift capacity of piles

Pile diameter (mm)	500	600	750
Safe compression capacity, kN	910	1221	1765
Safe Uplift capacity, kN	395	495	665

5.2.2. Lateral Load Capacity of the piles

The safe lateral capacity of piles is governed by the shear strength and modulus of the soil below the pile cut-off level. Generally, soil for a depth of five to seven times the pile diameter influences the resistance to lateral loading. Thus, the safe lateral capacity of piles will depend on the soil present at shallow depth. The safe lateral capacity of pile is estimated restricting the pile head deflection at the cut-off level embedded in soil as 5mm. The equivalent cantilever procedure suggested in IS 2911 (Latest revision) is used for estimating the safe lateral capacity corresponding to 5mm deflection at the pile head.

The safe Lateral Load carrying capacity of piles is calculated using the following formula as per IS 2911 (Part II/ sec 2):2010:

$$H = y * \frac{3EI}{(e + Z_f)^3} \quad \text{for Free head pile}$$

$$H = y * \frac{12EI}{(e + Z_f)^3} \quad \text{for Fixed head pile}$$

Where,

H = Lateral capacity in kN

E = Young's Modulus of the pile material in kN/m²

I = Moment of Inertia of the pile cross section in m⁴

y = Permissible deflection in m

Z_f = Depth to point of fixity in m

e = Cantilever length above ground to the point of load application

Typical estimation of safe lateral capacities corresponding to 5mm allowable deflection at the pile head is presented in **Appendix B**. The estimated lateral load capacity of the piles is summarized in **Table 2**.

Table 2: Lateral load capacity of the Pile

Pile diameter in mm	500	600	750
Safe lateral capacity (Fixed head) in kN	19.8	26.5	37.8
Depth to point of fixity in m (Fixed head)	6.1	7.1	8.5
Safe lateral capacity (Free head) in kN	7.1	9.5	13.6
Depth to point of fixity in m (Free head)	5.4	6.3	7.5

5.2.3. Pile Termination Depth

In view of the occurrence of the weathered shale layer below 23 to 24 m, it is desirable to terminate at the pile at a depth of 25m from the ground level.

6. SUMMARY AND RECOMMENDATIONS

It is proposed to construct 288 multistoried tenements (stilt+ 9 floors) at Thiruvalluvar Salai, Vanniapuram, Chennai. A detailed subsoil investigation using five exploratory boreholes was carried out to access the subsoil profile.

The top layer in the site predominantly consists of a filled up layer up to a depth of 1.4 m from the ground level. The subsoil of the site consists of alternate layers of soft/medium stiff clay and loose/medium dense sand layers up to a depth of about 21m from the ground level. A jointed weathered shale layer is encountered at a depth of 24 to 25 m from the ground level.

In the view of presence of a weak soil layers at shallow depths and considering the anticipated load intensity, it is recommended to adopt bored cast-in-situ concrete piles to support the proposed buildings.

a) The following type of foundation is recommended to support the proposed buildings:

- Type of foundation – Bored cast in-situ pile
- Pile termination depth – 25 m below E.G.L
- Pile cut off level – 1.5 m below the existing ground level
- Type of soil at pile termination – Jointed Weathered Shale layer

- Recommended pile capacities

Pile diameter (mm)	500	600	750
Safe compression capacity, kN	910	1220	1765
Safe uplift capacity, kN	395	495	665
Safe lateral capacity (Fixed head) in kN	19.8	26.5	37.8
Depth to point of fixity in m (Fixed head)	6.1	7.1	8.5
Safe lateral capacity (Free head) in kN	7.1	9.5	13.6
Depth to point of fixity in m (Free head)	5.4	6.3	7.5

- b) Pile capacities are calculated by using the static formula as per IS 2911-Part 1/Sec 2 (2010).
- c) The recommended safe load carrying capacities of the piles shall be confirmed by carrying out initial load tests (compression and lateral) on piles before the construction of piles and routine load test as per IS 2911-Part 4 (1985).
- d) It is recommended to carry out pile integrity tests on working piles minimum 25 percent of the total number of piles in each block.
- e) It is recommended to provide at least a two or more piles per pile group using suitable pile diameter instead of single pile–single column by selecting appropriate pile diameter to provide better resistance to bending forces from the column loads. All the pile caps must be rigidly inter-connected with each other in both the directions.
- f) Since the fill is present up to a depth of 1.4m, and the loose sand/soft clay layer occurs up to deeper depths, the lateral load carrying capacity of the piles will not be high. Hence, it is recommended to provide additional reinforcement of 25% at the pile top considering the design depth of fixity to achieve the required lateral pile capacity.
- g) Good quality of bentonite with a liquid limit of approx. 350 is recommended to be used as the drilling mud in boring operations. Proper cleaning of borehole bottom after lowering the reinforcement cage shall be strictly employed as quality control measures.

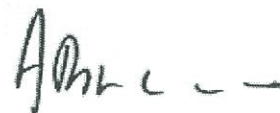
7. ACKNOWLEDGEMENT

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ANNEXURE 1

BORE HOLE NO:		BH/1
Date of start	:	13-Apr-2022
Date of finish	:	14-Apr-2022
GWL from GL	:	2.10m
Ground level RL	:	100.140m

Dia and type of boring : 150mm Rotary boring with drilling mud circulation

Depth from GL(m)		Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency	
						Test depth m	Blow Counts						
				UDS	DS		15	30	45	60	N**		
1.0	0.8		Greyish brown sandy silty clay with brick pieces with 100mm PCC		0.50							Fill	
2.0			Yellowish brown fine to medium sand with clay lumps		0.75							Medium dense	
3.0	2.9				1.50	1.50	10	11	14	16	25		
4.0	3.7		Greyish brown fine to medium sand with sandy clay lumps		2.25	2.25	7	7	5	9	12	Loose	
5.0	4.8		Dark grey silty clay with organic patches		3.00	3.00	5	3	4	3	7	Stiff	
6.0			Dark grey silty clay	4.50	3.75	3	5	7	8	12			
7.0					Not collected								
8.0	7.2				5.00	VST	Vane shear, S_u					0.162	
9.0	8.4		Dark grey silty clay with mica and shells		5.50	5.50	1	1	2	2	3	Soft	
10.0	9.7		Greyish clayey silty fine to medium sand with shells and sandy clay		6.50	6.50	1	1	1	2	2	Soft	
11.0					7.50	7.50	1	1	1	1	2		
12.0	12.6		Greyish dirty fine to medium sand		8.50	8.50	1	1	1	2	2	Loose	
13.0			Light greenish grey clayey silty fine sand with mica and sandy clay lumps		10.00	10.00	7	6	9	5	15	Medium dense	
14.0	14.1				11.50	11.50	7	9	9	11	18		
15.0	15.8		Light greenish grey silty clay with fine sand pockets		13.00	13.00	2	2	3	2	5	Loose	
16.0			Light greenish grey silty clay with fine sand pockets		14.50	14.50	1	2	1	1	3	Soft	
17.0	18.5				16.00	16.00	2	3	2	4	5		
18.0			Greyish silty clay		17.50	17.50	2	4	3	3	7	Medium stiff	
19.0	20.0		Light greenish grey sandy silty clay with brown patches		19.00	19.00	16	27	30		57	Hard	
20.0													
Continued in the next sheet				Borehole terminated at 25.50m									
**Note: SPT Conducted using winch cat-head device, N values reported are close to N_{ES}													

FIELD BORE LOG

Project

Site : Thiruvalluvar Salai, Vanniyapuram, Chennai 600018

Dia and type of boring : 150mm Rotary boring with drilling mud circulation

BORE HOLE NO:		BH/1	
Date of start	:	13-Apr-2022	
Date of finish	:	14-Apr-2022	
GWL from GL	:	2.10m	
Ground level RL	:	100.140m	

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency
			UDS	DS	Test depth m	Blow Counts					
						15	30	45	60	N**	
21.0		Light greenish grey and brown clayey silty fine sand with weathered shale		20.50	20.50	50/15cm				>100 RB	Hard clay
22.0				21.00	Rebound				RB		
23.0		Light grey and brown severely jointed weathered shale with black patches	21.50-22.50	DC Core drilling						R 19% Q nil	Weak to moderate soft rock
24.0			22.50-23.50	DC Core drilling						R 44% Q nil	
25.0		Light greyish brown jointed weathered shale with black patches	23.50-24.50	DC Core drilling						R 61% Q 40%	
26.0	24.50-25.50		DC Core drilling						R 65% Q 15%		
27.0		TC core drillin from 21.00m to 21.50m DC core drilling from 21.50m to 25.50m									
28.0											
29.0											
30.0											
31.0											
32.0											
33.0											
34.0											
35.0											
36.0											
37.0											
38.0											
39.0											
40.0											
Continued from sheet 1			Borehole terminated at 25.50m								
**Note: SPT Conducted using winch cat-head device, N values reported are close to N ₆₅											

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Dia and type of boring : 150mm Rotary boring with drilling mud circulation

BORE HOLE NO:	BH/2
Date of start	: 16-Apr-2022
Date of finish	: 19-Apr-2022
GWL from GL	: 2.20m
Ground level RL	: 100.250m

Depth from GL(m)		Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency	
						Test depth m	Blow Counts						
				UDS	DS		15	30	45	60	N**		
1.0	1.0		Brownish grey fine to medium sand with stones with 100 PCC	4.50	0.50							Fill	
2.0		Yellowish brown fine to medium sand	0.75									Medium dense	
3.0			1.50		1.50	10	11	9	10	20			
4.0	3.7		2.25		2.25	7	7	8	10	15			
5.0	4.3		3.00		3.00	5	7	7	8	14			
6.0	5.3	Light grey and brown clayey fine to medium sand	3.75		3.75	5	2	3	2	5		Loose	
7.0		Dark grey silty clay with organic patches	5.00		Collected							Soft	
8.0		Greyish silty clay	6.00		VST	Vane shear, S _u					0.251		
9.0	8.8		7.00		7.00	1	1	1	1	2	Soft		
10.0	9.7		8.00		8.00	1	1	1	1	2			
11.0			9.00		9.00	6	6	9	5	15		Medium dense	
12.0		Light greenish grey fine to medium sand with brown patches	10.00		10.00	6	10	12	13	22	Medium dense		
13.0			11.50		11.50	7	9	10	12	19			
14.0	14.0		13.00		13.00	7	10	12	12	22			
15.0			14.50		14.50	2	3	3	3	6		Medium stiff	
16.0		Greyish silty clay with sand pockets	16.00		16.00	3	4	3	3	7			
17.0	17.2		17.50		17.50	11	12	13	15	25	Medium dense		
18.0		Light greenish grey clayey fine to medium sand with brown patches	19.00		19.00	13	14	15	17	29			
19.0													
20.0	20.0												
Continued in the next sheet				Borehole terminated at 26.40m									
**Note: SPT Conducted using winch cat-head device, N values reported are close to N _{63.5}													

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FIELD BORE LOG

Project :
Site : Thiruvalluvar Salai, Vanniyapuram, Chennai 600018

Dia and type of boring : 150mm Rotary boring with drilling mud circulation

BORE HOLE NO:		BH/3
Date of start	:	20-Apr-2022
Date of finish	:	21-Apr-2022
GWL from GL	:	2.00m
Ground level RL	:	100.470m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency
			UDS	DS	Test depth m	Blow Counts					
						15	30	45	60	N**	
1.0		Brownish grey fine to medium sand with brick pieces and stones with 150 mm PCC		0.50							Fill
2.0		Brownish grey clayey silty fine to medium sand with brick pieces		0.75							Loose
3.0		Yellowish brown fine to medium sand with clay lumps		1.50	1.50	6	3	3	4	6	Medium dense
4.0		Light greenish grey and brown fine to medium sand		2.25	2.25	5	4	6	4	10	Loose
5.0		Dark grey silty clay with medium sand pockets		3.00	3.00	6	7	9	7	16	Soft
6.0		Greyish silty clay		3.75	3.75	4	5	3	3	8	Loose
7.0				4.50	4.50	2	1	1	1	2	Soft
8.0				5.50	5.50	1	0	1	1	1	Loose
9.0				6.50	6.50	1	0	1	0	1	Medium dense
10.0				7.50	7.50	1	0	1	1	1	Loose
11.0				8.50	8.50	2	3	3	3	6	Medium stiff
12.0				10.00	10.00	2	4	4	5	8	Loose
13.0				11.50	11.50	4	6	5	7	11	Medium dense
14.0				13.00	13.00	5	7	9	13	16	Medium stiff
15.0				14.50	14.50	2	3	3	3	6	Loose
16.0				16.00	16.00	3	3	5	10	8	Medium stiff
17.0				17.50		3	5	5	8	10	Medium stiff
18.0				19.00	19.00	5	6	5	5	11	Medium stiff
19.0											
20.0											

Continued in the next sheet

Borehole terminated at 26.95m

**Note: SPT Conducted using winch cat-head device, N values reported are close to N_{63.5}

FIELD BORE LOG

Project :
Site : Thiruvalluvar Salai, Vanniyapuram, Chennai 600018

Dia and type of boring : 150mm Rotary boring with drilling mud circulation

BORE HOLE NO:		BH/3	
Date of start	:	20-Apr-2022	
Date of finish	:	21-Apr-2022	
GWL from GL	:	2.00m	
Ground level RL	:	100.470m	

Depth from GL(m)		Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency
						Test depth m	Blow Counts					
				UDS	DS			15	30	45	60	
21.0	20.9		Brownish grey clayey silty fine to medium sand		20.50	20.50	4	6	7	9	13	Stiff
22.0	21.7		Light grey and brown sandy silty clay									
23.0			Light grey and yellowish brown sandy silty clay with weathered shale			22.00	22.00	22	33	37	70	Hard clay
24.0	23.4											
25.0	25.0		Light grey and brown weathered jointed shale			23.95-24.95	DC Core drilling					R 31% Q 11%
26.0		Light greyish brown severely jointed weathered shale with black patches	24.95-25.95	DC Core drilling					R 50% Q 10%	Weak soft rock		
27.0	27.0		25.95-26.95	DC Core drilling					R 53% Q 43%			
28.0												
29.0												
30.0												
31.0												
32.0												
33.0												
34.0												
35.0												
36.0												
37.0												
38.0												
39.0												
40.0												
		TC core drillin from 23.40m to 23.95m DC core drilling from 23.95m to 26.95m										
Continued from sheet 1				Borehole terminated at 26.95m								
**Note: SPT Conducted using winch cat-head device, N values reported are close to N ₆₀												

FIELD BORE LOG

Project :
Site : Thiruvalluvar Salai, Vanniyapuram, Chennai 600018

Dia and type of boring : 150mm Rotary boring with drilling mud circulation

BORE HOLE NO:		BH/4
Date of start	:	22-Apr-2022
Date of finish	:	23-Apr-2022
GWL from GL	:	2.00m
Ground level RL	:	100.540m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency
					Test depth m	Blow Counts					
			UDS	DS		15	30	45	60	N**	
1.0		Reddish and brown sandy silty clay with stone pieces with 150mm PCC	6.50	0.50							Fill
	1.2			0.75							
2.0		Greyish brown clayey silty fine to medium sand with sandy clay lumps		1.50	1.50	2	2	2	2	4	Loose
	2.2										
3.0		Greyish brown dirty fine to medium sand		2.25	2.25	2	5	3	6	8	Loose to medium
	3.7										
4.0		Greyish brown sandy silty clay with brown patches		3.00	3.00	6	10	9	11	19	
	4.4										
5.0				3.75	3.75	1	2	2	2	4	Soft
	6.3										
6.0		Greyish silty clay		4.50	4.50	1	1	1	1	2	Soft
	7.2			5.50	5.50	1	1	1	1	2	
7.0		Greyish silty clay with sand pockets and mica		6.50	Collected						Soft
	7.2			7.00	VST	Vane shear, S_u				0.325	
8.0				7.50	7.50	1	1	1	1	2	
	9.6										
9.0		Greyish silty clay with mica flakes.		8.50	8.50	1	1	1	1	2	Soft
	14.1										
10.0				10.00	10.00	2	3	2	2	5	
11.0											
12.0		Greyish fine to medium sand	11.50	11.50	3	3	4	3	7	Loose	
13.0											
			13.00	13.00	5	6	6	6	12		
14.0											
			14.50	14.50	1	2	1	2	3		
15.0											
16.0		Greyish silty clay with mica and white stones	16.00	16.00	1	2	2	2	4	Soft	
	17.3										
17.0			17.50	17.50	6	7	8	10	15	Medium dense	
	18.5										
18.0		Light greyish and brown clayey silty fine to coarse sand									
19.0			19.00	19.00	20	31	37		68	Hard clay	
	20.0										
20.0		Light grey and brown sandy silty clay									
Continued in the next sheet			Borehole terminated at 25.80m								

**Note: SPT Conducted using winch cat-head device, N values reported are close to N_{60}

FIELD BORE LOG

Project :
Site : Thiruvalluvar Salai, Vanniyapuram, Chennai 600018

Dia and type of boring : 150mm Rotary boring with drilling mud circulation

BORE HOLE NO:		BH/4
Date of start	:	22-Apr-2022
Date of finish	:	23-Apr-2022
GWL from GL	:	2.00m
Ground level RL	:	100.540m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST					RD / Consistency
					Test depth m	Blow Counts				
			UDS	DS		15	30	45	60	
21.0		Light grey and brown sandy silty clay		20.50	20.50	21	35	40	75	Hard clay
22.0		22.00			Rebound			RB		
23.0		22.80			Rebound			RB	Very weak	
24.0		Light grey and brown weathered severely jointed shale	22.80-23.80		DC Core drilling			R 38% Q nil		Weak soft rock
25.0	Light greyish brown jointed weathered shale with black patches	23.80-24.80		DC Core drilling			R 56% Q 21%			
26.0		24.80-25.80		DC Core drilling			R 55% Q 24%			
27.0										
28.0										
29.0										
30.0										
31.0										
32.0										
33.0										
34.0										
35.0										
36.0										
37.0										
38.0										
39.0										
40.0	TC core drillin from 22.00m to 22.80m DC core drilling from 22.80m to 25.80m									
Continued from sheet 1			Borehole terminated at 25.80m							

**Note: SPT Conducted using winch cat-head device, N values reported are close to N₆₀

FIELD BORE LOG

Project :
Site : Thiruvalluvar Salai, Vanniyapuram, Chennai 600018

Dia and type of boring : 150mm Rotary boring with drilling mud circulation

BORE HOLE NO:		BH/5
Date of start	:	25-Apr-2022
Date of finish	:	26-Apr-2022
GWL from GL	:	2.00m
Ground level RL	:	100.280m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency	
			UDS	DS	Test depth m	Blow Counts				N**		
						15	30	45	60			
1.0		Reddish brown sandy silty clay with brick pieces and 150mm PCC	6.50	0.50							Fill	
	1.4			0.75								
2.0		Greyish brown fine sand with clay lumps		1.50	1.50	5	6	6	7	12	Medium dense	
	2.2			2.25	2.25	4	6	5	6	11	Medium dense	
3.0		Greyish brown fine to medium sand		3.00	3.00	7	9	10	10	19	Medium dense	
	3.0			3.75	3.75	9	10	10	12	20		
4.0		Brownish grey medium sand with fine sand		4.50	4.50	4	6	6	9	12		
	5.2			5.50	5.50	1	1	1	1	2	Soft	
6.0		Greyish silty clay with shells		6.50	Collected							
	6.7			7.00	7.00	1	1	1	1	2	Soft	
7.0		Greyish silty clay with lot of shells and mica		8.00	8.00	1	1	2	1	3	Soft	
	7.2			9.00	9.00	2	3	5	5	8	Loose	
8.0		Greyish silty clay with mica		10.00	10.00	3	4	3	5	7		
	8.9			11.50	11.50	2	3	2	2	5		
9.0				13.00	13.00	3	5	4	6	9		
	14.2			14.50		1	1	2	0	3		
10.0		Greyish fine to medium sand		16.00	16.00	1	2	1	1	3	Soft	
					17.50	17.50	8	10	12	12	22	Medium dense
15.0				Greyish silty clay with mica	19.00	19.00	25	50/15cm			>100	Hard
16.0												
17.0												
18.0		Light greenish grey and brown clayey silty fine to medium sand with stones										
19.0		Light greenish grey sandy silty clay with brown patches										
20.0												
		Continued in the next sheet	Borehole terminated at 25.60m									

**Note: SPT Conducted using winch cat-head device, N values reported are close to N₆₅

FIELD BORE LOG

Project :
Site : Thiruvalluvar Salai, Vanniyapuram, Chennai 600018

Dia and type of boring : 150mm Rotary boring with drilling mud circulation

BORE HOLE NO: BH/5	
Date of start	: 25-Apr-2022
Date of finish	: 26-Apr-2022
GWL from GL	: 2.00m
Ground level RL	: 100.280m

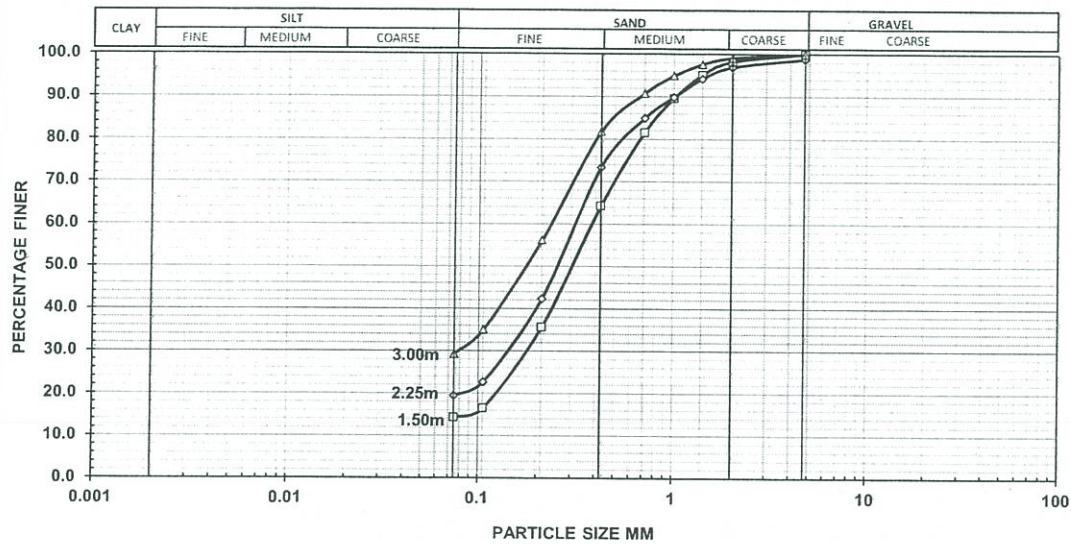
Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency
			UDS	DS	Test depth m	Blow Counts					
						15	30	45	60	N**	
21.0		Light grey and brown weathered shale		20.50	20.50	50/7cm				>100	Hard clay
22.0		21.8			21.80	Rebound				RB	
23.0		22.6	Weathered fractured shale	21.80-22.60		TC core drilling 22.60				Rebound	RB
24.0		Light grey and brown weathered shale with black patches	22.60-23.60		DC Core drilling				R 25% Q nil		Weak soft rock
25.0			23.60-24.60		DC Core drilling				R 54% Q nil		
26.0			24.60-25.60		DC Core drilling				R 70% Q 23%		
27.0		TC core drillin from 21.80m to 22.60m DC core drilling from 22.60m to 25.60m									
28.0											
29.0											
30.0											
31.0											
32.0											
33.0											
34.0											
35.0											
36.0											
37.0											
38.0											
39.0											
40.0											
Continued from sheet 1			Borehole terminated at 25.60m								
**Note: SPT Conducted using winch cat-head device, N values reported are close to N ₅₅											

BH₁ - 25.5
BH₂ - 26.4
BH₃ - 27.00
BH₄ - 25.80
BH₅ - 25.50

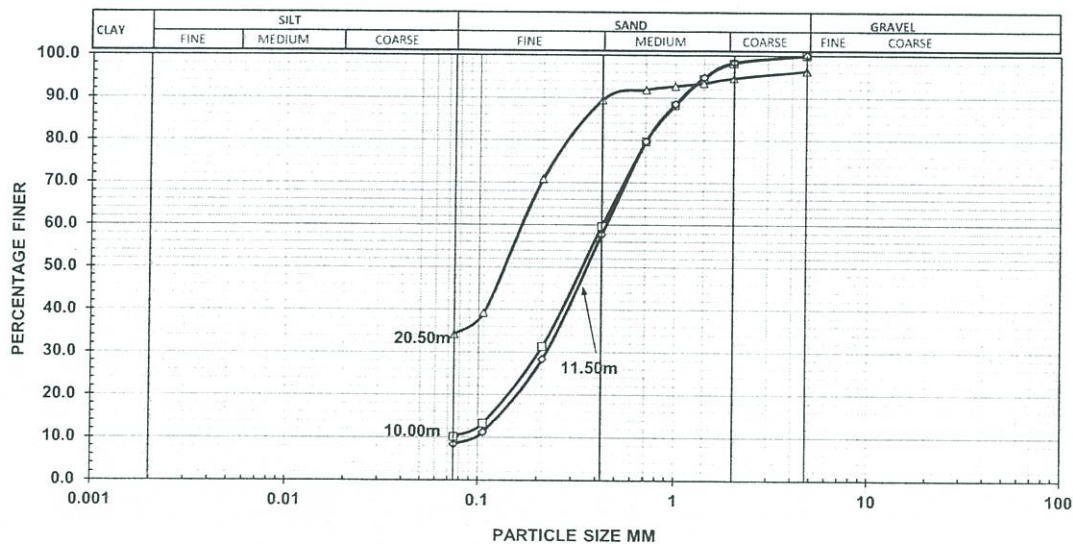
ANNEXURE 2

GRAIN SIZE DISTRIBUTION CURVES

PROJECT: Stilt + 9 Residential Building with 287
Tenements, Thiruvalluvar Salai,
Vanniyapuram for TNUHDB



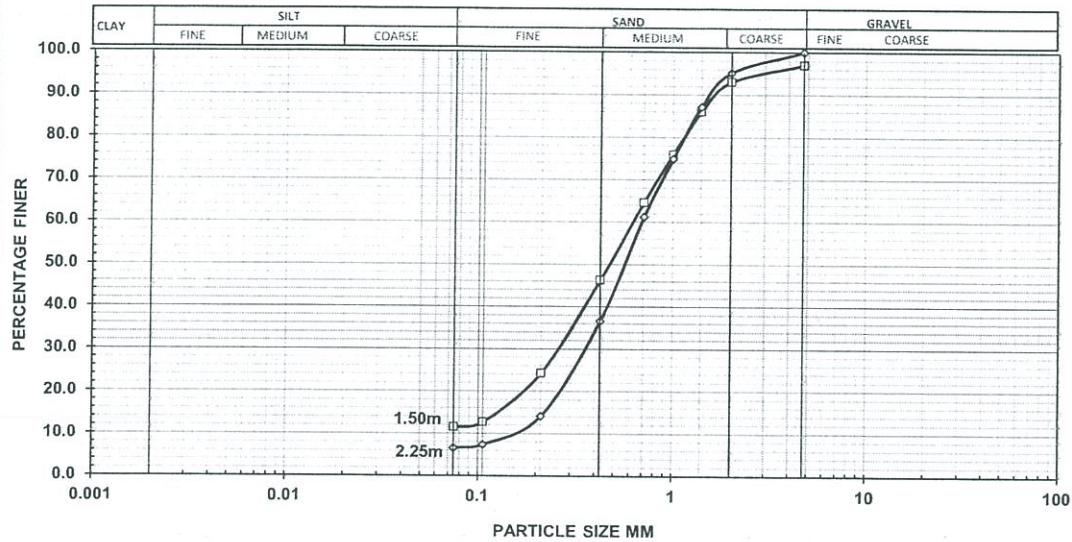
BH NO	DEPTH M	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classific ation	D50 mm	cu (sand)	cc (sand)
		80.0	20.0	4.75	2.00	0.425	0.075	0.002	G	CS	MS	FS	Si	C	CLASS			
BH/1	1.50m	100.0	100.0	98.2	64.2	14.3			0.0	1.8	34.0	49.9	14.3		SC-SP	0.301	3.328	0.938
BH/1	2.25m	100.0	98.8	96.9	73.3	19.4			1.2	1.9	23.6	53.9	19.4		SC-SP	0.252	2.993	1.012
BH/1	3.00m	100.0	100.0	99.1	81.7	29.2			0.0	0.9	17.4	52.5	29.2		SC-SP	0.174	2.927	0.865



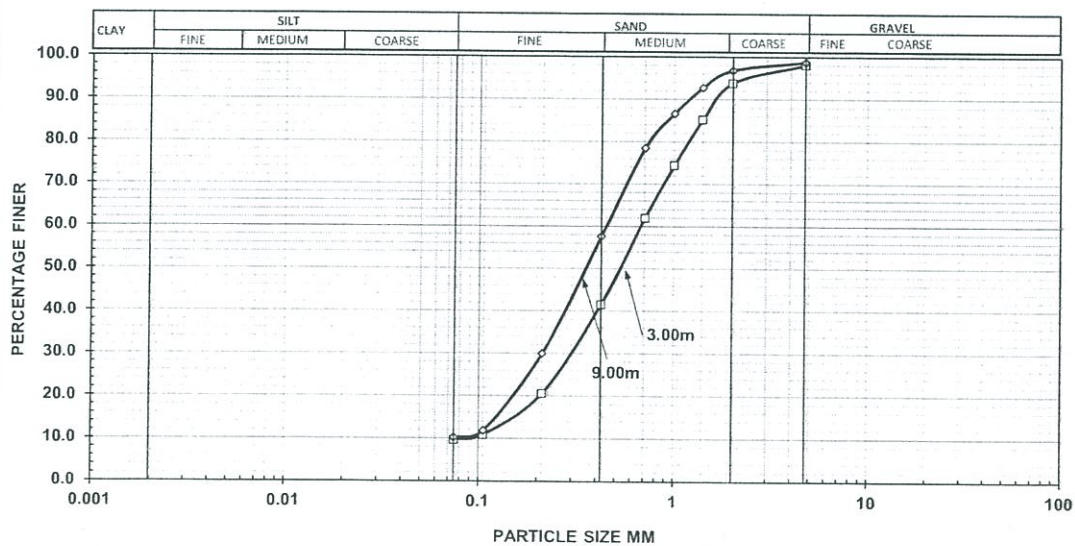
BH NO	DEPTH M	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classific ation	D50 mm	cu (sand)	cc (sand)
		80.0	20.0	4.75	2.00	0.425	0.075	0.002	G	CS	MS	FS	Si	C	CLASS			
BH/1	10.00m	100.0	100.0	98.2	59.7	10.2			0.0	1.8	38.5	49.5	10.2		SP	0.335	3.592	0.946
BH/1	11.50m	100.0	100.0	98.4	57.8	8.4			0.0	1.6	40.6	49.4	8.4		SP	0.353	3.544	0.968
BH/1	20.50m	100.0	96.4	94.7	89.5	34.2			3.6	1.7	5.2	55.3	34.2		SC	0.134	2.148	0.829

GRAIN SIZE DISTRIBUTION CURVES

PROJECT: Stilt + 9 Residential Building with 287 Tenements, Thiruvalluvar Salai, Vanniyapuram for TNUHDB



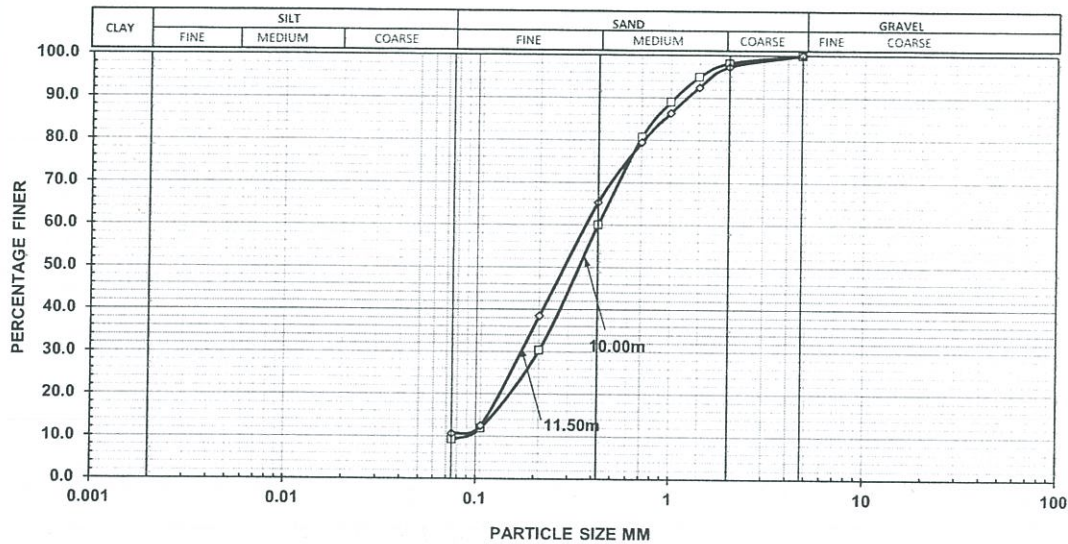
BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
		80.0	20.0	4.75	2.00	0.425	0.075	0.002	G	CS	MS	FS	Si	C	CLASS			
BH/2	1.50m		100.0	97.0	93.0	46.3	11.5		3.0	4.0	46.7	34.8	11.5		SP	0.472	4.309	0.888
BH/2	2.25m		100.0	100.0	95.2	36.6	6.6		0.0	4.8	58.6	30.0	6.6		SP	0.562	3.280	0.968



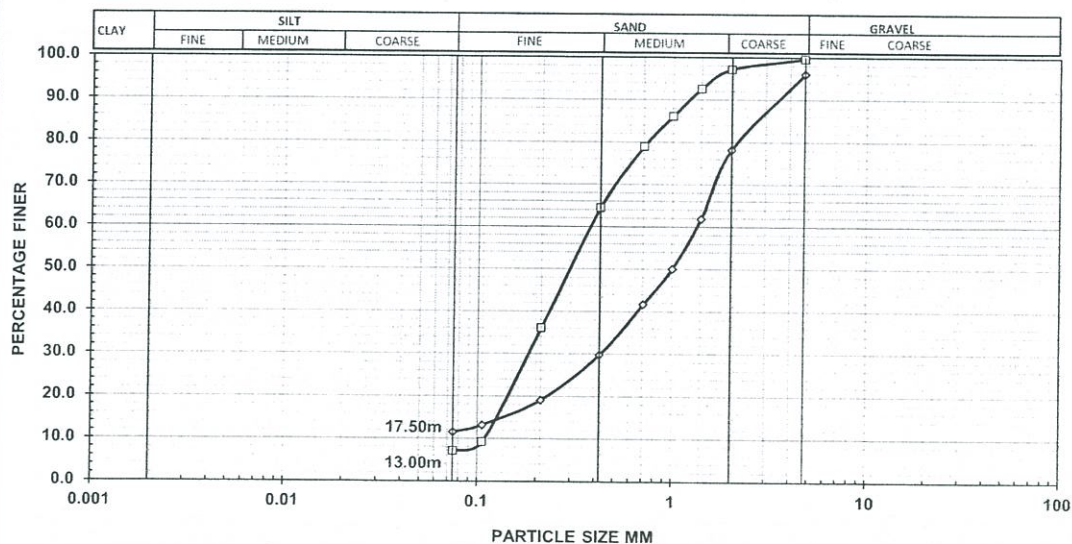
BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
		80.0	20.0	4.75	2.00	0.425	0.075	0.002	G	CS	MS	FS	Si	C	CLASS			
BH/2	3.00m		100.0	98.1	93.8	41.6	9.7		1.9	4.3	52.2	31.9	9.7		SP	0.525	4.031	0.947
BH/2	9.00m		100.0	98.8	96.8	57.6	10.2		1.2	2.0	39.2	47.4	10.2		SP	0.351	3.557	0.923

GRAIN SIZE DISTRIBUTION CURVES

PROJECT: Stilt + 9 Residential Building with 287 Tenements, Thiruvalluvar Salai, Vanniyapuram for TNUHDB



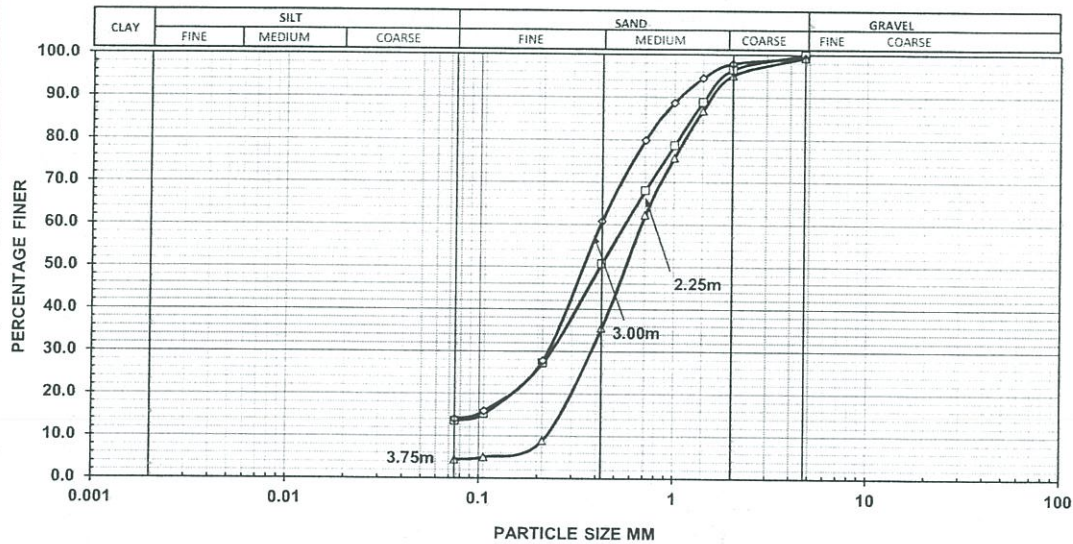
BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
		M	80.0	20.0	4.75	2.00	0.425	0.075										
BH/2	10.00m		100.0	100.0	98.2	60.0	9.2		0.0	1.8	38.2	50.8	9.2	C	SP	0.336	3.459	0.952
BH/2	11.50m		100.0	100.0	97.3	65.3	10.6		0.0	2.7	32.0	54.7	10.6		SP	0.286	3.233	0.802



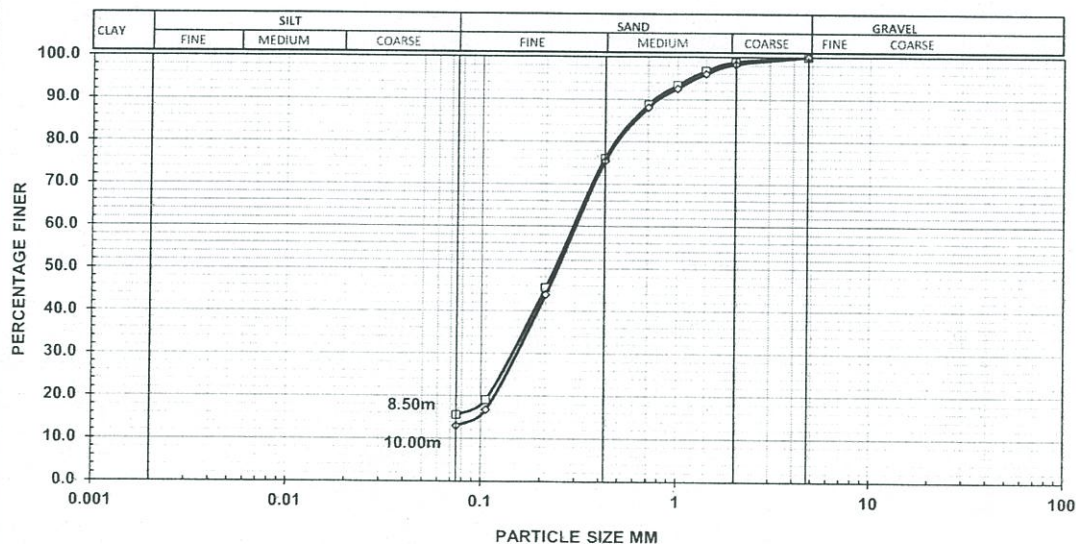
BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
		M	80.0	20.0	4.75	2.00	0.425	0.075										
BH/2	13.00m		100.0	99.6	97.2	64.4	7.1		0.4	2.4	32.8	57.3	7.1	C	SP	0.298	3.205	0.812
BH/2	17.50m		100.0	96.1	78.2	29.8	11.5		3.9	17.9	48.4	18.3	11.5		SW	0.996	6.460	1.078

GRAIN SIZE DISTRIBUTION CURVES

PROJECT: Stilt + 9 Residential Building with 287 Tenements, Thiruvalluvar Salai, Vanniyapuram for TNUHDB



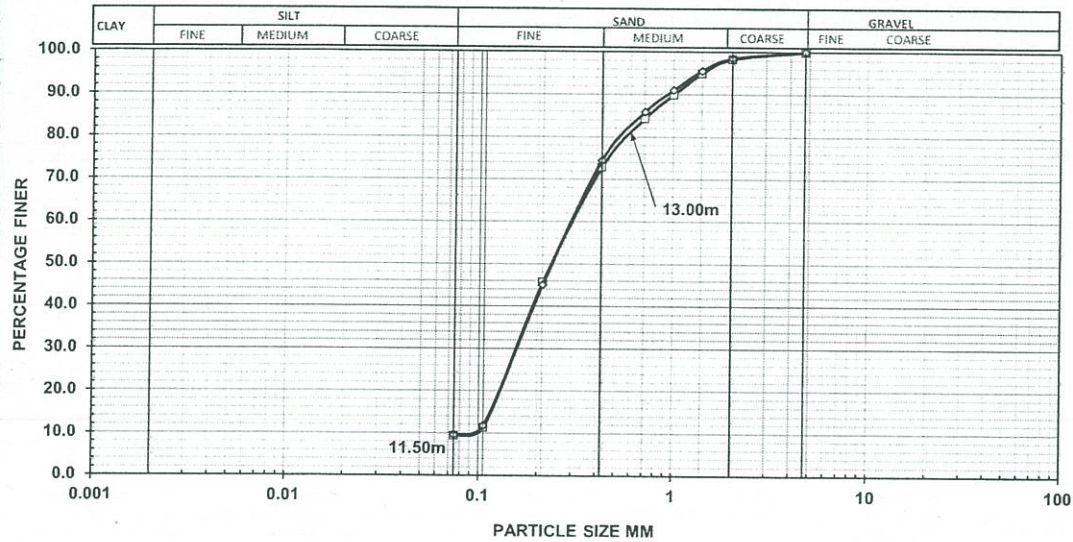
BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel G	Coarse Sand CS	Medium Sand MS	Fine Sand FS	Silt Si	Clay C	Classification CLASS	D50 mm	cu (sand)	cc (sand)	
		M	80.0	20.0	4.75	2.00	0.425	0.075											0.002
BH/3	2.25m		100.0	100.0	96.5	50.7	13.6		3.5	45.8	37.1		13.6		SC-SP	0.416	4.134	0.890	
BH/3	3.00m		100.0	99.3	97.9	60.8	14.0		0.7	1.4	37.1	46.8		14.0		SC-SP	0.339	3.087	0.984
BH/3	3.75m		100.0	99.3	95.1	35.5	4.4		0.7	4.2	59.6	31.1		4.4		SP	0.562	2.909	0.934



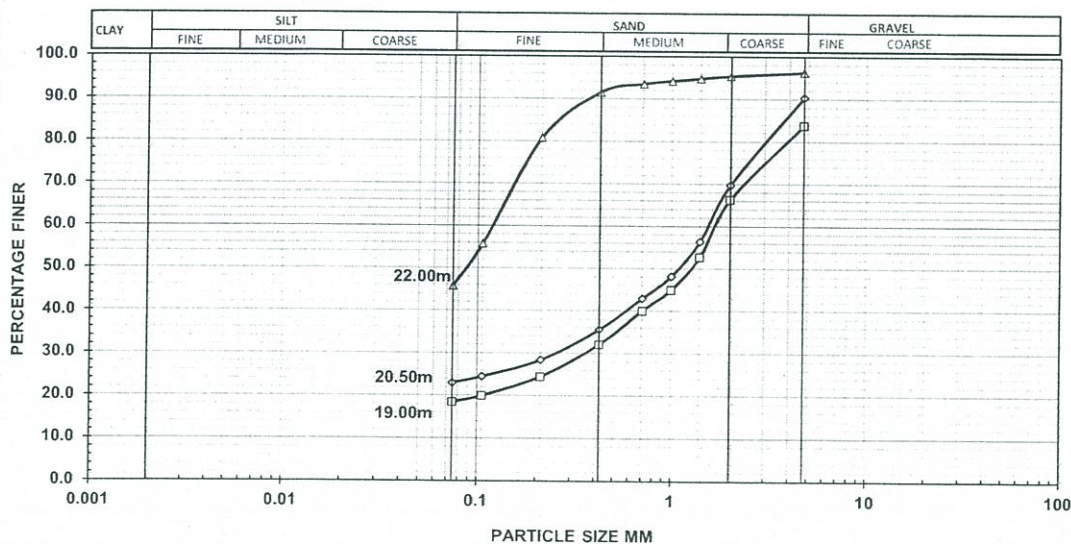
BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
		M	80.0	20.0	4.75	2.00	0.425	0.075										
BH/3	8.50m		100.0	100.0	98.9	76.1	15.6		G	1.1	22.8	60.5	15.6	C	SC-SP	0.234	2.819	0.860
BH/3	10.00m		100.0	100.0	98.3	75.4	13.0			1.7	22.9	62.4	13.0		SC-SP	0.243	2.823	0.862

GRAIN SIZE DISTRIBUTION CURVES

PROJECT: Stilt + 9 Residential Building with 287 Tenements, Thiruvalluvar Salai, Vanniyapuram for TNUHDB



BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		80.0	20.0	4.75	2.00	0.425	0.075	0.002										
BH/3	11.50m		100.0	100.0	98.3	72.8	9.4		G	1.7	25.5	63.4	Si	9.4	SP	0.237	2.753	0.756
BH/3	13.00m		100.0	100.0	98.5	74.4	9.6			1.5	24.1	64.8		9.6	SP	0.238	2.707	0.785

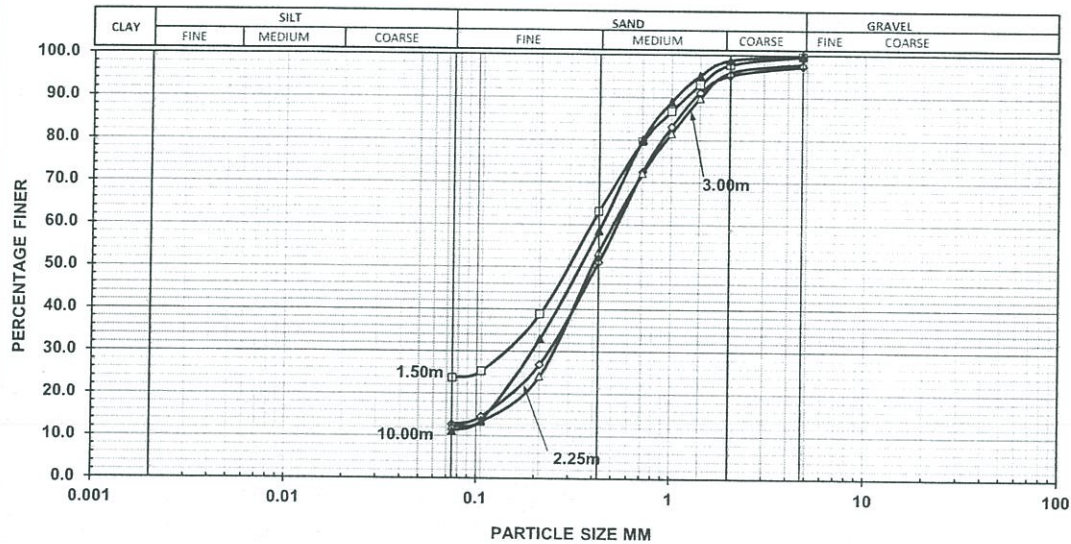


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		80.0	20.0	4.75	2.00	0.425	0.075	0.002										
BH/3	19.00m		100.0	83.8	66.3	32.1	18.5		16.2	17.5	34.2	13.6	18.5		GC-SW	1.241	7.971	1.414
BH/3	20.50m		100.0	90.4	69.7	35.6	23.0		9.6	20.7	34.1	12.6	23.0		SC-SW	1.077	7.455	1.452
BH/3	22.00m		100.0	96.3	95.4	91.5	45.8		3.7	0.9	3.9	45.7	45.8		SC	0.087	2.187	0.888

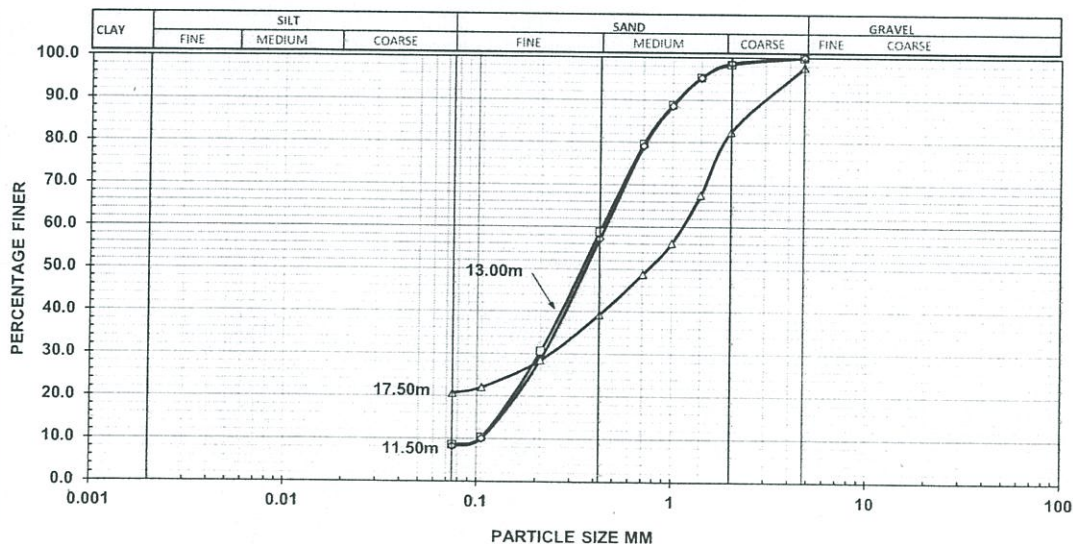
GRAIN SIZE DISTRIBUTION CURVES

PROJECT:

Stilt + 9 Residential Building with 287
Tenements, Thiruvalluvar Salai,
Vanniyapuram for TNUHDB



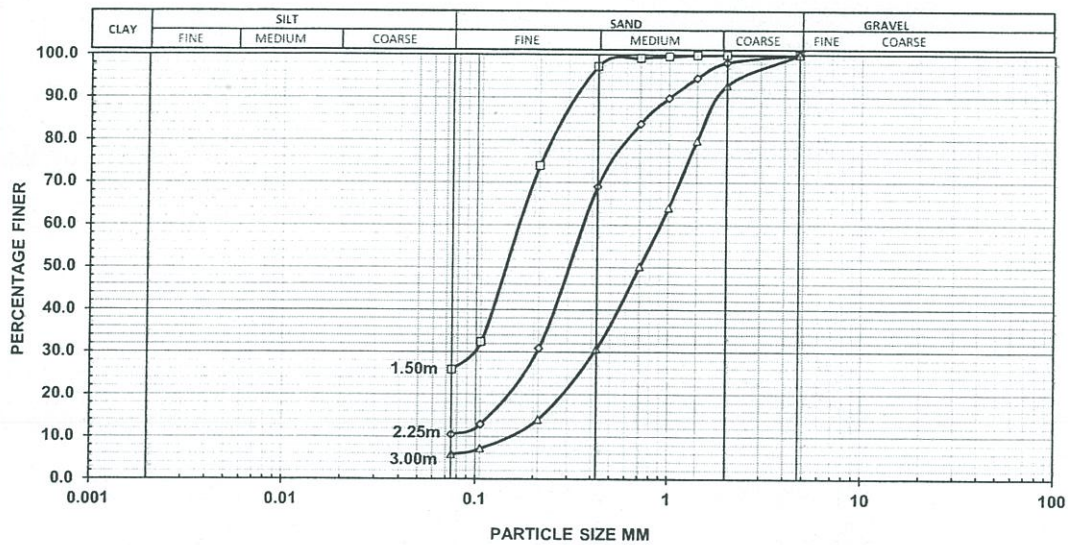
BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
	M	80.0	20.0	4.75	2.00	0.425	0.075	0.002	G	CS	MS	FS	Si	C				
BH/4	1.50m	100.0	99.7	97.7	63.1	23.7			0.3	2.0	34.6	39.4	23.7		SC-SP	0.292	3.587	0.938
BH/4	2.25m	100.0	97.4	95.2	51.1	12.7			2.6	2.2	44.1	38.4	12.7		SC-SP	0.412	3.815	0.967
BH/4	3.00m	100.0	98.0	95.9	53.5	12.2			2.0	2.1	42.4	41.3	12.2		SC-SP	0.391	3.353	0.882
BH/4	10.00m	100.0	100.0	98.8	58.5	11.2			0.0	1.2	40.3	47.3	11.2		SP	0.337	3.672	0.899



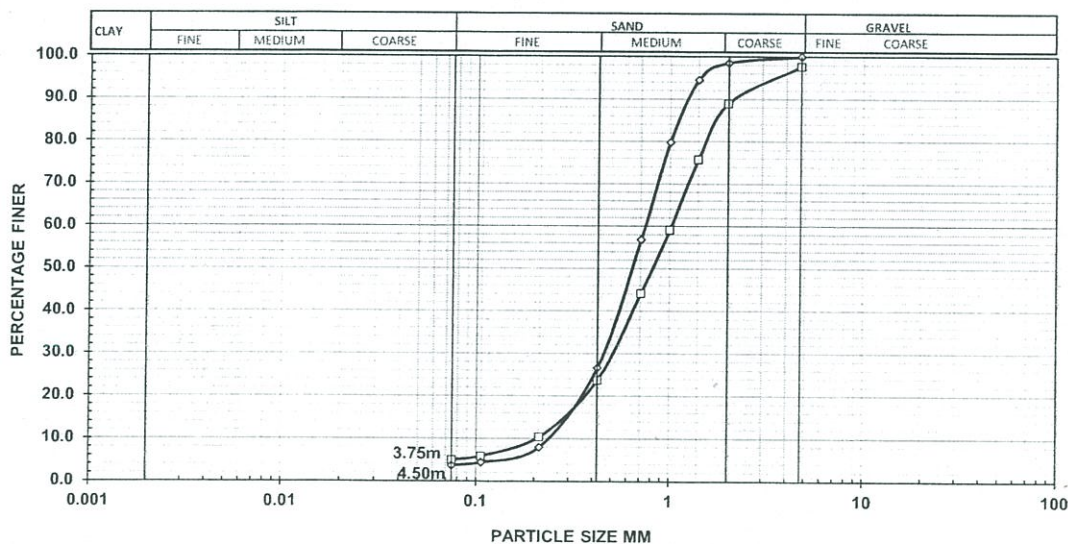
BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
	M	80.0	20.0	4.75	2.00	0.425	0.075	0.002	G	CS	MS	FS	Si					
BH/4	11.50m		100.0	100.0	98.4	58.9	8.6		0.0	1.6	39.5	50.3	8.6		CLASS SP	0.341	3.492	0.902
BH/4	13.00m		100.0	100.0	98.7	57.2	8.3		0.0	1.3	41.5	48.9	8.3		SP	0.356	3.521	0.927
BH/4	17.50m		100.0	97.8	82.5	39.3	20.7		2.2	15.3	43.2	18.6	20.7		SC-SW	0.748	6.656	1.034

GRAIN SIZE DISTRIBUTION CURVES

PROJECT: Stilt + 9 Residential Building with 287 Tenements, Thiruvalluvar Salai, Vanniyapuram for TNUHDB



BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel G	Coarse Sand CS	Medium Sand MS	Fine Sand FS	Silt Si	Clay C	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		M	80.0	20.0	4.75	2.00	0.425	0.075										
BH/5	1.50m		100.0	100.0	100.0	97.3	25.8		0.0	0.0	2.7	71.5	25.8		SC-SP	0.142	1.858	0.883
BH/5	2.25m		100.0	100.0	98.2	69.0	10.5		0.0	1.8	29.2	58.5	10.5		SP	0.300	2.854	1.071
BH/5	3.00m		100.0	100.0	92.8	30.8	5.8		0.0	7.2	62.0	25.0	5.8		SW	0.706	4.319	1.008

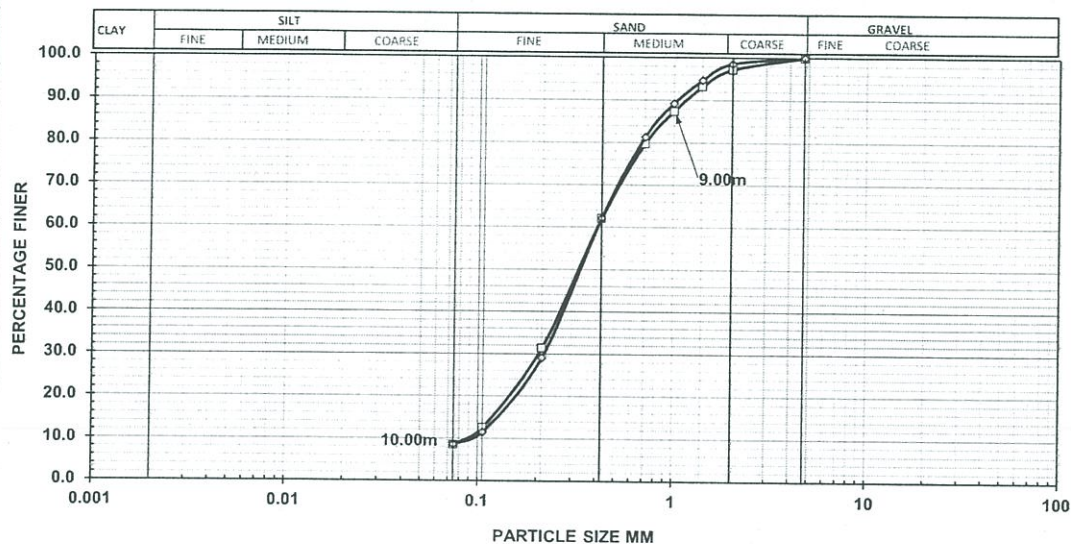


BH NO	DEPTH	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel G	Coarse Sand CS	Medium Sand MS	Fine Sand FS	Silt Si	Clay C	Classification CLASS	D50 mm	cu (sand)	cc (sand)
		M	80.0	20.0	4.75	2.00	0.425	0.075										
BH/5	3.75m		100.0	97.7	89.0	23.8	5.0		2.3	8.7	65.2	18.8	5.0		SW	0.811	4.035	1.060
BH/5	4.50m		100.0	100.0	98.5	26.7	3.7		0.0	1.5	71.8	23.0	3.7		SP	0.631	2.941	1.123

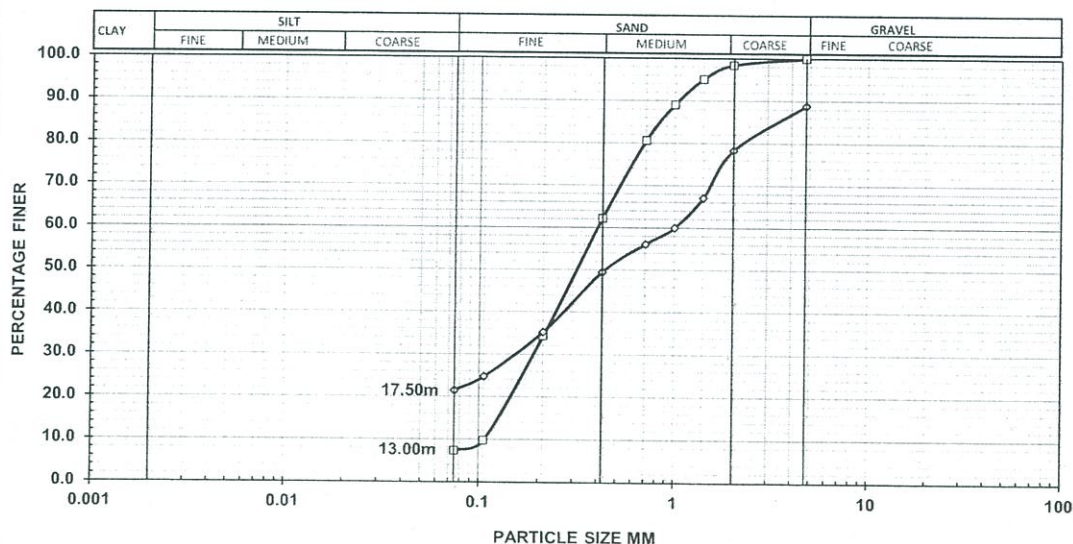
GRAIN SIZE DISTRIBUTION CURVES

PROJECT:

Stilt + 9 Residential Building with 287
Tenements, Thiruvalluvar Salai,
Vanniyapuram for TNUHDB



BH NO	DEPTH M	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classific ation CLASS	D50 mm	cu (sand)	cc (sand)
		80.0	20.0	4.75	2.00	0.425	0.075	0.002	G	CS	MS	FS	Si	C				
BH/5	9.00m	100.0	100.0	97.2	62.0	8.5			0.0	2.8	35.2	53.5	8.5		SP	0.324	3.466	0.978
BH/5	10.00m	100.0	100.0	98.6	62.1	8.6			0.0	1.4	36.5	53.5	8.6		SP	0.329	3.251	1.008



BH NO	DEPTH M	PERCENTAGE FINER (Sieve size in mm)							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classific ation CLASS	D50 mm	cu (sand)	cc (sand)
		80.0	20.0	4.75	2.00	0.425	0.075	0.002	G	CS	MS	FS	Si	C				
BH/5	13.00m	100.0	100.0	98.4	62.2	7.4			0.0	1.6	36.2	54.8	7.4		SP	0.313	3.376	0.837
BH/5	17.50m	100.0	88.9	76.3	49.5	21.5			11.1	10.6	28.8	28.0	21.5		SC-SP	0.442	10.262	0.556

SUMMARY OF LABORATORY TEST RESULTS

Project: Stilt + 9 Residential Building with 287 Tenements, Thiruvalluvar Salai, Vanniyapuram for TNUHDB
 Borehole Nos: BH/1, BH/2, BH/3, BH/4 & BH/5
 Type of Boring and dia of bore hole: 150mm diameter rotary boring with mud circulation

Ground Water Table: 2.0m to 2.5m below GL (Borehole)

SHEET 1 OF 5

Sample Depth m	Sample Type	Visual Identification of Soil	SPT "N"	Classification	Natural Moisture content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Liquidity Index	Differential Free Swell Index %	Specific Gravity	Gravel %	Coarse Sand %	Medium Sand %	Fine Sand %	Silt %	Clay %
Depth (1)	Type (2)	Description (3)	(4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	DFSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		BOREHOLE BH/1															
0.50	DS	Greyish brown sandy silty clay with brick pieces			6.2												
1.50	SPT	Yellowish brown fine to medium sand with clay lumps	25	SC-SP	16.3								1.8	34.0	49.9		14.3
2.25	SPT	Yellowish brown fine to medium sand with clay lumps	12	SC-SP	18.6							1.2	1.9	23.6	53.9		19.4
3.00	SPT	Greyish brown fine to medium sand with sandy clay lumps	7	SC-SP	23.1								0.9	17.4	52.5		29.2
3.75	SPT	Dark grey silty clay with organic patches	12	CH	39.3	74.7	29.7	45.0	0.213								
5.50	SPT	Dark grey silty clay	3		51.6												
6.50	SPT	Dark grey silty clay	2	CH	47.0	72.9	24.5	48.4	0.465								
7.50	SPT	Dark grey silty clay with mica and shells	2	CH	45.7	65.5	20.8	44.7	0.557								
8.50	SPT	Greyish clayey silty fine to medium sand with shells and sandy clay	2	SC-CL	36.8	33.6	LSL-3.7%										
10.00	SPT	Greyish dirty fine to medium sand	15	SP	19.8												
11.50	SPT	Greyish dirty fine to medium sand	18	SP	17.9												
13.00	SPT	Light greenish grey clayey silty fine sand with mica and sandy clay lumps	5	SC-CL	27.0	27.5	LSL-5.2%						1.8	38.5	49.5	10.2	
14.50	SPT	Light greenish grey silty clay with fine sand pockets	3	CH	58.9	73.6	24.7	48.9	0.699				1.6	40.6	49.4	8.4	
16.00	SPT	Greyish silty clay	5	CH	53.1	86.3	28.2	58.1	0.429								
17.50	SPT	Greyish silty clay	7	CH	52.0	83.5	27.4	56.1	0.439								
19.00	SPT	Light greenish grey sandy silty clay with brown patches	57	SC-CH	18.8	83.2	21.5	61.7	<0.00								

Project: **Stilt + 9 Residential Building with 287 Tenements, Thiruvalluvar Salai, Vanniyapuram for TNUHDB**

Unit 4 - 9 Residential Building with 287 Tenements, Thiruvalluvar Salai, Vanniyapuram for TNUHDB																			SHEET 2 OF 5	
Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	DFSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)			
20.50	SPT	Light greenish grey and brown clayey silty fine sand with weathered shale	>100	SC-SM								3.6	1.7	5.2	55.3		34.2			
21.50-22.50		Light grey and brown weathered shale with black patches																		
22.50-23.50		Light grey and brown severely jointed weathered shale with black patches																		
23.50-24.50		Light greyish brown jointed weathered shale with black patches																		
24.50-25.50		Light greyish brown jointed weathered shale with black patches																		
BOREHOLE BH/2																				
0.50-0.75 DS		Brownish grey fine to medium sand with stones			6.1															
1.50	SPT	Yellowish brown fine to medium sand	20	SP	16.1							3.0	4.0	46.7	34.8		11.5			
2.25	SPT	Yellowish brown fine to medium sand	15	SP	16.9								4.8	58.6	30.0		6.6			
3.00	SPT	Yellowish brown fine to medium sand	14	SP	16.9							1.9	4.3	52.2	31.9		9.7			
3.75	SPT	TOP: Light grey and brown clayey fine to medium sand	5		23.3															
		BOT: Dark grey silty clay with organic patches		CH	44.4	79.5	31.8	47.7	0.264											
4.50	UDS	Dark grey silty clay with organic patches		CH	51.0	87.4	36.5	50.9	0.285											
5.00	VST	Greyish silty clay			49.7															
6.00	SPT	Greyish silty clay	2		56.9															
7.00	SPT	Greyish silty clay	3	CH	54.5	79.0	29.8	49.2	0.502											
8.00	SPT	Greyish silty clay	2	CH	54.9	95.5	38.4	57.1	0.289											
9.00	SPT	Greyish fine to medium sand with brown patches	15	SP	20.9							1.2	2.0	39.2	47.4		10.2			
10.00	SPT	Light greenish grey fine to medium sand with brown patches	22	SP	17.0								1.8	38.2	50.8		9.2			
11.50	SPT	Light greenish grey fine to medium sand with brown patches	19	SP	24.3								2.7	32.0	54.7		10.6			
13.00	SPT	Light greenish grey and brown fine to medium sand	22	SP	17.6							0.4	2.4	32.8	57.3		7.1			
14.50	SPT	Greyish silty clay with sand pockets	6	SC-CI	37.4	47.0	18.9	28.1	0.658											
16.00	SPT	Greyish silty clay with sand pockets	7		50.4															
17.50	SPT	Light greenish grey clayey fine to medium sand with brown patches	25	SW	14.4							3.9	17.9	48.4	18.3		11.5			
19.00	SPT	Light greenish grey clayey fine to medium sand with brown patches	29		13.0															

SHEET 2 OF 5

Project: **Stilt + 9 Residential Building with 287 Tenements, Thiruvalluvar Salai, Vanniyapuram for TNUHDB**

SHEET 3 OF 5																		
Vanniapuram for TNUHDB																		
Sht. 3 - Residential Building with 287 Tenements, Thiruvalluvar Salai,																		
Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	DFSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)	
20.50	SPT	Light greenish grey and yellowish brown sandy silty clay	63	SC-CH	18.4	67.3	20.3	47.0	<0.00									
22.00	SPT	TOP: Light greenish grey and yellowish brown sandy silty clay	>100		18.0													
23.40-24.40		TIP: Light grey and yellowish brown weathered shale			18.3													
24.40-25.40		Light grey and brown weathered shale with black patches																
25.40-26.40		Light grey and brown severely jointed weathered shale with black patches																
BOREHOLE BH/3																		
0.50-0.75 DS		Brownish grey fine to medium sand with brick pieces and stones			3.5													
1.50	SPT	Brownish grey clayey silty fine to medium sand with brick pieces	6		20.0													
2.25	SPT	Yellowish brown fine to medium sand with clay lumps	10	SM-SP	14.6									3.5	45.8	37.1	13.6	
3.00	SPT	Greyish brown fine to medium sand with clay lumps	16	SC-SP	17.5								0.7	1.4	37.1	46.8	14.0	
3.75	SPT	Light greenish grey and brown fine to medium sand	8	SP	21.7								0.7	4.2	59.6	31.1	4.4	
4.50	SPT	Dark grey silty clay with medium sand pockets	2	CH	75.7	91.5	31.4	60.1	0.737									
5.50	SPT	Greyish silty clay	1	CH	54.8	66.0	22.9	43.1	0.740									
6.50	SPT	Greyish silty clay	1	CH	54.0	64.8	21.7	43.1	0.749									
7.50	SPT	Greyish silty clay	1		55.3													
8.50	SPT	Greyish clayey fine sand with medium sand	6	SC-SP	22.3									1.1	22.8	60.5	15.6	
10.00	SPT	Greyish clayey fine sand with medium sand	8	SC-SP	21.7									1.7	22.9	62.4	13.0	
11.50	SPT	Greyish fine sand with medium sand	11	SP	19.3									1.7	25.5	63.4	9.4	
13.00	SPT	Greyish fine sand with medium sand	16	SP	19.5									1.5	24.1	64.8	9.6	
14.50	SPT	TOP: Greyish silty clay with fine sand pockets	6	SC-CH	45.4	53.2	20.3	32.9	0.763									
		BOT: Greyish clayey fine to medium sand			16.6													
16.00	SPT	Greyish and brown sandy silty clay	8	SC-CI	35.4	42.1	17.7	24.4	0.725									
20.50	SPT	TOP: Brownish grey clayey silty fine to medium sand	13	SC-SW	17.6								9.6	20.7	34.1	12.6	23.0	
		BOT: Light grey and brown sandy silty clay			17.2													

SHEET 3 OF 5

Project: **Stilt + 9 Residential Building with 287 Tenements, Thiruvalluvar Salai, Vanniyapuram for TNUHDB**

Project:		SHEET 4 OF 5															
Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	DFSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
22.00	SPT	Light grey and yellowish brown sandy silty clay with weathered shale	70	SC	14.1							3.7	0.9	3.9	45.7		45.8
23.95-24.95		Light grey and brown weathered jointed shale															
24.95-25.95		Light greyish brown severely jointed weathered shale with black patches															
25.95-26.95		Light greyish brown severely jointed weathered shale with black patches															
BOREHOLE BH/4																	
0.50-0.75	DS	Reddish and brown sandy silty clay with stone pieces			10.1												
1.50	SPT	Greyish brown clayey silty fine to medium sand with sandy clay lumps	4	SC-SP	18.5							0.3	2.0	34.6	39.4		23.7
2.25	SPT	Greyish brown dirty fine to medium sand	8	SC-SP	18.5							2.6	2.2	44.1	38.4		12.7
3.00	SPT	Greyish brown dirty fine to medium sand	19	SC-SP	17.5							2.0	2.1	42.4	41.3		12.2
3.75	SPT	Greyish brown sandy silty clay with brown patches	4	CH	53.5	75.4	31.0	44.4	0.507								
4.50	SPT	Greyish silty clay	2	CH	66.0	77.8	26.2	51.6	0.771								
5.50	SPT	Greyish silty clay	2	CH	61.4												
6.50	UDS	TOP: Greyish silty clay with sand pockets BOT: Greyish silty clay with several mica flakes			47.8	99.5	30.6	68.9	0.250								
7.50	SPT	Greyish silty clay	2		42.4												
8.50	SPT	Greyish silty clay	2	CH	70.5												
10.00	SPT	Greyish fine to medium sand	5	SP	53.2	73.6	24.1	49.5	0.588				1.2	40.3	47.3	11.2	
11.50	SPT	Greyish fine to medium sand	7	SP	20.4								1.6	39.5	50.3	8.6	
13.00	SPT	Greyish fine to medium sand	12	SP	18.3								1.3	41.5	48.9	8.3	
14.50	SPT	Greyish silty clay with mica	3	CH	19.7												
16.00	SPT	Greyish silty clay with mica and white stones	4	CH	62.7	89.3	33.5	55.8	0.523								
17.50	SPT	Light greyish and brown clayey silty fine to coarse sand	15	SC-SW	62.2	89.1	32.0	57.1	0.529			2.2	15.3	43.2	18.6	20.7	
19.00	SPT	Light grey and brown sandy silty clay	68		14.6												
20.50	SPT	Light grey and brown sandy silty clay	75	SC-CH	21.7												
22.80-23.80		Light grey and brown weathered severely jointed shale			23.6	52.2	24.5	27.7	<0.00								

Project: Stilt + 9 Residential Building with 287 Tenements, Thiruvalluvar Salai, Vanniyapuram for TNUHDB

Depth		Type	Description	"N"	CLASS	NMC	LL	PL	PI	LI	DFS	SG	G	CS	MS	FS	Silt	Clay
(1)	(2)			(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
23.80-24.80			Light greyish brown jointed weathered shale with black patches															
24.80-25.80			Light greyish brown jointed weathered shale with black patches															
			BOREHOLE BH/5															
0.50-0.75	DS		Reddish brown brown sandy silty clay with brick pieces			10.3												
1.50	SPT		Greyish brown fine sand with clay lumps	12	SC-SP	17.6									2.7	71.5	25.8	
2.25	SPT		Greyish brown fine to medium sand	11	SP	17.3								1.8	29.2	58.5	10.5	
3.00	SPT		Brownish grey medium sand with fine sand	19	SW	17.4								7.2	62.0	25.0	5.8	
3.75	SPT		Brownish grey medium sand with fine sand	20	SW	16.5							2.3	8.7	65.2	18.8	5.0	
4.50	SPT		Brownish grey medium sand with fine sand	12	SP	20.2								1.5	71.8	23.0	3.7	
5.50	SPT		Greyish silty clay	2	CH	37.4	69.0	23.7	45.3	0.302								
6.50	UDS		Greyish silty clay with shells		CH	58.2	95.1	30.2	64.9	0.431								
			Greyish silty clay with lot of shells and mica			57.4												
7.00	SPT		Greyish silty clay with sand pockets and mica	2		64.8												
8.00	SPT		Greyish silty clay with mica	3	CH	42.1	79.7	25.4	54.3	0.308								
9.00	SPT		Greyish fine to medium sand	8	SP	18.0								2.8	35.2	53.5	8.5	
10.00	SPT		Greyish fine to medium sand	7	SP	19.3								1.4	36.5	53.5	8.6	
11.50	SPT		Greyish fine to medium sand	5		22.0												
13.00	SPT		Greyish fine to medium sand	9	SP	19.2								1.6	36.2	54.8	7.4	
16.00	SPT		Greyish silty clay with mica	3	CH	65.7	91.9	30.3	61.6	0.575								
17.50	SPT		Light greenish grey and brown clayey silty fine to medium sand with stones	22	SC-SP	16.8							11.1	10.6	28.8	28.0	21.5	
19.00	SPT		Light greenish grey sandy silty clay with brown patches	>100	SC-CH	20.1	55.8	28.4	27.4	<0.00								
20.50	SPT		Light grey and brown weathered shale	>100		17.9												
22.60-23.60			Light grey and brown weathered shale with black patches															
23.60-24.60			Light grey and brown severely jointed weathered shale with black patches															
24.60-25.60			Light grey and brown severely jointed weathered shale with black patches															

Unconfined Compression Strength Test UCC on soil sample

Project:

Stilt + 9 Residential Building with 287
Tenements, Thiruvalluvar Salai,
Vanniyapuram for TNUHDB

Date of Test 18-Apr-22

Borehole BH/2

Depth 4.50m

Soil

Dark grey silty clay

Insitu bulk density 1.697 gm/cc

Insitu Dry Density 1.133 gm/cc

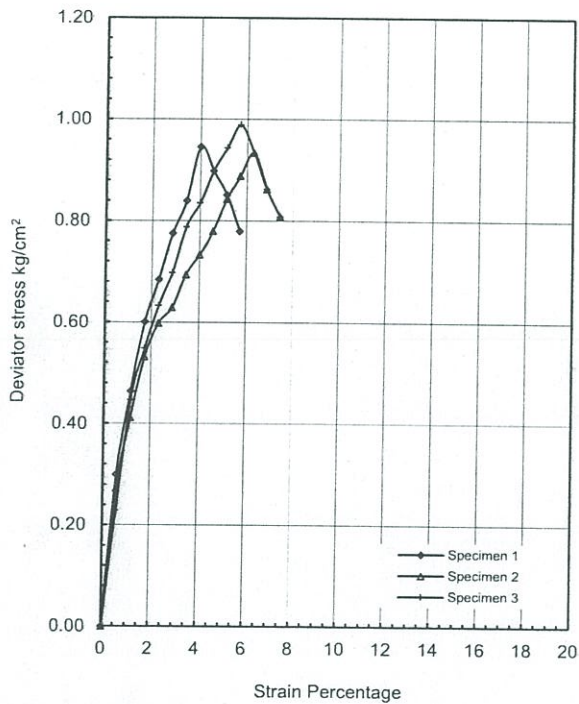
Water Content 49.73 %

Liquid Limit % 87.40

Plastic Limit % 36.50

Plasticity Index % 50.90

Liquidity Index 0.26



Maximum Shear Stress

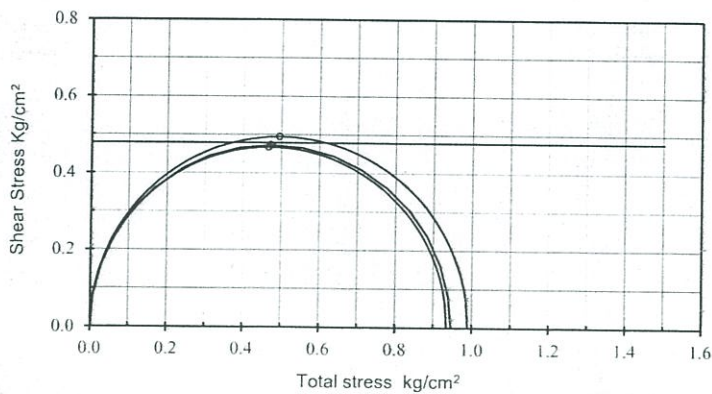
Specimen No:	Deviator stress	Shear stress kg/cm ²
Specimen 1	0.946	0.473
Specimen 2	0.934	0.467
Specimen 3	0.989	0.495

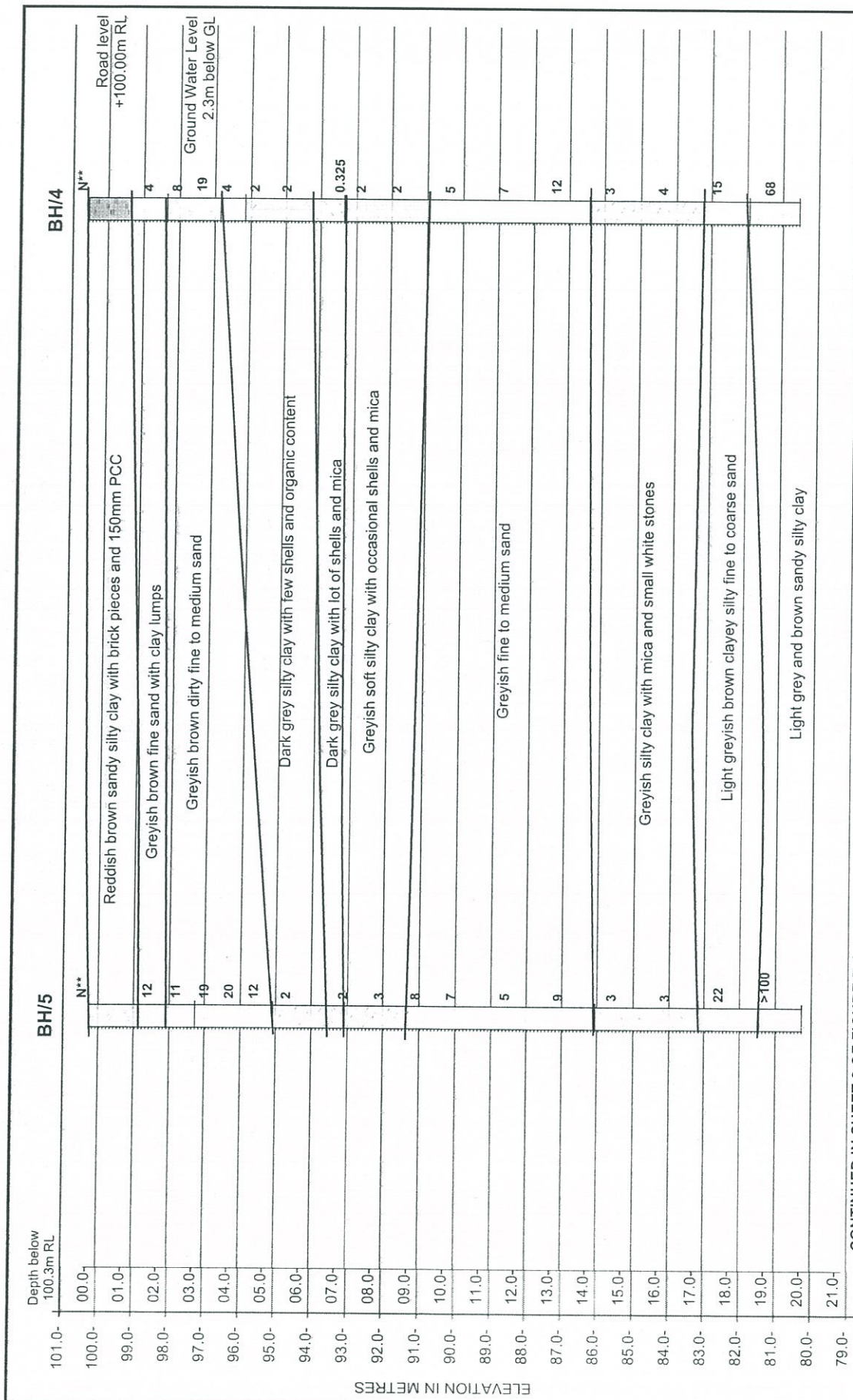
Results

Unconfined compression strength q_u 0.957 kg/cm²

Undrained Cohesion c_u 0.478 kg/cm²

Secant Modulus (undrained) 38.60 kg/cm²





CONTINUED IN SHEET 2 OF FIGURE P-1

Ground level with respect to TBM 100.0m RL marked on the road top

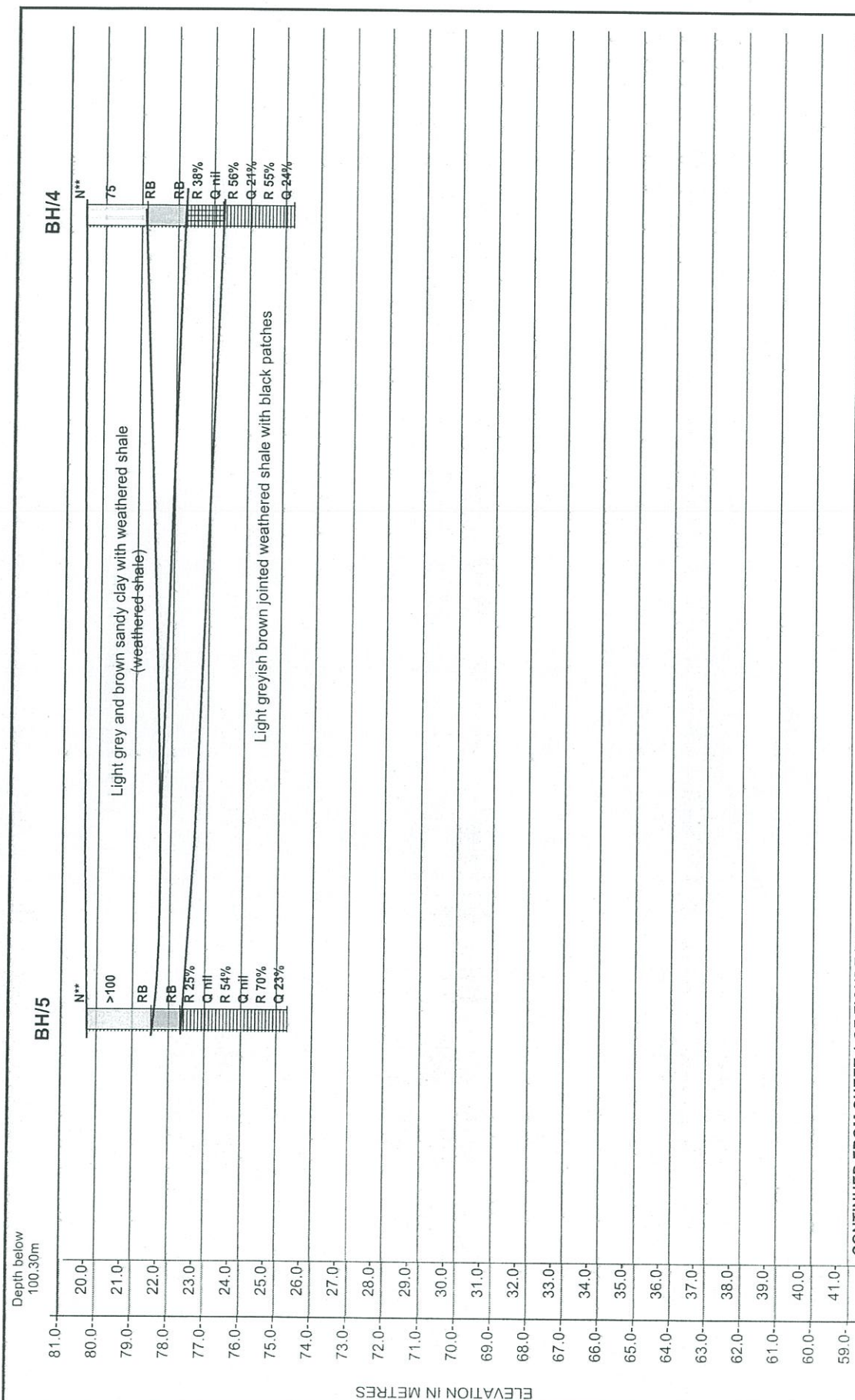
Important note: The subsoil variations can be different from what is shown here as the boreholes are at a distance. Refer respective bore logs for profile details.

FIGURE P-1

SHEET 1 OF 2

SUB-SOIL PROFILE BH/5 - BH/4

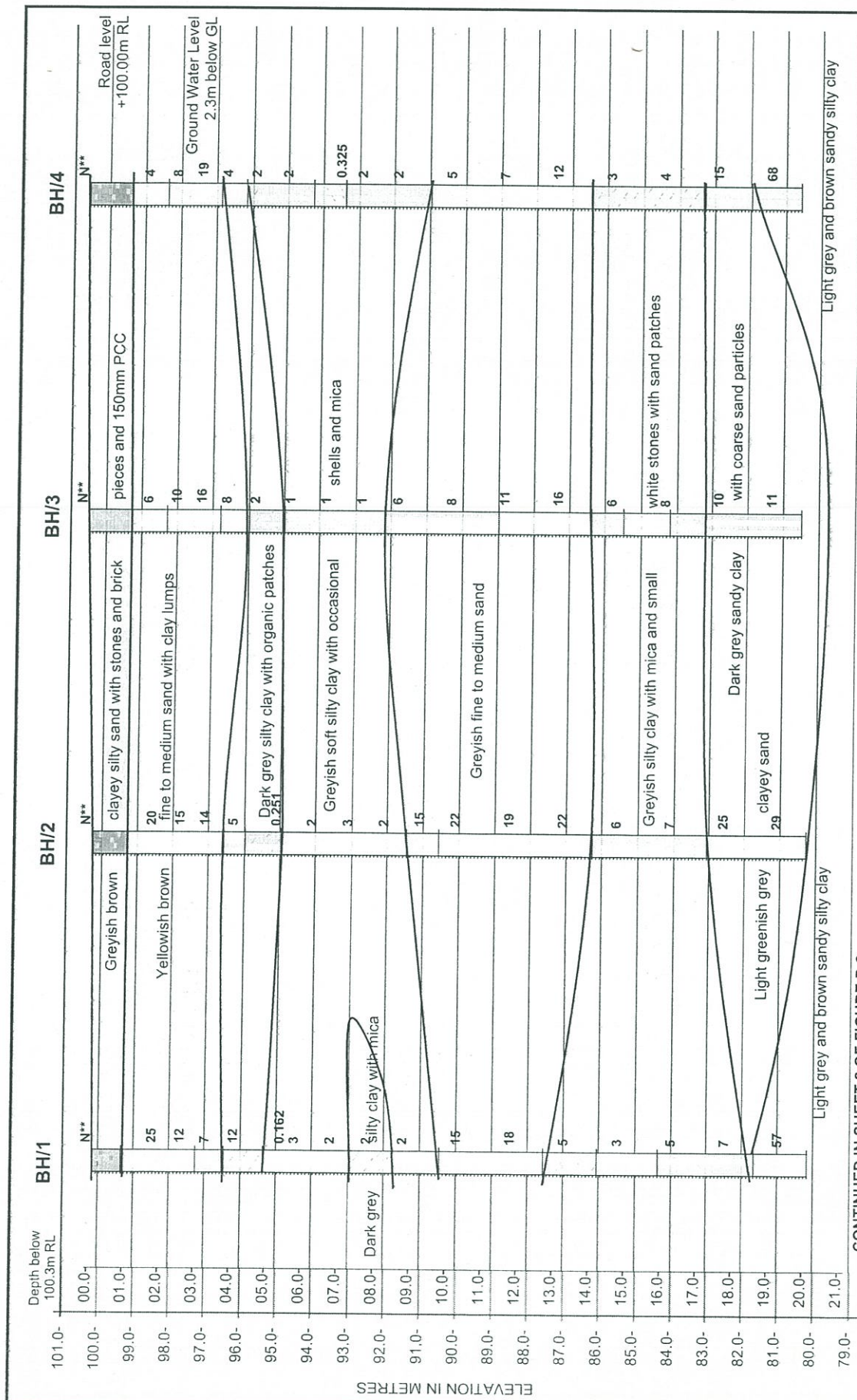
Stilt + 9 Residential Building with 287 Tenements, Thiruvalluvar Salai, Vanniyapuram for TNUHDB



CONTINUED FROM SHEET 1 OF FIGURE P-1

Ground level with respect to TBM 100.0m RL marked on the road top.
Important note: The subsoil variations can be different from what is shown here as the boreholes are at a distance. Refer respective bore logs for profile details.

FIGURE P-1
SHEET 2 OF 2
SUB-SOIL PROFILE BH/5 - BH/4
Stilt + 9 Residential Building with 287 Tenements, Thiruvalluvar Salai, Vanniyapuram for TNUHDB



CONTINUED IN SHEET 2 OF FIGURE P-2

Ground level with respect to TBM 100.0m RL marked on the road top
Important note: The subsoil variations can be different from what is shown here as the boreholes are at a distance. Refer respective bore logs for profile details.

FIGURE P-2
SHEET 1 OF 2
SUB-SOIL PROFILE BH/1- BH/2 - BH/3 - BH/4
Stilt + 9 Residential Building with 287 Tenements, Thiruvalluvar Salai, Vanniyapuram for TNUHDB

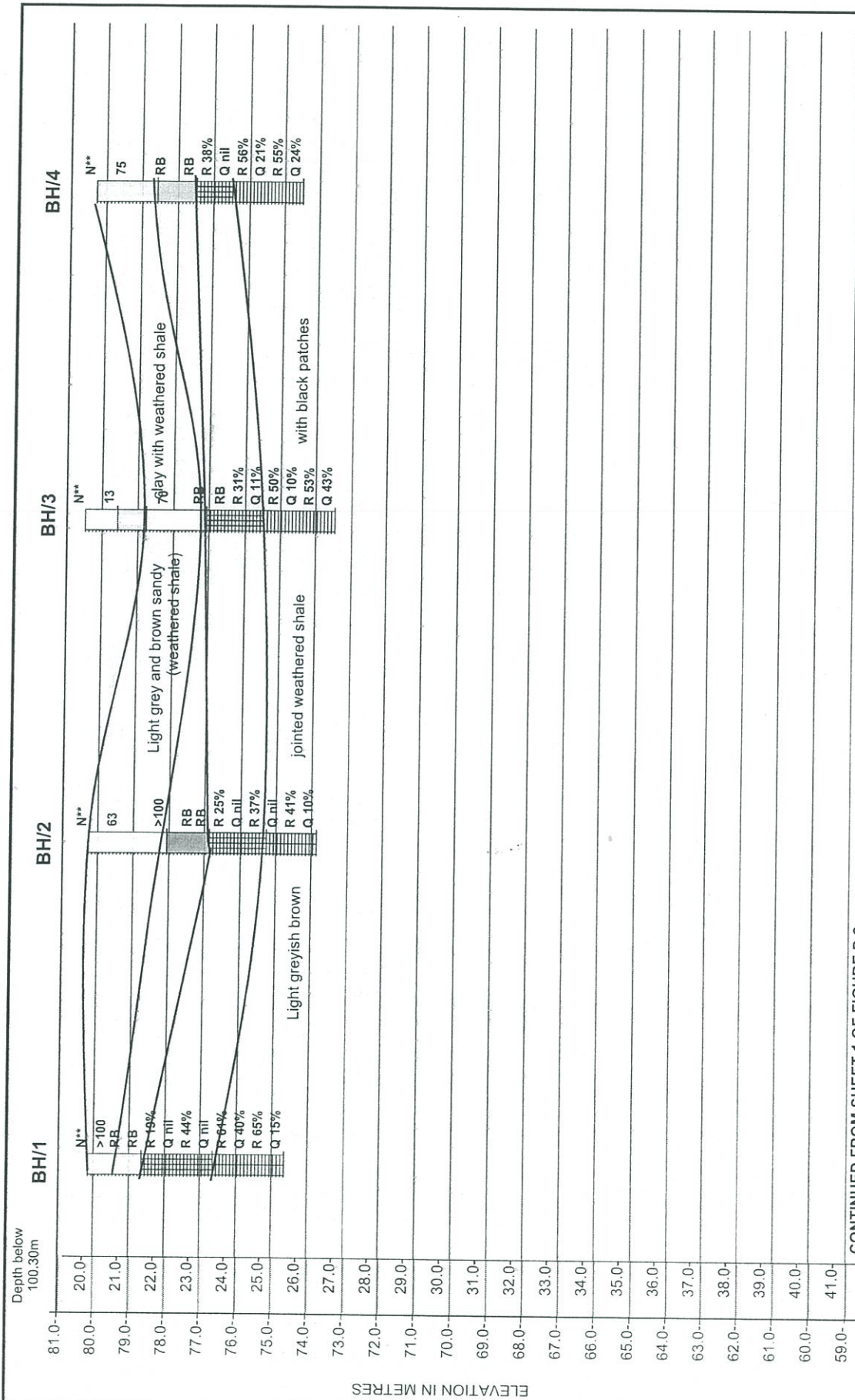


FIGURE P-2
SHEET 2 OF 2
SUB-SOIL PROFILE BH/1 -BH/2 - BH/3 - BH/4
Stilt + 9 Residential Building with 287 Tenements, Thiruvalluvar Salai, Vanniyapuram for TNUHDB

CONTINUED FROM SHEET 1 OF FIGURE P-2

Ground level with respect to TBM 100.0m RL marked on the road top.
Important note: The subsoil variations can be different from what is shown here as the boreholes are at a distance. Refer respective bore logs for profile details.

Soil Description	Layers		Thickness (m)	SPT N value	V' kN/m ³	Relative Density/Consistency	Eff. over burden pressure kN/m ²	N'	N''	k	α	ϕ Degree	δ Degree	C kPa	Ultimate unit skin friction kPa
	from(m)	to(m)													
Fill	0.00	1.20	1.2		5.0	Fill	6.00								
Sand	1.20	2.20	1.0	4	4.0	Very loose	10.00	6	6	0.8					
	2.20	3.00	0.8	8	5.0	Loose	14.00	10	10	1		26	17.3		2.50
	3.00	3.70	0.7	19	7.0	Medium dense	18.90	21	18	1.1		30	20.0		5.09
	3.70	4.40	0.7	4	5.0	Soft	22.40	4	4		1.00	32	21.3		8.12
Clay	4.40	5.50	1.1	2	4.0	Very soft	26.80	2	2		1.00			20	20.00
	5.50	6.30	0.8	2	4.0	Very soft	30.00	2	2		1.00			12	12.00
	6.30	7.20	0.9	2	4.0	Very soft	33.60	2	2		1.00			12	12.00
	7.20	8.50	1.3	2	4.0	Very soft	38.80	2	2		1.00			12	12.00
	8.50	9.60	1.1	2	4.0	Very soft	43.20	2	2		1.00			12	12.00
	9.60	11.50	1.9	5	5.0	Loose	52.70	7	7	0.85				12	12.00
Sand	11.50	13.00	1.5	7	5.0	Loose	60.20	9	9	0.95		27	18.0		14.55
	13.00	14.10	1.1	12	5.0	Loose	65.70	15	15	1.1		29	19.3		20.05
Clay	14.10	16.00	1.9	3	5.0	Soft	75.20	3	3		1.00	32	21.3		28.21
Sand	16.00	17.30	1.3	4	5.0	Soft	81.70	4	4		1.00			16.0	16.00
	17.30	18.50	1.2	15	7.0	Medium dense	90.10	16	15	1.1		32	21.3	20.0	20.00
Clay	18.50	20.00	1.5	68	10.0	Hard	105.10	68	68		0.25			200.0	50.00
	20.00	21.70	1.7	75	10.0	Hard	122.10	75	75		0.25			250.0	62.50
Weathered Shale Sediments	21.70	22.80	1.1	100	12.0	Very weak					0.25			450.0	112.50
Weathered Shale	22.80	25.00	2.2	100	12.0	Very weak					0.25			750	187.50
Pile Diameter (m)															
C/S Area (sq.m)															
Bearing capacity factor Nc															
Cohesion at pile tip kPa															
Ultimate End bearing capacity of the pile (kN)															
Safe End bearing capacity of the pile (kN)															
Total Negative Skin friction (kN)															
Total Positive skin friction (kN)															
Positive skin friction with FOS (kN)															
Safe Bearing Capacity of the pile (kN)															
Safe Bearing Capacity of the pile (T)															
Weight of pile, (kN)															
Uplift Capacity of pile (kN)															
Uplift Capacity of pile (T)															

Note: Pile capacities are estimated based on the procedure suggested in IS:2911 (Part 1/Sec 2)-2010 with suitable modifications and Cole and Stroud recommendations.

ESTIMATION OF SAFE COMPRESSION CAPACITY OF BORED CAST-IN-SITU PILES

Appendix B

Lateral Load Carrying capacity of the pile (IS 2911)

Project: Vanniapuram

Type of pile = Bored cast-in-situ piles

Grade of Concrete = M25

$f_{ck} = 25 \text{ N/mm}^2$

Elastic modulus of concrete, $E_c = 5000 \sqrt{f_{ck}} \text{ Mpa}$

Coefficient of modulus variation = 25 MN/m³

Allowable deflection at pile head = 5 mm

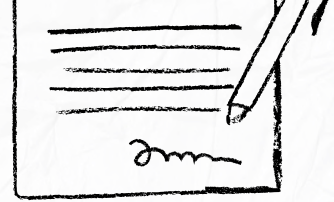
	Fixed head	Free head
Diameter of the pile (cm)	50	50
Characteristic strength of concrete (MPa)	25	25
Characteristic strength of concrete (kg/sq.cm)	255	255
E (MPa)	25000	25000
E (kg/sq.cm)	250000	250000
I (cm ⁴)	306796.16	306796.16
$\eta h \text{ (kN/m}^3 \text{)} \times 10^3$	0.45	0.45
$\eta h \text{ (kg/cm}^3 \text{)}^*$	0.045	0.045
T (cm)	279.46	279.46
L1	0.00	0.00
Lf/T **	2.20	1.95
Lf (cm)	614.81	544.94
Y (permissible deflection) cm	0.50	0.50
H (kg)	1980.28	710.94
H in kN	19.80	7.11
H in tons	1.98	0.71

Pile Dia (m)	Lateral Load Capacity of the piles (kN)		Lateral Load Capacity of the piles (tons)	
	Fixed Head	Free Head	Fixed Head	Free Head
0.5	19.8	7.11	1.98	0.71
0.6	26.51	9.52	2.65	0.95
0.75	37.89	13.6	3.79	1.36

**Lf/T, ratio between depth of fixity and T read from IS 2911 corresponding to the ratio L1/T, L1 being the free standing length

* ηh , modulus of subgrade reaction as per IS 2911

NOTE: The total depth of fixity below the pile head is sum of cantilever length L1 and Lf



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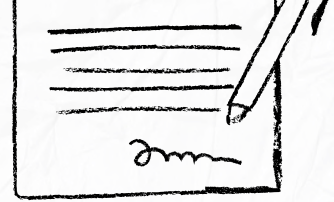
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