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CLIENT	**M/s. JAIN HOUSING LLP, CHENNAI**
PROJECT	**PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING OF "JAINS ANUSHREE" (BASEMENT+STILT+19) AT NATTAN-EGATTUR ROAD, EGATTUR VILLAGE, THIRUPORUR TALUK, CHENGALPET DISTRICT**
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	20-04-2023	GMEPL/M/s. JAIN HOUSING LLP/034/2023-24	

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.

GEOMINES ENGINEERS GMEPL Chennai

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CHAPTER-1

INTRODUCTION

1.0 Preamble

M/s. Jain Housing LLP, Chennai proposed to construct a **Residential Building of "JAINS ANUSHREE" (Basement+Stilt+19) at Nattan-Egattur Road, Egattur Village, Thiruporur Taluk, Chengalpet District.**

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 Three Standard Soil investigation bore holes of 150mm diameter up to a depth of 13.00m 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:

Three 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.

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2.4.2 Ground Water

For conducting suitable chemical tests, the ground water sample was 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 to 2.3.

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 2.3.

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 2.3.

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-2.4.

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Project : Proposed Construction of Residential Building of "JAINS ANUSHREE" (Basement+Stilt+19) at Nattan-Egattur Road, Egattur Village, Thiruporur Taluk, Chengalpet District

Location: BH-01

Started On : 16/04/2023; Ended On : 16/04/2023 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
1.00			Greyish to Yellowish Medium Stiff Silty Sandy Clay							M.Stiff	DS
G.W.T	↓		Greyish Stiff Silty Sandy Clay	1.50	5	5	7	12		Stiff	SS
4.00				3.00	10	6	8	14		Stiff	SS
6.50			Soft Disintegrated Rock	4.50	11	23	28	51		V.Dense	SS
				6.00	15	25	29	54		V.Dense	SS
7.70			Weathered Rock	7.50	SPT Hammer Rebounded					V.Dense	SS

Bore Hole Terminated at a depth of 7.70m below the existing grou

Fig. 2.1 Soil Profile at BH-01 Location

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Location: BH-02

Started On : 17/04/2023; Ended On : 17/04/2023 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 c 0 1 2 3 4 5 6 7 8 9	Relative Density/Consistency	Type of Sample
1.00			Greyish to Yellowish Medium Stiff Silty Sandy Clay							M.Stiff	DS
G.W.T 2.50	↓		Greyish Stiff Silty Sandy Clay	1.50	5	5	9	14		Stiff	SS
4.00			Greyish Very Stiff Silty Sandy Clay	3.00	6	8	10	18		V.Stiff	SS
5.80			Soft Disintegrated Rock	4.50	10	22	26	48		Dense	SS
7.00			Weathered Rock	6.00	SPT Hammer Rebounded					V.Dense	SS
				7.00	SPT Hammer Rebounded					V.Dense	SS

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

Fig. 2.2 Soil Profile at BH-02 Location

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Location: BH-03

Started On : 18/04/2023; Ended On : 19/04/2023 G.W.T: 2.00m below existing ground level

R.L of Layer (m)	G.W.T. (m)	Soil Profile	Engineering Description of Soil	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
1.00			Greyish to Yellowish Medium Stiff Silty Sandy Clay							M.Stiff	DS
G.W.T	↓		Greyish Stiff Silty Sandy Clay	1.50	4	5	8	13		Stiff	SS
3.50				3.00	5	7	8	15		Stiff	SS
5.80			Soft Disintegrated Rock	4.50	8	23	26	49		Densee	SS
			Weathered Rock	6.00	SPT Hammer Rebounded					V.Dense	SS
				7.50	SPT Hammer Rebounded					V.Dense	SS
				9.00	SPT Hammer Rebounded					V.Dense	SS
				10.00	SPT Hammer Rebounded					V.Dense	SS
12.00				12.00	SPT Hammer Rebounded					V.Dense	SS
			Soft		Rock Core Recovery: 17%					V.Dense	CS
13.00			Rock	13.00	SPT Hammer Rebounded					V.Dense	SS

Bore Hole Terminated at a depth of 13.00m below the existing grou

Fig. 2.3 Soil Profile at BH-03 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 1.00	-	DS	Silty Sandy Clay	34	1.5	59	21	38	0.66	9	M.Stiff	0	0	0	10	10	80	CH
1.00 to 4.00	13	SS	Silty Sandy Clay	31	1.7	53	28	25	0.88	-	Stiff	0	0	0	13	11	76	CH
4.00 to 6.50	52	SS	Soft Disintegrated Rock	-	2.0	-	-	-	-	-	V.Dense	37	16	22	12	13	0	SDR
6.50 to 7.70	>100	SS	Weathered Rock	-	2.0	-	-	-	-	-	V.Dense	47	19	17	9	8	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 1.00	-	DS	Silty Sandy Clay	39	1.5	65	23	42	0.62	13	M.Stiff	0	0	0	9	9	82	CH
1.00 to 2.50	14	SS	Silty Sandy Clay	29	1.7	50	27	23	0.91	-	Stiff	0	0	0	11	11	78	CI
2.50 to 4.00	18	SS	Silty Sandy Clay	27	1.8	49	28	21	1.05	-	V.Stiff	0	0	0	12	11	77	CI
4.00 to 5.80	48	SS	Soft Disintegrated Rock	-	1.9	-	-	-	-	-	Dense	37	18	23	13	9	0	SDR
5.80 to 7.00	>100	SS	Weathered Rock	-	2.0	-	-	-	-	-	V.Dense	41	13	24	17	5	0	SDR

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Table 2.3: Laboratory Test Results on the Soil Samples 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 1.00	-	DS	Silty Sandy Clay	36	1.6	59	24	35	0.66	12	M.Stiff	0	0	0	10	9	81	CH
1.00 to 3.50	14	SS	Silty Sandy Clay	29	1.7	52	28	24	0.96	-	Stiff	0	0	0	12	9	79	CH
3.50 to 5.80	49	SS	Soft Disintegrated Rock	-	1.9	-	-	-	-	-	Dense	33	23	14	25	5	0	SDR
5.80 to 12.00	>100	SS	Weathered Rock	-	2.0	-	-	-	-	-	V.Dense	41	10	18	26	5	0	SDR
12.00 to 13.00	>100	SS	Soft Rock	-	2.0	-	-	-	-	-	V.Dense	-	-	-	-	-	-	-

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Table 2.4: Chemical Analysis Results conducted on Water Samples collected from BH-01 to BH-03

Location	Depth of Sample below E.G.L. (m)	pH	Chlorides (ppm)	Sulphates (ppm)
BH-01	3.00	6.88	288.38	324.42
BH-02	3.00	6.87	291.74	328.20
BH-03	3.00	6.87	293.08	329.71

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CHAPTER-3

SUB-SURFACE STRATIFICATION

3.0 Preamble

The sub-surface stratifications 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 1.00m depth)**

Type of Strata	Silty Sandy Clay
Colour	Greyish to Yellowish
Thickness of Layer	1.00m
SPT of the layer	-
Consistency	Medium Stiff
Un-drained Cohesion, Cu	-

* **Layer-2 (from 1.00m to 4.00m depth)**

Type of Strata	Silty Sandy Clay
Colour	Greyish
Thickness of Layer	3.00m
SPT of the layer	13
Consistency	Stiff
Un-drained Cohesion, Cu	86.66kPa

* **Layer-3 (from 4.00m to 6.50m depth)**

Type of Strata	Soft Disintegrated Rock
Colour	-
Thickness of Layer	2.50m
SPT of the layer	52
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	41.30^0

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* **Layer-4 (from 6.50m to 7.70m 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 2.00m below the existing ground level during the fourth week of April 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 1.00m depth)**

Type of Strata	Silty Sandy Clay
Colour	Greyish to Yellowish
Thickness of Layer	1.00m
SPT of the layer	-
Consistency	Medium Stiff
Un-drained Cohesion, Cu	-

* **Layer-2 (from 1.00m to 2.50m depth)**

Type of Strata	Silty Sandy Clay
Colour	Greyish
Thickness of Layer	1.50m
SPT of the layer	14
Consistency	Stiff
Un-drained Cohesion, Cu	93.33kPa

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

Type of Strata	Silty Sandy Clay
Colour	Greyish
Thickness of Layer	1.50m
SPT of the layer	18
Consistency	Very Stiff
Un-drained Cohesion, Cu	120.00kPa

* **Layer-4 (from 4.00m to 5.80m depth)**

Type of Strata	Soft Disintegrated Rock
Colour	-
Thickness of Layer	1.80m
SPT of the layer	48
Relative Density	Dense
Angle of Shearing Resistance, ϕ	40.55^0

* **Layer-5 (from 5.80m to 7.00m 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

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Ground Water

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

Type of Strata	Silty Sandy Clay
Colour	Greyish to Yellowish
Thickness of Layer	1.00m
SPT of the layer	-
Consistency	Medium Stiff
Un-drained Cohesion, Cu	-

* **Layer-2 (from 1.00m to 3.50m depth)**

Type of Strata	Silty Sandy Clay
Colour	Greyish
Thickness of Layer	2.50m
SPT of the layer	14
Consistency	Stiff
Un-drained Cohesion, Cu	93.33kPa

* **Layer-3 (from 3.50m to 5.80m depth)**

Type of Strata	Soft Disintegrated Rock
Colour	-
Thickness of Layer	2.30m
SPT of the layer	49
Relative Density	Dense
Angle of Shearing Resistance, ϕ	40.775^0

* **Layer-4 (from 5.80m to 12.00m depth)**

Type of Strata	Weathered Rock
Colour	-
Thickness of Layer	6.20m
SPT of the layer	>100
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	42.50^0

* **Layer-5 (from 12.00m to 13.00m depth)**

Type of Strata	Soft Rock
Colour	-
Thickness of Layer	1.00m
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 2.00m below the existing ground level during the fourth week of April 2023.

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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

As, it is intimated that the proposed structure will have a provision of single basement with a least headroom of 4.50m, the sub-soil strata encountered below such levels shall be evaluated to determine their suitability for proposed foundation system.

From field investigations, it can be observed that the sub-soil strata encountered below 4.50m depth are soft disintegrated rock which are 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 below 4.50m 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 footing and effective surcharge over the bearing strata.

Considering the above, suitable foundation system is presented below.

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4.2 Foundation System

4.2.1 Open Foundation System (BH-02)

Considering the bearing strata characteristics of sub-soil strata encountered at shallow depths, open foundation system of ***Raft*** type located at a least depth of 4.50m below present existing ground level (E.G.L) can be adopted.

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

S. No.	Type of Open Foundation System	Total Depth of Excavations below Present 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)
1	Raft	4.50	0.00	4.50	Soft Disintegrated Rock	30	18

The computations for above are annexed to this report.

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CHAPTER5

CONCLUSIONS & RECOMMENDATIONS

1. Open foundation system of raft type located at shallow depths over coarse-grained strata can be adopted for foundation design purposes.
2. Safe bearing capacity presented in Clause 4.2.1, Chapter-IV can be adopted for open foundation design purposes.
3. **In no case, the least depth of raft can be less than 4.50m below existing ground level.**
4. Care shall be taken so that the ultimate bearing strata are none other than coarse-grained **Soft Disintegrated Rock** type.
5. Excavated coarse-grained soil encountered at shallow depths can be used for back filling purposes.
6. Safe bearing capacity presented above is computed considering any rise in the ground water table at or above the level of raft.
7. Special provisions to contain any lateral collapse of soil from the walls excavated foundation pits are required up to their bottom levels.
8. In case, the ground water table is encountered within the recommended depths of foundation system, the same shall be bailed out continuously to keep the sub-grade well consolidated.

Other Recommendations

9. As the sub-soil strata encountered up to the proposed excavation depths of 4.50m below existing ground level may not self-supportive, suitable provisions like Sheet Piling to contain any lateral collapse from the walls of excavated open foundation pits are strongly recommended. (IMPORTANT)
10. As the ground water table is encountered within recommended excavations depth of foundation system, provisions shall be made to continuously bail the water out of the foundation pits to keep the surfaces of pit consolidated dry.

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11. In case, the proposed structure is in the vicinity of a busy neighbourhood, suitable arrangements shall be made to rule out any hindrance to the dispersion stresses impending from adjoining building foundations. (IMPORTANT)
12. Until the sub-structure foundation excavations procedures are in progress, a full-time Geo-Technical Consultant shall be appointed to exclude any possibility of site accidents. (Note).

General

13. As the chlorides and sulphates present in the water samples are within the permissible limits, no special steel or cement is required to be used for foundation construction purposes.

For Geo Mines Engineers Pvt Ltd

Director

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DESIGN OF OPEN FOUNDATION SYSTEM (Ref. BH-02)

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):	4.50	m
Observed Thickness of fill at site:	0.00	m
Effective Depth of Foundation below natural ground level (D_f):	4.50	m
Design Width of Foundation (B):	1.00	m
Thickness of Foundation (T) :	0.25	m

1.2 Soil Data :

Type of Bearing Strata :	Soft Disintegrated Rock	
Design SPT-value of the Bearing Strata :	48	
(considered based upon the density of the strata)		
Type of Shear Failure:	General	
Angle of Shearing Resistance - Limited to a Maximum of:	40.55	Deg.

1.3 Design Parameters:

Bulk Density of Soil above the foundation depth (γ_{bulk})	19.00	kN/m^3
Effective Overburden pressure at foundation level (q)	40.50	kPa
Water Table Correction Factor (w')	0.50	

Bearing Capacity Factors:

N_c = N/A

N_q = 71.97

N_γ = 127.27

Shape Factors:

S_c = N/A

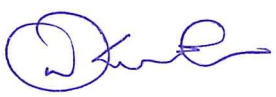
S_q = 1.86

S_γ = 0.60

Depth Factors :

D_c = N/A

D_q = 1.00



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$D_\gamma = 1.00$

Inclination Factor:

$I_c = N/A$

$I_q = 1.00$

$I_\gamma = 1.00$

1.4 Ultimate Bearing Capacity (Qu) :

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

$Q_u =$ 5771.72 kPa

1.5 Safe Bearing Capacity (Qsafe) :

Factor of Safety (F.S.) :	2.50
Qsafe :	2308.69 kPa
Recommended Safe Bearing Capacity:	300.00 kPa

1.6 Settlements

Since, the bearing strata are coarse-grained type, the settlements under the allowable safe bearing pressure 300kPa will be of immediate elastic nature. The elastic settlements corresponding to a safe bearing pressure of 300kPa and average SPT of 48 considering extent of pressure bulb below bottom level of footing are computed to be in the order of 18mm which is within the permissible limits of 70mm for raft as per I.S:1904.

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