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CLIENT	**SILVERSKY BUILDERS LLP, CHENNAI**
PROJECT	**PROPOSED CONSTRUCTION OF RESIDENTIAL APARTMENT (STILT+10) AT S.NO: 449/2 & 450/1B, 1C, NEDUNKUNDRAM VILLAGE, PERUNGALATHUR, CHENNAI-600063**
TITLE	**GEOTECHNICAL INVESTIGATION REPORT**

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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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CONTENTS

	SEC. NO.		PAGE NO.
		REPORT COVER PAGE	1
		CONTENTS	1
CHAPTER-1		INTRODUCTION	
	1.0	Preamble	1
	1.1	Scope of Work	1
	1.2	Structure of the Report	1
CHAPTER-2		INVESTIGATION METHODOLOGY & TEST RESULTS	
	2.0	Field Testing	2
	2.1	Preamble	2
	2.2	Equipment Used and Method of Drilling	2
	2.2.1	Equipment Used	2
	2.2.2	Method of Drilling	2
	2.3	In-situ Strength Tests	2
	2.3.1	Standard Penetration Tests	2
	2.4	Collection of Samples	2
	2.4.1	Disturbed Soil Samples	2
	2.4.2	Ground Water	3
	2.5	Summary of Field Work	3
	2.6	Laboratory Testing	3
	2.6.1	Coarse Grained Soil Samples	3
	2.6.1.1	Grain Size Analysis Tests	3
	2.6.2	Fine Grained Soil Samples	3
	2.6.2.1	Index Property & Free Swell Tests	3
	2.6.3	Chemical Analysis Tests	3
	2.6.3.1	Water Samples	3
FIGURES	2.0	Site Plan representing the locations of Field investigation points	4
	2.1	Soil Profile at BH-01 Location	5
	2.2	Soil Profile at BH-02 Location	6
	2.3	Soil Profile at BH-03 Location	7
	2.4	Soil Profile at BH-04 Location	8
TABLES	2.1	Laboratory Test Results on the Soil Samples collected from BH-01 Location	9
	2.2	Laboratory Test Results on the Soil Samples collected from BH-02 Location	10
	2.3	Laboratory Test Results on the Soil Samples collected from BH-03 Location	11
	2.4	Laboratory Test Results on the Soil Samples collected from BH-04 Location	12

	2.5	Chemical Analysis Test Results on the Water Samples collected from borehole Locations	13
CHAPTER-3		**SUB-SURFACE STRATIFICATION**	
	3.0	Preamble	14
	3.1	Sub surface Stratification	14
	3.1.1	Soil Profile at BH-01 Location	14
	3.1.2	Soil Profile at BH-02 Location	15
	3.1.3	Soil Profile at BH-03 Location	16
	3.1.4	Soil Profile at BH-04 Location	16-17
CHAPTER-4		**FOUNDATION SYSTEM**	
	4.0	Preamble	18
	4.1	Bearing Strata Characteristics	18
	4.2	Foundation System	18
	4.2.1	Open Foundation System	18
	4.2.2	Deep Foundation System- 9.00m Long Bored Cast-in-Situ Friction cum End Bearing Piles	19
CHAPTER-5		**CONCLUSIONS AND RECOMMENDATIONS**	20-21
ANNEXURE		Design of Deep Foundation System (Ref. BH-04 & BH-02)	22-23
ANNEXURE-I		Sample Computations for Lateral Load Carrying Capacity of Piles	24-26

CHAPTER-1

INTRODUCTION

1.0 Preamble

Silversky Builders LLP, Chennai proposed to construct a **Residential Apartment (Stilt+10) at S.No: 449/2 & 450/1B, 1C, Nedunkundram Village, Perungalathur, Chennai-600063.** 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 Four Standard Soil investigation bore holes of 150mm diameter up to a depth below existing ground level where SPT>100 or 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:

Four 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.

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 are shown in Fig. 2.1 to 2.4.

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 to 2.4.

2.6.2 Fine Grained Samples:

2.6.2.1 Index Property – Free Swell Tests:

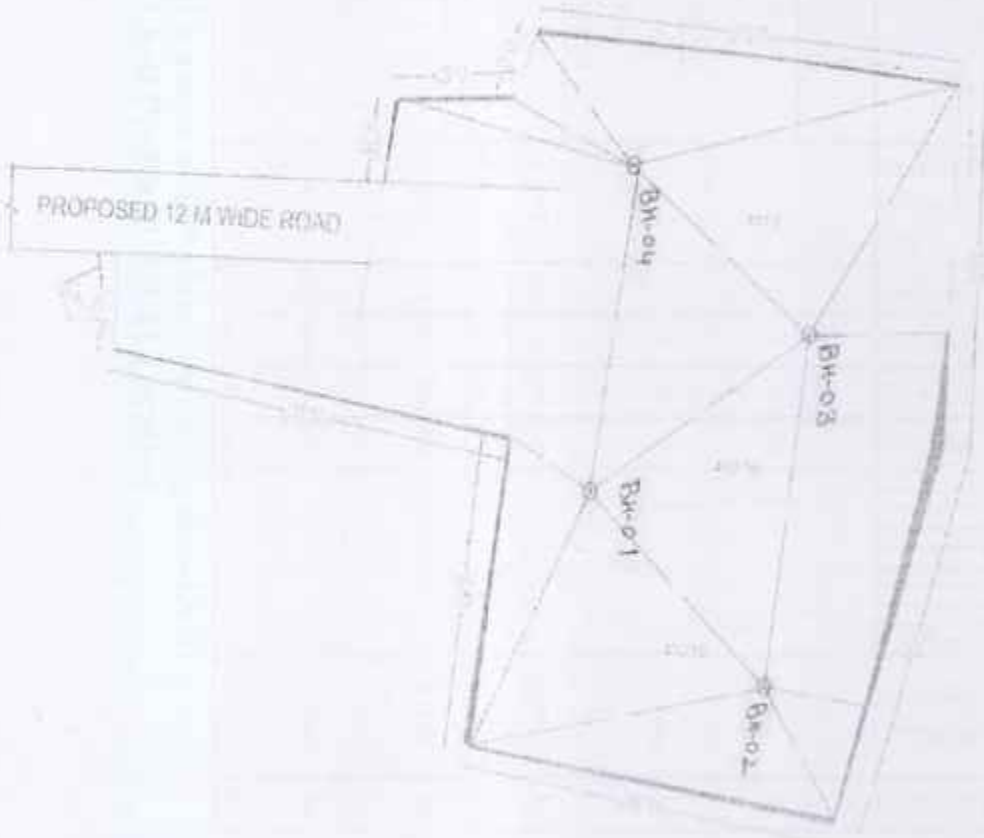
Atterberg Limits were carried out on fine grained soil samples to evaluate the limits of different consistency states. Generally Liquid limits, Plastic limits and Shrinkage Limits tests were conducted as per I.S.2720 (Part-5)-1985 and I.S.2720 (Part 6)-1972. On such type of soil strata encountered at the investigation locations, such tests were conducted and the test results are presented in Tables 2.1 to 2.4.

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 Tables-2.5.

Proposed Residential Building for M/s. SILVERSKY BUILDERS LLP Survey No: 449/ 2, & 450/ 1B, 1C, @ Perungalathur, Chennai.



Project : Proposed Construction of Residential Apartment (Stilt+10) at S.No: 449/2 & 450/1B, 1C, Nedunkundram Village, Perungalathur, Chennai-600063

Location: BH-01

Started On : 23/11/2023 Ended On : 24/11/2023 G.W.T: 0.50m 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	▼		Filled Up Soil							-	DS
0.80											
			Brownish to Greyish Loose Silty Clayey Fine Sand	1.50	5	6	9	15		Loose	SS
2.30											
			Brownish to Greyish Medium Dense Silty Clayey Fine Sand	3.00	6	7	12	19		M.Dense	SS
4.00											
			Soft Disintegrated Rock	4.50	13	16	20	36		Dense	SS
5.50											
			Weathered Rock	6.00	25	08cms Penetration for 50 Blows				V.Dense	SS
				7.50	SPT Hammer Rebounded					V.Dense	SS
8.50				8.50	SPT Hammer Rebounded					V.Dense	SS

Bore Hole Terminated at a depth of 8.50m below the existing ground level

Fig. 2.1 Soil Profile at BH-01 Location

Project : Proposed Construction of Residential Apartment (Stilt+10) at S.No: 449/2 & 450/1B, 1C, Nedunkundram Village, Perungalathur, Chennai-600063

Location: BH-02

Started On : 24/11/2023 Ended On : 24/11/2023 G.W.T: 0.50m 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 (0 1 2 3 4 5 6 7 8 9)	Relative Density/Consistency	Type of Sample
0.50	▼		Filled Up Soil							-	DS
2.50			Brownish to Greyish Loose Silty Clayey Fine Sand	1.50	6	7	7	14		Loose	SS
4.00			Brownish to Greyish Medium Dense Silty Clayey Fine Sand	3.00	7	8	8	16		M.Dense	SS
5.50			Soft Disintegrated Rock	4.50	09cms Penetration for 50 Blows					V.Dense	SS
				6.00	SPT Hammer Rebounded					V.Dense	SS
			Weathered Rock	7.50	SPT Hammer Rebounded					V.Dense	SS
9.00				9.00	SPT Hammer Rebounded					V.Dense	SS

Bore Hole Terminated at a depth of 9.00m below the existing ground level

Fig. 2.2 Soil Profile at BH-02 Location

Project : Proposed Construction of Residential Apartment (Stilt+10) at S.No: 449/2 & 450/1B, 1C, Nedunkundram Village, Perungalathur, Chennai-600063

Location: BH-03

Started On : 25/11/2023 Ended On : 25/11/2023 G.W.T: 0.50m 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	ical Representation (0 1 2 3 4 5 6 7 8 9)	Relative Density/Consistency	Type of Sample
G.W.T			Brownish Very Stiff Silty Sandy Clay	1.50	5	7	10	17		V.Stiff	SS
3.50				3.00	8	10	13	23		V.Stiff	SS
			Soft Disintegrated Rock	4.50	10cms Penetration for 50 Blows					V.Dense	SS
6.00				6.00	SPT Hammer Rebounded					V.Dense	SS
			Weathered Rock	7.50	SPT Hammer Rebounded					V.Dense	SS
8.00				8.00	SPT Hammer Rebounded					V.Dense	SS

Bore Hole Terminated at a depth of 8.00m below the existing ground level

Fig. 2.3 Soil Profile at BH-03 Location

Project : Proposed Construction of Residential Apartment (Stilt+10) at S.No: 449/2 & 450/1B, 1C, Nedunkundram Village, Perungalathur, Chennai-600063

Location: BH-04

Started On : 25/11/2023 Ended On : 25/11/2023 G.W.T: 0.50m 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 o 0 1 2 3 4 5 6 7 8 9	Relative Density/Consistency	Type of Sample
G.W.T			Brownish Stiff Silty Sandy Clay	1.50	7	8	7	15		Stiff	SS
3.00				3.00	07cms Penetration for 50 Blows, SPT Hammer					V.Dense	SS
			Weathered Rock	4.50	SPT Hammer Rebounded					V.Dense	SS
				6.00	SPT Hammer Rebounded					V.Dense	SS
7.00				7.00	SPT Hammer Rebounded					V.Dense	SS

Bore Hole Terminated at a depth of 7.00m below the existing ground level

Fig. 2.4 Soil Profile at BH-04 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 0.80	-	DS	Filled Up Soil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.80 to 2.50	15	SS	Silty Clayey Fine Sand	-	1.5	-	-	-	-	-	Loose	0	0	0	67	13	20	SM
2.50 to 4.00	19	SS	Silty Clayey Fine Sand	-	1.6	-	-	-	-	-	M.Dense	0	0	0	78	9	13	SM
4.00 to 5.50	36	SS	Soft Disintegrated Rock	-	1.9	-	-	-	-	-	Dense	31	29	13	14	13	0	SDR
5.50 to 8.50	>100	SS	Weathered Rock	-	2.0	-	-	-	-	-	V.Dense	56	21	13	7	3	0	SDR

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 0.50	-	DS	Filled Up Soil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.50 to 2.50	14	SS	Silty Clayey Fine Sand	-	1.5	-	-	-	-	-	Loose	0	0	0	61	12	27	SM
2.50 to 4.00	16	SS	Silty Clayey Fine Sand	-	1.6	-	-	-	-	-	M.Dense	0	0	0	70	14	16	SM
4.00 to 5.50	>100	SS	Soft Disintegrated Rock	-	2.0	-	-	-	-	-	V.Dense	37	28	11	11	13	0	SDR
5.50 to 9.00	>100	SS	Weathered Rock	-	2.0	-	-	-	-	-	V.Dense	55	19	14	8	4	0	SDR

Table 2.3: Laboratory Test Result on the Soil Sample Collected from BH-03

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 3.50	20	SS	Silty Sandy Clay	28	1.8	41	31	10	1.30	9	V.Stiff	0	0	0	13	17	70	CI
3.50 to 6.00	>100	SS	Soft Disintegrated Rock	-	2.0	-	-	-	-	-	V.Dense	38	19	23	9	11	0	SDR
6.00 to 8.00	>100	SS	Weathered Rock	-	2.0	-	-	-	-	-	V.Dense	48	16	21	11	4	0	SDR

Table 2.4: Laboratory Test Result on the Soil Sample Collected from BH-04

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 3.00	15	SS	Silty Sandy Clay	31	1.7	50	29	21	0.90	11	Stiff	0	0	0	13	11	76	CI
3.00 to 7.00	>100	SS	Weathered Rock	-	2.0	-	-	-	-	-	V.Dense	44	19	25	7	5	0	SDR

Table 2.5: Chemical Analysis Results conducted on Water Samples collected from BH-01 to BH-04				
Location	Depth of Sample below E.G.L. (m)	pH	Chlorides (ppm)	Sulphates (ppm)
BH-01	3.00	6.89	384.83	155.38
BH-02	3.00	6.88	390.91	161.58
BH-03	3.00	6.88	391.49	161.93
BH-04	3.00	6.87	400.11	168.48

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 0.80m depth)**	
Type of Strata	Filled Up Soil
Colour	-
Thickness of Layer	0.80m
* **Layer-2 (from 0.80m to 2.50m depth)**	
Type of Strata	Silty Clayey Fine Sand
Colour	Brownish to Greyish
Thickness of Layer	1.70m
SPT of the layer	15
Relative Density	Loose
Angle of Shearing Resistance, ϕ	31.50^0
* **Layer-3 (from 2.50m to 4.00m depth)**	
Type of Strata	Silty Clayey Fine Sand
Colour	Brownish to Greyish
Thickness of Layer	1.50m
SPT of the layer	19
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	32.70^0
* **Layer-4 (from 4.00m to 5.50m depth)**	
Type of Strata	Soft Disintegrated Rock
Colour	-
Thickness of Layer	1.50m
SPT of the layer	36

Relative Density	Dense
Angle of Shearing Resistance, ϕ	37.65^0

* **Layer-5 (from 5.50m to 8.50m depth)**

Type of Strata	Weathered Rock
Colour	-
Thickness of Layer	3.00m
SPT of the layer	>100
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	41.60^0

Ground Water

Ground water table was encountered at a depth of 0.50m below the existing ground level during the fourth week of November 2023.

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 0.50m depth)**

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

* **Layer-2 (from 0.50m to 2.50m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Brownish to Greyish
Thickness of Layer	2.00m
SPT of the layer	14
Relative Density	Loose
Angle of Shearing Resistance, ϕ	31.20^0

* **Layer-3 (from 2.50m to 4.00m depth)**

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

* **Layer-4 (from 4.00m to 5.50m depth)**

Type of Strata	Soft Disintegrated Rock
Colour	-
Thickness of Layer	1.50m
SPT of the layer	>100
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	42.50^0

* **Layer-5 (from 5.50m to 9.00m depth)**

Type of Strata	Weathered Rock
Colour	-
Thickness of Layer	3.50m
SPT of the layer	>100
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	41.60^0

Ground Water

Ground water table was encountered at a depth of 0.50m below the existing ground level during the fourth week of November 2023.

3.1.3 Soil Profile at BH-03 Location
(At BH-03 Location, as presented in Site plan)

* **Layer-1 (from E.G.L to 3.50m depth)**

Type of Strata	Silty Sandy Clay
Colour	Brownish
Thickness of Layer	3.50m
SPT of the layer	20
Consistency	Very Stiff
Un-drained Cohesion, Cu	133.33kPa

* **Layer-2 (from 3.50m to 6.00m depth)**

Type of Strata	Soft Disintegrated Rock
Colour	-
Thickness of Layer	2.50m
SPT of the layer	>100
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	42.50^0

* **Layer-3 (from 6.00m to 8.00m depth)**

Type of Strata	Weathered Rock
Colour	-
Thickness of Layer	2.00m
SPT of the layer	>100
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	41.60^0

Ground Water

Ground water table was encountered at a depth of 0.50m below the existing ground level during the fourth week of November 2023.

3.1.4 Soil Profile at BH-04 Location
(At BH-04 Location, as presented in Site plan)

* **Layer-1 (from E.G.L to 3.00m depth)**

Type of Strata	Silty Sandy Clay
Colour	Brownish
Thickness of Layer	3.00m
SPT of the layer	15
Consistency	Stiff
Un-drained Cohesion, Cu	100.00kPa

* **Layer-2 (from 3.00m to 7.00m depth)**

Type of Strata	Weathered Rock
Colour	-
Thickness of Layer	4.00m
SPT of the layer	>100
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	41.60^0

Ground Water

Ground water table was encountered at a depth of 0.50m below the existing ground level during the fourth week of November 2023.

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 weak from both shear strength characteristics and deformation considerations to act as bearing strata for proposed impending loads from structure which are presumed to be in the average order of 400MT to 500MT per column.

However, the refusal soil strata (SPT>100) encountered below a maximum depth of 6.00m from present existing ground level can be considered as good end bearing strata for proposed impending loads from structure.

Considering the above, suitable foundation system is presented below.

4.2 Foundation System

4.2.1 Deep Foundation System-9.00m long Bored Cast-in-Situ Friction cum End Bearing Piles (Ref. BH-02 & BH-04)

Considering weak shear strength characteristics of sub-soil strata encountered at shallow depths, deep foundation system consisting of 9.00m 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 9.00m 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)	Diameter of Pile (mm)	Safe Load Carrying Capacity (MT)	Safe Pull Out Capacity (MT)
1	Bored Cast-in-Situ	9.00	750	180	69
2			900	210	83
3			1000	230	92
4			1200	260	111

The computations of safe load carrying capacity for 750mm diameter and 9.00m long bored cast-in-situ Friction cum End Bearing Pile are annexed to this report.

CONCLUSIONS AND RECOMMENDATIONS

DEEP FOUNDATION SYSTEM

1. M40 grade of concrete is considered to determine the design parameters of deep foundation system and hence the same is recommended for pile casting process in view of less deformation in High Grade concrete over Low Grade.
2. Suitable pile load tests shall be conducted to affirm the **guideline safe** load carrying capacities for different diameter of piles and to arrive at the **allowable** load carrying capacity of piles under considerations as per IS 2911 part-IV which can further be used for structural design purposes.
3. Pile cap can be located at existing ground surface provided that the surrounding coarse-grained soil is well compacted as per their laboratory proctor compaction design parameters.
4. Test load can be taken as 2.50 times of the guideline safe load carrying capacities of piles as presented in this report. Allowable load carrying capacity of pile is taken as 2/3 of Pile load for which the settlements of Test Pile is 2% of pile diameter.
5. Group action of piles shall be designed based upon efficiency of 1 for piles located in medium dense sands.
6. Pile grouping shall be done with the load data provided by the consultant and designed as fixed head.
7. For casting bored piles in such type of coarse-grained soil with higher depths, caution shall be exercised to avoid isolated collapse of soil from the sides of the bore which may induce bulging/necking phenomenon in pile.
8. It is recommended to conduct pile integrity test on all test piles to confirm the soundness of piles before undergoing any vertical compression tests on it. Tests shall be conducted directly on the pile head. Also, pile integrity test is recommended for routine piles for better quality checks on foundation system.
9. Ground water shall be tested at different levels up to the recommended final pile depth to assess the type of concrete and steel to be used in casting the pile to safeguard against high sulphate and chloride content.

OPEN FOUNDATION SYSTEM

10. For lightly loaded structures like compound walls, security cabin or small office buildings, open foundation system of isolated column footing located at a design depth of 1.70m over 0.30m thick well compacted CNS (cohesive non swelling) soil cushion. The safe bearing capacity of such type of open foundation system can be taken as 15MT/sq.m. for total Permissible settlements of 50mm for isolated column footings as per I.S:1904.
11. Excavated fine-grained soil encountered in the form of Silty Clay/Silty Sandy Clay shall be in no case used for back-filling purposes.
12. Care shall be taken to contain any lateral soil collapse from the walls of excavated open foundation pits.
13. In case, ground water table is encountered within the recommended open foundation depth of 2.00m below existing ground level, the same shall be bailed out to keep the sub-grade well consolidated.
14. As the chlorides and sulphates present in the ground water samples collected at shallow levels are within the permissible limits, no special steel or cement is required to be used for **open** foundation construction purposes.

For Geo Mines Engineers Pvt. Ltd.

Director

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DESIGN OF PILE FOUNDATION (BH-04 & BH-02)

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):	**750.0**	mm
Assumed R.L of E.G.L.:	0.000	m
Length of pile below E.G.L.(l) :	**9.000**	m
R.L. of Bot. of Pile	-9.00	m

1.2 Design of Pile for Vertical Compression

1.2.1 Computation of Skin Resistance:

1.2.1.1 **Layer-I**

Type of Strata:	Silty Sandy Clay	
Average SPT of the strata,N:	15	
Bulk Density of the strata,γ:	17	kN/m^3
Undrained Shear Strength,C_u:	100.00	kPa
R.L of top of Strata:	0.00	m
R.L of bottom of Strata:	-3.00	m
Average Thickness of Strata,l_c:	3.00	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}:	21.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	10.50	kN/m^2
Adhesion,α:	0.40	
Skin Resistance of the pile,q_s:	282.74	kN

(q_s:α*Cu*pi()*d*lc)

1.2.1.2 **Layer-II**

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:	-3.00	m
R.L of bottom of Strata:	-4.00	m
Average Thickness of Strata,l_c:	1.00	m
Effective overburden pressure over the top of strata,σ_{top}:	21.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	27.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	24.00	kN/m^2
Coeff. Of Earth Pressure, k:	1.50	
Skin Resistance of the pile,q_s:	52.59	kN

(q_s:σ*k*tanϕ*pi()*d*lc)

1.2.1.3 **Layer-III**

Type of Strata:	Soft Disintegrated 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:	-4.00	m
R.L of bottom of Strata:	-5.50	m
Average Thickness of Strata,l_c:	1.50	m
Effective overburden pressure over the top of strata,σ_{top}:	27.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	42.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	34.50	kN/m^2
Coeff. Of Earth Pressure, k:	2.50	
Skin Resistance of the pile,q_s:	279.33	kN
(q_s:σ*k*tanϕ*pi()*d*lc)		

1.2.1.4 **Layer-IV**

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:	-5.50	m
R.L of bottom of Strata:	-9.00	m
Average Thickness of Strata,l_c:	3.50	m
Effective overburden pressure over the top of strata,σ_{top}:	42.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	77.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	59.50	kN/m^2
Coeff. Of Earth Pressure, k:	2.50	
Skin Resistance of the pile,q_s:	1124.06	kN
(q_s:σ*k*tanϕ*pi()*d*lc)		
Ultimate Skin Resistance,q_s:	**1738.72**	**kN**

1.2.2 Computation of End Bearing Resistance:

Type of Bearing Strata	Weathered Rock	
Cross-Sectional Area of pile,Ap:	0.442	m^2
R.L of bottom of pile:	-9.00	
Minimum SPT-value of the Bearing Strata	60	
Angle of Shear Resistance, ϕ:	42.50	Deg.
Effective Overburden Pressure, q:	36.00	kPa
Bearing Capacity Factor(Nq)	220.00	
Ultimate End Bearing Resistance (Qp)	**3498.9**	**kN**
(Qp=Ap*q*Nq)		

1.3.0

Ultimate Load Carrying Capacity (Q_u=Q_s+Q_p)	**5237.7**	**kN**
Safe Load Carrying Capacity (Qsafe =Qu/2.50)	**2095.1**	**kN**
However, limit Q_{safe} to the structural capacity of pile:	**180.00**	**MT**

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/mm²

Diameter of Pile — D = 75 cm

Modulas of Elasticity of Concrete (E) — $5000 \times \sqrt{f_{ck}} = 5000 \times \sqrt{30}$ N/mm²
[As per IS 456 :2000 pg. no : 16]

= 273861.28 Kg/cm²

Moment of Inertia of Pile (I) — $\frac{\pi \times D^4}{64} = \frac{3.14 \times 75^4}{64}$ cm⁴

= 1552368.2 cm⁴

K_s (constant) = 48.800 Kg/cm²
[As per IS : 2911 (Part 1 / Sec 1) - appendix-B]

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

= 305.51 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

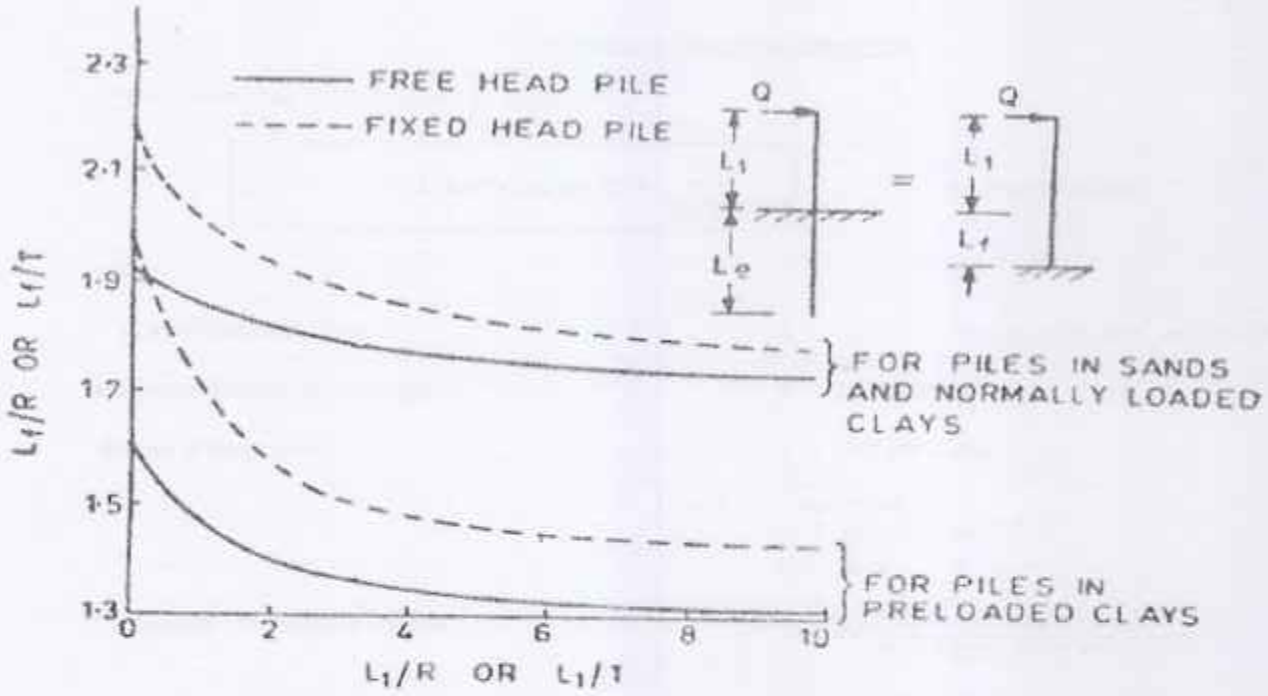


FIG. 2 DETERMINATION OF DEPTH FIXITY

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

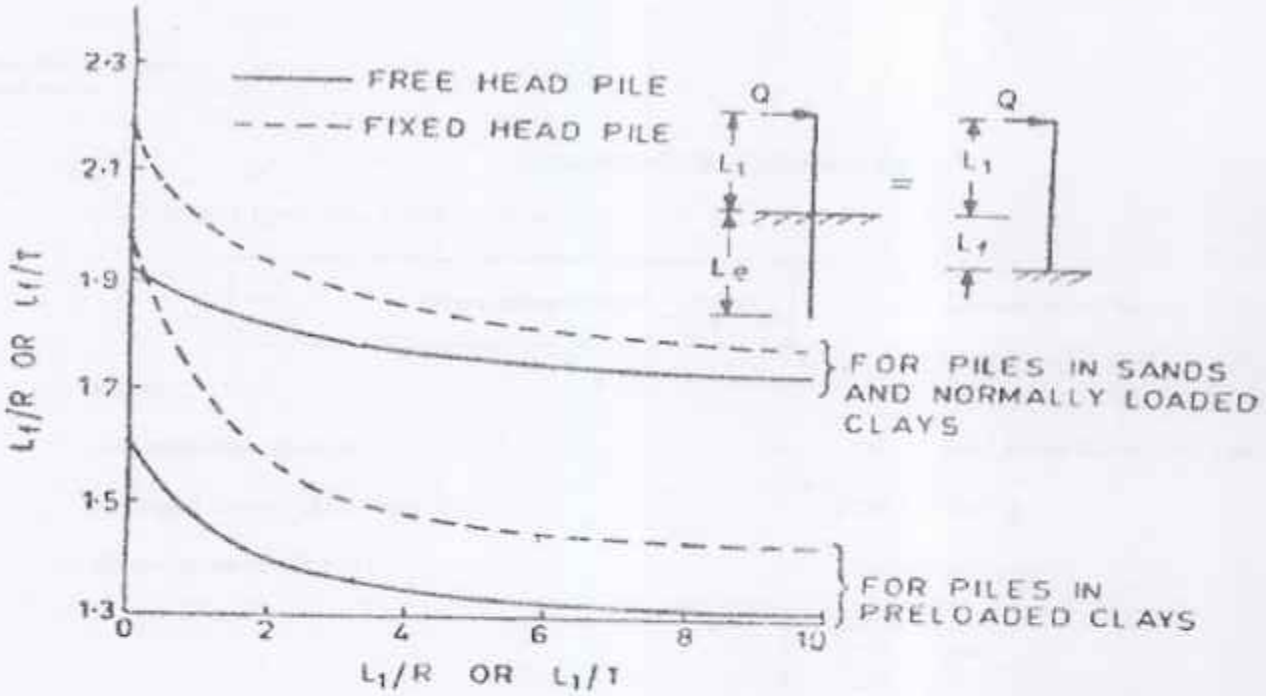
L_f = 672.12 cm [As per IS : 2911 (Part 1 / Sec 1) - appendix-B, Cl.5.5.2]

= 6.72 m

Embedded Length

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

> 12.2 m



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= 6.72 m appendix-B, Cl.5.5.2]

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