

# INDEX LAB & CONSULTANTS

B-11, Navlakha Complex, Agrasen Square, Indore (M.P.) 452 001, India  
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## Test Report

ILC / TC / 2680/18-19

Format: F-5.1 0/T

The detailed scope of work was as per the instruction of Engineer in-charge. A complete geo-technical investigation work was undertaken to obtain the required subsurface information to study and define the nature and behavior of soil, under the application of loads of proposed structures. Such information was obtained through following steps:

- By making borehole and collecting disturbed soil samples.
- Conducting laboratory tests to classify it and to determine the engineering properties of soil.

An analysis was made to derive the allowable bearing capacity, taking into considerations the anticipated settlements and the present soil conditions with future possibilities. Based on such analysis of the soil properties, the conclusions are made regarding the precautions and protective measures to be taken, if found necessary.

This report has been prepared after a careful study of the field testing and laboratory test results. The type and depth of foundation are suggested.

### **Site Conditions:**


**Site Location:** Kanadiya Near Impetus I.T. Park.

**1.1 Sub Soil Profile:** The field data and laboratory classification reveals, from 0 to 3.0 mtr Weather Rock then 3.0 mtr to 15.0 mtr Rock.

### **2.0 Nature of Investigation:**

**2.1 Bore Holes:** Boreholes were conducted by machinery drilling up to 15.0 mtrs depth below existing ground level. Boring was carried out in accordance with IS: 1892 – 1979 and the disturbed rock samples were collected in core box and sealed packed and brought to our laboratory at Indore for



  
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ILC / TC / 2680/18-19  
further investigation.

Format: F-5. I O/T

- 2.2 **Recording of Water Table:** Water table is recorded after 24 hours of completion of the Boreholes and after the analysis water table is not found.
- 2.3 **Sampling:** During the advancement of the boring Disturbed samples are collected up to 15.0 mtrs.
- 3.0 **Laboratory Tests:** Following laboratory tests were carried out to determine the Mechanical properties of disturbed soil samples. Detail procedures are explained in Annexure. I
- |  |                      |
|--|----------------------|
| (A) Field Dry Density & Field Moisture Content | (D) Shear Parameter  |
| (B) Atterberg's Limits                         | (E) Specific Gravity |
| (C) Particle size distribution                 | (F) Free Swell Test  |
- 4.0 **Design:** Calculations for both Safe Bearing Capacity (SBC) and Safe Bearing Pressure (SBP) are carried out considering shear parameters and consolidation characteristics of the sub strata. Values of SBC & SBP are mentioned below:
- 4.1 **SBC Based on Shear:** The ultimate net bearing capacity is evaluated after taking into consideration of shape factor and depth factor of the foundation in accordance with IS: 6403-1981. The net bearing capacity worked out using the following equation.

$$Q = C N_c S_c d_c i_c + q (N_q - 1) S_q d_{q1} + 0.5 B N_r S_r d_r i_r w'$$

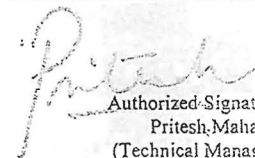
Where, C = Cohesion

Q = Overburden Pressure Density

B Width of the Foundation

$N_c, N_q, N_r$  = Bearing Capacity Factor



  
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 $S_c, S_q, S_r$  = Shape Factor

Format: F-5.10/T

$d_c, d_q, d_r$  = Depth Factor

$i_c, i_a, i_y$  = Inclination Factor

$W'$  = Correction Factor of Location of Water Table

- 4.2 **Safe Bearing Pressure :** ( IS: 8009 Part I) The Settlement calculation involves many simplifying assumptions.

The total settlement is computed as summation of immediate and secondary settlement.

$$S_t = S_i + S_c$$

Where,  $S_i$  is Immediate Settlement

$$S_i = p B \frac{(1 - \mu^2)}{E} I$$

Where,  $p$  = Foundation Pressure,  $\text{kg/cm}^2$

$B$  = Width of Footing, m

$\mu$  = Poisson's Ratio

$I$  = Influence Factor

$E$  = Modulus of Elasticity,  $\text{kg/cm}^2$

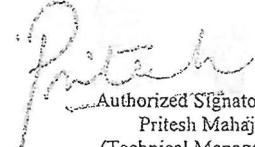
$S_c$  is Secondary Settlement

$$S_c = \frac{Ht}{1+e_0} Cc \log_{10} \frac{(p_0 + p)}{p_0}$$

Where,  $Ht$  = Thickness of Soil Layer, m

$Cc$  = Compression Index



  
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$e_0$  = Initial Void Ratio

$p_0$  = Initial Effective Pressure

$p$  = Increase in effective pressure

### 5.0 Guideline Properties of Rock Mass Classes

Class Description	I Very good rock	II Good rock	III Fair rock	IV Poor rock	V Very poor rock
RMR	100-81	80-61	60-41	40-21	20-0
Q Value	>40	10-40	4-10	1-4	<1
Friction angle $\phi$ (°)	>45	35-45	25-35	15-25	<15
Cohesion (kPa)	>400	300-400	200-300	100-200	<100
SBP (MPa)	10	4-6	1-2	0.5	<0.2
Safe cut slope (°)	>70	65	55	45	<40
Tunnel support	none	Spot bolts	Pattern bolts	Bolts + Shotcrete	Steel ribs
Stand up time for span	20 yr for 15 m	1 yr for 10m	1 wk for 5m	12h for 2 m	30 min for 1 m

### General Shear Failure

$$q_{ult} = cN_c + 0.5 \gamma B N_\gamma + \gamma D N_q$$

Where

$q_{ult}$  = the ultimate bearing capacity

$\gamma$  = effective unit weight (i.e. submerged unit wt. if below water table) of the rock mass

$B$  = width of foundation

$D$  = depth of foundation below ground surface

$c$  = the cohesion intercepts for the rock mass



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$$q_{ult} = cN_c + 0.5 \gamma BN_\gamma$$

### Compressive Failure:

A case characterized by poorly constrained columns of poor rock.

$$q_{ult} = 2c \tan (45 + \phi / 2)$$

### Splitting Failure

For widely spaced and vertically oriented discontinuities, failure generally initiates by splitting beneath the foundation.

The ultimate bearing capacity is given by:

For circular foundations

$$q_{ult} = JcN_{ct}$$

For square foundations

$$q = 0.85 JcN_{ct}$$

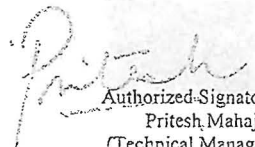
For continuous strip foundations for  $L/B \leq 32$

$$q_{ult} = JcN_{ct} / (22 + 0.18 L/B)$$

Where

J = correction factor dependent upon thickness of the foundation rock and width of foundation.



  
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L = length of the foundation

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The bearing capacity factor  $N_{ct}$  is given by:


$$N_{ct} = \frac{2N\phi^2}{1+N\phi} (\cot \phi) (S/B) \left[ 1 - \frac{1}{N\phi} \right]$$
$$- N\phi (\cot \phi) + 2 N\phi^{1/2}$$

**5.1 Summary of Analysis:** Based on the field and laboratory test data allowable bearing capacity is derived for foundation with the consideration of following points.

5.1 The sub soil comprises of Soil & Rock.

5.2 Net bearing capacity is derived based shear parameters and UCS obtained from test conducted on remolded density.



  
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**Table 1: Safe Bearing Capacity**

Ground level for Bore No.1 (LIG), Kanadia Site is 102.670

Depth Below GL in Mtrs.	Ultimate Bearing Capacity, (T/m <sup>2</sup> )	Safe Bearing Capacity, (T/m <sup>2</sup> )
0.0 to 3.0 mtrs	67.8	27.1
3.0 to 4.5 mtrs	81.3	32.5
4.5 to 6.0 mtrs	89.0	35.6
6.0 to 7.5 mtrs	94.8	37.9
7.5 to 9.0 mtrs	101.5	40.6
9.0 to 10.5 mtrs	106.3	42.5
10.5 to 12.0 mtrs	111.8	44.7
12.0 to 13.5 mtrs	118.3	47.3
13.5 to 15.0 mtrs	126.0	50.4

### 6.0 Recommendations:

6.1 The Rock/Soil is suitable for footing purpose.

6.2 Safe bearing capacity of soil / rock at a different depth mention above for foundation. Settlement shall be within permissible limits.

### General Note:

1. Factor of Safety considered is 2.5 for foundation.
2. The foundation shall in no mean rest on Filled up Soil or Black Cotton Soil.
3. If in the course of excavation, sub soil strata differs from the bore log strata same shall be reported for necessary steps.

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ILC / TC / 2680/18-19

Format: F-5. 10/T

### Annexure I

#### 7.0 Sampling:

7.1.1 **Disturbed Soil Samples:** Disturbed samples were collected during the boring and also from the split spoon sampler. The samples recovered were logged, labeled and placed in polythene bags and sent to laboratory for testing. The samples collected up to 15.0 mtrs depth.

#### 7.2 Laboratory Test Procedures:

7.2.1 **Field Dry Density & Field Moisture Content:** Field dry density and Field moisture content were carried out in accordance with I.S. 2720 Part-2 – 1983. The field density is found out by following equation. The value of F.D.D. & F.M.C. is shown in summary table -3.


Field Density (bulk) = Weight of soil mass / Volume of soil mass

And Field Dry Density = Bulk Density/ (1 + w), Where w is field moisture content.

7.2.2 **Atterberg's Limit:** Liquid limit and Plastic limits are carried out for the determination of different characteristic of soil. The tests performed in accordance with I.S.2720 Part – 5-1985 by using Mechanical Liquid Limit Apparatus. About 120 g of the soil sample passing 425-micron IS Sieve shall be mixed thoroughly with distilled water in the evaporating dish or on the flat glass plate to form a uniform paste. The paste shall have a consistency that will require 30 to 35 drops of the cup to cause the required closure of the standard groove.

Liquid limit and plastic limit of soils are both depend up on the amount and type of clay in a soil and form the basis for the soil classification system for cohesive soils based on the Plasticity index.



  
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Format: F-5.10/T

For Plastic Limit, a soil sample weighing at least 20 gm of the soil sample passing 425 micron IS sieve is thoroughly mixed with water such that it can be easily molded with fingers. A ball is formed with about 8 gm of this soil and is rolled between the fingers and the glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter of 3 mm throughout its length. The soil is kneaded to a uniform mass and rolled again. The process is continued until the thread crumbles. The pieces of crumbled soil thread are collected for moisture content determination and reported as plastic limit. Values of LL, PL & PI are shown in summary table.


**7.2.3 Particle Size Distribution (IS: 2720 Part IV):** The sieve analysis is carried out in accordance with IS. The results are shown in the summary table.

**7.2.4 Specific Gravity (IS: 2720 Part III):** In order to determine specific gravity of soil particles these tests were conducted on Selected samples in 50 ml volumetric density bottle using procedure described in IS. The value of Specific Gravity is shown in summary table.

**7.2.5 Direct Shear Test (IS: 2720 Part XIII):** Direct shear test is carried out using shear box with the specimens (60mm x 60mm). Specimen with plain grid plate at the bottom of the specimen and plain grid plate at the top of the specimen is fitted into position in the shear box housing and assembly placed on the load frame. The serrations of the grid plates are kept at the right angle to the direction of shear. Loading pad is placed on top grid plate. The required normal stress is applied and the rate of



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Format: F-5. 10/T


longitudinal displacement / shear stress application so adjusted that no drainage can occur in the sample during the test (1.25mm/min). The upper part of the shear box is raised such that a gap of about 1mm is left between the two parts of the box. Test is conducted by applying horizontal shear load to failure or to 20 percent longitudinal displacement whichever occurs first. Test is repeated on identical specimens. The shear parameters obtained from the shear stress Vs normal stress plot. Direct Shear Test is conducted on remolded samples at FDD & FMC.

7.2.6 **Free Swell test (IS: 2720 (Part – XL):** In order to determine the swelling characteristics of the soil, differential free swell test is carried out. An oven dried soil sample, 10 gm passing through 425 micron is poured in two 100 ml graduated cylinder. One cylinder was filled with distilled water and in kerosene up to 100 ml mark. After the removal of entrapped air, sample was allowed sufficient time to attain equilibrium state of volume. The final volume of soil in each cylinder was recorded.

Free Swell Index (FSI)

$$\text{FSI \%} = \frac{\text{Soil volume in water} - \text{Soil volume in kerosene}}{\text{Soil volume in kerosene}} \times 100$$



  
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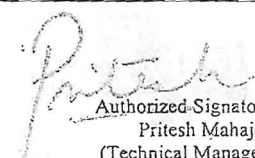
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### Shear by Triaxial as per IS: 2720 (Part XII)-1981:

The test should be conducted in environment in which ambient temperature is constant. All valves are assumed to be closed and it is also assumed that the pedestal at the base of triaxial cell is covered with water. Gently slide one de-aired coarse porous stone on to the top of the pedestal and blow off any excess water from the pedestal. Place a filter paper disc on the stone and then place the soil sample on the disc. Place the second de-aired disc and the coarse porous stone on top of the sample and the loading cap on top of the second porous stone. Ensure that the sample, the stones, the discs, and the loading cap are all concentrically placed on the pedestal.

Strength of Intact Rock Material (MPa)			
	Compressive Strength	Point Load Strength	Rating
Exceptionally Strong	>250	>8	15
Very Strong	100-250	4-8	12
Strong	50-100	2-4	7
Average	25-50	1-2	4
Weak	10-25	Use of uni axial compressive strength is preferred	2
Very Weak	2-10		1
Extremely Weak	<2		0



  
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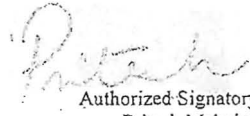
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Table – 2 BORE LOG (As per I.S. 1892: 1979)

Depth in Mtr. From EGL	Description of Strata	Soil Legend	Nature of Sample	SPT Value/RR-RQD
0.0 to 3.0 Mtr	Rock		RR/RQD	35cm/Nil
3.0 to 4.5 mtrs	Rock		RR/RQD	60cm/Nil
4.5 to 6.0 mtrs	Rock		RR/RQD	74cm/Nil
6.0 to 7.5 mtrs	Rock		RR/RQD	82cm/30cm
7.5 to 9.0 mtrs	Rock		RR/RQD	94cm/48cm
9.0 to 10.5 mtrs	Rock		RR/RQD	105cm/62cm
10.5 to 12.0 mtrs	Rock		RR/RQD	126cm/74cm
12.0 to 13.5 mtrs	Rock		RR/RQD	132cm/82cm
13.5 to 15.0 mtrs	Rock		RR/RQD	138cm/93cm



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### SBC of Rock as per IS: 12070 - 1987

Bore No.1	Depth Mtr.	Water Absorption	Dry Density	Net SBC T/m <sup>2</sup>
	0.0 to 3.0 mtrs	1.48	2.57	27.1
	3.0 to 4.5 mtrs	1.26	2.60	32.5
	4.5 to 6.0 mtrs	1.00	2.66	35.6
	6.0 to 7.5 mtrs	0.74	2.73	37.9
	7.5 to 9.0 mtrs	0.68	2.80	40.6
	9.0 to 10.5 mtrs	0.65	2.82	42.5
	10.5 to 12.0 mtrs	0.63	2.85	44.7
	12.0 to 13.5 mtrs	0.60	2.89	47.3
	13.5 to 15.0 mtrs	0.56	2.91	50.4

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## Glossary

Abbreviations	Descriptions
BC	Black Cotton
BH	Bore Hole
SBC	Safe Bearing Capacity
T	Tone
SPT	Standard Penetration Test
UDS	Undisturbed Sample
DS	Disturbed Sample
G	Gravel
S	Sand
M	Silt
C	Clay
LL	Liquid Limit
PL	Plastic Limit
PI	Plasticity Index
FDD	Field Dry Density
NMC	Natural Moisture Content
C	Cohesion
$\emptyset$	Angle of Internal Friction
SL	Shrinkage Limit
FSI	Free Swell Index
RMR	Rock Mass Rating
RR	Rock Recovery



  
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RQD	Rock Quality Designation
FMC	Field Moisture Content
SG	Specific Gravity
NA	Not Applicable



  
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