GEOTECHNICAL ENGINEERING LABORATORY

Report on Soil Investigation

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DEPARTMENT OF CIVIL ENGINEERING
S.V.U. COLLEGE OF ENGINEERING
TIRUPATI - 517 502

REPORT ON SOIL INVESTIGATION CARRIED OUT BY GEOTECHNICAL ENGINEERING DIVISION DEPARTMENT OF CIVIL ENGINEERING S.V.U.COLLEGE OF ENGINEERING

Sub: Managing Director, Usha Sanjeeva Reddy (USR) Techlinks PVT LTD., Tirupati– Construction of Residential Apartment at C.Mallavaram in Chittor District - Soil investigation for assessing Safe Bearing Capacity – Reg.

Ref: Lr.No. Nil, Dated 29-01-2013.

1.0 INTRODUCTION

The Managing Director, USR Techlinks Pvt. Ltd., Tirupati is proposing to construct a Residential Apartment at C.Mallavaram in Chittoor District. The undersigned have been requested to carry out the necessary soil investigation to assess the S.B.C of the soils at the proposed site for construction.

2.0 STRUCTURE

The proposed Residential Apartment is an RCC framed structure consisting of Cellar + Stilt + 5 floors. The exact location of the columns and load coming on to each column are not known at the time of this investigation. However, a maximum column load of 1200 kN is presumed for assessment of allowable bearing pressure in this investigation.

3.0 FIELD INVESTIGATION

The client concerned had made an open excavation extending up to a depth of proposed Cellar Floor level (2.4m from the existing Ground Level) extending over the entire site. Further, three trial pits of size 1.5m x 1.5m were opened extending up to a depth of about 4.8m from the proposed cellar floor level. The undersigned visited the site for inspection of trial pits and to collect both undisturbed and disturbed but representative soil samples. The trial pits are designated as TP1, TP2 and TP3 for convenience. Both undisturbed and disturbed but representative soil samples were collected from the bottom of trial pits TP1, TP2 and TP3 apart from conducting a field penetration test devised by the undersigned. Fig.1. shows the layout of the proposed structure along with approximate location of trial pits.

4.0 LAORATORY TESTING

The following tests have been conducted on the undisturbed and disturbed but representative soil samples obtained from the field in accordance with the procedures laid down in relevant BIS codes of practice.

1. Grain Size Distribution
2. Atterberg Limits
3. Free Swell Index
4. Triaxial Shear Test
5. In-situ Density & Natural Moisture Content
6. One Dimensional Consolidation Test

All the test results are summarized in Table 1 along with the results of Field Penetration Test.

5.0 SOIL PROFILE

Based on visual inspection of trial pits, Field and laboratory test results, soil profile has been arrived at and is shown in Fig.2. The same is described below.

The proposed site for construction is located amidst Agricultural fields located near C. Mallavaram village. In all the trial pits the top layer is Clayey Sand extending up to about 1.0m depth from the existing ground level. In TP1 it is followed by low compressible clay of about 1.1m thickness. The subsequent layer is also low compressible clay but with unburnt Calcium (Locally known as Sudda) extending up to the excavated depth of 3.2m. In TP2 the top layer is followed by Greenish and Reddish low compressible clay with Calcium extending up to the excavated depth of 3.8m. In TP3 also the top layer is followed by low compressible clay with Calcium extending up to 4.3m depth. However, there exists a layer of loose silty sand beyond 3.0m extending up to 4.8m. Ground Water Table is reported to be well beyond 10m depth even during rainy season with bounty rainfall.

6.0 SUGGESTIONS

Based on soil profile and test results, taking into consideration the location of Ground Water Table, the following suggestions are made.

1. Open isolated foundations in the form of individual footings located at a depth of 1.8m may be adopted for foundations.
2. All the footings shall be underlain by 150mm thick lean concrete mat underlain by 150mm thick well compacted Sand cushion (Total depth of Excavation 2.1m). The sand cushion may be laid in 1 or 2 layers each layer being well compacted under inundation. In the absence of Sand, the cushion may be laid using stone dust and 6mm chips in equal proportion.
3. The foundations may be designed for a SBC of 200 kPa (20.0 t/m^2) at this foundation depth (See Appendex – 1 & 2 for supporting calculations).
4. Uniform spacing of columns is preferable.
5. Stiff plinth beams shall connect the columns both longitudinally and laterally. This renders the sub-structure additional rigidity
6. Considering the variability in soil profile and properties it is preferable to provide one to two expansion joints extending from top of the structure to the foundation level.

The undersigned may be contacted for further clarifications, if any.

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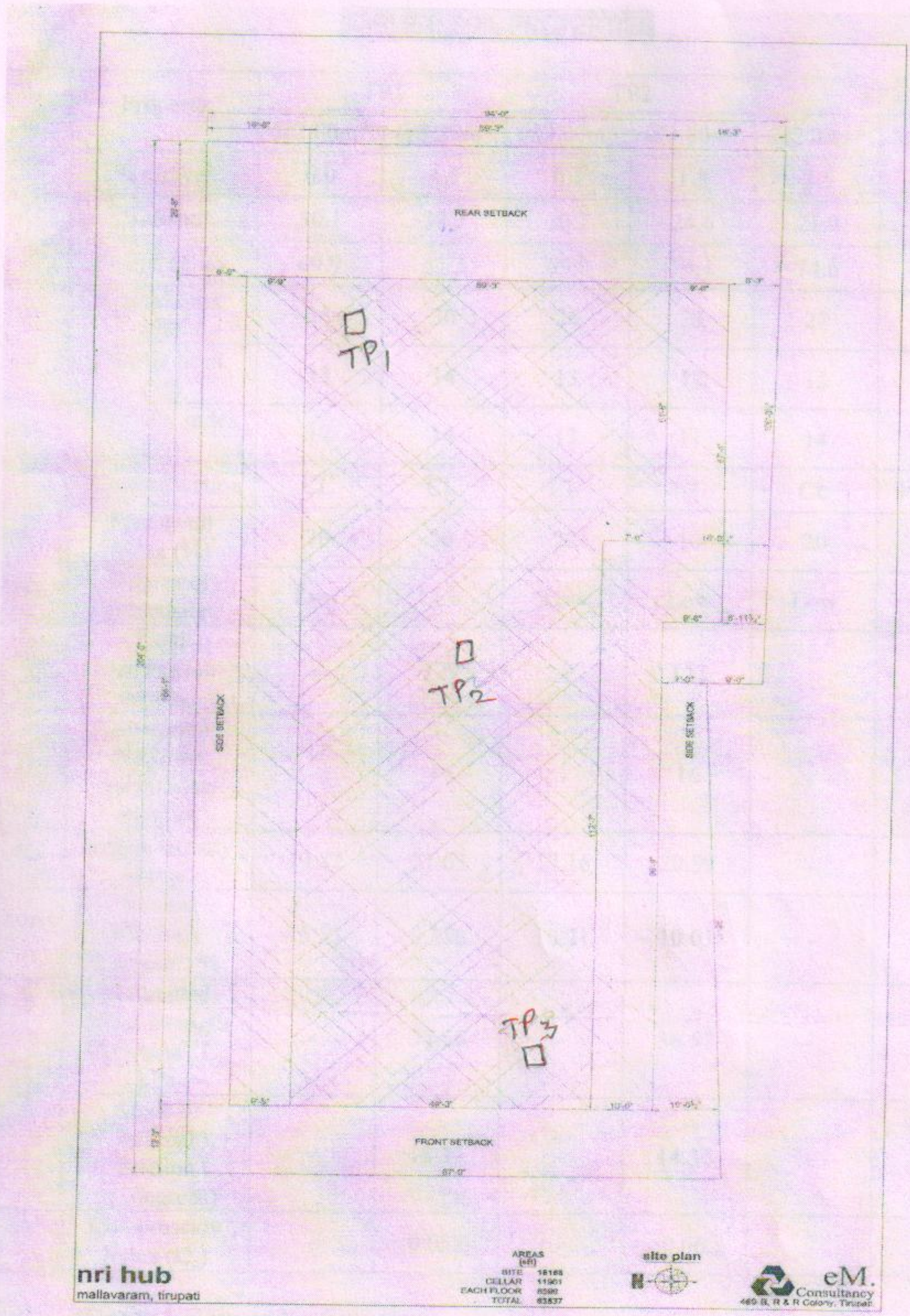

FIG.1 SITE LAYOUT SHOWING TRIAL PIT LOCATIONS

TABLE 1: SOIL PROPERTIES

S.No.	Property	TP1		TP2		TP3	
		@2.00m*	@3.20m*	@2.00m*	@3.80m*	@2.00m*	@4.80m*
1	% Gravel	0.0	4.5	0.3	1.3	3.5	1.7
2	% Sand	30.1	38.2	30.7	24.6	21.9	82.3
3	% Silt +Clay	69.9	57.3	69.0	74.1	74.6	16.0
4	Liquid limit (%)	25	30	26	23	27	NP
5	Plastic limit (%)	13	14	13	12	13	NP
6	Plasticity index (%)	12	16	13	11	14	NP
7	IS classification	CL	CL	CL	CL	CL	SM
8	Free swell index (%)	20	30	20	10	20	5
9	Degree of Expansion	Low	Low	Low	Low	Low	Low
10	Field penetration number	-	129	-	122		68
11	Estimated Standard penetration number	-	17	-	16	-	9
12	In-Situ density kN/m^3	19.82	21.03	17.16	20.39	-	16.75
13	Natural Moisture Content %	15.53	9.880	10.71	10.01	-	8.34
14	Undrained Shear strength Cohesion C_u kPa	-	37.56	-	36.57	-	0**
	Angle of Internal Friction (φ_u,degrees)	-	18.33	-	14.35	-	30**
15	Compression Index (C_c)	-	0.055	-	0.06		

*Depth below cellar floor level.
**Drained shear strength parameters.

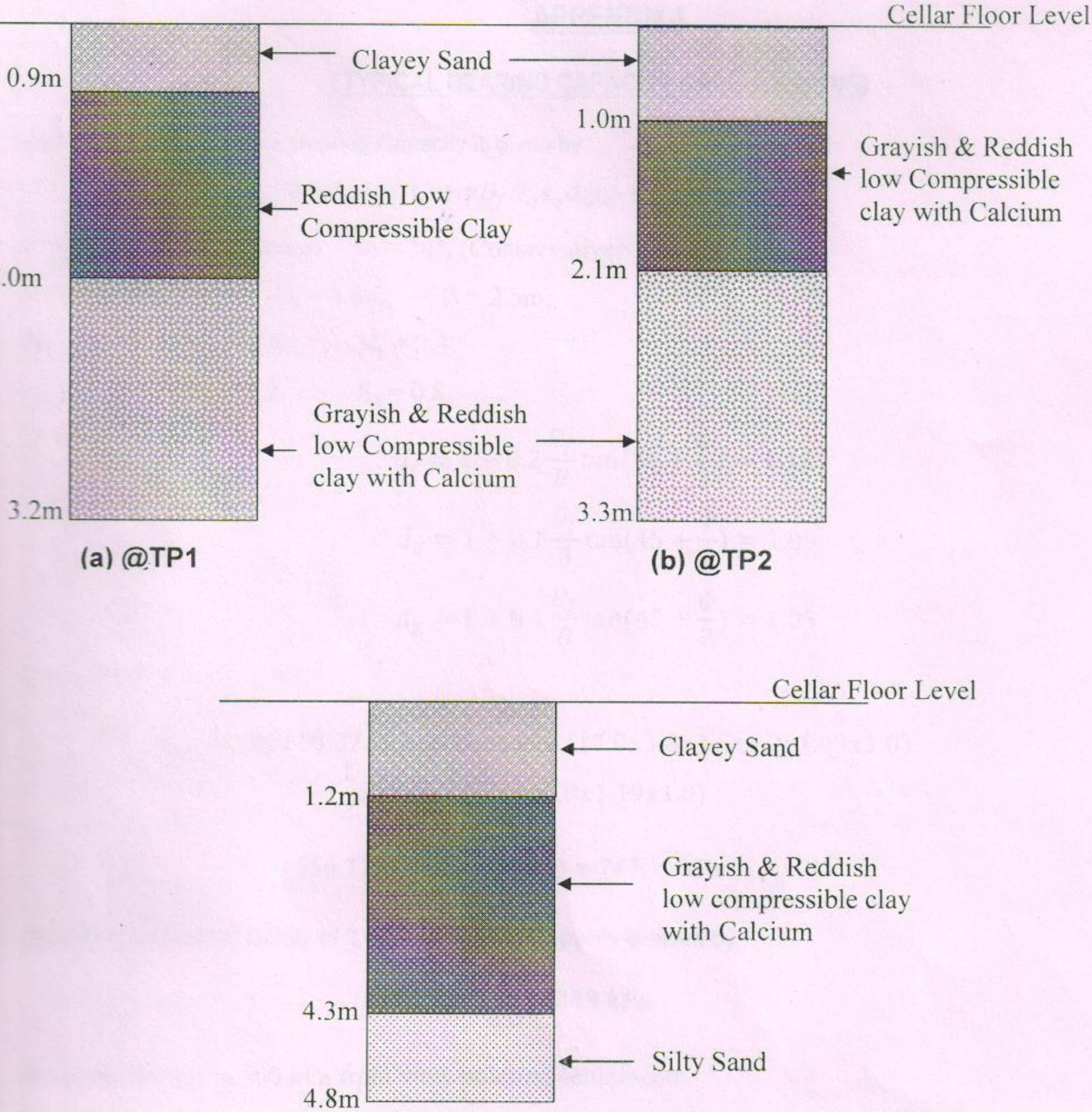

Fig.2.Soil Profiles

APPENDIX-I

(TYPICAL BEARING CAPACITY CALCULATIONS)

As Per IS 6403: Ultimate Bearing Capacity is given by

$$q_{ult} = cN_c s_c d_c i_c + \gamma D_f N_q s_q d_q i_q + \frac{1}{2}\gamma B N_\gamma s_\gamma d_\gamma i_\gamma$$

c = 35 kPa, (Conservative) Φ = 14°, (Conservative)

γ = 17 kN/m^3, D_f = 1.8m, B = 2.5m,

N_c = 10.37, N_q = 3.6, N_γ = 2.3

S_c = 1.3, S_q = 1.2, S_γ = 0.8

$$d_c = 1 + 0.2\frac{D_f}{B}\tan(45 + \frac{\phi}{2}) = 1.18$$

$$d_q = 1 + 0.1\frac{D_f}{B}\tan(45 + \frac{\phi}{2}) = 1.09$$

$$d_\gamma = 1 + 0.1\frac{D_f}{B}\tan(45 + \frac{\phi}{2}) = 1.09$$

$i_c = i_q = i_\gamma = 1$

$$\therefore q_{ult} = (35x10.37x1.3x1.18x1.0 + (17.0x1.8x3.6x1.2x1.09x1.0) + (\frac{1}{2}x17.0x2.5x2.3x0.8x1.19x1.0)$$

$$= 556.77 + 144.09 + 46.53 = 747.39 \text{ kPa}$$

Assuming a Factor of Safety of 3.0, Safe Bearing Capacity is given by

$$SBC = \frac{748}{3.0} \approx 249\ kPa$$

However limit it to 200 kPa from view pointing settlements.

APPENDIX-II
(Typical Settlement Calculations)

Let Allowable Bearing Pressure = q_a = 200 kPa

Load acting on the footing = Q = 1200 kN

Width of Foundation = B = 2.5m

Depth of Foundation = D_f = 1.8m

Unit Weight of Soil = γ = 17.0 kN/m^3

Compression Index = Cc = 0.06

Initial Void Ratio = e_o = 0.374

Consider the thickness of compressible strata as 5m and divide it into three layers of each 1.7m thickness

@ The centre of layer 1 (thickness is 1.7m)

Overburden pressure = $\sigma o_1^{'}$ = (1.8+0.85)*17.0= 45.05 kN/m^2

Increase in Pressure due to externally applied load = $\Delta\sigma_1^{'}$ = 106.93 kN/m^2

@ The centre of layer 2 (thickness is 1.7m)

Overburden pressure = $\sigma o_2^{'}$ = 73.95 kN/m^2

Increase in Pressure due to externally applied load = $\Delta\sigma_2^{'}$ = 47.05 kN/m^2

@ The centre of layer 3 (thickness is 1.7m)

Overburden pressure = $\sigma o_2^{'}$ = 102.85 kN/m^2

Increase in Pressure due to externally applied load = $\Delta\sigma_3^{'}$ = 26.34 kN/m^2

Total settlement, $Sc = \frac{Cc}{1+e_0} x\ H\ x \log_{10}(\frac{\sigma o^{'} + \Delta\sigma^{'}}{\sigma o^{'}})$

$$S_c = \frac{0.056}{1+0.374} x1.7x\{\log_{10}(\frac{45.05+106.93}{45.05}) + \log_{10}(\frac{73.95+47.05}{73.95}) + \log_{10}(\frac{102.89+26.34}{102.89})$$

S_C = 0.0693(0.5281+ 0.2138+0.0990) x 1000 mm = 57.9 mm
