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CONSULTANTS	**GEO MINES ENGINEERS PVT. LTD.** Nep-II **GEOTECHNICAL ENGINEERING DIVISION,** **#96, 3rd FLOOR, VELLALAR STREET,** **MOGAPPAIR WEST, CHENNAI-600037** **Ph. No. 98413 16631, 9840157478** **Email: geomines@gmail.com, gmepl77@gmail.com** **Website: www.geominesengineers.com**
CLIENT	**MARUTHAM APPARTMENT, CHENNAI**
PROJECT	**PROPOSED CONSTRUCTION OF RESIDENTIAL APARTMENT (G+05) AT NO: 51 N.T. PATEL ROAD, NERKUNDRAM, CHENNAI-600107** **PLOT NO: B, S.NO: 268/1PART, NERKUNDRAM VILLAGE, MADURAVOYAL TALUK, CHENNAI DISTRICT**
TITLE	**GEOTECHNICAL INVESTIGATION REPORT**

		ASHOK KUMAR NAGINDAS PATEL M.Tech. (Soil Engg.) CMDA ROTE No. GTE/19/MA025	
		For Geo Mines Engineers Pvt. Ltd.	
		Director	
			GEO MINES ENGINEERS GMEPL Chennai
0	09-06-2023	GMEPL/MARUTHAM APPARTMENT/123/2023-24	
REV.	**DATE**	**REPORT NUMBER**	**PREP. BY**

DISCLAIMER

We've been asked to look into the ground and identify and quantify everything that mother nature has put there and 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.

GEO MINES ENGINEERS PVT. LTD.
GMEPL
Chennai

CONTENTS

CHAPTER-1

INTRODUCTION

1.0 Preamble

Marutham Appartment, Chennai proposed to construct a **Residential Apartment (G+05) at No: 51, N.T. Patel Road, Nerkundram, Chennai-600107. Plot No: B, S.No: 268/1Part, Nerkundram Village, Maduravoyal Taluk, Chennai District.**

For the purpose of designing the foundations, the responsibility of carrying out suitable soil investigations 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 33.00m 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 have been 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 boreholes 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 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.

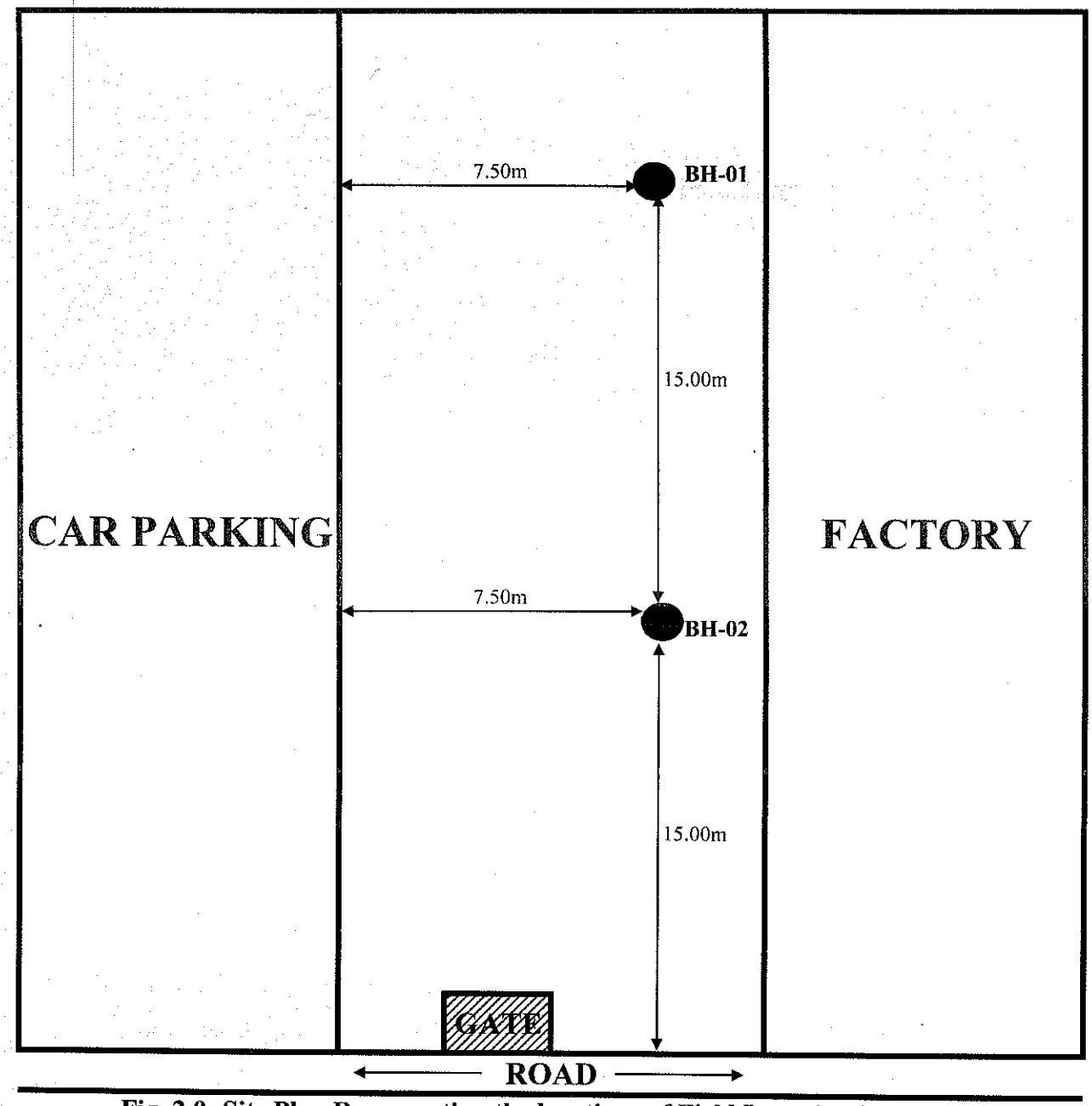


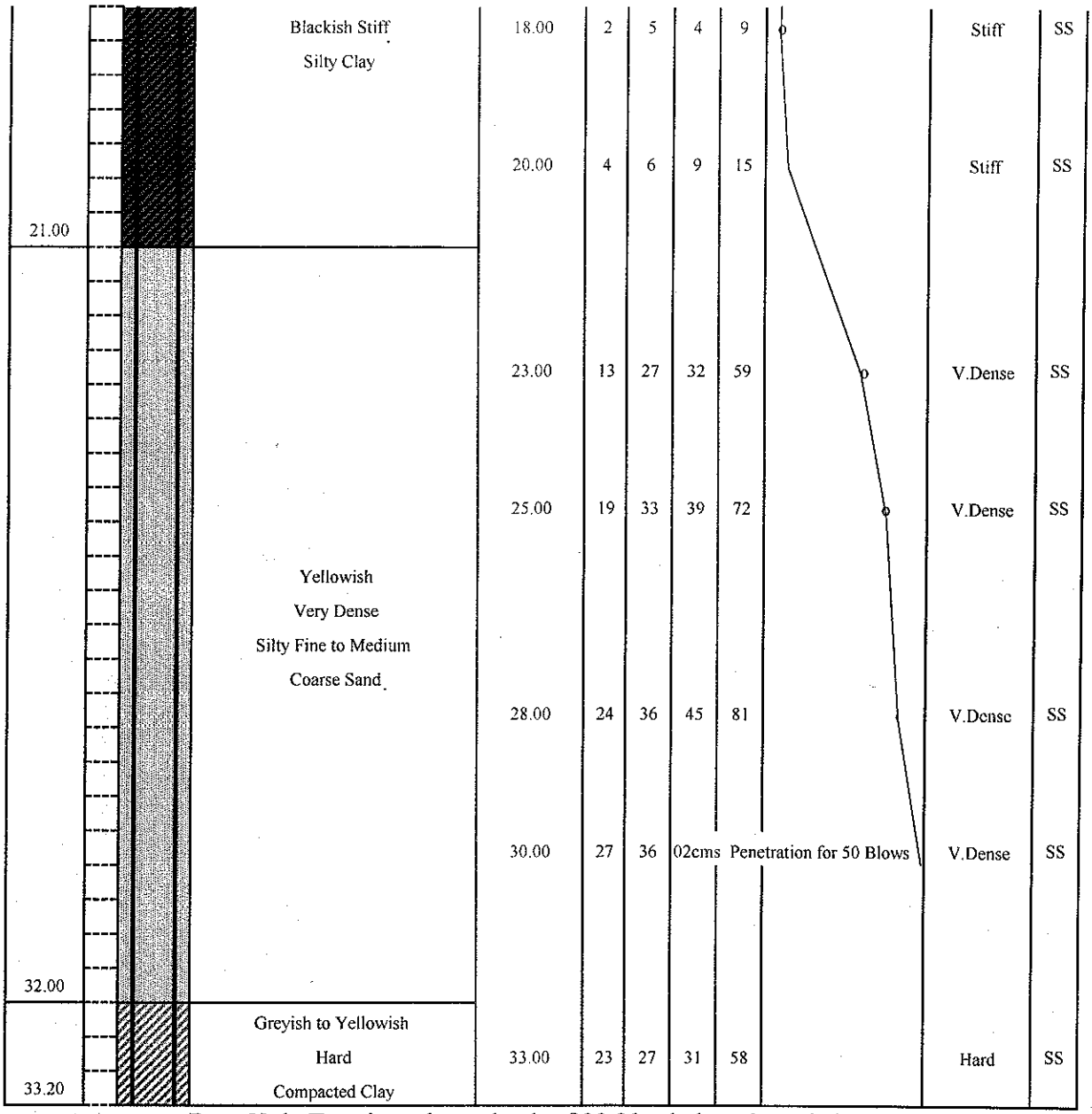
Fig. 2.0: Site Plan Representing the locations of Field Investigation Points

Project : Proposed Construction of Residential Apartment (G+05) at No: 51, N.T. Patel Road, Nerkundram, Chennai-600107. Plot No: B, S.No: 268/1Part, Nerkundram Village, Maduravoyal Taluk,

Location: BH-01

Started On : 01/06/2023; Ended On : 02/06/2023 G.W.T: 2.00m 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	ical Representation (0 1 2 3 4 5 6 7 8 9)	Relative Density/Consistency	Type of Sample
2.00	↓		Brownish Stiff Silty Clay	1.50	7	7	3	10		Stiff	SS
4.00			Brownish Medium Dense Silty Fine Sand	3.00	8	12	15	27		M.Dense	SS
7.00			Brownish Dense Silty Fine Sand	4.50	4	14	17	31		Dense	SS
				6.00	12	17	25	42		Dense	SS
10.00			Blackish Dense Silty Clayey Fine Sand	7.50	14	18	28	46		Dense	SS
				9.00	16	21	28	49		Dense	SS
12.00			Blackish Very Dense Silty Clayey Fine Sand	10.00	18	22	29	51		V.Dense	SS
13.50			Blackish Dense Silty Clayey Fine Sand	12.00	11	16	23	39		Dense	SS
15.00			Blackish Medium Stiff Silty Clay	14.00	3	4	4	8		M.Stiff	SS
				16.00	2	5	7	12		Stiff	SS



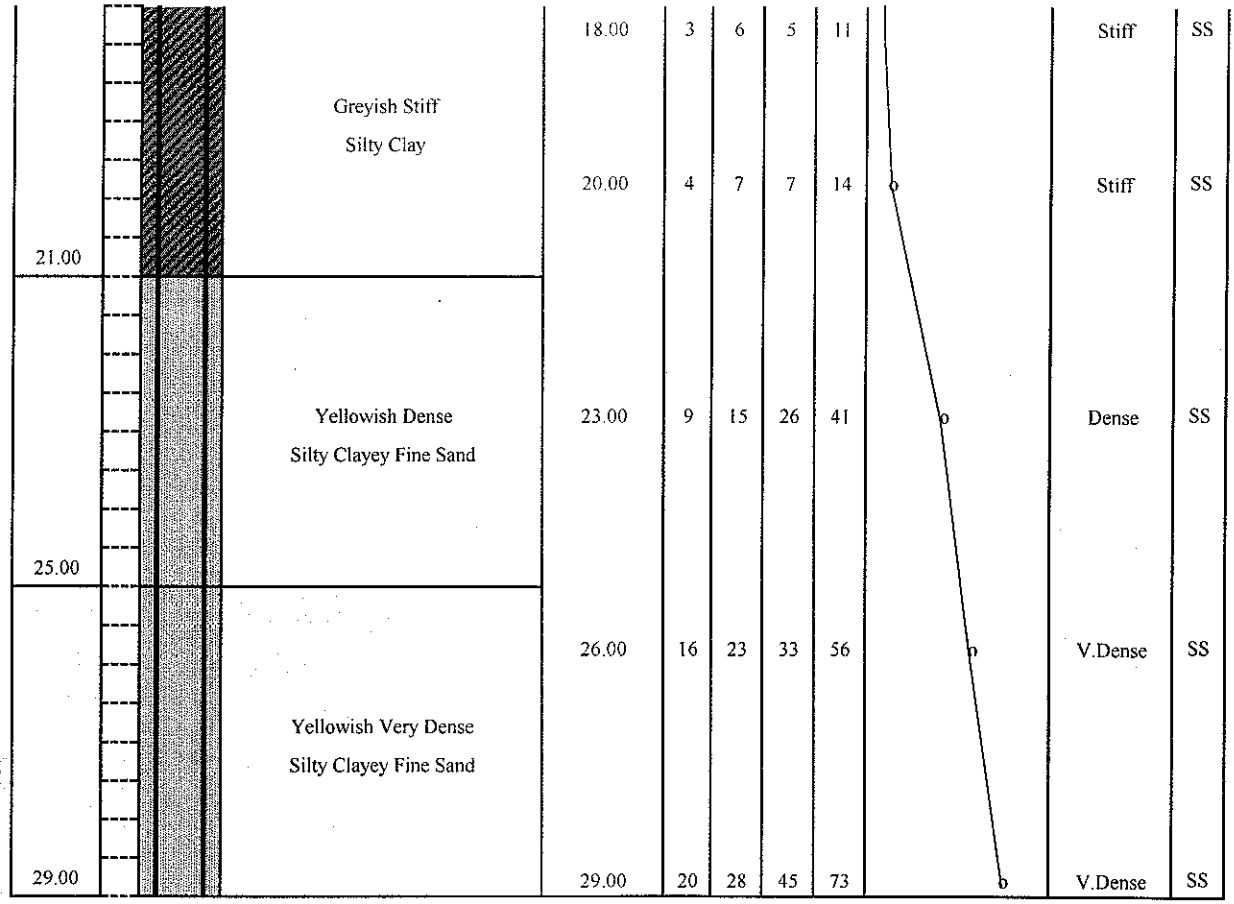
Bore Hole Terminated at a depth of 33.20m below the existing grou

Fig. 2.1 Soil Profile at BH-01 Location

Project : Proposed Construction of Residential Apartment (G+05) at No: 51, N.T. Patel Road, Nerkundram, Chennai-600107. Plot No: B, S.No: 268/1Part, Nerkundram Village, Maduravoyal Taluk,
Location: BH-02

Started On : 04/06/2023; Ended On : 05/06/2023 G.W.T: 1.50m 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 2.00	↓		Brownish Loose Silty Fine Sand	1.50	3	6	9	15		Loose	SS
				3.00	4	8	14	22		M.Dense	SS
			Brownish Medium Dense Silty Fine Sand	4.50	6	12	17	29		M.Dense	SS
5.50				6.00	9	14	19	33		Dense	SS
			Brownish Dense Silty Fine Sand	7.50	8	14	17	31		Dense	SS
9.50				9.00	8	14	17	31		Dense	SS
				10.00	7	7	13	20		M.Dense	SS
			Greyish Medium Dense Silty Clayey Fine Sand	12.00	5	15	8	23		M.Dense	SS
13.00											
			Greyish Very Stiff Silty Clay	14.00	4	6	11	17		V.Stiff	SS
15.00											
			Greyish Medium Stiff Silty Clay	16.00	4	4	3	7		M.Stiff	SS
17.00											



Bore Hole Terminated at a depth of 29.00m below the existing grou

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 2.00	10	SS	Silty Clay	33	1.7	57	29	28	0.86	13	Stiff	0	0	0	0	20	80	CH
2.00 to 4.00	27	SS	Silty Fine Sand	-	1.8	-	-	-	-	-	M.Dense	0	0	0	77	23	0	SM
4.00 to 7.00	36	SS	Silty Fine Sand	-	1.9	-	-	-	-	-	Dense	0	0	0	81	19	0	SM
7.00 to 10.00	47	SS	Silty Clayey Fine Sand	-	1.9	-	-	-	-	-	Dense	0	0	0	79	11	10	SM
10.00 to 12.00	51	SS	Silty Clayey Fine Sand	-	2.0	-	-	-	-	-	V.Dense	0	0	0	79	9	12	SM
12.00 to 13.50	39	SS	Silty Clayey Fine Sand	-	1.9	-	-	-	-	-	Dense	0	0	0	75	12	13	SM
13.50 to 15.00	8	SS	Silty Clay	34	1.6	60	26	34	0.76	-	M.Stiff	0	0	0	0	17	83	CH
15.00 to 21.00	12	SS	Silty Clay	29	1.7	50	26	24	0.88	-	Stiff	0	0	0	0	22	78	CI
21.00 to 32.00	78	SS	Silty Fine to Medium Coarse Sand	-	2.0	-	-	-	-	-	V.Dense	0	21	18	43	18	0	SM
32.00 to 33.20	58	SS	Compacted Clay	17	2.0	35	28	7	2.57	-	Hard	0	0	0	0	26	74	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 2.00	15	SS	Silty Fine Sand	-	1.5	-	-	-	-	-	Loose	0	0	0	78	22	0	SM
2.00 to 5.50	25	SS	Silty Fine Sand	-	1.7	-	-	-	-	-	M.Dense	0	0	0	80	20	0	SM
5.50 to 9.50	31	SS	Silty Fine Sand	-	1.9	-	-	-	-	-	Dense	0	0	0	81	19	0	SM
9.50 to 13.00	21	SS	Silty Clayey Fine Sand	-	1.7	-	-	-	-	-	M.Dense	0	0	0	77	9	14	SM
13.00 to 15.00	17	SS	Silty Clay	29	1.8	50	30	20	1.05	-	V.Stiff	0	0	0	0	22	78	CI
15.00 to 17.00	7	SS	Silty Clay	36	1.6	61	24	37	0.68	-	M.Stiff	0	0	0	0	16	84	CH
17.00 to 21.00	12	SS	Silty Clay	33	1.7	54	29	25	0.84	-	Stiff	0	0	0	0	21	79	CH
21.00 to 25.00	41	SS	Silty Clayey Fine Sand	-	1.9	-	-	-	-	-	Dense	0	0	0	80	11	9	SM
25.00 to 29.00	56	SS	Silty Clayey Fine Sand	-	2.0	-	-	-	-	-	V.Dense	0	0	0	83	8	9	SM

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	319.73	159.84
BH-02	3.00	6.79	311.74	150.18

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 2.00m depth)**

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	2.00m
SPT of the layer	10
Consistency	Stiff
Un-drained Cohesion, Cu	66.66kPa

* **Layer-2 (from 2.00m to 4.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	2.00m
SPT of the layer	27
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	35.10^0

* **Layer-3 (from 4.00m to 7.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	3.00m
SPT of the layer	36
Relative Density	Dense
Angle of Shearing Resistance, ϕ	37.65^0

* **Layer-4 (from 7.00m to 10.00m depth)**

Type of Strata	Silty Clayey Fine Sand

Colour	Blackish
Thickness of Layer	3.00m
SPT of the layer	47
Relative Density	Dense
Angle of Shearing Resistance, ϕ	40.325^0
* **Layer-5 (from 10.00m to 12.00m depth)**	
Type of Strata	Silty Clayey Fine Sand
Colour	Blackish
Thickness of Layer	2.00m
SPT of the layer	51
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	41.15^0
* **Layer-6 (from 12.00m to 13.50m depth)**	
Type of Strata	Silty Clayey Fine Sand
Colour	Blackish
Thickness of Layer	1.50m
SPT of the layer	39
Relative Density	Dense
Angle of Shearing Resistance, ϕ	38.475^0
* **Layer-7 (from 13.50m to 15.00m depth)**	
Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	1.50m
SPT of the layer	08
Consistency	Medium Stiff
Un-drained Cohesion, Cu	53.33kPa
* **Layer-8 (from 15.00m to 21.00m depth)**	
Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	6.00m
SPT of the layer	12
Consistency	Stiff
Un-drained Cohesion, Cu	80.00kPa
* **Layer-9 (from 21.00m to 32.00m depth)**	
Type of Strata	Silty Fine to Medium Coarse Sand
Colour	Yellowish
Thickness of Layer	11.00m
SPT of the layer	78
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	42.50^0
* **Layer-10 (from 32.00m to 33.20m depth)**	
Type of Strata	Compacted Clay
Colour	Greyish to Yellowish
Thickness of Layer	1.20m
SPT of the layer	58
Consistency	Hard
Un-drained Cohesion, Cu	386.66kPa

Ground Water

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

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	2.00m
SPT of the layer	15
Relative Density	Loose
Angle of Shearing Resistance, ϕ	31.50^0

* **Layer-2 (from 2.00m to 5.50m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	3.50m
SPT of the layer	25
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	34.50^0

* **Layer-3 (from 5.50m to 9.50m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	4.00m
SPT of the layer	31
Relative Density	Dense
Angle of Shearing Resistance, ϕ	36.275^0

* **Layer-4 (from 9.50m to 13.00m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	3.50m
SPT of the layer	21
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	33.30^0

* **Layer-5 (from 13.00m to 15.00m depth)**

Type of Strata	Silty Clay
Colour	Greyish
Thickness of Layer	2.00m
SPT of the layer	17
Consistency	Very Stiff
Un-drained Cohesion, Cu	113.33kPa

* **Layer-6 (from 15.00m to 17.00m depth)**

Type of Strata	Silty Clay
Colour	Greyish
Thickness of Layer	2.00m
SPT of the layer	07
Consistency	Medium Stiff
Un-drained Cohesion, Cu	46.66kPa

* **Layer-7 (from 17.00m to 21.00m depth)**

Type of Strata	Silty Clay
Colour	Greyish
Thickness of Layer	4.00m
SPT of the layer	12
Consistency	Stiff
Un-drained Cohesion, Cu	80.00kPa

* **Layer-8 (from 21.00m to 25.00m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Yellowish
Thickness of Layer	4.00m
SPT of the layer	41
Relative Density	Dense
Angle of Shearing Resistance, ϕ	38.975^0

* **Layer-9 (from 25.00m to 29.00m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Yellowish
Thickness of Layer	4.00m
SPT of the layer	56
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	41.90^0

Ground Water

Ground water table was encountered at a depth of 1.50m below the existing ground level during the first week of June 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 non-uniformly stratified from type and also possess varying shear strength characteristics, BH-01 being relatively weak from deformation considerations than that of other borehole location and hence shall be considered as design borehole to determine the bearing strata and its safe bearing capacity.

Considering BH-01 as design borehole, it can be further envisaged that the coarse-grained soil strata encountered below 2.00m thick highly plastic fine-grained soil strata will hold good to act as bearing strata from shear strength characteristics and deformation considerations for nominal column loads in the range of 800kN to 900kN respectively.

If coarse-grained soil strata encountered uniformly below 2.00m depths from present existing ground level are considered as bearing strata, the safe bearing capacity of open foundation system will be a function of least dimension of foundation and effective overburden pressure over the bearing strata.

Also, the sub-soil strata encountered up to the depth of investigations may also offer a good frictional resistance against a suitably designed structural member of 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)

*Considering the shear strength characteristics of coarse-grained soil strata encountered below 2.00m depths from present existing ground level, open foundation system of **Isolated Column Footing** type located at a design depth of 2.50m below present existing ground level (EGL) 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	Total Depth of Excavations below existing ground level (m)	Backfill with well compacted CNS (m)	Depth of **Isolated Column Footing** below Present Existing Ground Level (m)	Type of Bearing Strata	Safe Bearing Capacity (MT/m^2)	Elastic Settlements (mm)
Isolated Column Footing	**2.50**	**0.00**	**2.50**	**Silty Sand**	**18**	**36**

The computations for above are annexed to this report.

4.2.2 Deep Foundation System-23.00m Long Bored Cast-in-Situ Friction Piles

In case, the impending foundation stresses are more than the safe bearing capacity of open foundation system presented in Clause 4.2.1, deep foundation system consisting of 23.00m long bored cast-in-situ Friction Piles can also be adopted.

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

For four different diameters, the safe load carrying capacities of 23.00m long bored cast-in-situ Friction Piles are computed and presented below which can be adopted for foundation design purposes.

S. No	Type of Installation of Pile	Group Head of Piles	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	Fixed	23.00	500	120	120
2				550	130	130
3				600	140	140
4				650	150	150

The computations of safe load carrying capacity for 500mm diameter and 23.00m long bored cast-in-situ Friction pile are annexed to this report.

CHAPTER5

CONCLUSIONS & RECOMMENDATIONS

1. Foundation systems presented in Clause 4.2.1 & 4.2.2, Chapter-IV can be adopted for foundation design purposes.

Open Foundation System.

2. Safe bearing capacity of open foundation system is computed considering any rise in the ground water table up to or above the level of isolated column footing.
3. In no case, the least depth of foundation system can be less than 2.50m below present existing ground level.
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. **Excavated highly plastic fine-grained soil strata encountered up to 2.00m depths from present existing ground level shall be in no case used for back filling purposes.**
6. **No structural units can be in direct contact of highly plastic fine-grained soil strata encountered at shallow depths. A 0.30m thick CNS soil layer is recommended to be sand-witched in between.**
7. Suitable provisions to contain the lateral collapse of soil from the walls of excavated open foundation pits are recommended.
8. It is recommended to connect the grade beams so that the entire structure can act as a single unit against any differential settlements in between the individual raft.

IMPORTANT RECOMMENDATIONS

9. Open foundation system presented above will be conducive only if proper drainage arrangements are made to channel the run-off into the drains and hence containing any water seepage into the ground. Also, there shall not be

any underground plumbing line leakages which may lead to softening of highly plastic fine-grained soil recommended as bearing strata.

Deep Foundation System

10. Suitable pile load tests (as per I.S: 2911, part-IV) shall be performed to confirm the presented **theoretical** safe load carrying capacities and the same shall be taken as **allowable/design** load carrying capacities of piles under consideration and attached to detailed project report.
11. Pile cap can be located over 0.30m thick well compacted existing ground to be replaced with CNS (Cohesive Non-Swelling) soil surface.
12. Piles shall be grouped according to the column design load requirements.
13. Safe load carrying capacities of piles shall be limited to their structural capacities.

General

14. **CNS can be well graded coarse-grained soil like quarry dust or clean river sand or sand: gravels mix (1:2) or fly-ash.**
15. As the chlorides and sulphates present in the collected water samples are within the permissible limits, no special steel or cement is recommended to be used for foundation construction purposes.

For Geo Mines Engineers Pvt Ltd

Director

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:	Isolated Col. Footing	
R.L of the top of Borehole (m):	0.00	m
Depth of Foundation below existing ground level (D_f):	2.50	m
Anticipated Depth of Soil Liquefaction:	0.00	m
Effective Depth of Foundation below natural ground level (D_f):	2.50	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 :	22	
(considered based upon the density of the strata)		
Type of Shear Failure:	General	
Angle of Shearing Resistance - Limited to a Maximum of:	33.60	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)	15.00	kPa
Water Table Correction Factor (w')	0.50	

Bearing Capacity Factors:

N_c = N/A

N_q = 29.13

N_γ = 40.85

Shape Factors:

S_c = N/A

S_q = 1.66

S_γ = 0.60

Depth Factors :

D_c = N/A

D_q = 1.00

$D_\gamma = 1.00$

Inclination Factor:

$I_c = N/A$

$I_q = 1.00$

$I_\gamma = 1.00$

1.4 Ultimate Bearing Capacity (Qu) :

$Qu = Cu*Nc*Sc*D_C*I_C+q*(Nq-1)*Sq*Dq*Iq + 0.5*B*\gamma*N\gamma*S\gamma*D\gamma*Ig*w'$

$Q_u =$ 825.26 kPa

1.5 Safe Bearing Capacity (Qsafe) :

Factor of Safety (F.S.) :	2.50
Qsafe :	330.10 kPa
Recommended Safe Bearing Capacity:	180.00 kPa

1.6 Settlements

Since, the bearing strata are coarse-grained type, the settlements under the allowable safe bearing pressure 180kPa will be of immediate elastic nature. The elastic settlements corresponding to a safe bearing pressure of 180kPa and average SPT of 22 considering extent of pressure bulb below bottom level of footing are computed to be in the order of 36mm which is within the permissible limits of 50mm for Isolated Column Footings as per I.S:1904.

DESIGN OF PILE FOUNDATION (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) :	**23.000**	m
R.L. of Bot. of Pile	-23.00	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 Clay	
Average SPT of the strata,N:	10	
Bulk Density of the strata,γ:	17	kN/m^3
Undrained Shear Strength,C_u:	66.67	kPa
R.L of top of Strata:	0.00	m
R.L of bottom of Strata:	-2.00	m
Average Thickness of Strata,l_c:	2.00	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}:	14.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	7.00	kN/m^2
Adhesion,α:	0.40	
Skin Resistance of the pile,q_s:	83.78	kN

(q_s:α*Cu*pi()*d*lc)

1.2.1.2 **Layer-II**

Type of Strata:	Silty Fine Sand	
Average SPT of the strata,N:	27	
Bulk Density of the strata,γ:	18	kN/m^3
Angle of Shearing Resistance,ϕ:	35.1	Deg.
R.L of top of Strata:	-2.00	m
R.L of bottom of Strata:	-4.00	m
Average Thickness of Strata,l_c:	2.00	m
Effective overburden pressure over the top of strata,σ_{top}:	14.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	30.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	22.00	kN/m^2
Coeff. Of Earth Pressure, k:	1.50	
Skin Resistance of the pile,q_s:	72.86	kN

(q_s:σ*k*tanϕ*pi()*d*lc)

1.2.1.3 **Layer-III**

Type of Strata:	Silty Fine Sand
Average SPT of the strata,N:	36

Bulk Density of the strata,γ:	19	kN/m^3
Angle of Shearing Resistance,ϕ:	37.65	Deg.
R.L of top of Strata:	-4.00	m
R.L of bottom of Strata:	-7.00	m
Average Thickness of Strata,I_c:	3.00	m
Effective overburden pressure over the top of strata,σ_{top}:	30.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	57.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	43.50	kN/m^2
Coeff. Of Earth Pressure, k:	2.00	
Skin Resistance of the pile,q_s:	316.30	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.4 **Layer-IV**

Type of Strata:	Silty Clayey Fine Sand	
Average SPT of the strata,N:	47	
Bulk Density of the strata,γ:	19	kN/m^3
Angle of Shearing Resistance,ϕ:	40.325	Deg.
R.L of top of Strata:	-7.00	m
R.L of bottom of Strata:	-10.00	m
Average Thickness of Strata,I_c:	3.00	m
Effective overburden pressure over the top of strata,σ_{top}:	57.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	84.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	70.50	kN/m^2
Coeff. Of Earth Pressure, k:	2.00	
Skin Resistance of the pile,q_s:	563.99	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.5 **Layer-V**

Type of Strata:	Silty Clayey Fine Sand	
Average SPT of the strata,N:	51	
Bulk Density of the strata,γ:	20	kN/m^3
Angle of Shearing Resistance,ϕ:	41.15	Deg.
R.L of top of Strata:	-10.00	m
R.L of bottom of Strata:	-12.00	m
Average Thickness of Strata,I_c:	2.00	m
Effective overburden pressure over the top of strata,σ_{top}:	84.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	104.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	94.00	kN/m^2
Coeff. Of Earth Pressure, k:	2.50	
Skin Resistance of the pile,q_s:	645.17	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.6 **Layer-VI**

Type of Strata:	Silty Clayey Fine Sand	
Average SPT of the strata,N:	39	
Bulk Density of the strata,γ:	19	kN/m^3

Angle of Shearing Resistance,ϕ:	38.475	Deg.
R.L of top of Strata:	-12.00	m
R.L of bottom of Strata:	-13.50	m
Average Thickness of Strata,I_c:	1.50	m
Effective overburden pressure over the top of strata,σ_{top}:	104.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	117.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	110.75	kN/m^2
Coeff. Of Earth Pressure, k:	2.00	
Skin Resistance of the pile,q_s:	414.76	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.7 **Layer-VII**

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	8	
Bulk Density of the strata,γ:	16	kN/m^3
Undrained Shear Strength,C_u:	53.33	kPa
R.L of top of Strata:	-13.50	m
R.L of bottom of Strata:	-15.00	m
Average Thickness of Strata,I_c:	1.50	m
Effective overburden pressure over the top of strata,σ_{top}:	117.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	126.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	122.00	kN/m^2
Adhesion,α:	0.60	
Skin Resistance of the pile,q_s:	75.40	kN

(q_s:α*Cu*pi()*d*Ic)

1.2.1.8 **Layer-VIII**

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	12	
Bulk Density of the strata,γ:	17	kN/m^3
Undrained Shear Strength,C_u:	80.00	kPa
R.L of top of Strata:	-15.00	m
R.L of bottom of Strata:	-21.00	m
Average Thickness of Strata,I_c:	6.00	m
Effective overburden pressure over the top of strata,σ_{top}:	126.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	168.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	147.50	kN/m^2
Adhesion,α:	0.40	
Skin Resistance of the pile,q_s:	301.59	kN

(q_s:α*Cu*pi()*d*Ic)

1.2.1.9 **Layer-IX**

Type of Strata:	Silty Fine to Medium Coarse Sand	
Average SPT of the strata,N:	59	
Bulk Density of the strata,γ:	20	kN/m^3
Angle of Shearing Resistance,ϕ:	42.35	Deg.

R.L of top of Strata:	-21.00	m
R.L of bottom of Strata:	-22.00	m
Average Thickness of Strata, I_c:	1.00	m
Effective overburden pressure over the top of strata, σ_{top}:	168.50	kN/m^2
Effective overburden pressure over the bottom of strata, σ_{bottom}:	178.50	kN/m^2
Effective overburden pressure at the middle of the strata, σ_{middle}:	173.50	kN/m^2
Coeff. Of Earth Pressure, k:	2.50	
Skin Resistance of the pile, q_s:	621.05	kN
(q_s:σ*k*tanϕ*pi()*d*Ic)		
Ultimate Skin Resistance, q_s:	**3094.91**	**kN**

1.2.2 Computation of End Bearing Resistance:

Ultimate End Bearing Resistance (Qp) Neglected for Friction Pile

1.3.0	**Ultimate Load Carrying Capacity (Qu=Qp+Qs**	**3094.9**	**kN**
	Safe Load Carrying Capacity (Qsafe =Qu/2.5)	**1238.0**	**kN**
	However, limit Q_{safe} to the structural capacity of pile:	**1200.0**	**kN**

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hello@verified.realestate
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