Report on Soil Testing at Bongaigaon Refinery

-Client-

Indian Oil Corporation Limited, Bongaigaon Refinery
Dhaligaon, Chirang, Assam

-Turnkey Investigating & Consulting Agency-

Project Engineering & Controls Pvt. Ltd.
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C O N T E N T

1. INTRODUCTION:

M/s Indian Oil Corporation Limited, Bongaigaon Refinery, Assam (IOCL), A Govt. of India Undertaking has proposed to develop ground mounded LPG bullet plant. Accordingly for the purpose of the foundation design and construction of the proposed infrastructure of the project, a subsoil exploration work was entrusted to M/s Project Engineering and Controls Private Limited, 160D, Bakul Bagan Road, Kolkata – 700025 (PECPL) vide their LOA No. 24690094 dated 04.03.2016. Pursuant to the said LOA, the field investigation was commenced by PECPL on 8th April, 2016 and completed on 16th April, 2016. PECPL approached Department of Civil Engineering, Jadavpur University for testing of disturbed and undisturbed soil samples and preparation of soil testing report with recommendation for foundation design.

The undisturbed and SPT samples were sent to Soil Mechanics Laboratory, Dept. of Civil Engineering, Jadavpur University. This report deals with soil profile as obtained from borehole and engineering properties of each soil stratum alongwith recommendation for foundation design for different structures to be built at the site.

1.1. Brief Description of the Proposed Construction:

The proposed structure is LPG Mounded Bullets. These are horizontal bullets installed for bulk storage of liquefied petroleum gas (LPG). Offering a safer method for storing highly inflammable LPG; mounded LPG bullets are large, buried, horizontal cylindrical steel tanks.

1.2. Purpose and Scope of Investigation:

Soil Testing is very important in understanding the physical properties of soil and the rocks beneath. This is required to ascertain the type of foundation required for the proposed construction. Various tests have been done to explore the sub surface and surface characteristics of soil.

The Scope of work broadly consists of the followings:

I. Mobilization of various tools, tackle and manpower at site for boring, collection of soil/water samples, carrying out field tests as per specification and demobilization.
II. Carrying out laboratory tests on soil and water samples for determination of design parameters as per specification.
III. Submission of Report as per specification.

2. SITE CONDITIONS

2.1. Site Geology – general description:

The area forms a part of the vast alluvial plains of Brahmaputra River system and sub-basin of River Manas. Physiographically, it is characterised by the alluvial plains. The formation is comprised of sand, clay with mixtures of pebble, cobble and boulders. The Newer alluvium includes sand, gravel, pebble with silt and clay.

2.2. Potential Geological Hazards:

This is well known as a flood prone or Erosion prone district but equally it is also declared as one of the multi hazard area of Assam from the viewpoint of earth quake disasters. The region also falls within the highest seismic belt and experienced two major earthquakes, one in 1897 and another in 1950. In recent times the upcoming mushrooming man-made structures, mostly the non engineered buildings, really severe the situation and strengthen the intensity of damages from the probable hazard like earthquake.

2.3. Site Surface Description:

The surface of the site falls in a jungle with results presence of sandy-silty clay at the top of the surface.

2.4. Site Topography – general description:

The site falls in a slightly undulated area with ample of branching trees and bushes.

2.5. Description of above ground obstructions:

At the site, no above ground obstruction was found.

3. SUBSURFACE CONDITION

3.1. Stratigraphy and General Description of Subsurface Material Properties

Stratigraphy as revealed by borings is shown in Annexure. The depth wise variation of N values along the boreholes is shown alongside the soil profile. The worst subsoil stratification has been encountered in BH-1 and this has been considered for the design. The soil stratification therefore has been summarized as shown in Table – 1.

Table – 1: Subsoil Profile

Stratum	Description	Thickness (m)	N-Value
I	Medium Stiff brownish grey sandy clayey silt	7.50	9-13
II	Medium dense brownish grey silty fine sand with mica	4.50	14-28
III	Dense brownish grey silty medium to fine sand with mica	3.00	30-49
IV	Very dense brownish grey silty fine sand with mica and gravel	10.00	50-89

3.2. Groundwater elevations and expected variations:

Groundwater was encountered at a depth between 2.8m to 3.2m below ground level. Water levels reflect a dynamic balance between ground-water recharge, storage, and discharge. If recharge exceeds discharge, the volume of water in storage will increase and water levels will rise; if discharge exceeds recharge, the volume of water in storage will decrease and water levels will fall. Because recharge and discharge are not distributed uniformly in space and time, ground-water levels are continuously rising or falling to adjust to the resulting imbalances. Therefore with seasonal variation water table is likely to fluctuate and the water table has been considered to be at ground surface for design purpose.

3.3. Description of underground obstructions encountered or otherwise identified:

No underground obstructions were encountered or during the field work. However, if required, underground utility survey may be carried out before construction.

3.4. Corrosion Potential for Underground Utilities and Storage Tanks:

Table 2A and 2B of the geotechnical report suggest that average pH value of groundwater and subsurface soil is about 6.5. Further the soil resistivity is in general greater than 20Ω-m for any depth as per ERT carried out by PECPL.

The standard given in Table 2 of the document "Soil Corrosivity Analysis" available in internet (*www.corrosionsurvey.co.kr/viewer/pdf/n_02.pdf*) may be referred for studying corrosivity of soil and water.

Considering both pH and resistivity criteria it is observed that corrosivity comes to 0 point in the scale hence it is expected buried steel or concrete foundations would not come under corrosive attack.

4. FIELD INVESTIGATION

4.1. Summary of Operations:

Derrick mounted winch rig was deployed to execute the boring works. Boreholes of 150 mm diameter were made and the borehole progressed with the combination of Auger boring technique followed by Rotary Mud Circulation method. Wherever hard strata were met with, sinker bar and chisel were used to proceed with the boring. Casing pipes and bentonite slurry were used to prevent collapse of the loose materials inside the borehole.

The borings progressed down to the specified depth. Where caving of the borehole occurred, casing was used to keep the borehole stable.

4.2. Description of Sampling Procedures:

Three types of samples were collected from the field namely SPT samples and Undisturbed soil samples and Groundwater samples.

i. **SPT Samples:** Disturbed samples were collected from the split spoon after conducting SPT. The samples were preserved in transparent polythene bags.

ii. Undisturbed Soil Samples: Undisturbed samples were collected by attaching 75mm diameter thin walled 'Shelby' tubes and driving the sampler. The tubes were sealed with wax at both ends.

iii. Groundwater Samples: The water level in borehole allowed to stabilize after completion of boring. When water level inside the borehole was found stable, the depth of water level below ground level was measured and the water collected in plastic jerry can.

4.3. Description of field tests:

i. Standard Penetration Test:

Standard Penetration Tests(SPT) were conducted in the boreholes at 1.5 m depth intervals by connecting a split spoon sampler to 'A' rods and driving it by 45cm using a 65kg hammer falling freely from a height of 75 cm. The number of blows for each 15 cm of penetration of the split spoon sampler was recorded. The blows required to penetrate the initial 15 cm of the split spoon for seating the sampler was ignored due to the possible presence of loose materials or cuttings from the drilling operation. The cumulative number of blows required to penetrate the balance 30 cm of the 45 cm sampling interval is termed the SPT value or the 'N' value. The 'N' values were presented on the soil profile for each borehole.

ii. Electrical Resistivity Test:

The electrical resistivity test was used for shallow subsurface exploration by means of electrical measures made at the ground surface. Resistivity measurements were made by driving four electrodes in to the soil at pre-selected electrode spacing. The Wenner electrode configuration was used for this study. The four electrodes were spaced at equal distance along a line.

Measurements were made by causing a current, 'I', to pass through the earth and distribute within a relatively large hemispherical earth mass. The portion of the current that flows along the surface produces a voltage drop, 'V'. The resistance 'R', ratio of voltage drop 'V' to current 'I' is directly measured by Digital Earth Resistance Tester. The resistivity was determined from the following equation:

$$\boldsymbol{\rho = 2\pi a R}$$

Where,

ρ = Apparent Resistivity in ohm-m

a = Spacing between the electrodes in m

R = Resistance in ohm

The apparent resistivity of the subsurface stratum comes more than 40Ω-m.

iii. California Bearing Ratio Test:

For each test, the CBR plunger of 5 cm diameter was penetrated into the soil under a standard surcharge load at a rate of approximately 1.25 mm per minute. A proving ring is to be used to measure the load. A dial gauge of 0.01 mm sensitivity was used to measure the penetration with reference to a stable datum. The CBR value was calculated as percent ratio of pressure applied for specified penetrations into the soil to that required to penetrate into the standard material.

4.4. Logs of borings:

A boring log is a written record of information about the soil removed from a hole drilled in the earth which contains the soubsoil stratification, N-values and details of samples. Logs of Boring, which represent the field data, are attached in the Annexure.

4.5. Location Plan:

Borehole Locations were marked with the help of IOCL personnel and the Borehole Location plan is attached in the Annexure

5. LABORATORY TESTS

The following tests were done on representative samples.

a) Grain Size Analysis
b) Natural Moisture Content
c) Dry Density and Bulk Density
d) Liquid Limit and Plastic Limit
e) Unconsolidated Undrained Triaxial Test
f) Consolidation Test
g) Specific Gravity
h) Direct Shear Test
i) Chemical Test of Soil and Water to determine pH, Cl^- and SO_4^{2-}

The laboratory tests were run to ascertain the average engineering properties of the sub-soil strata and to obtain the necessary data required for determination of particulars of the foundation. These are detailed below. A summary of all test results has been given in the enclosed laboratory sheet.

5.1. Description of Tests:

I. Grain Size Analysis:

a. SIEVE ANALYSIS

The complete sieve analysis can be divided into two parts, i.e, the coarse analysis and fine analysis. An oven dried samples of soil is separated into two fractions by sieving it through a 4.75 mm IS sieve. The portion retained of it (+4.75mm size) is termed as the gravel fraction and is kept for the coarse analysis, while the portion passing through it (-4.75mm size) is subjected to fine sieve analysis.

b. HYDROMETER ANALYSIS

In the wet method of mechanical analysis or sedimentation analysis, the soil fraction, finer than 75 micron size is kept in suspension in a liquid (usually water) medium. The analysis is based on stoke’s law, according to which the velocity at which grains settle out of suspension, all other factor being equal, is depended upon the shape, weight and size of the particles/grains.

II. Natural Moisture Content:

It is the ratio of the weight of water to the dry weight of soil determined by oven drying.

III. Dry Density and Bulk Density:

These were determined by measuring the weights and dimensions of tri-axial shear and unconfined compressive strength test samples before testing and after oven drying. The bulk density & dry density values of the samples have been given in the enclosed laboratory sheet.

IV. Liquid Limit and Plastic Limit:

These are arbitrary moisture contents to determine the instant at which the soil is on the verge of being viscous liquid (Liquid limit) or non–plastic /Plastic limit. Liquid limits determined with the help of a liquid limit apparatus. Plastic limit is the water content at which the soil begins to crumble when rolled out into a thin thread of 3mm.

V. Unconsolidated Undrained Triaxial Test:

For triaxial shear and unconfined compressive strength tests, three no. 38mm diameter 76mm long specimens were obtained by jacking out the soil core, each into a thin-walled brass tube, having the wall thickness of 1/32". The inside of the tubes was coated with a thin layer of silicon oil.

These were run on the clayey silt samples to determine their shear strengths. The cell pressures employed were 0.5, 1.0 and 1.5 kg/sq.cm. The samples were tested under quick condition at a rate of 1.25 mm/min and were loaded up to maximum 20% axial strain.

VI. Consolidation Test:

To obtain specimens for consolidation test, the odometer ring was placed on the trimmed horizontal faces of the soil within the 10 cm diameter sampling tube and the soil around the cutting edge was gradually removed with a spatula as the ring was gently pushed into the soil. The ring with the soil was then removed by cutting across the soil core with the help of a piano wire saw.

Consolidation tests were run in floating ring type odometers, in single & four unit consolidation frames under standard load increment ratio starting from 0.25 kg/sq.cm and going up to 16 kg/sq.cm in general. The pressure vs void ratio curves are given in this report.

VII. Specific Gravity:

The Specific Gravity of the soil samples was determined by adopting standard procedure. The soil sample was dried in oven dried for 24 hours and pulverized. The sample was then poured into a specific gravity bottle and topped up with distilled water. The specific gravity bottle was stirred and heated to eliminate air bubbles. The weight of the specific gravity bottle was recorded along with the temperature of the sample.

VIII. Direct Shear Test:

Direct Shear Test is a strength test which is performed on the soil sample to determine the value of angle of internal friction.

The direct shear test is generally conducted on cohesion less soil as consolidated drained (CD) test. In the present case, the soil samples were prepared for various depths and were tested in the Direct Shear Apparatus under CD-condition.

The result of all the laboratory tests have been reflected in a borehole log and test result data sheet enclosed at the annexure. Graphical and pictorial presentations of test observations wherever relevant are to be also reflected and enclosed at the annex for their better appreciation.

5.2. Test Results:

Soil Test Result:

A summary of all laboratory test results is given in Annexure. From a study of these test results, the engineering properties of different strata can be summarized as follows:

Stratum I: Medium Stiff brownish grey sandy clayey silt (0.00 – 7.50m below G.L)

Bulk density: $1.86 t/m^3$
Natural moisture content: 30 %
LL: 38%
PL: 23%
C_u: $3.0 t/m^2$
ϕ: 8^0
m_v: $0.0040 m^2/t$, At Pressure range ($0.50\text{-}1.00\ kg/cm^2$)

Stratum II: Medium dense brownish grey silty fine sand with mica (7.50m – 12.00m below GL)

Bulk density: $1.88 t/m^3$
ϕ: 30^0

Stratum III: Dense brownish grey silty medium to fine sand with mica. (12.00m – 15.00m below GL)

Bulk density: $1.92 t/m^3$
ϕ: 32^0

Stratum IV: Very dense brownish grey silty fine sand with mica and gravel. (15.00m – 25.00m below GL)

Bulk density: $1.94 t/m^3$
ϕ: 33^0

Chemical Test Result:

The test results on chemical analysis of water and subsoil samples have been appended in Table 2(A and B), which was carried out by M/s Aglow Quality Control Laboratory Pvt. Ltd., Kolkata - 700107. Chemical Tests were conducted in six (6) soil samples and six (6) groundwater samples to determine pH, Cloride (Cl) and Sulphate ($S0_4$) ions. The results of the tests are given below:

Table – 2A: Chemical Test Result of Soil Samples

Sl. No.	Sample No.	pH	Chloride (as Cl) in mg/Kg	Sulphate (as SO_4) in mg/Kg
01	IOCL/BH01/SPT/1.50	5.95	1638.5	BDL
02	IOCL/BH02/SPT/6.00	5.5	983.1	BDL
03	IOCL/BH03/SPT/10.50	6.29	1968	BDL
04	IOCL/BH04/SPT/15.00	6.55	1521.7	BDL
05	IOCL/BH05/SPT/19.50	6.30	657	BDL
06	IOCL/BH06/SPT/24.00	6.54	952.15	BDL

NB: BDL = Below Detection Level < 10.00 mg/Kg

Table – 2B: Chemical Test Result of Water Samples

Sl. No.	Sample No.	pH	Chloride (as Cl) in mg/L	Sulphate (as SO_4) in mg/L
01	IOCL/BH01/GW/2.90	7.05	50.17	77.17
02	IOCL/BH02/GW/3.10	6.25	33.45	105.40
02	IOCL/BH03/GW/3.20	6.50	66.90	95.2
04	IOCL/BH04/GW/2.80	6.57	66.90	70.58
05	IOCL/BH05/GW/3.10	6.47	66.90	99.29
06	IOCL/BH06/GW/3.20	6.45	50.17	60.70

6. Foundation Recommendation:

General Consideration:

- Foundation of a structure is to be designed from considerations of superstructure loading as well as subsoil condition at the site. Suitable foundations for a structure should satisfy the following basic design criteria.
- For ultimate bearing capacity, groundwater table calculation is not needed for clayey soil as per IS:6403. However, parameters have been considered for saturated condition with water table at ground surface.
- There must be adequate factor of safety of the foundations against any possible bearing capacity failure and the settlement of the foundations must be within permissible limits.
- On the basis of requirement, both shallow and deep foundation may be adopted at the site for different types of structures. Hence both shallow and deep foundation has been studied as follows:

a. Shallow Foundation:

i. Shallow Footing:

Net allowable bearing capacity of shallow foundation of different width in the form of strip and isolated footings has been obtained as per IS: 6403. The value of net allowable bearing capacity has been furnished in Table – 3A, 3B and 3C. The sample calculation has been furnished in annexure.

Table – 3A: Bearing Capacity of Square Footing

Size of Footing	Depth of Footing	Net Safe Bearing Capacity (t/m^2)	Estimated Settlement (mm)	Suggested Net Allowable Bearing Capacity (t/m^2)		
				25mm	40mm	50mm
1mx1m	1.0m	9.62	18	Not Possible	Not Possible	Not Possible
2mx2m		8.82	32	6.89	Not Possible	Not Possible
3mx3m		8.55	47	4.55	7.28	Not Possible
4mx4m		8.42	62	3.40	5.43	6.79
5mx5m		8.34	75	2.78	4.45	5.56
1mx1m	2.0m	9.62	17	Not Possible	Not Possible	Not Possible
2mx2m		9.62	35	6.87	Not Possible	Not Possible
3mx3m		9.09	50	4.55	7.27	9.09
4mx4m		8.82	64	3.45	5.51	6.89
5mx5m		8.66	75	2.89	4.62	5.77
1mx1m	3.0m	9.62	18	Not Possible	Not Possible	Not Possible
2mx2m		9.62	35	6.87	Not Possible	Not Possible
3mx3m		9.62	53	4.54	7.26	9.08
4mx4m		9.22	65	3.55	5.67	7.09
5mx5m		8.98	75	2.99	4.79	5.99

Table – 3B: Bearing Capacity of Circular Footing

Size of Footing	Depth of Footing	Net Safe Bearing Capacity (t/m^2)	Estimated Settlement (mm)	Suggested Net Allowable Bearing Capacity (t/m^2)		
				25mm	40mm	50mm
1m	1.0m	9.62	18	Not Possible	Not Possible	Not Possible
2m		8.82	32	6.89	Not Possible	Not Possible
3m		8.55	47	4.55	7.28	Not Possible
4m		8.42	62	3.40	5.43	6.79
5m		8.34	75	2.78	4.45	5.56
1m	2.0m	9.62	17	Not Possible	Not Possible	Not Possible
2m		9.62	35	6.87	Not Possible	Not Possible
3m		9.09	50	4.55	7.27	9.09
4m		8.82	64	3.45	5.51	6.89
5m		8.66	75	2.89	4.62	5.77
1m	3.0m	9.62	18	Not Possible	Not Possible	Not Possible
2m		9.62	35	6.87	Not Possible	Not Possible
3m		9.62	53	4.54	7.26	9.08
4m		9.22	65	3.55	5.67	7.09
5m		8.98	75	2.99	4.79	5.99

Table – 3C: Bearing Capacity of Strip Footing

Size of Footing	Depth of Footing	Net Safe Bearing Capacity (t/m^2)	Estimated Settlement (mm)	Suggested Net Allowable Bearing Capacity (t/m^2)		
				25mm	40mm	50mm
1m	1.0m	7.40	27	6.85	Not Possible	Not Possible
2m		6.78	49	3.46	5.53	Not Possible
3m		6.58	72	2.28	3.66	4.57
4m		5.61	75	1.87	2.99	3.74
5m		4.93	75	1.64	2.63	3.29
1m	2.0m	7.40	27	6.85	Not Possible	Not Possible
2m		7.40	54	3.43	5.48	6.85
3m		6.88	75	2.29	3.67	4.59
4m		6.01	75	2.00	3.21	4.01
5m		5.32	75	1.77	2.84	3.55
1m	3.0m	7.40	27	6.85	Not Possible	Not Possible
2m		7.40	54	3.43	5.48	6.85
3m		6.88	75	2.29	3.67	4.59
4m		6.58	75	2.19	3.51	4.39
5m		5.83	75	1.94	3.11	3.89

ii. **Raft Foundation:**

Raft foundation of size 25mx95m founded at depth of 1m, 2m and 3m below GL may be adopted for the foundation of mounded bullets and the values of net allowable bearing capacities have been furnished in Table – 3D. The sample calculation has been furnished in annexure.

Table – 3D: Bearing Capacity of Raft Foundation

Size of Footing	Depth of Footing	Net Safe Bearing Capacity (t/m^2)	Estimated Settlement (mm)	Suggested Net Allowable Bearing Capacity (t/m^2)		
				25mm	40mm	50mm
25mx95m	1.0m	3.89	100	0.97	1.56	1.94
	2.0m	4.16	100	1.04	1.66	2.08
	3.0m	4.49	100	1.12	1.79	2.24

b. **Deep Foundation:**

Deep foundation in the form of RCC bored cast-in-situ piles has been investigated. Pile toe may be kept at 15.0 below the Existing Ground Level. Cut-off level may be considered at 1.5m below the EGL. The ultimate load carrying capacity (Qu) of a pile foundation has been estimated as given below and shown in the Annexure of the report.

$$Qu = Ap\,(0.5 \times D \times \gamma \times N\gamma + Pd \times Nq) + \sum \alpha\, C\, As + K\, Pdi \tan\delta\, Asi$$

where, Ap = Cross-sectional area of pile toe, D = Pile stem diameter,

γ = Effective unit weight of soil at pile toe,

Pd = Effective overburden pressure at pile toe,

Nγ & Nq = Bearing capacity factors depending upon the angle of internal friction (Φ) of soil at pile toe,

∑ = Summation for n layers in which pile is installed,

α = Reduction factor, C = Average cohesion of soil,

As = Surface area of pile stem, K = Coefficient of earth pressure = 1.5,

Pdi = Effective overburden pressure for the ith layer;

δ = Angle of wall friction between pile and soil in degrees (may be taken equal to Φ) and

Asi = Surface area of pile stem in the i^{th} layer.

Values of safe load carrying capacity of RCC Bored Cast in situ pile with tip resting at 15.0m from EGL (with 1.5m cut-off from EGL) for different diameters have been estimated as shown in the Annexure of the report and given as shown in the Table – 4 below :

Table – 4: Bearing Capacity of Pile Foundation

Pile Diameter (mm)	Cut off Depth below GL (m)	Pile Tip Depth below GL (m)	Pile Length below cut of Depth (m)	Safe Vertical Pile Capacity (MT)	Safe Uplift Load Capacity (MT)	Safe Lateral Load Capacity (MT)	Depth of Fixity (m)
450	1.5	15	13.5	40	28	2.79	4.77
600	1.5	15	13.5	60	37	4.46	6.36
750	1.5	15	13.5	85	46	6.97	7.95
1000	1.5	15	13.5	145	62	12.38	10.59

The above tabulated pile capacities should be checked at the site by conducting initial land routine load tests on piles according to IS: 2911 (Part-IV). Minimum pile spacing should be kept equal to 3 times the diameter of pile. It is also suggested to supplement the pile capacity by conducting dynamic load test by pile driving analyzer (PDA) and to carry out pile integrity test to check the soundness of the piles to be cast in situ.

RECOMMENDATIONS:

It has been proposed to construct three mounded bullets alongwith some ancillary structures at the site. A detailed soil investigation programme was undertaken to assess the quality of the existing subsoil and to suggest suitable foundation systems for the proposed structures. Based on field and laboratory tests and analysis of the results the following recommendations may be made.

1. At this site, shallow foundations may be adopted and the values of net allowable bearing capacity for strip, square and circular footings of different sizes founded at 1m, 2m and 3m below G.L. are recommended as shown in Table – 3A, 3B and 3C.
   1.1. Tie beams, properly designed against probable differential settlement, if any, should be provided between columns.
   1.2. Safety of adjacent structures must be ensured during excavation work and also during construction of foundations.
   1.3. For mounded bullets, raft foundation of 25mx95m, founded at a depth of 1m, 2m and 3m below GL, may be adopted and the values of net allowable bearing capacities have been furnished in Table – 3D. However, in case raft foundation is not capable of bearing the load intensity, deep foundation in the form of pile foundation may be adopted.
2. R.C.C. Cast- in- situ bored piles of shaft length 13.5 m below cut off length of 1.5m below GL is suggested.
   2.1. The capacity of such piles of different diameter with 1.5m cut off length has been given in the preceding chapter in Table – 4. There should be adequate provision for Load test of piles according to IS 2911 – Part IV (latest edition). The minimum spacing of piles should be kept equal to 3 times the pile diameter.
   2.2. For use of pile, higher diameter may be chosen for increased capacity and reduction of number of piles. For further increase in pile length, at least three borings of minimum 50m depth should be done as per clause no. 4.1(a) of IS:2911-1-4 (2010)
3. Liquefaction is not likely to occur under present site condition since there is a cohesive deposit covering the sandy soil and it has a sufficient depth of 7.5m. It is therefore expected that it will prevent dissipation of pore water pressure since its permeability is comparatively low.
4. Downdrag forces do not arise since there is no recently placed fill.
5. Active earth pressure, at-rest earth pressure etc. are to be obtained from the given shear strength parameters.
6. For Slabs, Pavements and Roadways, CBR value has been given. Improvement, if required, is to be addressed by the constructor.
7. If required, scheme for deep excavation including dewatering can be made by conducting field permeability test and on the basis of the soil data presented in this report.
8. If required, ground improvement techniques, appropriate to the site condition may be adopted and proper scheme has to be designed for that purpose based on the soil data presented in this report.