CLIENT	**M/s. SRIHARII RESIDENTIAL VENTURE PRIVATE LIMITED, CHENNAI**
PROJECT	**PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING (STILT+03) AT NO:2, KARUNAKARAN NAGAR, POONAMALLEE, CHENNAI 600056**
TITLE	**GEOTECHNICAL INVESTIGATION REPORT**

REV.	DATE	REPORT NUMBER	REMARK
0	**10.04.2024**	**BAG/ M/s. SRIHARII RESIDENTIAL VENTURE PRIVATE LIMITED /M-1746/24-25**	

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CHAPTER-1

INTRODUCTION

1.0 Preamble

M/S. Sriharii Residential Venture Private Limited, Chennai Proposed To Construct A **Residential Building (Stilt+03) At No:2, Karunakaran Nagar, Poonamallee, Chennai 600056.**

For the purpose of designing the foundations, the responsibility of carrying out suitable soil investigations was entrusted to **M/s. Booshnam Associates Pvt. Ltd., Chennai.**

This report contains the field and laboratory test results along with Design computations and recommendations for suitable foundation systems.

1.1 Scope of Work

- Sinking Two Standard Soil investigation bore holes of 150mm diameter up to a depth of 30.00m below existing ground level as directed by the engineer-in-charge.
- Conducting Standard Penetration Test (SPT) at regular depth intervals.
- Collection of Split Spoon Samples or Disturbed Soil Samples
- Collection of water samples from each bore hole.
- Conducting relevant laboratory test results.

1.2 Structure of the Report

- Contents
- Introduction
- Investigation Methodology & Test Results
- Figures & Tables
- Sub-Surface Stratification
- Foundation Systems
- Recommendations
- Annexure (Design Computations)

CHAPTER-2

INVESTIGATION METHODOLOGY & TEST RESULTS

2.0 Field Testing:

2.1 Preamble:

Two standard soil investigation boreholes were put. The equipment used and the methodology adopted to carry out the fieldwork is described below.

2.2 Equipment Used and Method of Drilling:

2.2.1 Equipment Used

The equipment used for performing the drilling operations is a Calyx Rotary Drill Rig with direct mud circulation technique. The drill mud used was made out of Sodium Bentonite.

2.2.2 Methodology of drilling

In the soil strata, the drilling operations were carried out using special drill bits and cutters coupled with direct mud circulation.

2.3 In-Situ Strength Tests:

2.3.1 Standard Penetration Test:

Standard penetration tests were conducted at the borehole locations, in accordance with IS: 2131. The tests were conducted at every change of strata up to the depth of termination of the borehole as directed by the engineer-in-charge.

2.4. Collection of Samples:

2.4.1 Disturbed Soil 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.

2.5 Summary of Field Work

The locations of the boreholes are shown in site plan given in Fig.2.0. The soil profiles obtained at location is shown in Figs. 2.1 & 2.2.

2.6 Laboratory Testing:

2.6.1 Coarse Grained Samples:

2.6.1.1 Grain size Analysis Tests:

On the coarse grained samples, grain size distribution tests were conducted as per I.S.2720 (Part 4)-1985, to know the gradation characteristics and to classify them. These results are presented in Tables 2.1 & 2.2.

2.6.2 Fine Grained Samples:

2.6.2.1 Index Property – Free Swell Tests:

Atterberg Limits were carried out on fine grained soil samples to evaluate the limits of different consistency states. Generally Liquid limits, Plastic limits and Shrinkage Limits tests were conducted as per I.S.2720 (Part-5)-1985 and I.S.2720 (Part 6)-1972. On such type of soil strata encountered at the investigation locations, such tests were conducted and the test results are presented in Tables 2.1 & 2.2.

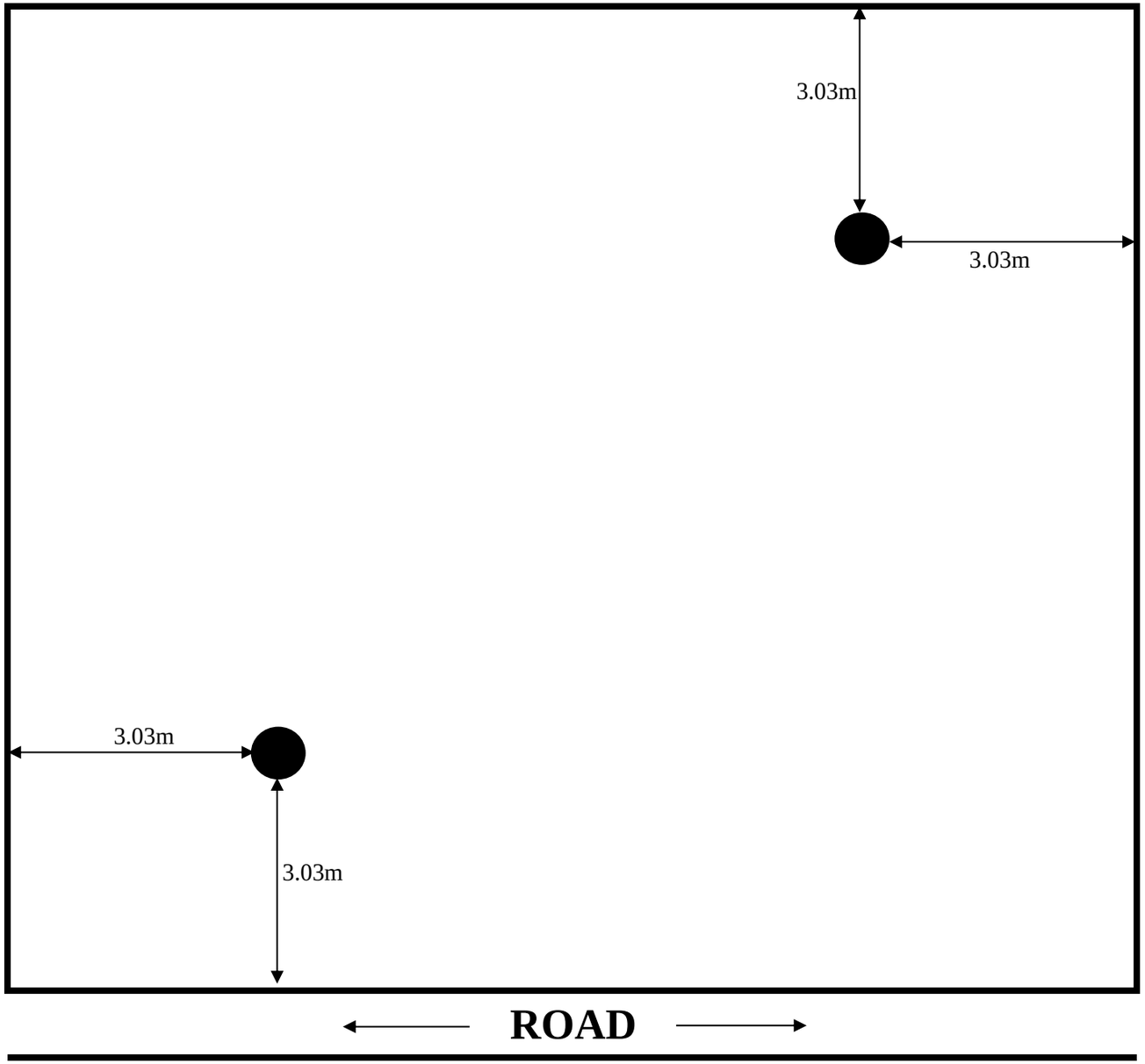


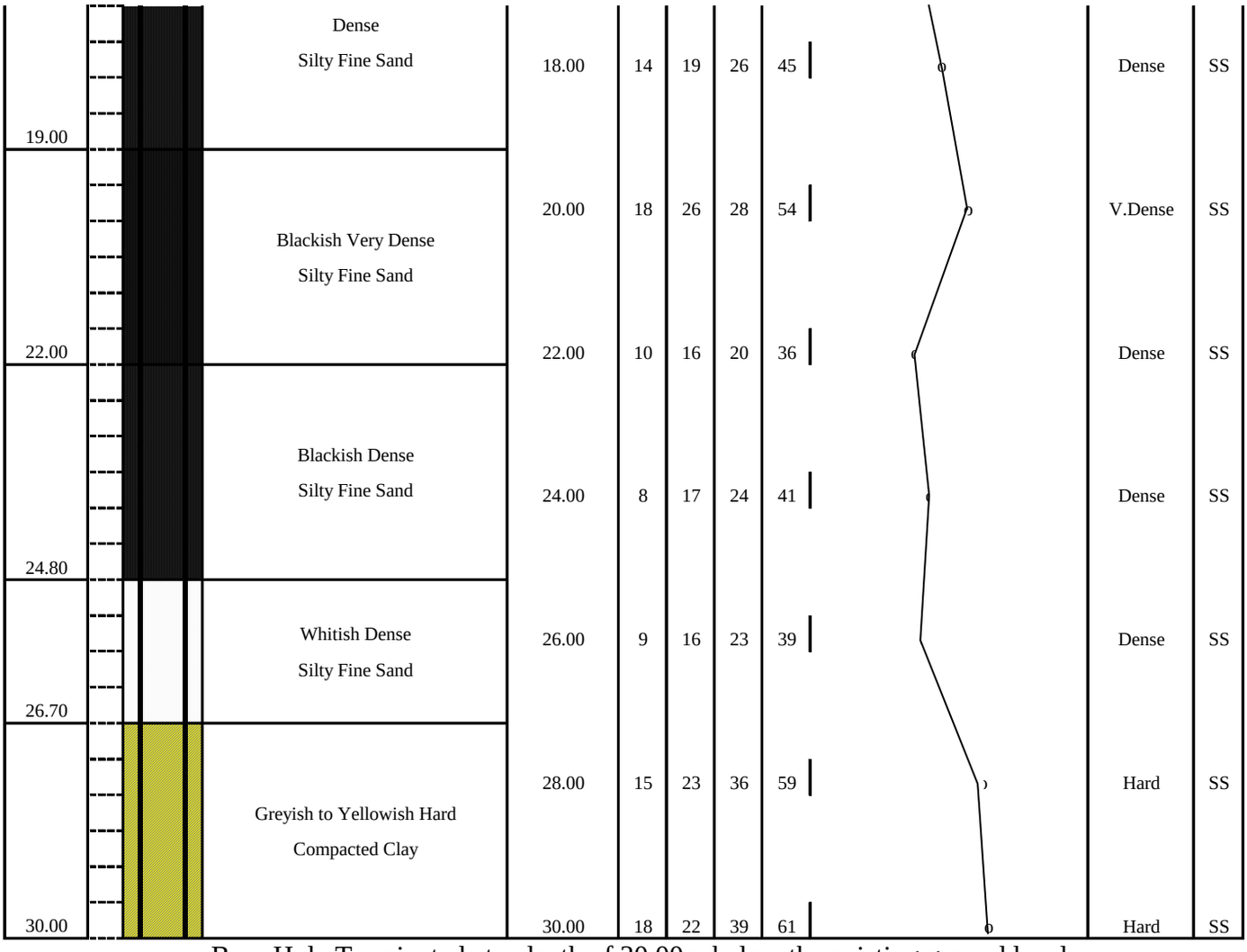
Fig. 2.0: Site Plan Representing the locations of Field Investigation Points

Project : Proposed Construction of Residential Building (Stilt+03) at No:2, Karunakaran Nagar, Poonamallee, Chennai 600056.

Location: BH-01

Started On : 06/04/2024; Ended On : 07/04/2024 G.W.T: 4.00mm below existing ground level

(R.L of Layer (m)	G.W.T. (m)	Soil Profile	Engineering Description of Soil	SPT - Details: Depth of SPT below E.G.L (m)	0-15 cm	15-30 cm	30-45 cm	N-Value	Graphical Representation of SPT (0 10 20 30 40 50 60 70 80 90)	Relative Density/Consistency	Type of Sample
0.30			Filled Up Soil							-	DS
2.40			Brownish Stiff Silty Clay	1.50	4	4	5	9		Stiff	SS
			Brownish Medium Dense Silty Fine Sand	3.00	7	9	11	20		M.Dense	SS
G.W.T 5.00	↓			4.50	10	12	14	26		M.Dense	SS
6.30			Brownish Dense Silty Fine Sand	6.00	13	15	18	33		Dense	SS
8.20			Blackish Medium Stiff Silty Clay	7.50	3	4	4	8		M.Stiff	SS
			Blackish Loose Silty Clayey Fine Sand	9.00	5	5	7	12		Loose	SS
				10.50	6	7	7	14		Loose	SS
12.40				12.00	5	6	6	12		Loose	SS
			Greyish Dense Silty Fine Sand	13.50	8	13	18	31		Dense	SS
15.60				15.00	10	15	22	37		Dense	SS
			Blackish	16.50	12	17	21	38		Dense	SS



Bore Hole Terminated at a depth of 30.00m below the existing ground level

Fig. 2.1 Soil Profile at BH-01 Location

Project : Proposed Construction of Residential Building (Stilt+03) at No:2, Karunakaran Nagar, Poonamallee, Chennai 600056.

Location: BH-02

Started On : 08/04/2024; Ended On : 08/04/2024 G.W.T: 4.00m below existing ground level

(R.L of Layer (m)	G.W.T. (m)	Soil Profile	Engineering Description of Soil	SPT - Details: Depth of SPT below E.G.L (m)	0-15 cm	15-30 cm	30-45 cm	N-Value	Graphical Representation of SPT (0 10 20 30 40 50 60 70 80 90)	Relative Density/Consistency	Type of Sample
0.60			Filled Up Soil							-	DS
			Brownish Medium Stiff Silty Clay	1.50	3	4	4	8		M.Stiff	SS
2.30											
			Brownish Medium Dense Silty Fine Sand	3.00	6	8	11	19		M.Dense	SS
G.W.T	↓			4.50	8	11	13	24		M.Dense	SS
5.00											
			Brownish Dense Silty Fine Sand	6.00	12	15	17	32		Dense	SS
6.60											
			Blackish Stiff Silty Clay	7.50	4	4	5	9		Stiff	SS
				9.00	4	5	5	10		Stiff	SS
9.50											
			Blackish Medium Stiff Silty Clay	10.50	4	3	3	6		M.Stiff	SS
10.70											

Bore Hole Terminated at a depth of 10.70m below the existing ground level

Fig. 2.2 Soil Profile at BH-02 Location

Table 2.1: Laboratory Test Result on the Soil Sample Collected from BH-01

Depth of Sample below E.G.L. (m)	SPT of Sample	Type of Sample	Engineering Description of Soil	NMC(%)	Natural Density (g/cc)	Clay					Relative Density/ Consistency	Sieve Analysis						IS-Classification
						LL (%)	PL (%)	PI	I_c	FS		Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	
0.00 to 0.30	-	DS	Filled Up Soil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.30 to 2.40	9	SS	Silty Clay	33	1.7	62	21	41	0.71	11	Stiff	0	0	0	0	18	82	CH
2.40 to 5.00	23	SS	Silty Fine Sand	-	1.7	-	-	-	-	-	M.Dense	0	0	0	78	22	0	SM
5.00 to 6.30	33	SS	Silty Fine Sand	-	1.9	-	-	-	-	-	Dense	0	0	0	81	19	0	SM
6.30 to 8.20	8	SS	Silty Clay	34	1.6	60	20	40	0.65	-	M.Stiff	0	0	0	0	17	83	CH
8.20 to 12.40	12	SS	Silty Clayey Fine Sand	-	1.5	-	-	-	-	-	Loose	0	0	0	77	11	12	SM
12.40 to 15.60	34	SS	Silty Fine Sand	-	1.9	-	-	-	-	-	Dense	0	0	0	82	18	0	SM
15.60 to 19.00	41	SS	Silty Fine Sand	-	1.9	-	-	-	-	-	Dense	0	0	0	84	16	0	SM
19.00 to 22.00	54	SS	Silty Fine Sand	-	2.0	-	-	-	-	-	V.Dense	0	0	0	85	15	0	SM
22.00 to 24.80	38	SS	Silty Fine Sand	-	1.9	-	-	-	-	-	Dense	0	0	0	83	17	0	SM
24.80 to 26.70	39	SS	Silty Fine Sand	-	1.9	-	-	-	-	-	Dense	0	0	0	83	17	0	SM
26.70 to 30.00	59	SS	Compacted Clay	18	2.0	38	31	7	2.86	-	Hard	0	0	0	0	22	78	CL

Table 2.2: Laboratory Test Result on the Soil Sample Collected from BH-02

Depth of Sample below E.G.L. (m)	SPT of Sample	Type of Sample	Engineering Description of Soil	NMC(%)	Natural Density (g/cc)	Clay					Relative Density/ Consistency	Sieve Analysis						IS-Classification
						LL (%)	PL (%)	PI	I_c	FS		Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	
0.00 to 0.60	-	DS	Filled Up Soil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.60 to 2.30	8	SS	Silty Clay	38	1.6	66	24	42	0.67	10	M.Stiff	0	0	0	0	18	82	CH
2.30 to 5.00	21	SS	Silty Fine Sand	-	1.7	-	-	-	-	-	M.Dense	0	0	0	77	23	0	SM
5.00 to 6.60	32	SS	Silty Fine Sand	-	1.9	-	-	-	-	-	Dense	0	0	0	82	18	0	SM
6.60 to 9.50	9	SS	Silty Clay	32	1.7	69	25	44	0.84	-	Stiff	0	0	0	0	19	81	CH
9.50 to 10.70	6	SS	Silty Clay	44	1.5	79	22	57	0.61	-	M.Stiff	0	0	0	0	16	84	CH

CHAPTER-3

SUB-SURFACE STRATIFICATION

3.0 Preamble

The sub surface stratification at borehole location, with respect to foundation/geotechnical engineering application are derived based on the visual identification, laboratory classification tests and field in-situ strength tests. Further, the strength parameters are estimated based on the in-situ strength test results as per the following correlation.

* **For Coarse Grained Samples, Ref. Fig.1, IS: 6403 to estimate Angle of Shearing Resistance.**
* **For Fine Grained Samples, Ref. Terzaghi & Peck, 1948, to estimate Unconfined Compressive Strength.**

3.1 Sub Surface Stratification:

3.1.1 Soil Profile at BH-01 Location

(At BH-01 Location, as presented in Site plan)

* **Layer-1 (from E.G.L to 0.30m depth)**

Type of Strata	Filled Up Soil
Colour	-
Thickness of Layer	0.30m

* **Layer-2 (from 0.30m to 2.40m depth)**

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	2.10m
SPT of the layer	09
Consistency	Stiff
Un-drained Cohesion, Cu	60.00kPa

* **Layer-3 (from 2.40m to 5.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	2.60m
SPT of the layer	23
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	33.90^0

* **Layer-4 (from 5.00m to 6.30m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	1.30m
SPT of the layer	33
Relative Density	Dense
Angle of Shearing Resistance, ϕ	36.825^0

* **Layer-5 (from 6.30m to 8.20m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	1.90m
SPT of the layer	08
Consistency	Medium Stiff
Un-drained Cohesion, Cu	53.33kPa

* **Layer-6 (from 8.20m to 12.40m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Blackish
Thickness of Layer	4.20m
SPT of the layer	12
Relative Density	Loose
Angle of Shearing Resistance, ϕ	30.60^0

* **Layer-7 (from 12.40m to 15.60m depth)**

Type of Strata	Silty Fine Sand
Colour	Greyish
Thickness of Layer	3.20m
SPT of the layer	34
Relative Density	Dense
Angle of Shearing Resistance, ϕ	37.10^0

* **Layer-8 (from 15.60m to 19.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Blackish
Thickness of Layer	3.40m
SPT of the layer	41
Relative Density	Dense
Angle of Shearing Resistance, ϕ	38.975^0

* **Layer-9 (from 19.00m to 22.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Blackish
Thickness of Layer	3.00m
SPT of the layer	54
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	41.60^0

* **Layer-10 (from 22.00m to 24.80m depth)**

Type of Strata	Silty Fine Sand
Colour	Blackish
Thickness of Layer	2.80m
SPT of the layer	38
Relative Density	Dense
Angle of Shearing Resistance, ϕ	38.20^0

* **Layer-11 (from 24.80m to 26.70m depth)**

Type of Strata	Silty Fine Sand
Colour	Whitish
Thickness of Layer	1.90m
SPT of the layer	39
Relative Density	Dense
Angle of Shearing Resistance, ϕ	38.475^0

* **Layer-12 (from 26.70m to 30.00m depth)**

Type of Strata	Compacted Clay
Colour	Greyish to Yellowish
Thickness of Layer	3.30m
SPT of the layer	59
Consistency	Hard
Un-drained Cohesion, Cu	393.33kPa

Ground Water

Ground water table was encountered at a depth of 4.00m below the existing ground level during the second week of April 2024.

3.1.2 Soil Profile at BH-02 Location

(At BH-02 Location, as presented in Site plan)

* **Layer-1 (from E.G.L to 0.60m depth)**

Type of Strata	Filled Up Soil
Colour	-
Thickness of Layer	0.60m

* **Layer-2 (from 0.60m to 2.30m depth)**

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	1.70m
SPT of the layer	08
Consistency	Medium Stiff
Un-drained Cohesion, Cu	53.33kPa

* **Layer-3 (from 2.30m to 5.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	2.70m
SPT of the layer	21
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	33.30^0

* **Layer-4 (from 5.00m to 6.60m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	1.60m
SPT of the layer	32
Relative Density	Dense
Angle of Shearing Resistance, ϕ	36.55^0

* **Layer-5 (from 6.60m to 9.50m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	2.90m
SPT of the layer	09
Consistency	Stiff
Un-drained Cohesion, Cu	60.00kPa

* **Layer-5 (from 9.50m to 10.70m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	1.20m
SPT of the layer	06
Consistency	Medium Stiff
Un-drained Cohesion, Cu	40.00kPa

Ground Water

Ground water table was encountered at a depth of 4.00m below the existing ground level during the second week of April 2024.

CHAPTER-4

FOUNDATION SYSTEM

4.0 Preamble

The foundation system design is an interface between super structure and the sub soil bearing strata characteristics. A sound foundation system should be safe against bearing strata shear response under the super structure load intensity. Similarly, the stability of the foundation system is governed by the bearing strata deformation response under the super structure load intensity. In addition, as a combined system of super structure and foundation, the overall stability is also governed by the super structure arrangement.

Considering the above aspects of foundation design, the suitable type of foundation system with respect to the sub soil conditions encountered at the borehole locations is presented in the subsequent sections.

4.1 Bearing Strata Characteristics

From field investigations, it can be observed that the sub-soil strata encountered at shallow depths are coarse-grained type and good from both shear strength characteristics and deformation considerations to act as bearing strata for proposed impending loads form structure.

If coarse-grained soil strata encountered at shallow depths are considered as bearing strata, the safe bearing capacity of open foundation system will be a function of least dimension of footing and effective surcharge over the bearing strata.

Care shall also be taken in designing the open foundation system so that the dispersed open foundation stresses on the underlying relatively weak soil layer encountered at 6.30m depths from existing ground level (SPT @ 7.50m is 08, Ref. BH-01) are within its safe bearing capacity limits.

Further, the sub-soil strata encountered up to the depth of investigations can also offer a good frictional resistance against a suitably designed structural member or element if being cast or driven in such soils.

Considering the above, suitable foundation systems are presented below.

4.2 Foundation System

4.2.1 Open Foundation System (BH-01)

*4.2.2 Considering the shear strength characteristics of coarse-grained soil strata encountered at shallow depths and presence of underlying relatively weak soil strata encountered at 6.30m below existing ground level, open foundation system of **Raft** located at a design depth of 2.50m below present existing ground level can be adopted.*

The safe bearing capacity of such type of open foundation system is presented below which can be adopted for foundation design purposes.

Type of Open Foundation System	Depth of Raft below Existing Ground Level (m)	Observed Thickness of Fill (m)	Depth of Raft below Natural Ground Level (m)	Type of Bearing Strata	Safe Bearing Capacity (MT/m^2)	Elastic Settlements <=70mm (mm)
Raft	2.50	0.30	2.20	Silty Fine Sand	14	42

The computations for above are annexed to this report.

Notes

Safe Bearing Capacity of open foundation system is restricted considering the presence of underlying relatively weak soil layer encountered at 6.30m depths from existing ground level i.e. 4.10m distant apart from the bottom level of footing.

CHAPTER-5

CONCLUSIONS & RECOMMENDATIONS

1. Foundation systems presented in Clause 4.2.1 Chapter-IV can be adopted for foundation design purposes.

Open Foundation System

2. Open foundation System of isolated column footing type located at shallow depths over coarse-grained strata can be adopted for foundation design purposes.
3. Care shall be taken so that the ultimate bearing strata are none other than coarse-grained **Silty Fine Sand** type.
4. In case, ground water table is encountered within recommended depth of foundation system, provision shall be made to continuously bail the water out of the foundation pits to keep the surfaces of pit consolidated dry.
5. Safe Bearing Capacity of open foundation is restricted considering the presence of underlying relatively weak soil layer encountered at a depth of 6.30m below existing ground level i.e. 4.10m distant apart from the bottom level of footing.
6. Excavated coarse-grained soil strata encountered at shallow depths 0.30m thick filled up soil can only be used for back filling purposes.

Open Foundation Depths

7. Depth of open excavations below present existing ground level shall be 2.50m.
8. Observed Thickness of filled up soil @ Site is 0.30m.
9. Depth of Raft Footing below natural ground level will be 2.20m.

Other Recommendations

10. It is recommended to connect the grade beams so that the structure can act as a single unit against any differential settlements in between the Raft footings.
11. Special provisions to contain any lateral collapse of soil from the walls excavated foundation pits are required up to the recommended depths of open foundation system.

DESIGN OF OPEN FOUNDATION SYSTEM (Ref. BH-01)

1 COMPUTATION OF BEARING CAPACITY AS PER IS:6403

1.1 Geometrical Data :

Type of Foundation System:	Raft	
R.L of the top of Borehole (m):	0.00	m
Depth of Foundation below existing ground level (D_f):	2.50	m
Observed Thickness of fill at site:	0.30	m
Effective Depth of Foundation below natural ground level (D_f):	2.20	m
Design Width of Foundation (B):	1.00	m
Thickness of Foundation (T) :	0.25	m

1.2 Soil Data :

Type of Bearing Strata :	Silty Fine Sand	
Design SPT-value of the Bearing Strata : (considered based upon the density of the strata)	20	
Type of Shear Failure:	General	
Angle of Shearing Resistance - Limited to a Maximum of:	33.00	Deg.

1.3 Design Parameters:

Bulk Density of Soil above the foundation depth (γ_{bulk})	16.00	kN/m^3
Effective Overburden pressure at foundation level (q)	13.20	kPa
Water Table Correction Factor (w')	0.50	

Bearing Capacity Factors:

N_c = N/A

N_q = 27.34

N_γ = 37.78

Shape Factors:

S_c = N/A

S_q = 1.65

S_γ = 0.60

Depth Factors :

D_c = N/A

D_q = 1.00

D_γ = 1.00

Inclination Factor:

I_c = N/A

I_q = 1.00

I_γ = 1.00

1.4 Ultimate Bearing Capacity (Qu) :

Qu = Cu*Nc*Sc*D_C*I_C+q*(Nq-1)*Sq*Dq*Iq + 0.5*B*γ*Nγ*Sγ*Dγ*Ig*w'

Q_u = 685.92 kPa

1.5 Safe Bearing Capacity (Qsafe) :

Factor of Safety (F.S.) : 2.50

Qsafe : 274.37 kPa

Recommended Safe Bearing Capacity: 140.00 kPa

Restricted considering the presence of underlying relatively weak soil layer encountered at 6.30m depths from existing ground level i.e. 4.10m distant apart from the bottom level of footing.

1.6 Settlements

Since, the bearing strata are coarse-grained type, the settlements under the allowable safe bearing pressure 140kPa will be of immediate elastic nature. The elastic settlements corresponding to a safe bearing pressure of 140kPa and average SPT of 20 considering extent of pressure bulb below bottom level of footing are computed to be in the order of 42mm which is within the permissible limits of 70mm for Raft footing as per I.S:1904.