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CLIENT	**KAAVIYA PROPERTIES (P) LTD., CHENNAI**
PROJECT	**PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING (STILT+05) AT 81/38, INDIRA NAGAR, 4TH MAIN ROAD, FIRST AVENUE, INDIRA NAGAR, ADYAR, CHENNAI-600020**
TITLE	**GEOTECHNICAL INVESTIGATION REPORT**

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For Geo Mines Engineers Pvt. Ltd

Director

GEOMINES ENGINEERS (P) LTD. GMEPL Chennai

REV.	DATE	REPORT NUMBER	PREP. BY
0	21-05-2024	GMEPL/KAAVIYA PROPERTIES (P) LTD/094/2024-25	

DISCLAIMER

We've been asked to look into the ground and identify and quantify everything that mother nature has put thereand predict how those materials will react to construction and long-term performance of a facility - and we may fall short of this lofty goal.

We have made reasonable and prudent conclusions but a cloud of uncertainty inherently looms over the project as per the pre and post facilities laid and their elemental behaviour on the mother soil.

Also, the variable nature of soil strata and it's varying characteristics may make the recommended foundation system disqualify and hence it's recommended that special care shall be taken by the owner during and after the construction is complete and during the run period of the building.

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CHAPTER-1

INTRODUCTION

1.0 Preamble

Kaaviya Properties (P) Ltd., Chennai proposed to construct a **Residential Building (Stilt+05) at 81/38, Indira Nagar, 4th Main Road, First Avenue, Indira Nagar, Adyar, Chennai-600020.**

For the purpose of designing the foundations, the responsibility of carrying out suitable soil investigation was entrusted to M/s. Geo Mines ENGINEERS 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 12.00m 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)

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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 was 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.

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2.4.2 Ground Water

For conducting suitable chemical tests, the ground water samples were collected from the respective boreholes.

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 each 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 soil 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:

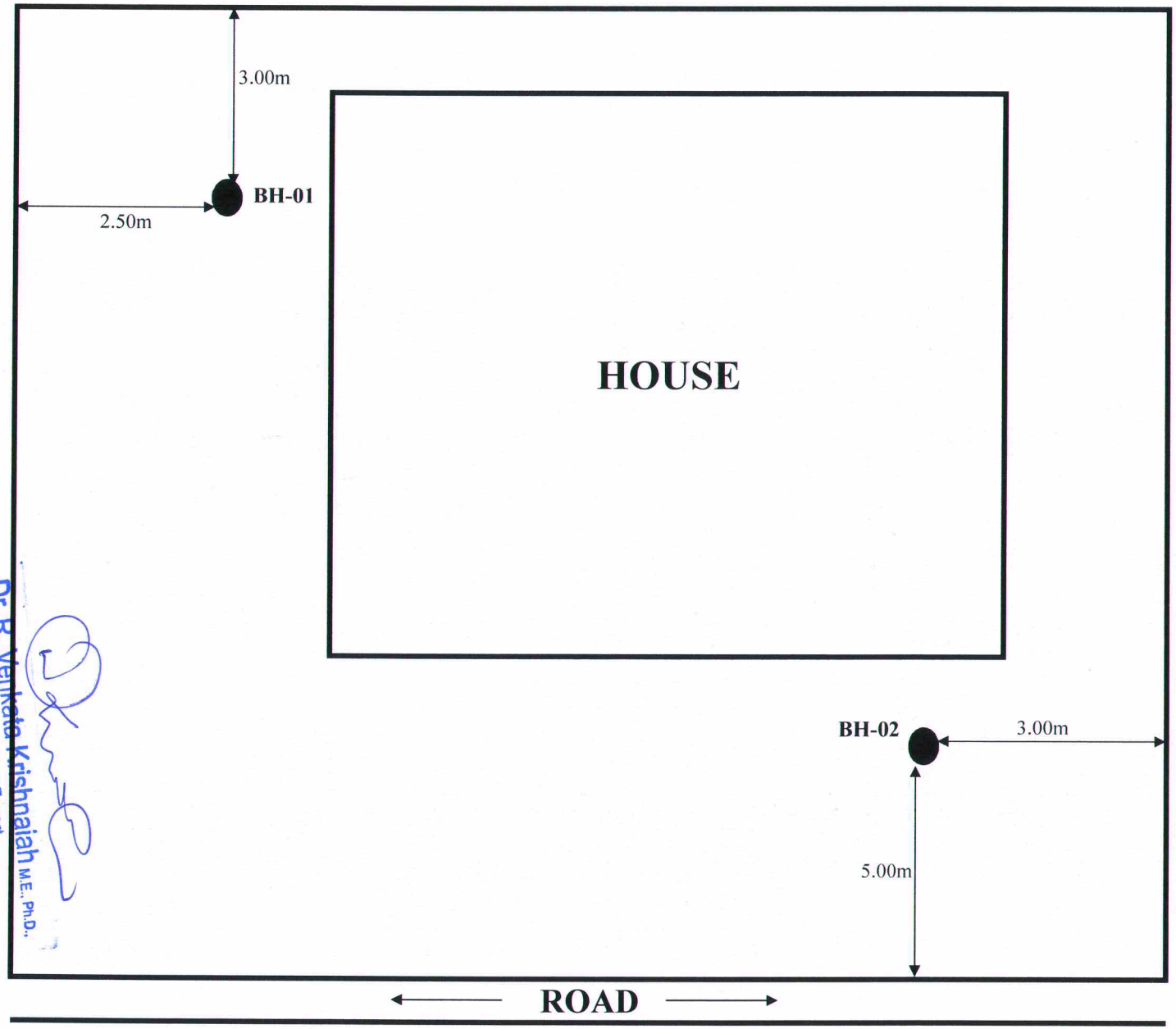
Atterberg Limits were carried out on fine grained soil samples to evaluate the limits of different consistency states. Generally Liquid limits, Plastic limits and Shrinkage Limits tests were conducted as per I.S.2720 (Part-5)-1985 and I.S.2720 (Part 6)-1972. On such type of soil strata encountered at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

2.6.3 Chemical Analysis Tests:

2.6.3.1 Water Samples:

On representative water samples, chemical analysis tests were conducted to estimate pH, Chlorides and Sulphates. These results are presented in Table-2.3.

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

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Location: BH-01

Started On : 14/03/2024; Ended On : 15/03/2024 G.W.T: 1.00m below existing ground level

R.L of Layer (m)	G.W.T. (m)	Soil Profile	Engineering Description of Soil	Depth of SPT below E.G.L (m)	SPT - Details 0-15 cm	15-30 cm	30-45 cm	N-Value	ical Representation c 0 1 2 3 4 5 6 7 8 9	Relative Density/Consistency	Type of Sample
0.50			Filled Up Soil							-	DS
G.W.T			Brownish Medium Stiff Silty Clay	1.50	3	3	2	5		M.Stiff	SS
2.00											
3.00			Brownish Soft Silty Clay	2.50	3	2	1	3		Soft	SS
4.00			Brownish Medium Stiff Silty Clay	3.50	2	2	3	5		M.Stiff	SS
5.50			Greyish Medium Stiff Silty Clay	4.50	3	2	4	6		M.Stiff	SS
7.00			Greyish Loose Silty Clayey Fine Sand	6.00	5	4	6	10		Loose	SS
8.50			Greyish Medium Dense Silty Clayey Fine Sand	7.50	4	7	9	16		M.Dense	SS
11.00			Greyish Loose Silty Clayey Fine Sand	9.00	5	4	5	9		Loose	SS
				10.00	6	7	7	14		M.Dense	SS
12.20			Weathered Rock	12.00	SPT Hammer Rebounded					V.Dense	SS

Bore Hole Terminated at a depth of 12.20m below the existing ground level

Fig. 2.1 Soil Profile at BH-01 Location

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Location: BH-02

Started On : 15/03/2024; Ended On : 16/03/2024 G.W.T: 1.00m below existing ground level

R.L of Layer (m)	G.W.T. (m)	Soil Profile	Engineering Description of Soil	Depth of SPT below E.G.L (m)	SPT - Details 0-15 cm	15-30 cm	30-45 cm	N-Value	ical Representation 0 1 2 3 4 5 6 7 8 9	Relative Density/Consistency	Type of Sample
G.W.T	↓		Brownish Stiff Silty Clay	1.50	2	4	5	9		Stiff	SS
2.00											
			Brownish Medium Stiff Silty Clay	2.50	2	3	2	5		M.Stiff	SS
3.00											
			Greyish Medium Stiff Silty Clay	3.50	4	2	5	7		M.Stiff	SS
4.50				4.50	2	2	2	4		Soft	SS
			Greyish Soft Silty Clay								
5.50											
			Greyish Medium Stiff Silty Clay	6.00	2	2	3	5		M.Stiff	SS
7.00											
			Greyish Soft Silty Clay	7.50	2	3	1	4		Soft	SS
8.00											
			Greyish Loose Silty Clayey Fine Sand	9.00	4	6	7	13		Loose	SS
				10.00	5	8	3	11		Loose	SS
11.00											
			Weathered Rock	12.00	SPT Hammer Rebounded					V.Dense	SS
12.20											

Bore Hole Terminated at a depth of 12.20m below the existing grou

Fig. 2.2 Soil Profile at BH-02 Location

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Table 2.1: Laboratory Test Results on the Soil Samples 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 0.50	-	DS	Filled Up Soil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.50 to 2.00	5	SS	Silty Clay	42	1.5	58	23	35	0.46	13	M.Stiff	0	0	0	0	16	84	CH
2.00 to 3.00	3	SS	Silty Clay	48	1.3	60	21	39	0.31	-	Soft	0	0	0	0	14	86	CH
3.00 to 4.00	5	SS	Silty Clay	43	1.5	58	24	34	0.44	-	M.Stiff	0	0	0	0	16	84	CH
4.00 to 5.50	6	SS	Silty Clay	40	1.5	56	27	29	0.55	-	M.Stiff	0	0	0	0	17	83	CH
5.50 to 7.00	10	SS	Silty Clayey Fine Sand	-	1.5	-	-	-	-	-	Loose	0	0	0	68	13	19	SM
7.00 to 8.50	16	SS	Silty Clayey Fine Sand	-	1.6	-	-	-	-	-	M.Dense	0	0	0	77	10	13	SM
8.50 to 11.00	11	SS	Silty Clayey Fine Sand	-	1.5	-	-	-	-	-	Loose	0	0	0	70	12	18	SM
11.00 to 12.20	>100	SS	Weathered Rock	-	2.0	-	-	-	-	-	V.Dense	43	23	14	14	6	0	SDR

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Table 2.2: Laboratory Test Results on the Soil Samples 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 2.00	9	SS	Silty Clay	33	1.7	53	28	25	0.80	11	Stiff	0	0	0	0	18	82	CH
2.00 to 3.00	5	SS	Silty Clay	41	1.5	57	23	34	0.47	-	M.Stiff	0	0	0	0	15	85	CH
3.00 to 4.50	7	SS	Silty Clay	35	1.6	54	25	29	0.66	-	M.Stiff	0	0	0	0	17	83	CH
4.50 to 5.50	4	SS	Silty Clay	46	1.4	60	23	37	0.38	-	Soft	0	0	0	0	15	85	CH
5.50 to 7.00	5	SS	Silty Clay	42	1.5	58	25	33	0.48	-	M.Stiff	0	0	0	2	16	82	CH
7.00 to 8.00	4	SS	Silty Clay	46	1.4	61	23	38	0.39	-	Soft	0	0	0	0	14	86	CH
8.00 to 11.00	12	SS	Silty Clayey Fine Sand	-	1.5	-	-	-	-	-	Loose	0	0	0	69	14	17	SM
11.00 to 12.20	>100	SS	Weathered Rock	-	2.0	-	-	-	-	-	V.Dense	49	14	14	21	2	0	SDR

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Table 2.3: Chemical Analysis Results conducted on Water Samples collected from BH-01 & BH-02

Location	Depth of Sample below E.G.L. (m)	pH	Chlorides (ppm)	Sulphates (ppm)
BH-01	3.00	6.77	287.44	143.68
BH-02	3.00	6.76	290.54	147.55

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CHAPTER-3

SUB-SURFACE STRATIFICATION

3.0 Preamble

The sub surface stratification at borehole locations, 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 0.50m depth)**

Type of Strata	Filled Up Soil
Colour	-
Thickness of Layer	0.50m

* **Layer-2 (from 0.50m to 2.00m depth)**

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	1.50m
SPT of the layer	05
Consistency	Medium Stiff
Un-drained Cohesion, Cu	33.33kPa

* **Layer-3 (from 2.00m to 3.00m depth)**

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	1.00m
SPT of the layer	03
Consistency	Soft
Un-drained Cohesion, Cu	20.00kPa

* **Layer-4 (from 3.00m to 4.00m depth)**

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	1.00m
SPT of the layer	05

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Consistency	Medium Stiff
Un-drained Cohesion, Cu	33.33kPa

* **Layer-5 (from 4.00m to 5.50m depth)**

Type of Strata	Silty Clay
Colour	Greyish
Thickness of Layer	1.50m
SPT of the layer	06
Consistency	Medium Stiff
Un-drained Cohesion, Cu	40.00kPa

* **Layer-6 (from 5.50m to 7.00m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	1.50m
SPT of the layer	10
Relative Density	Loose
Angle of Shearing Resistance, ϕ	30.00^0

* **Layer-7 (from 7.00m to 8.50m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	1.50m
SPT of the layer	16
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	31.80^0

* **Layer-8 (from 8.50m to 11.00m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	2.50m
SPT of the layer	11
Relative Density	Loose
Angle of Shearing Resistance, ϕ	30.30^0

* **Layer-9 (from 11.00m to 12.20m depth)**

Type of Strata	Weathered Rock
Colour	-
Thickness of Layer	1.20m
SPT of the layer	>100
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	42.50^0

Ground Water

Ground water table was encountered at a depth of 1.00m below the existing ground level during the second week of February 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 2.00m depth)**

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	2.00m
SPT of the layer	09

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Consistency	Stiff
Un-drained Cohesion, Cu	60.00kPa
* **Layer-2 (from 2.00m to 3.00m depth)**	
Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	1.00m
SPT of the layer	05
Consistency	Medium Stiff
Un-drained Cohesion, Cu	33.33kPa
* **Layer-3 (from 3.00m to 4.50m depth)**	
Type of Strata	Silty Clay
Colour	Greyish
Thickness of Layer	1.50m
SPT of the layer	07
Consistency	Medium Stiff
Un-drained Cohesion, Cu	46.66kPa
* **Layer-4 (from 4.50m to 5.50m depth)**	
Type of Strata	Silty Clay
Colour	Greyish
Thickness of Layer	1.00m
SPT of the layer	04
Consistency	Soft
Un-drained Cohesion, Cu	26.66kPa
* **Layer-5 (from 5.50m to 7.00m depth)**	
Type of Strata	Silty Clay
Colour	Greyish
Thickness of Layer	1.50m
SPT of the layer	05
Consistency	Medium Stiff
Un-drained Cohesion, Cu	33.33kPa
* **Layer-6 (from 7.00m to 8.00m depth)**	
Type of Strata	Silty Clay
Colour	Greyish
Thickness of Layer	1.00m
SPT of the layer	04
Consistency	Soft
Un-drained Cohesion, Cu	26.66kPa
* **Layer-7 (from 8.00m to 11.00m depth)**	
Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	3.00m
SPT of the layer	12
Relative Density	Loose
Angle of Shearing Resistance, ϕ	30.60^0
* **Layer-8 (from 11.00m to 12.20m depth)**	
Type of Strata	Weathered Rock
Colour	-
Thickness of Layer	1.20m
SPT of the layer	>100
Relative Density	Very Dense

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Angle of Shearing Resistance, ϕ	42.50^0

Ground Water

Ground water table was encountered at a depth of 1.00m below the existing ground level during the second week of February 2024.

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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 uniformly stratified from type but possess varying shear strength characteristics, BH-01 being relatively weak from deformation considerations and hence shall be considered as design borehole to determine the bearing strata for proposed foundation system.

Considering BH-01 as design borehole, it is an evident that the sub-soil strata encountered at shallow depths are weak from both shear strength characteristics and deformation considerations and hence cannot be considered as bearing strata for proposed impending loads from structure.

However, the refusal soil strata (SPT>60) encountered below a maximum depth of 11.00m from existing ground level (Ref. BH-01) can be considered as good end bearing strata for proposed impending loads from structure.

Considering the above, suitable foundation system is presented below.

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4.2. Foundation System

4.2.1 Deep Foundation System-12.00m long Bored Cast-in-Situ Friction cum End Bearing Piles

Considering the weak shear strength characteristics of sub-soil strata encountered at shallow depths, deep foundation system consisting of 12.00m long bored cast-in-situ Friction cum End Bearing Piles can be adopted.

Piles shall be drilled through DMC (direct mud circulation) technique.

For four different diameters, the safe load carrying capacities of 12.00m long bored cast-in-situ Friction cum End Bearing Piles are computed and presented below which can be adopted for foundation design purposes.

S. No	Type of Installation of Pile	Length of Pile below Existing Ground Level (m)	Type of Bearing Strata	Diameter of Pile (mm)	Safe Load Carrying Capacity (MT)	Safe Pull Out Capacity (MT)
1	Bored Cast-in-Situ	12.00	Weathered Rock	500	60	22
2				550	70	24
3				600	80	26
4				650	90	28

The computations of safe load carrying capacity for 500mm diameter and 12.00m long bored cast-in-situ Friction cum End Bearing pile are annexed to this report.

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CHAPTER-5

CONCLUSIONS & RECOMMENDATIONS

1. Deep Foundation system presented in Clause 4.2.1, Chapter-IV can be adopted for foundation design purposes.
2. Suitable pile load tests (as per I.S: 2911, part-IV) shall be performed to confirm the presented **theoretical** safe load carrying capacities and arrive at the **allowable** load carrying capacity of piles under considerations. (**Note)**
3. *Care shall be taken so that the ultimate end bearing soil strata are none other than recommended "Weathered Rock" type. The same shall be reaffirmed by our Geotechnical Engineer during foundation laying works are under progress*
4. Pile cap can be located over 0.30m thick well compacted ground replaced CNS (Cohesive Non-Swelling) soil surface.
5. Piles shall be installed using DMC (direct mud circulation) technique only.
6. Piles shall be grouped according to the column design load requirements.
7. Allowable load carrying capacities of piles shall be limited to their structural capacities.
8. **CNS can be well graded and non-plastic earth like quarry dust or clean river sand or sand: gravels mix (1:2) or fly-ash that shall be well compacted at site to achieve more than 95% of laboratory maximum dry density at optimum moisture content.**
9. As the chlorides and sulphates present in the collected water samples from shallow levels are within the permissible limits, no special steel or cement is recommended to be used for pile cap or shallow structure construction purposes. **However, it is recommended to extract the water samples at different intervals up to higher depths from an open-well/dug-well and tested for the chemical parameters as per the required usages or purposes and also to understand the construction material to be used for deep foundation purposes.**

For Geo Mines Engineers Pvt Ltd

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DESIGN OF PILE FOUNDATION (Refer:BH-01)

Refer, IS:2911(Part I/Sec 2)-1979, Reaffirmed 1997

1.0 Type of Installation of Pile — **Bored Cast in Situ**

1.1 Geometrical Data

Assumed Diameter of pile(D):	**500.0**	mm
Assumed R.L of E.G.L:	0.000	m
Length of pile below E.G.L.(l) :	**12.000**	m
R.L. of Bot. of Pile	-12.00	m

1.2 Design of Pile for Vertical Compression

1.2.1 Computation of Skin Resistance:

1.2.1.1 **Layer-II**

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	5	
Bulk Density of the strata,γ:	15	kN/m^3
Undrained Cohesion, Cu:	33.33	kPa
R.L of top of Strata:	-0.50	m
R.L of bottom of Strata:	-2.00	m
Average Thickness of Strata,I_c:	1.50	m
Effective overburden pressure over the top of strata,σ_{top}:	0.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	7.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	3.75	kN/m^2
Adhesion Factor, α:	0.70	
Skin Resistance of the pile,q_s:	54.98	kN

(q_s:α*Cu*pi()*d*Ic)

1.2.1.2 **Layer-III**

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	3	
Bulk Density of the strata,γ:	13	kN/m^3
Undrained Cohesion, Cu:	20.00	kPa
R.L of top of Strata:	-2.00	m
R.L of bottom of Strata:	-3.00	m
Average Thickness of Strata,I_c:	1.00	m
Effective overburden pressure over the top of strata,σ_{top}:	7.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	10.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	9.00	kN/m^2
Adhesion Factor, α:	1.00	

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Negative Skin Resistance of the pile,q_s: -31.42 kN

(q_s:α*Cu*pi()*d*Ic)

1.2.1.3 Layer-IV

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	5	
Bulk Density of the strata,γ:	15	kN/m^3
Undrained Cohesion, Cu:	33.33	kPa
R.L of top of Strata:	-3.00	m
R.L of bottom of Strata:	-4.00	m
Average Thickness of Strata,I_c:	1.00	m
Effective overburden pressure over the top of strata,σ_{top}:	10.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	15.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	13.00	kN/m^2
Adhesion Factor, α:	0.70	
Skin Resistance of the pile,q_s:	36.65	kN

(q_s:α*Cu*pi()*d*Ic)

1.2.1.4 Layer-V

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	6	
Bulk Density of the strata,γ:	15	kN/m^3
Undrained Cohesion, Cu:	40.00	kPa
R.L of top of Strata:	-4.00	m
R.L of bottom of Strata:	-5.50	m
Average Thickness of Strata,I_c:	1.50	m
Effective overburden pressure over the top of strata,σ_{top}:	15.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	23.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	19.25	kN/m^2
Adhesion Factor, α:	0.70	
Skin Resistance of the pile,q_s:	65.97	kN

(q_s:α*Cu*pi()*d*Ic)

1.2.1.5 Layer-VI

Type of Strata:	Silty Clayey Fine Sand	
Average SPT of the strata,N:	10	
Bulk Density of the strata,γ:	15	kN/m^3
Angle of Shearing Resistance,ϕ:	30	Deg.
R.L of top of Strata:	-5.50	m
R.L of bottom of Strata:	-7.00	m

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Average Thickness of Strata,I_c:	1.50	m
Effective overburden pressure over the top of strata,σ_{top}:	23.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	30.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	26.75	kN/m^2
Coeff. Of Earth Pressure, k:	1.00	
Skin Resistance of the pile,q_s:	36.39	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.6 **Layer-VII**

Type of Strata:	Silty Clayey Fine Sand	
Average SPT of the strata,N:	16	
Bulk Density of the strata,γ:	16	kN/m^3
Angle of Shearing Resistance,ϕ:	31.8	Deg.
R.L of top of Strata:	-7.00	m
R.L of bottom of Strata:	-8.50	m
Average Thickness of Strata,I_c:	1.50	m
Effective overburden pressure over the top of strata,σ_{top}:	30.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	39.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	35.00	kN/m^2
Coeff. Of Earth Pressure, k:	1.50	
Skin Resistance of the pile,q_s:	76.70	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.7 **Layer-VIII**

Type of Strata:	Silty Clayey Fine Sand	
Average SPT of the strata,N:	11	
Bulk Density of the strata,γ:	15	kN/m^3
Angle of Shearing Resistance,ϕ:	30.3	Deg.
R.L of top of Strata:	-8.50	m
R.L of bottom of Strata:	-11.00	m
Average Thickness of Strata,I_c:	2.50	m
Effective overburden pressure over the top of strata,σ_{top}:	39.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	52.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	45.75	kN/m^2
Coeff. Of Earth Pressure, k:	1.00	
Skin Resistance of the pile,q_s:	104.98	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.8 **Layer-IX**

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Type of Strata:	Weathered Rock	
Average SPT of the strata,N:	60	
Bulk Density of the strata,γ:	20	kN/m^3
Angle of Shearing Resistance,ϕ:	42.5	Deg.
R.L of top of Strata:	-11.00	m
R.L of bottom of Strata:	-12.00	m
Average Thickness of Strata,I_c:	1.00	m
Effective overburden pressure over the top of strata,σ_{top}:	52.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	62.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	57.00	kN/m^2
Coeff. Of Earth Pressure, k:	2.50	
Skin Resistance of the pile,q_s:	205.11	kN
(q_s:σ*k*tanϕ*pi()*d*Ic)		
Ultimate Skin Resistance,q_s:	**549.37**	**kN**

1.2.2 Computation of End Bearing Resistance:

Type of Bearing Strata	Weathered Rock	
Cross-Sectional Area of pile,Ap:	0.196	m^2
R.L of bottom of pile:	-12.00	
Minimum SPT-value of the Bearing Strata	60	
Angle of Shear Resistance, ϕ:	42.50	Deg.
Effective Overburden Pressure, q:	28.00	kPa
Bearing Capacity Factor(Nq)	220.00	
Ultimate End Bearing Resistance (Qp)	**1209.5**	**kN**
(Qp=Ap*q*Nq)		

1.3.0	**Ultimate Load Carrying Capacity ($Qu=Qs+Q_p$)**	**1758.9** **kN**
	Safe Load Carrying Capacity (Qsafe =Qu/2.5)	**703.6** **kN**
	However, limit Q_{safe} to the structural capacity of pile:	**600.0** **kN**

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Depth of fixity of Pile

Length of Pile — L_1 = 0 cm
[since the pile cast at ground level with fixed head]

Characteristic strength of Concrete — f_{ck} = 30 N/mm^2

Diameter of Pile — D = 50 cm

Modulas of Elasticity of Concrete (E) — $5000 \times \sqrt{f_{ck}} = 5000 \times \sqrt{30}$ N/mm^2
[As per IS 456 :2000 pg. no : 16]

= 273861.28 Kg/cm^2

Moment of Inertia of Pile (I) — $\frac{\pi \times D^4}{64} = \frac{3.14 \times 45^4}{64}$ cm^4

= 306640.6 cm^4

K_2 (constant) = 48.800 Kg/cm^2
[As per IS : 2911 (Part 1 / Sec 1) - appendix-B]

R (constant) = $\sqrt[4]{\frac{(E \times I)}{K_2}}$
[As per IS : 2911 (Part 1 / Sec 1) - appendix-B, Cl.5.5.2]

= 203.67 cm

Hence L_1 / R = $\frac{L_1}{R}$
[As per IS : 2911 (Part 1 / Sec 1) - appendix-B, Cl.5.5.2]

= 0.0E+00

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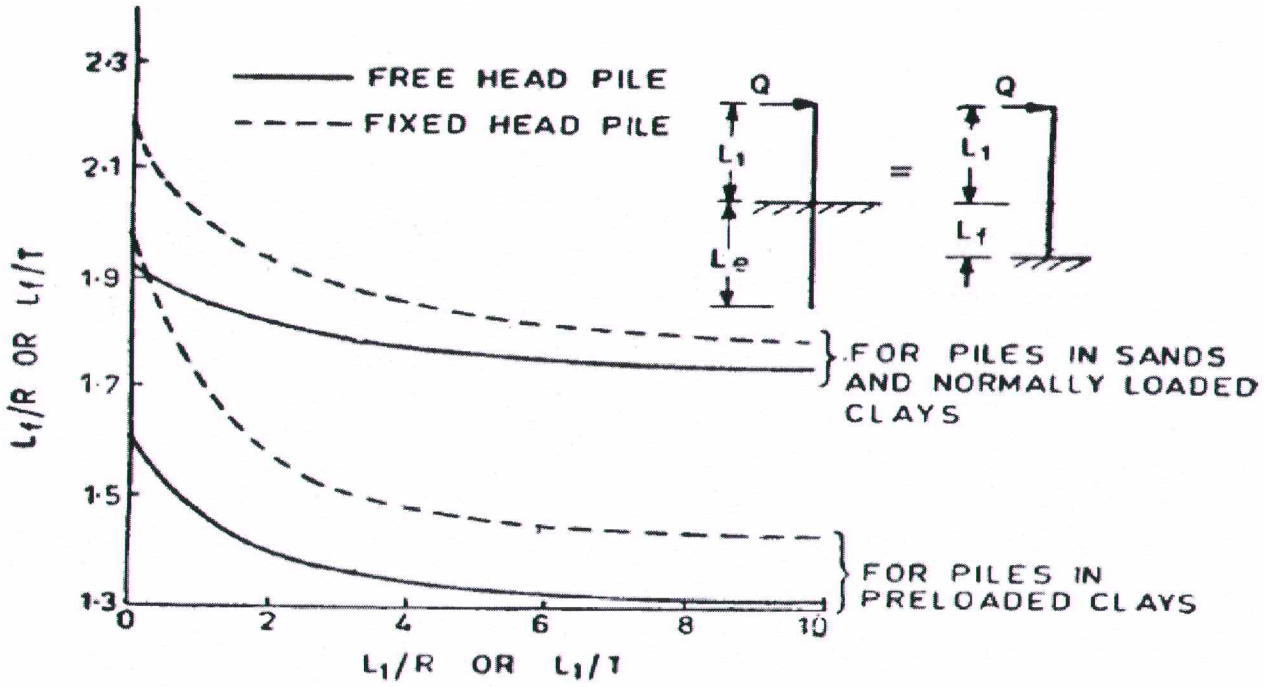


FIG. 2 DETERMINATION OF DEPTH FIXITY

For fixed head pile

$\frac{L_1}{R} = 2.2$ [As per IS : 2911 (Part 1 / Sec 1) - appendix-B, Cl.5.5.2 fig 2]

Length of fixity

L_f = 448.08 cm [As per IS : 2911 (Part 1 / Sec 1) -
= 4.48 m appendix-B, Cl.5.5.2]

Embedded Length

Le > 4 x R [As per IS : 2911 (Part 1 / Sec 1) -
> 8.1 m appendix-B, Cl.5.5.2]

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Calculation of Lateral capacity of pile

(From IS:2911, Part 1 / Sec. 1, Cl.5.5.2 - Appendix A)

$$\text{Lateral capacity , } Q = \frac{12\,E\,I\,Y}{(L_1 + L_f)^3}$$ for Fixed Head Pile

Where ,

Y = Lateral deflection of pile = 5 mm (As per IS2911, part1 / sec.1)

Modulas of Elasticity of Concrete (E) = 273861.28 Kg/cm2

Moment of Inertia of Pile (I) = 306640.6 cm4

L1 + Lf = 0 + 448.10
= 448.1 cm
= 4.48 m

Safe Lateral Load Carrying Capacity

$$Q = \frac{12 \times 273861.28 \times 306640.60 \times 0.05}{448.1 \times 448.10 \times 448.10 \times 2.5}$$

= 2.2 MT

= 22 kN

S.No	Diameter of Pile (mm)	Depth of Fixity of Pile below Ground Level (m)	Safe Lateral Load Carrying Capacity (MT)
1	500	4.48	2.20
2	550	4.93	2.50
3	600	5.38	2.70
4	650	5.83	2.90

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