INDIAN BANK
CORPORATE OFFICE
CHENNAI

Geotechnical Investigation for the "Proposed Construction of Residential Apartments(stilt+5 floors) at No:75, Musiri Subramaniam Road (Oliver road), Mylapore, Chennai-600 004 for Indian Bank

GEO TECHNICAL INVESTIGATION REPORT

SUBMITTED TO

**M/s. Indian Bank Estate Dept,
Corporate Office,
Royapettah, Chennai-14**

**January 2024
By**

Sakthi Developments Coy
Consultants & Engineers

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Dr. Radhakrishnan Nagar,
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1. INTRODUCTION

1.1 M/s Indian Bank, Corporate Office, 254-260, Avvai Shanmugam Salai, Royapettah, Chennai – 600 014. M/s Indian Bank is in the process for the "Construction of Residential Apartments at No:75, Musiri Subramaniam Road (Oliver road), Mylapore, Chennai-600 004 for Indian Bank"

1.2 M/s Indian Bank Estate Dept, Royapettah, Chennai decided to conduct soil exploration and investigate the subsoil layers at the aforementioned construction site.

1.3 The geotechnical investigations were carried out by M/s. Sakthi Developments Coy, Chennai. No.12, 2nd Cross Street, Dr. Radhakrishnan Nagar, Thiruvanmiyur, Chennai- 600 041 against the request made by M/s Indian Bank Corporate Office.

1.4 Detailed studies were carried out at the site by drilling one exploratory borehole, conducting relevant in-situ tests, collecting soil samples, and testing the samples in the laboratory.

1.5 This report summarizes the field and laboratory test results and furnishes recommendations for the type of foundations suitable for the proposed structure.

2. SCOPE OF WORK

2.1 The scope of field and laboratory work covers:

   a) Mobilizing all necessary equipment and personnel at the site.

   b) Drilling one borehole at the selected location and collecting disturbed and undisturbed samples

   c) Conducting SPT in the borehole during the drilling operation.

   d) Conducting laboratory tests on soil samples to enable the classification of soils and to obtain engineering properties of soils

   e) Computation of bearing capacity/ Pile capacity for the design of foundations.

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2.2 Based on the studies and observations, recommendations are made by covering the following:

    I)   Choice of foundation

    II)   Safe Bearing Capacity / Pile carrying Capacity for foundation

2.3 The bore logs field observations, results of field and laboratory tests, conclusions and recommendations are presented in this report.

3.0 FIELD INVESTIGATIONS

A. BORING AND IN-SITU SAMPLING

3.1 One exploratory borehole of 150mm diameter was drilled by the Rotary drilling method. The borehole was always kept full of the drilling mud so that a positive head was maintained in the boreholes, thus preventing any disturbance to the soil within the test zone. The Borehole BH1 was terminated at 28.0m after drilling into harder formations. The bore log is given in Annexure II and the location of the borehole was given in Annexure 1.

B. STANDARD PENETRATION TEST

3.2 Standard penetration tests were conducted at every 1.0 to 1.5m interval of depths or at the change of stratum as per Indian Standard IS: 2131 - 1981 and the split spoon sampler was used as per Indian Standard IS: 9640 - 1980.

3.3 The split spoon sampler resting on the bottom of the borehole could sink under its own weight; then the split spoon sampler was seated for 15cm with the blows of a hammer weighing 63.5kg falling through 75cm. Thereafter, the split spoon sampler was further driven to a depth of 30cm or 50 blows whichever was earlier.

The number of blows required to effect each 15cm of penetration was recorded. The first 15cm of the drive was a seating drive. The total number of blows required for the second and third 15cm lengths of penetration is termed as the penetration resistance `N'. If however, the split spoon sampler is driven less than 45cm (total) then the penetration resistance for the last 30cms of penetration is considered, and in the case where the penetration length is less than 30cms the depth of penetration and the corresponding number of blows is being indicated in the bore logs.

3.4 The disturbed samples were collected from the split spoon sampler.

4. LABORATORY TESTS

4.1 The soil samples were brought from the site and the following tests were conducted in the laboratory for determining the following properties.

i) Grain Size Distribution (Sieve Analysis) ii) Hydrometer

iii) Atterberg Limits/ Consistency Limits iv) Natural Moisture Content

v) Free Swell Index

4.2 The test results on soil sample are tabulated in **Annexure III**

5. SUB SOIL DESCRIPTION

5.1 The subsurface stratification at the borehole location, with respect to foundation / geotechnical engineering application are derived based on the visual identification, laboratory tests, and field in situ strength tests. The N-value provides an indication of the relative density of the subsurface soil, and it is used in the widely published and accepted standard method of empirical geotechnical correlation to estimate the approximate shear strength properties of the soils

Table-1 BH 1

B.H. Ref.	Depth from EGL m	Soil description	Average Corrected SPT 'N'	Shear strength	
				Cu T/m²	Φ°
1	0-0.50	Filled up soil with boulders	—	—	—
	0.50-4.0	Medium dense brownish silty medium to fine sand/ with blackish tree routes SM/ SP-SM	14	—	32°
	4.0-5.0	Medium dense brownish fine to medium sand trace silt SP-SM	11	—	30°
	5.0-7.50	Medium dense brownish medium to fine sand trace silt SP-SM	15	—	31°
	7.50-9.0	Medium stiff dark greyish black silty clay CH	5	3.10	—
	9.0-10.50	Soft dark greyish black silty clay CH	3	1.90	—
	10.50-12.0	Very soft dark greyish black silty clay CH	2	1.30	—
	12.0-13.50	Soft dark greyish black silty clay CH	3	1.90	—
	13.50-16.5	Medium dense greyish brown fine to medium sand trace gravel SP-SM	16	—	35°

16.50-19.50	Very stiff reddish clayey silty fine to medium sand/Brownish yellow clayey silty fine to medium sand SC-CI	24	12.90	—
19.50-21.0	Medium dense greenish white clayey silty medium to fine sand with lime SC-CL	23		33°
21.0-22.50	Medium dense whitish brown greenish silty medium to fine sand with lime SM	25	—	33°
22.50-24.0	Dense whitish brown greenish silty medium to fine sand with lime SM	28	—	34°
24.0-27.0	Dense Whitish brown greenish silty medium to fine sand with lime SM	31	—	35°
27.0-28.0	Very dense Greyish silty medium to fine sand SM	>100	—	39°

5.2 GROUNDWATER LEVEL

The groundwater table was met in the borehole at a depth of 1.50m for BH1, from the existing ground level at the time of carrying out soil investigation. Groundwater will fluctuate due to seasonal variations.

6. DISCUSSIONS AND RECOMMENDATIONS

6.1 M/s Indian Bank, Corporate Office, Chennai proposed to Construct Residential Apartments with stilt plus 5 floors at No:75, Musiri Subramaniam Road (Oliver road), Mylapore, Chennai-600 004.

6.2 **The soil strata at BH1:** The top 0.50m is filled up with soil mixed up with boulders. Below the fill , the subsoil consists of Medium dense brownish silty medium to fine sand/ with blackish tree routes from 0.50m to 4.0m depth having recorded SPT 'N' values of 11 to 18, Medium dense brownish fine to medium sand trace silt from 4.0 to 5.0m having recorded SPT 'N' value of 8, Medium dense brownish medium to fine sand trace silt from 5.0 to 7.50m having recorded SPT 'N' value of 11 to 12, Medium stiff dark greyish black silty clay from 7.50 to 9.0m having recorded SPT 'N' value of 5, Soft dark greyish black silty clay from 9.0 to 10.50m depth having recorded SPT 'N' value of 3, Very soft dark greyish black silty clay from 10.50 to 12.0m having recorded SPT 'N' value of 2, Soft dark greyish black

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silty clay from 12.0 to 13.50m having recorded SPT 'N' value of 3, Medium dense greyish brown fine to medium sand trace gravel from 13.50 to 16.50m depth having recorded SPT 'N' value of 16, Very stiff reddish clayey silty fine to medium sand/Brownish yellow clayey silty fine to medium sand from 16.50 to 19.50m having recorded SPT 'N' values ranging from 19 to 28, Medium dense greenish white clayey silty medium to fine sand with lime from 19.50 to 21.0m depth having recorded SPT 'N' value of 23, Medium dense whitish brown greenish silty medium to fine sand with lime from 21.0 to 22.50m having recorded SPT 'N' value of 25, Dense whitish brown greenish silty medium to fine sand with lime from 22.50m to 24.0m having recorded SPT 'N' value of 28, Dense Whitish brown greenish silty medium to fine sand with lime from 24.0 to 27.0 m with recorded SPT N value of 48 to 70 , Very dense greyish silty medium to fine sand from 27.0m to 28.0m with recorded SPT N Value of greater than 100. The borehole BH1 was terminated at 28.0m depth from E.G.L.

6.3 The probability of founding a multi-storey building (stilt+5 floors) of heavily loaded structure sensitive to settlement directly on the top medium dense sandy strata followed by very soft to medium stiff clayey strata of highly compressible up to a depth of 13.50m is not advisable ..

Substructure for the main building

Since the column loads are heavy, bored cast in situ piles are suggested to support the tall Super structure and also to provide sufficient anchorage into harder formations to withstand uplift due to hydrostatic pressure or overturning moment . The pile carrying capacities are calculated based on static formula as per IS 2911 (Part 1/Sec 2) : 2010 . The values can be taken as a guide for carrying capacity. The actual load carrying capacity of pile can be decided after conducting the load test as per the guide lines laid down in IS :2911(Part-IV)

Substructure for Ancillary buildings :

Isolated footings for ancillary buildings : RCC Substructure in the form of isolated footings may be founded at a depth of 1.50m to 2.0m below the ground level. Safe bearing capacity for foundation design is based on Shear criterion as per I : IS 6403 and settlement criterion as per the IS 8009 (Part 1).

6.4 The allowable carrying capacity of the pile placed at various depths below the existing ground level for various diameters of piles are given below in tabular form to support the **Main building.**

Pile Diameter	Depth	Vertical Pile capacity	Uplit Pile capacity	Lateral capacity Fixed head
m	m	kN	kN	kN
0.45	28	712	314	20
0.45	29	745	330	20
0.45	30	779	346	20
0.5	28	841	355	22
0.5	29	880	373	22
0.5	30	919	391	22
0.6	28	1217	515	26
0.6	29	1276	543	26
0.6	30	1335	571	26
0.75	28	1808	724	33
0.75	29	1896	764	33
0.75	30	1984	804	33

6.4.1 Since the pile load carrying capacity is not only a function of soil shear parameters, but also a function of installation technique and care, the above mentioned safe loads shall be considered as provisional .

6.4.2 Adequate care shall be taken to ensure proper cleaning of bottom of bore before concreting. This is carried out by continuous flushing of bentonite slurry for 15 minutes. After cleaning the bottom, the concreting shall be carried out immediately without any delay. Also, the mud used for the circulation for bored piles shall be made out of sodium bentonite with density maintained at 1.05 to 1.08 gr/cc.

6.4.3 Normally concreting of the piles should be uninterrupted In exceptional cases of interruption of concreting, it shall be resumed within 1 or 2 h, but the tremie shall not be taken out of the concrete. Instead, it shall be raised and lowered from time-to- time to prevent the concrete around the tremie from setting.

6.5 The allowable safe bearing pressure for various depths and sizes of footings are furnished below for the design of foundation for supporting **Ancillary buildings.**

Length (m)	Breadth (m)	Depth (m)	Foundation type	Shear Capacity T/sq.m.	Allowable Load intensity T/sq.m.	Settlement mm
2	1.25	1.5	Rectangular footing	8.5	8	21
3	1.5	1.5	Rectangular footing	8.5	8.5	30
4	2	1.5	Rectangular footing	9	8.5	38
2	2	1.5	Square footing	9	9	32
2.5	2.5	1.5	Square footing	10	9	39
3	3	1.5	Square footing	10	9	44
2	1.25	2.0	Rectangular footing	12	11	28
3	1.5	2.0	Rectangular footing	11	11	36
4	2	2.0	Rectangular footing	11	11	46
2	2	2.0	Square footing	12	12	40
2.5	2.5	2.0	Square footing	12	12	48

6.5.1 The effective area of the footing should be assumed as $(L - 2e_L)(B - 2e_B)$ Where e_L and e_B are eccentricities of the applied axial loads in the length and breadth directions.

6.5.2 If the space between the exterior edges of the footing is less than B/2, the footings should be combined so that there is no loss of allowable bearing pressure due to interference effects.

6.5.3 The bottom of excavated pit for foundation shall be watered and compacted using hand rammer or vibratory hammer without wetting.

6.5.4 During compaction if undue subsidence is noticed it should be brought to the notice of the supervisory personnel for appropriate remedial measures.

6.5.5 P.C.C. for the column footings shall be laid as a mud mat over the compacted base of the foundation pit to receive footing foundation

6.5.6 In the case of groundwater table occurring within the recommended depth of foundations, sumps may be made at one or more corners of foundation pits of column footings to an additional depth of 0.30m and water collected in the sumps may be bailed out.

6.5.7 The excavated sandy soil can be used for backfilling of foundations. Backfilling shall be done in layers of not more than 150mm thickness. Each layer shall be watered and well compacted (mere spreading the excavated earth for backfilling is not adequate. Layered compaction shall be done for back filling).
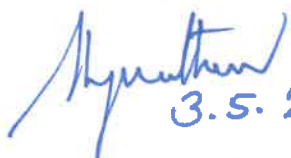
7.0 CONCLUSION

Deep foundation in the form of Bored cast in situ piles is suggested to support the Super structure of the Main building and shallow foundation in the form of isolated footings is suggested to support the super structure of the Ancillary buildings.

8.0 LIMITATIONS

The above recommendation is based upon the field data collected and laboratory test carried out on soil samples recovered from only one borehole and our experience in this regard. It is suggested to carry out additional exploratory bore holes to confirm whether the data indicated in the present bore hole is representative and whether any local weak layers/ change in strata are present in the entire foundation area.

For Sakthi Developments Coy.,

3.5. 2024

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Bore log

Name of work	Geotechnical Investigation for the Construction Residential Apartments at No:75, Musiri Subramaniam Road (Oliver road), Alwarpet, Chennai-600 004 for Indian Bank.

Location									Sheet	1
Bore Number		G.L				Bore type	Bore dia	Ground water level		
1						Rotary drilling	150 mm	1.50m		
Work commenced on:		19.01.2024			Work completed on :		20.01.2024			

Depth from GL (m)	Thickness of Layer (m)	Soil Profile	Visual description of strata	Sample details		SPT- Details					Graphical Representation of N value					Core Drilling			
				Depth	Type	Depth m	0-15 Cm	15-30 Cm	30-45 Cm	N-Value	20	40	60	80	100	Depth From	Depth To	C.R.R (%)	R.Q.D (%)
0.50	0.50		Filled up soil with boulders	0.50		0.50													
			Brownish silty medium to fine sand	1.00	SPT	1.00	4	5	6	11									
				2.00	SPT	2.00	4	5	5	10									
				3.00	SPT	3.00	3	4	4	8									
4.00	1.00		Brownish silty medium to fine sand with blackish tree roots	4.00	SPT	4.00	3	4	4	8									
5.00	1.00		Brownish fine to medium sand trace silt	5.00	SPT	5.00	3	5	6	11									
			Brownish medium to fine sand trace silt	6.00	SPT	6.00	6	6	6	12									
7.50	2.50			7.50	SPT	7.50	2	2	3	5									
			Dark greyish black silty clay	9.00	SPT	9.00	1	1	2	3									
10.50	3.00			10.50	SPT	10.50	1	1	1	2									
			Dark greyish black clayey silt	12.00	SPT	12.00	1	1	2	3									
13.50	3.00			13.50	SPT	13.50	5	7	10	17									
			Greyish brown fine to medium sand trace gravel	15.00	SPT	15.00	5	8	9	17									
16.50	3.00			16.50	SPT	16.50	7	9	10	19									
			Reddish clayey silty fine to medium sand	18.00	SPT	18.00	9	13	15	28									
19.50	3.00		Brownish yellow clayey silty fine to medium sand	19.50	SPT	19.50	10	15	20	35									
21.00	1.50		Greenish white clayey silty medium to fine sand with lime	21.00	SPT	21.00	13	19	21	40									
				22.50	SPT	22.50	14	22	26	48									
			Whitish brown greenish silty medium to fine sand with lime	24.00	SPT	24.00	16	21	27	48									
				25.50	SPT	25.50	20	32	38	70									
27.00	6.00			27.00	SPT	27.00	96	100/11cm hammer rebound											
28.00	28.00		Greyish silty medium to fine sand	28.00	SPT	28.00	100/3cm hammer rebound												

ANNEXURE-III
LABORATORY TEST RESULTS
SAKTHI DEVELOPMENTS COY
Consultants & Engineers

Plot-14/D-12 II Cross Street, Dr.R.K.Nagar, Thiruvanmiyur, Chennai-600 041.

Geotechnical Investigation for the Construction Residential Apartments at No:75, Musiri Subramaniam Road (Oliver road), Alwarpet, Chennai-600 004 for Indian Bank.

BH.No	Depth (m)	Type of Soil	IS Soil Classification	Natural Moisture %	LL	PL	PI	Free Swell Index (%)	Gravel (>4.75mm)	Coarse (4.75 to 2.00 mm)	Medium (2.00 to 0.425mm)	Fine (0.425 to 0.075 mm)	Silt	Clay	γ Bulk density KN/m³	c Cohesion Kg/cm2	φ Angle of friction	SPT Depth of testing	N value for 30 cm	Corrected N	Consistency / Relative density	Core Depth of testing	Water Absorption in %	Density in gm/cc	Compressive strength Mpa (Without)
1	0-0.50	Filled up soil with boulders	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.00	Brownish silty medium to fine sand	SM	17.51	-	NP	-	-	4	1	23	50	22		16	-	32°	1.00	11	18	M.Dense	-	-	-	-
	2.00	Brownish silty medium to fine sand	SP-SM	20.10	-	NP	-	-	7	3	33	45	12		16	-	31°	2.00	10	15	M.Dense	-	-	-	-
	3.00	Brownish silty medium to fine sand with blackish tree roots	SM	21.37	-	NP	-	-	1	0	25	44	30		16	-	31°	3.00	8	11	M.Dense	-	-	-	-
	4.00	Brownish fine to medium sand trace silt	SP-SM	18.92	-	NP	-	-	0	0	69	26	5		16	-	30°	4.00	8	11	M.Dense	-	-	-	-
	5.00	Brownish medium to fine sand trace silt	SP-SM	20.79	-	NP	-	-	0	0	42	53	5		16	-	31°	5.00	11	14	M.Dense	-	-	-	-
	6.00	Brownish medium to fine sand trace silt	SP-SM	19.89	-	NP	-	-	0	0	35	58	7		16	-	31°	6.00	12	15	M.Dense	-	-	-	-
	7.50	Dark greyish black silty clay	CH	76.60	93	42	51	50	0	0	1	2	48	49	16	0.31	-	7.50	5	5	M.stiff	-	-	-	-
	9.00	Dark greyish black silty clay	CH	83.10	104	72	32	55	0	0	1	3	41	55	15	0.19	-	9.00	3	3	Soft	-	-	-	-
	10.50	Dark greyish black clayey silt	CH	84.54	93	41	53	60	0	0	1	2	55	42	14	0.13	-	10.50	2	2	V.Soft	-	-	-	-
	12.00	Dark greyish black clayey silt	CH	71.63	89	39	50	30	0	0	3	3	79	15	15	0.19	-	12.00	3	3	Soft.	-	-	-	-
	13.50	Greyish brown fine to medium sand trace gravel	SP-SM	20.34	-	NP	-	-	0	0	61	32	7		16	-	32°	13.50	17	16	M.Dense	-	-	-	-
	15.00	Greyish brown fine to medium sand trace gravel	SP-SM	19.11	-	NP	-	-	0	0	62	30	8		16	-	32°	15.00	17	16	M.Dense	-	-	-	-
	16.50	Reddish clayey silty fine to medium sand	SC-CI	13.05	41	21	20	22	0	0	46	25	26	3	19	1.05	-	16.50	19	19	V.Stiff	-	-	-	-
	18.00	Brownish yellow clayey silty fine to medium sand	SC-CI	11.90	47	20	27	10	0	4	51	20	24	1	19	1.54	-	18.00	28	28	V.Stiff	-	-	-	-
	19.50	Greenish white clayey silty medium to fine sand with lime	SC-CL	17.35	26	19	7	22	3	3	11	41	41	1	18		33°	19.50	35	23	M.Dense	-	-	-	-
	21.00	Whitish brown greenish silty medium to fine sand with lime	SM	16.56	-	NP	-	-	8	3	10	38	41		16	-	33°	21.00	40	25	M.Dense	-	-	-	-
	22.50	Whitish brown greenish silty medium to fine sand with lime	SM	15.63	-	NP	-	-	0	1	18	55	26		17	-	34°	22.50	48	28	Dense	-	-	-	-
	24.00	Whitish brown greenish silty medium to fine sand with lime	SM	19.71	-	NP	-	-	1	1	14	50	34		17	-	34°	24.00	48	28	Dense	-	-	-	-
	25.50	Whitish brown greenish silty medium to fine sand with lime	SM	17.64	-	NP	-	-	12	12	44	10	22		17	-	35°	25.50	70	35	Dense	-	-	-	-
	27.00	Greyish silty medium to fine sand	SM	19.36	-	NP	-	-	0	1	17	58	24		-	-	39°	27.00	100/11cm rebound	>100	V.Dense	-	-	-	-
	28.00	Greyish silty medium to fine sand	SM	15.88	-	NP	-	-	1	1	18	62	18		-	-	39°	28.00	100/3cm rebound	>100	V.Dense	-	-	-	-

BEARING CAPACITY BASED ON SHEAR CRITERIA
(Based on IS: 6403-1981)

Geotechnical Investigation for the Construction Residential Apartments at No:75, Musiri Subramaniam Road (Oliver road), Alwarpet, Chennai-600 004 for Indian Bank.

Ground water table location (Dw) = 0.0 m below NGL

Unit weight of soil (γ) = 1.6 t/m^3

Submerged unit of soil (γ') = 0.6 t/m^3

Type of footing : Rectangular footing

Width of footing (B) = 2.5 m

Length of footing(L) = 2.5 m

Depth of footing from NGL (D_f) = 2 m

Angle of internal friction (ϕ) = 31 deg.   average

Cohesion (C) = 0 t/m^2

If ϕ value is in between local & general shear failure. As per
IS: 6403 - 1981 the SBC value is to be interpolated between

ϕ = 36 deg (for general shear failure)

ϕ = 29 deg (for local shear failure)

A) Local shear failure :

$\phi' = \tan^{-1}(0.67 \tan\phi)$ = 20 deg.

Cohesion (C) = 0 t/m^2
Bearing capacity factors

Nc' = 14.83

Nq' = 6.40

Nγ' = 5.39

Shape factors :

Sc = 1.20

Sq = 1.20

Sγ = 0.60

Inclination factors :
ic = iq = iγ =1

Depth factors :

dc	=	1.23
dq	=	1.11
dγ	=	1.11

Effective overburden pressure (q)	=	1.2 t/m^2
Factor of safety (F.S)	=	2.5

Ultimate bearing capacity (UBC)

$$UBC = C' * Nc' * Sc * dc * ic + q * (Nq' - 1) * Sq * dq * iq + 0.5 * B * γ * Nγ' * Sγ * dγ * iγ * w$$

Where w = Water table correction factor

w = 0.5

Ultimate bearing capacity (Local)	=	9.976 t/m^2

Safe bearing capacity as per shear criteria,

(SBC) Local = UBC/F.S	=	4 t/m^2

B) General Shear Failure :

φ	=	36 deg.
Cohesion (C)	=	0 t/m^2

Bearing capacity factors

Nc	=	50.59
Nq	=	37.75
Nγ	=	56.31

Depth factors

dc	=	1.31
dq	=	1.16
dγ·	=	1.16

Over burden pressure (q = γ' * Df)	=	1.2 t/m^2
Factor of safety (F.S)	=	2.5

Ultimate bearing capacity (UBC)

UBC = C *Nc * Sc * dc *ic + q * (Nq - 1)* Sq * dq * iq +0.5 *B*γ * Nγ' * Sγ * dγ * iγ *w

$$= \quad 76 \ t/m^2$$

(SBC)general = UBC/F.S $\quad = \quad$ 30 t/m^2

From above Local & General shear failures the SBC for actual case can be calculated as follows

SBC = (SBC)local + {[(SBC)general - (SBC)local] / (36-29)} * (ϕ - 29)

Therefore,

SBC $\quad = \quad$ 12.0 t/m^2

SAKTHI DEVELOPMENTS COY

SETTLEMENT ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS : 8009 Part 1 - 1976, Clause 9.2

Project : **Construction Residential Apartments at No:75, Musiri Subramaniam Road (Oliver road), Alwarpet, Chennai-600 004 for Indian Bank**

Applied Bearing Pressure q :	**12.0**	T/m^2	Poisson's Ratio =	0.30
Depth of Foundation **D :**	**2.00**	m		
Foundation Shape : **square**				
Foundation Width **B :**	**2.5**	m	B' = B/2 :	1.25 m
L	**2.5**	m	L' = L/2 :	1.25 m

$M = B'/L' = 1$ $N = H/B' = 10.00$ H = Thickness of compressible strata

Is Rigid Layer met?   N   9.0

$I_1 = 0.498$ $I_2 = 0.016$ Influence factor, $I = 0.507$

Design Water Table Depth :   0.0   m
Fox's Depth Factor to be considered ?   Y

Fox's Depth Factor, $d_f = 0.77$ Rigidity Factor, $d_r = 0.80$

Consolidation Settlement calculations based on Cc or mv ? :   mv

Stress Distribution Theory : Enter B for **B**   Oedometer Correction Factor, λ :   0.80
Boussenesq or W for Westergaard   Overburden Pressure @ Fndn Lvl :   **1.40** T/m^2

Layer No.	Depth, m From	Depth, m To	Soil Classification	SoilType* C,G or H	Density T/m^3	Modulus of Elasticity, T/m^2	Precons. Press (p_c), T/m^2	Initial Void Ratio	mv1, sq m/T $(p < p_c)$	mv2, sq m/T $(p>=p_c)$
1	0.0	0.5	Filled up soil with boulders	G	1.70	330				
2	0.5	3.0	Brownish sand	G	1.70	660				
3	3.0	5.0	Brownish silty sand	G	1.70	480				
4	5.0	7.5	Brownish sand trace silt	G	1.70	660				
5	7.5	13.5	Dark greyish black silty clay	C	1.70	200				
6	13.5	16.5	Greyish brown sand trace gra	G	1.70	1020				
7	16.5	18.5	Reddish clayey silty sand	G	1.70	1140				
8	18.5	21.0	Brownish yellow clayey silty s	G	1.70	1890				
9	21.0	27.0	Whitish silty sand	G	1.70	3120				
10	27.0	30.0	Greyish silty medium to fine s	G	1.70	6000				

* For "Soil Type", Enter : C (Cohesive soil), G (Granular soil) or H (Hard soils/Rock - no consolidation)

SAKTHI DEVELOPMENTS COY

SETTLEMENT ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS : 8009 Part 1 - 1976, Clause 9.2

Project : **Construction Residential Apartments at No:75, Musiri Subramaniam Road (Oliver road), Alwarpet, Chennai-600 004 for Indian Bank**

SETTLEMENT ELASTIC AND CONSOLIDATION SETTLEMENT

Total settlement, $S = S_i + S_c$ where S_i = immediate settlement

S_c = consolidation settlement

As per Terzaghi's one dimensional consolidation :	Elastic Settlement in Cohesive :
$S_c = \dfrac{c_c H}{1+e_0} \{log(p+\Delta p)/p\} \lambda_{oed} \, d_f \, d_r$ $= m_v \, \Delta p \, H \, \lambda_{oed} \, d_f \, d_r$	$S_i = \dfrac{\Delta p \, H \, d_f \, d_r}{Esoil}$
where: c_c = compression index e_0 = Initial void ratio	Δp = incremental pressure computed using stress distribution theory (**Boussenesq** or **Westergaard**)
p = overburden pressure m_v = coeff. of volume change, to be selected depending on the pressure in layer	H = Thickness of layer c_{c1} = c_c for stress range < pre-consoli-dation pressure = recompression index
λ_{oed} = oedometer correction factor	c_{c2} = c_c for stress range >= pre-consoli-dation pressure

Applied Bearing Pressure :   12.0 T/m²
Foundation Depth, (D)   :   2.0 m
Foundation Width (B)   :   2.5 m
L   2.5 m

LAYER No.	Layer Thickness, m	Soil Type	Depth,m (Z) Below Fndn.	Depth, m below GL.	p T/m²	m=L'/Z	n=B'/Z	Influence Factor*	Δp T/m²	mv	mv dp H	Modulus of Soil T/m²	Immediate Settlement (m)
					Average Influence Factor								
2	1.0	G	0.50	2.50	1.750	2.50	2.50	0.994	11.93			660	0.018
3	1.0	G	1.50	3.50	2.450	0.83	0.83	0.892	10.70			480	0.022
3	1.0	G	2.50	4.50	3.150	0.50	0.50	0.701	8.41			480	0.018
4	1.0	G	3.50	5.50	3.850	0.36	0.36	0.522	6.26			660	0.009
4	1.0	G	4.50	6.50	4.550	0.28	0.28	0.388	4.65			660	0.007
4	0.5	G	5.25	7.25	5.075	0.24	0.24	0.314	3.76			660	0.003
5	1.0	C	6.00	8.00	5.600	0.21	0.21	0.257	3.08	0.0000	0.0000	200	
5	1.0	C	7.00	9.00	6.300	0.18	0.18	0.201	2.41	0.0000	0.0000	200	
5	1.0	C	8.00	10.00	7.000	0.16	0.16	0.160	1.92	0.0000	0.0000	200	
ΣH =	8.5 m		* BOUSSENESQ INFLUENCE FACTORS						ΣS_{oed} (m) =		0.0000	$\Sigma Si(m)$	0.077

Consolidation Settlement = $\Sigma S_{oed}*d_f*d_r*\lambda$	Immediate Settlement = $\Sigma Si*d_f*d_r$

Total Settlement = Elastic Settlement + Consolidation Settlement
=   47.6   +   0.0
=   **47.6 mm**

Sakthi Developments Coy
Consultants & Engineers

Construction Residential Apartments at No:75, Musiri Subramaniam Road (Oliver road), Alwarpet, Chennai-600 004 for Indian Bank

SUMMARY OF SAFE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERIA

Length (m)	Breadth (m)	Depth (m)	Foundation type	Shear Capacity T/sq.m.	AllowableLoad intensity T/sq.m.	Settlement mm
2	1.25	1.5	Rectangular footing	8.5	8	21
3	1.5	1.5	Rectangular footing	8.5	8.5	30
4	2	1.5	Rectangular footing	9	8.5	38
2	2	1.5	Square footing	9	9	32
2.5	2.5	1.5	Square footing	10	9	39
3	3	1.5	Square footing	10	9	44
2	1.25	2.0	Rectangular footing	12	11	28
3	1.5	2.0	Rectangular footing	11	11	36
4	2	2.0	Rectangular footing	11	11	46
2	2	2.0	Square footing	12	12	40
2.5	2.5	2.0	Square footing	12	12	48

PROFESSIONAL REGISTRATION CERTIFICATE

This is to certify that the **Thiru. S. LOGANATHEN** has enrolled as **Registered Geo-Technical Engineer (RGTE)** with Chennai Metropolitan Development Authority (CMDA) who has the qualification of **M.E., (Soil Mechanics & Foundation Engg.).**, and experience in the relevant field for **40 years**.

He has been given the Registration No.**GTE/2019/04/021 Renewed** on **22.04.2024.** He shall be required to comply with the duties and responsibilities prescribed by the Government of Tamil Nadu in Part-V, "Registration of Professionals", Tamil Nadu Combined Development and Building Rules, 2019 approved vide G.O.(Ms) No.18 MAWS (MA1) Dept. dated 04.02.2019.

This Registration is valid upto **21.04.2029**.

(A. MEGANATHAN)
Superintendent

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