

# GEOTECHNICAL INVESTIGATION REPORT

**NAME OF PROJECT : CONSULTANCY SERVICES FOR  
PREPARATION OF PROJECT REPORT FOR 2- LANING  
OF JORAM-KOLORIANG ROAD FROM KM.70/000 TO  
138/000 (LENGTH : 68 KM) IN THE STATE OF  
ARUNACHAL PRADESH UNDER SARDP-NE ON EPC  
MODE**

**CLIENT: NATIONAL HIGHWAYS & INFRASTRUCTURE  
DEVELOPMENT CORPORATION LTD.**

**:CONSULTANT:  
K & J PROJECTS PVT. LTD.  
ALLIANCE ENGINEERS & CONSULTANTS (JV)**

**REPORT PREPARED BY**



**RELIANT FOUNDATIONS PVT. LTD.**

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**SSI REPORT FOR  
CONSTRUCTION OF RCC BRIDGE  
AT  
KM – 72+070**





## REPORT ON SUB SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-72+070.

### 1. INTRODUCTION:

**1.1** This report presented herein deals with the field and laboratory investigations carried out by us to access the nature of sub-strata and to evaluate the soil parameters required for design of foundations proposed to be constructed for proposed bridge.

**1.2** Client's help is gratefully acknowledged in providing bore hole locations, close supervision and checking during boring, sampling, various testing operations and cooperation and guidance during finalization of report.

**1.3** The work of Geotechnical Investigation was awarded to RELIANT FOUNDATIONS PVT LTD., H-7, BYE LANE NO.1 (A.NORTH), PANJABARI ROAD, SIXMILE, GUWAHATI-22 for the project construction of bridge.

**1.4** This report is based upon the results of field, laboratory tests conducted on selected soil/rock samples collected from three bore hole up to the depth of 14.95 M each and interpretation of results were done as per IRC 78-2000 and pertinent IS code of practices.

### 2. GEOLOGICAL BACKGROUND :

**GEOLOGICAL BACKGROUND :** Arunachal Pradesh, the 'Land of the rising sun' is located towards the northeastern tip of India. It presents a breathtaking beautiful landscape with towering snowclad peaks, steep precipitous gorges, lush green valleys and innumerable streams. The state is bound by neighboring countries like China (Tibet), Bhutan and Myanmar towards North, West and East respectively. Arunachal Pradesh lies between 26°28' and 29°30' N and 91°30' and 97°25' E. It occupies an area of 83,578 sq. kms. Arunachal Pradesh is largely inaccessible rugged terrain with dense impenetrable forests, unpredictable climatic conditions and poor road communications. Thus, it is geologically, a rather lesser known region. Arunachal Pradesh consists of four physiographic domains viz. a) Himalayan range, b) Trans-Himalayan range c) Naga-Patkoï range and d) Brahmaputra plain. Each domain has a distinctive geological and tectonic history.

**LANDSLIDES AND SIESMOTECTONICS:** The region is prone to earthquake. Since the middle of the nineteenth century, there had been at least two major earthquakes (1897 and 1950), which are among the most destructive earthquakes in human history. The mountainous tracts of the region are inhabited by people of diverse ethnic groups and cultural affinities lured by the pioneering spirit of man in quest of the unknown, be it geographical or geological. The earliest reference of the region is found in the Mahabharata and





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documentation of the geological information was made mostly by the British military expeditions during the early part of the

nineteenth century prior to establishment of the GSI in 1851. This excludes the meticulous records of the earthquakes which are available since the middle of the last century.

### 3. SCOPE OF WORK:

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**3.1** Mobilizing necessary plant, equipments and personnel to the project site, setting up the equipment, carrying out the field investigations on land and demobilization on completion of work.

**3.2** Making 150 mm nominal diameter bore holes at the site in all types of soil using suitable approved method of boring to be given at site by the Engineer-in-Charge. Refusal shall mean when SPT field 'N' value reaches 50 for 30 cm or less penetration of SPT sampler.

**3.2.1** Conducting standard penetration tests in the bore holes at 1.50 m interval in depth as per specifications / instructions of Engineer-in-Charge.

**3.2.2** Collecting undisturbed soil samples from bore holes at 3.0m interval or every change of strata, whichever is earlier as per specifications.

**3.2.3** Collecting disturbed soil samples from bore hole at regular interval and at every identifiable change of strata to supplement the boring records.

**3.2.4** Recording the depth of ground water table in all the bore hole if observed up to the depth of exploration during boring work as per specifications & withdrawing the casing pipe.

**3.3** Conducting the following laboratory tests on selected disturbed / undisturbed soil samples collected from bore hole / test locations :-

(a) Bulk density and Moisture content

(b) Sieve analysis

(c) Hydrometer analysis

(d) Liquid limit & Plastic limits

(e) Specific gravity

(f) Shear test on undisturbed and remoulded saturated disturbed soil samples

(g) Determination of void ratio.







## REPORT ON SUB SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-72+070.

**3.4** Preparation and submission of report in three copies.

### **4.0 FIELD INVESTIGATIONS:**

**4.1** Necessary plant, equipment and personnel for conducting the requisite field work were mobilized to the site.

**4.2** one number borehole was first marked on the ground surface as per the layout given to us by the Engineer-in-Charge.

**4.3** Bore hole was bored at this site using rotary drilling method as per IS: 1892-1979.

**4.3.1 Standard penetration** tests were conducted in the above bore hole at every 1.50 m interval & at change of strata as per specifications / instructions of Engineer-in-Charge. The bore was cleaned up to the desired depths. Standard split spoon sampler attached to lower end of 'A' drill rods was driven in the bore holes by means of standard hammer of 63.5 Kg. falling freely from a height of 75 cm. The sampler was driven 45 cm as per specifications & the numbers of blows required for each 15 cm penetration were recorded. The numbers of blows for the first 15 cm penetration were not taken into account. This was considered as seating drive. The numbers of blows for next 30 cm penetration were designated as SPT 'N' value. Wherever the total penetration was less than 45 cm, the number of blows & the depth penetrated is incorporated in respective bore logs. Disturbed soil samples obtained from standard split spoon sampler for all the above standard penetration tests were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded and carefully transported to the laboratory for testing.

**4.3.2 Undisturbed** soil samples were collected from the bore hole at every 3.00 m interval in depth & at change of strata as per sampling specifications. These sampling tubes after retrieval from the bore hole was properly waxed and sealed at both ends. These were carefully labeled and transported to the laboratory for testing. Undisturbed soil samples wherever slipped during lifting, were duly marked in the field bore logs as well as in the soil profile.

**4.3.3 Disturbed soil** samples were also collected from the bore hole at suitable depths/intervals to supplement the boring records. These samples were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded & carefully transported to the laboratory for testing.

**4.3.4** The depth of ground water table was checked / measured in all bore holes.





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### 4.3.5 Summary of bore holes:

Table1

RL of bore hole top	Depth of Bore hole(M)	Water level during the time of field work( M)
952.500	15.0	Not encountered

### 5.0 LABORATORY INVESTIGATIONS:

**5.1** The following laboratory tests were conducted on selected soil samples recovered

from bore hole / test locations: -

- (a) Bulk density and Moisture content
- (b) Sieve analysis
- (c) Hydrometer analysis
- (d) Liquid limit & Plastic limits
- (e) Specific gravity
- (f) Shear test on remolded and saturated disturbed soil samples
- (g) Determination of void ratio..

All the above laboratory tests were carried out as per relevant Indian Standards. All the soil samples were identified and classified as per IS: 1498-1970.

### 6.0 FINDING OF GEOTECHNICAL INVESTIGATION:

The study of bore logs/results of laboratory and other field tests are tabulated through different tables as annexure.

### 7.0 Analysis of liquefaction potential

It is analysed through Seed and Idriss ( 1982) approach

Liquefaction is generally occurs in fine to medium sand within a depth of 10.0M from ground surface. With increasing overburden pressure the chances of liquefaction usually decrease. ( CI 13.5.1, Theory and practice of Foundation design NN Som, S.C. Das, Prentice hall of India Pvt Ltd Publisher) . **As the area is mostly bouldery/ Shale probability of liquefaction is almost nil.**





## REPORT ON SUB SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-72+070.

### 8.0 CALCULATION OF BEARING CAPACITY

#### (A) Calculation of Net Safe Bearing Capacity based on shear Criteria

IS: 6403-1981 recommends the following equation to calculate the net Safe Bearing Capacity " $q_s$ " based on Hansen's Bearing Capacity analysis:

$$q_s = 1/F \{ C N_c S_c d_c i_c + q (N_q - 1) S_q d_q i_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma \times R_w \}$$

Where, C = Cohesion of soil.

$\gamma$  = Saturated Density of soil

B = Width of footing = 2.0 m (assumed)

$R_w$  = Water table correction factor depending upon position of water table with respect to founding level

Q = Effective surcharge at footing level =  $\gamma D$  (D = depth of footing)

$N_c, N_q, N_\gamma$  = Bearing capacity factor

$S_c, S_q, S_\gamma$  = Shape factor

$d_c, d_q, d_\gamma$  = depth factor

$i_c, i_q, i_\gamma$  = inclination factors

F = Factor of safety = 3.0

#### B) Calculation of safe bearing pressure based on tolerable settlement.

The safe bearing pressure is to be found out from the elastic settlement consideration and is found from the following equation given I.S. 8009 (part-1) 1976

$$S_f = S_{\text{oud}} = (H_f / 1 + e_o) C_c \log_{10} (p_o + \Delta p) / p_o$$

$S_f$  = Final settlement in mm

$S_{\text{oud}}$  = Settlement computed from one dimensional test

$H_f$  = Thickness of soil layer in m

$e_o$  = Initial void ratio at mid height of of layer

$C_c$  = Compression Index

$p_o$  = Initial effective pressure at mid height of layer

$\Delta p$  = pressure increment

For the computation of settlement of foundation founded at certain depth, a correction should be applied to the calculated  $S_f$  in the form of a depth factor to be read from Fig:12 of I.S. 8009 (part-1) 1976.

Corrected settlement  $S_{fd} = S_f \times \text{depth factor}$

Depth factor is dependent on the following

- i. D= Depth of footing
- ii. L= Length of footing
- iii B= Width of footing





## REPORT ON SUB SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-72+070.

**Table1 Safe Bearing Capacity at different depth**

Foundation Depth below ground level (M)	RL of founding level	Recommended net safe bearing Capacity (M ton/sqm)
3.0	894.123	63.21
4.0	893.123	78.62
5.0	892.123	94.06
6.0	891.123	109.54
7.0	890.123	125.05
8.0	879.123	140.59
9.0	878.123	156.16
10.0	877.123	171.77

### 9.0 CONCLUSION AND RECOMMENDATION

Sub soil at this site is of weathered rocky type upto a depth of 9.0m after that it is hard rock . Safe bearing capacity for open foundation is shown in above table.



# BORE LOG CUM LABORATORY TEST RESULT

Name of Project: Construction of RCC Bridge at KM – 72+070.

Boring method: Rotary Drilling

Date Commenced: 28-05-2016

Date completed: 29-05-2016

DEPTH OF WATER TABLE=Not Encountered

Depth in meters below reference	Visual description of soil	% Gravel > 75mm	% Sand 4.75-0.075 mm	Silt 0.075-0.002	% Clay < 0.002 mm	Field density, gms/cm <sup>3</sup>	Specific Gravity	Void Ratio	Water absorption (%)	Uniaxial compressive Strength MPa (U D)	Shear Parameter		Compression Index Cc
											Cohesion 'c' Kg/cm <sup>2</sup>	Angle of shearing resistance (Φ°)	
0-1.50	Weathered Rock, Grade V	Non Coring Rock Strata				2.29	2.67					38	
1.50-3.0													
3.00-4.50													
4.50-6.0													
6.00-7.50						2.31	2.67					38	
7.50-9.0													
9.00-10.5													
10.50-12.0	Hard Rock	Core recovery= 16.67% RQD= Nil				2.34	2.67			10.8			
12.00-13.5		Core recovery= 28.67% RQD= Nil											
13.5-15.0		Core recovery= 36.00% RQD= Nil				2.33	2.67			14.5			

U: Undisturbed Sample::

D: Disturbed Sample::

P: Standard Penetration test::

DS: Direct shear test::

R=Refusal, N-value>100

**ANNEX II**

SBC calculation

Abutment Right bank

Depth	Cohesion(c) (kg/Sqcm)	Angle of Shearing	Relative density	
	0	36	62	

Relative Density  $ID > 70.00$  ( General shear condition )  
 Relative Density  $ID < 20.00$  ( local shear condition )  
 Corresponding to  $ID = 62.00$  Intermediate shear condition

**FAILURE TYPE :** Intermediate shear

**DESIGN ANGLE OF SHEARING RESISTANCE :**

	For General shear	For Local Shear
Angle of Shearing Resistance of End Bearing Soil Layer ( $\phi$ )	36	25

**Depth of foundn(M)Df = 9**

<b>Soil parameter</b>			
C=	( ) kg/scm=	0 t/sqm	$\gamma_{sub}$ ( ton/m3 ) = 1.14
$\phi$ =	36	General	
	Bearing capacity factor		
	Nc	Nq	N $\gamma$
$\phi$ = 36	50.6	37.8	41.1
<b>Width(B)M= 6      Length L = 6</b>			
<b>Shape Factor</b>			
Sc=	1.3	Sq=	1.2
(square and circular)		(square and circular)	
Sc = 1+ 0.2x B/L =	1.2	Sq = 1+ 0.2x B/L =	1.20
( Rectangle)		( Rectangle)	
Sy=	(square ) 0.8	Sy=	(square ) 0.8
	(circular) 0.6		(circular) 0.6
Sy = 1- 0.4x B/L =	0.6	Sy = 1- 0.4x B/L =	0.6
( Rectangle)		( Rectangle)	
Sc ( to be adopted )=	1.3	Sq ( to be adopted )=	1.2
		Sy(to be adopted)=	0.8
<b>Depth Factor</b>			
dc=(1+0.2(Df/B)tan(45+ $\phi$ /2)	dq=dy=1+0.1( Df/B) tan(45+ $\phi$ /2) for $\phi > 10$		
= 1.47	1.24		
	dq=dy= 1 for $\phi < 10$		



$dq=dy=(\text{to be adopted})$  1.04

#### Inclination factor

$ic=iq=iy=(1 - \alpha/90)$   
 $= 1$

Water table correction factor  $R_w =$  0.5

$$q_d = \{ sc \ dc \ ic \ c \ N_c + sq \ dq \ iq \ \gamma \ D \ (N_q - 1) + 0.5s_y \ dy \ iy \ \gamma \ B \ N_y \ R_w \}$$

$$q_s = 1/F \{ sc \ dc \ ic \ c \ N_c + sq \ dq \ iq \ \gamma \ D \ (N_q - 1) + 0.5s_y \ dy \ iy \ \gamma \ B \ N_y \ R_w \}$$

$$q_d = 529.68 \text{ ton/sqm}$$

Depth of foundn(M)Df = 9.0

#### Soil parameter

$C=$  (l kg/scm= 0 t/sqm  $\gamma_{sub}$  ( ton/m3) = 1.14  
 $\phi=$  36 , shear condition Local

Angle of shearing resistance for local failure =  $\phi_m = \tan^{-1} 2/3 \tan \phi$

		Bearing capacity factor		
$\phi$		$N_c$	$N_q$	$N_y$
36				
$\phi_m$	25	20.72	10.66	10.88

Width(B)M= 6 Length L = 6

#### Shape Factor

$Sc=$ 1.3 (square and circular)	$Sq=$ 1.2 (square and circular)	$Sy=$ (square ) 0.8 $Sy=$ (circular) 0.6
$Sc = 1 + 0.2 \times B/L =$ 1.2 ( Rectangle)	$Sq = 1 + 0.2 \times B/L =$ 1.20 ( Rectangle)	$Sy = 1 - 0.4 \times B/L =$ 0.6 ( Rectangle)
$Sc$ ( to be adopted )= 1.3	$Sq$ ( to be adopted )= 1.2	$Sy$ ( to be adopted )= 0.8

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$dc=(1+0.2(Df/B)\tan(45+\phi/2))$   $dq=dy=1+0.1(Df/B)\tan(45+\phi/2)$  for  $\phi > 10$   
 $=$  1.47 1.24  
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Inclination factor

$$i_c = i_q = i_\gamma = (1 - \alpha/90)$$
$$= 1$$

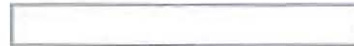
Water table correction factor  $R_w =$

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$$q_d = 147.25 \text{ ton/sqm}$$



corresponding to  $ID >$

70 General shear failure

$$UBC(\text{gen}) = 529.68 \text{ Ton/sqm}$$

Corresponding to  $ID <$

20 Local Shear failure

$$UBC (\text{Loc}) = 147.25 \text{ Ton/sqm}$$

Corresponding to  $ID = 62.00$

To be interpolated between General and local shear failure condition

NET ULTIMATE LOAD BEARING CAPACITY ( $Q_{nu}$ ) =

468.49 Ton/sqm

For ( $ID = 147.249118$ )

Safe bearing capacity  
( $FOS = 3$ ) 156.16





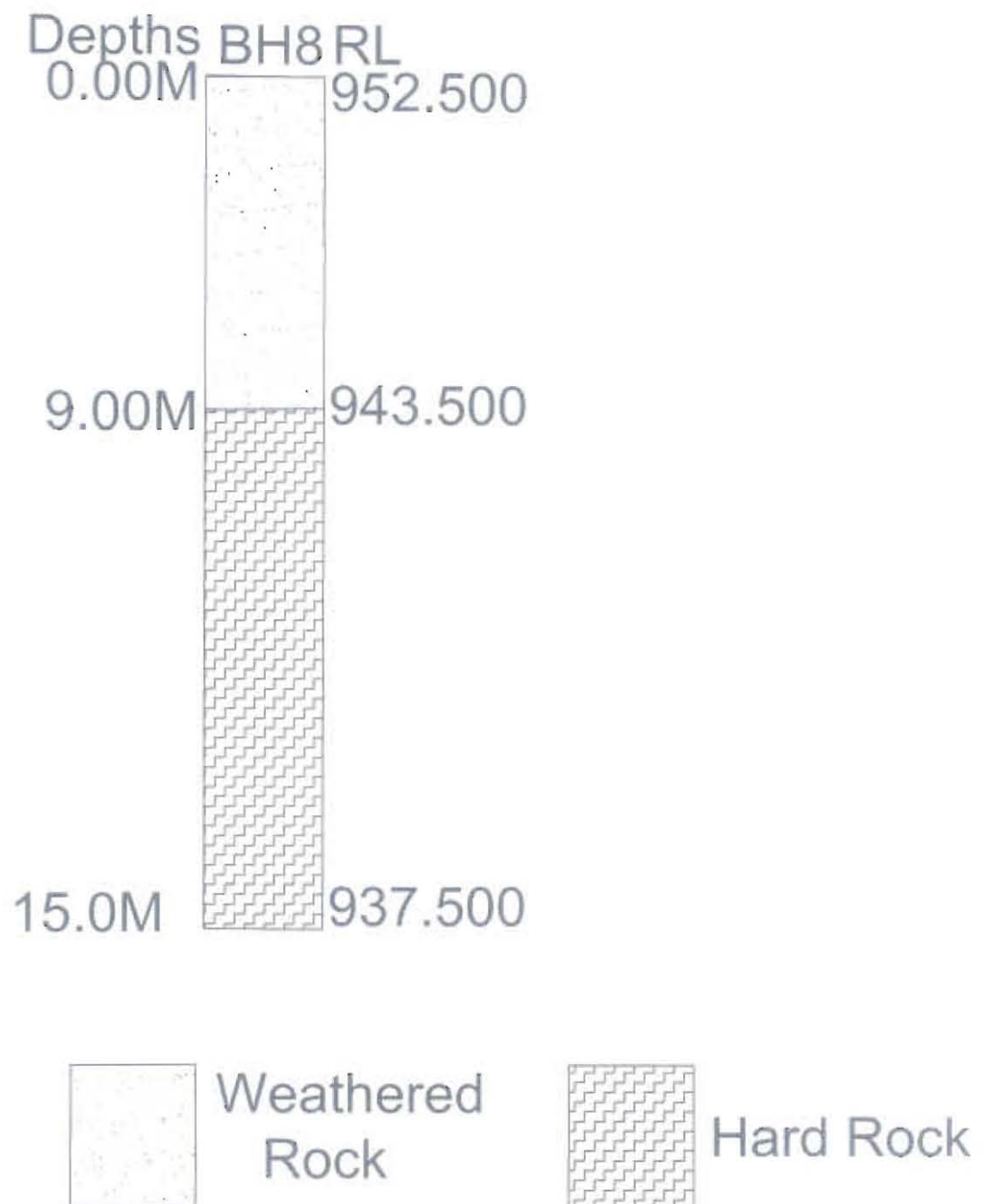


Fig1:Cross-section & subsoil profile



**SSI REPORT FOR  
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**4.3.4** The depth of ground water table was checked / measured in all bore holes.

**4.3.5** Summary of bore holes:

Table1

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#### B) Calculation of safe bearing pressure based on tolerable settlement.

The safe bearing pressure is to be found out from the elastic settlement consideration and is found from the following equation given I.S. 8009 (part-1) 1976

$$S_f = S_{\text{ecd}} = (H_f / 1 + e_0) C_c \log_{10} (p_0 + \Delta p) / p_0$$

$S_f$  = Final settlement in mm

$S_{\text{ecd}}$  = Settlement computed from one dimensional test

$H_f$  = Thickness of soil layer in m

$e_0$  = Initial void ratio at mid height of of layer

$C_c$  = Compression Index

$p_0$  = Initial effective pressure at mid height of layer

$\Delta p$  = pressure increment

For the computation of settlement of foundation founded at certain depth, a correction should be applied to the calculated  $S_f$  in the form of a depth factor to be read from Fig:12 of I.S. 8009 (part-1) 1976.

Corrected settlement  $S_{fd} = S_f \times \text{depth factor}$

Depth factor is dependent on the following

- i. D= Depth of footing    ii. L= Length of footing    iii. B= Width of footing



## REPORT ON SUB SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-81+536.

Here the safe bearing capacity of soil for open foundation is calculated based foundation on rock.

### As per IS 12070 -1987

The safe bearing pressure should be estimated from the following equation

$$q_s = q_c \times N_i$$

$N_i$  = Discontinuity factor = 0.1 ( Minimum value)

Depth 3.0 M

Uniaxial compressive strength ,  $q_c = 7.5$  MPa

$$q_s = q_c \times N_i$$

$$= 7.5 \times 0.1 = 0.75 \text{ MPa} = 75 \text{ Ton/sqm}$$

**Table I Safe Bearing Capacity at different depth**

Foundation Depth below ground level (M)	RL of founding level	Recommended net safe bearing Capacity (M ton/sqm)
3.0	997.00	75.0
4.0	996.00	75.0
5.0	995.00	100.0
6.0	994.00	100.0
7.0	993.00	120.0
8.0	992.00	120.0
9.0	991.00	120.0
10.0	990.00	120.0

### 9.0 CONCLUSION AND RECOMMENDATION

Sub soil at this site is of rocky type . Safe bearing capacity for open foundation is shown in above table.



# BORE LOG CUM LABORATORY TEST RESULT

Name of Project: Construction of RCC Bridge at KM – 81+536

Boring method: Rotary Drilling

Date Commenced: 07-05-2016

Date completed: 10-05-2016

DEPTH OF WATER TABLE=Not Encountered

Depth in meters below reference	Types of Sample	Observed N-Value	Group Symbol	Visual description of soil	% Gravel > .75mm	% Sand 4.75-0.075 mm	Silt 0.075-0.002	% Clay < 0.002 mm	Field density, gms/cm <sup>3</sup>	Specific Gravity	Void Ratio	Water absorption (%)	Uniaxial compressive Strength MPa (U D)	Shear Parameter		Compression Index Cc
														Cohesion 'c' Kg/cm <sup>2</sup>	Angle of shearing resistance (Φ°)	
0.0-3.0	P	R		Rocky strata	Core recovery= 18.00% RQD= Nil											
3.00-4.50	P	R			Core recovery= 16.00% RQD= Nil				2.20	2.66		3.8	7.5			
4.50-6.0	P	R			Core recovery= 20.00% RQD= 11.8%				2.28	2.67		3.5	10.3			
6.00-7.50	P	R			Core recovery= 21.33% RQD= 12.6%											
7.50-9.0	P	R			Core recovery= 18.67% RQD= 11.6%				2.32	2.67		2.2	14.3			
9.00-10.5	P	R			Core recovery= 22.00% RQD= 16.8%											
10.50-12.0	P	R			Core recovery= 18.00% RQD= Nil				2.36	2.67		3.2	16.8			
12.00-13.5	P	R			Core recovery= 24.67% RQD= 13.9%											
13.50-15.0	P	R			Core recovery= 13.33% RQD= Nil				2.39	2.67		2.0	17.3			
15.00-16.5	P	R			Core recovery= 24.00% RQD= 17.6%											
16.50-18.0	P	R			Core recovery= 32.00% RQD= 22.6%				2.40	2.70			20.5			
18.00-18.5	P	R		18.5M	Core recovery= 36.00% RQD= 22.0%											

U: Undisturbed Sample::

D: Disturbed Sample::

P: Standard Penetration test::

DS: Direct shear test::

R=Refusal, N-value>100

Depths BH1 RL  
0.00M 1009.700

18.5M 991.200



Rock

Fig1:Cross-section & subsoil profile



**SSI REPORT FOR  
CONSTRUCTION OF RCC BRIDGE  
AT  
KM – 83+424**





## REPORT ON SUB SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-83+424.

### 1. INTRODUCTION:

**1.1** This report presented herein deals with the field and laboratory investigations carried out by us to access the nature of sub-strata and to evaluate the soil parameters required for design of foundations proposed to be constructed for proposed bridge.

**1.2** Client's help is gratefully acknowledged in providing bore hole locations, close supervision and checking during boring, sampling, various testing operations and cooperation and guidance during finalization of report.

**1.3** The work of Geotechnical Investigation was awarded to RELIANT FOUNDATIONS PVT LTD., H-7, BYE LANE NO.1 (A.NORTH), PANJABARI ROAD, SIXMILE, GUWAHATI-22 for the project construction of bridge.

**1.4** This report is based upon the results of field, laboratory tests conducted on selected soil/rock samples collected from three bore hole up to the depth of 20.45 M each and interpretation of results were done as per IRC 78-2000 and pertinent IS code of practices.

### 2. GEOLOGICAL BACKGROUND :

**GEOLOGICAL BACKGROUND :** Arunachal Pradesh, the 'Land of the rising sun' is located towards the northeastern tip of India. It presents a breathtaking beautiful landscape with towering snowclad peaks, steep precipitous gorges, lush green valleys and innumerable streams. The state is bound by neighboring countries like China (Tibet), Bhutan and Myanmar towards North, West and East respectively. Arunachal Pradesh lies between 26°28' and 29°30' N and 91°30' and 97°25' E. It occupies an area of 83,578 sq. kms. Arunachal Pradesh is largely inaccessible rugged terrain with dense impenetrable forests, unpredictable climatic conditions and poor road communications. Thus, it is geologically, a rather lesser known region. Arunachal Pradesh consists of four physiographic domains viz. a) Himalayan range, b) Trans-Himalayan range c) Naga-Patkoi range and d) Brahmaputra plain. Each domain has a distinctive geological and tectonic history.

**LANDSLIDES AND SIESMOTECTONICS:** The region is prone to earthquake. Since the middle of the nineteenth century, there had been at least two major earthquakes (1897 and 1950), which are among the most destructive earthquakes in human history. The mountainous tracts of the region are inhabited by people of diverse ethnic groups and cultural affinities lured by the pioneering spirit of man in quest of the unknown, be it geographical or geological. The earliest reference of the region is found in the Mahabharata and





## REPORT ON SUB SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-83+424.

documentation of the geological information was made mostly by the British military expeditions during the early part of the nineteenth century prior to establishment of the GSI in 1851. This excludes the meticulous records of the earthquakes which are available since the middle of the last century.

### 3. SCOPE OF WORK:

The scope of work provided to us for this project was limited to the following:-

**3.1** Mobilizing necessary plant, equipments and personnel to the project site, setting up the equipment, carrying out the field investigations on land and demobilization on completion of work.

**3.2** Making 150 mm nominal diameter bore holes at the site in all types of soil using suitable approved method of boring to be given at site by the Engineer-in-Charge. Refusal shall mean when SPT field 'N' value reaches 50 for 30 cm or less penetration of SPT sampler.

**3.2.1** Conducting standard penetration tests in the bore holes at 1.50 m interval in depth as per specifications / instructions of Engineer-in-Charge.

**3.2.2** Collecting undisturbed soil samples from bore holes at 3.0m interval or every change of strata, whichever is earlier as per specifications.

**3.2.3** Collecting disturbed soil samples from bore hole at regular interval and at every identifiable change of strata to supplement the boring records.

**3.2.4** Recording the depth of ground water table in all the bore hole if observed up to the depth of exploration during boring work as per specifications & withdrawing the casing pipe.

**3.3** Conducting the following laboratory tests on selected disturbed / undisturbed soil samples collected from bore hole / test locations :-

- (a) Bulk density and Moisture content
- (b) Sieve analysis
- (c) Hydrometer analysis
- (d) Liquid limit & Plastic limits
- (e) Specific gravity
- (f) Shear test on undisturbed and remoulded saturated disturbed soil samples







## REPORT ON SUB SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-83+424.

(g) Determination of void ratio.

**3.4** Preparation and submission of report in three copies.

### **4.0 FIELD INVESTIGATIONS:**

**4.1** Necessary plant, equipment and personnel for conducting the requisite field work were mobilized to the site.

**4.2** one number borehole was first marked on the ground surface as per the layout given to us by the Engineer-in-Charge.

**4.3** Bore hole was bored at this site using rotary drilling method as per IS: 1892-1979.

**4.3.1 Standard penetration** tests were conducted in the above bore hole at every 1.50 m interval & at change of strata as per specifications / instructions of Engineer-in-Charge. The bore was cleaned up to the desired depths. Standard split spoon sampler attached to lower end of 'A' drill rods was driven in the bore holes by means of standard hammer of 63.5 Kg. falling freely from a height of 75 cm. The sampler was driven 45 cm as per specifications & the numbers of blows required for each 15 cm penetration were recorded. The numbers of blows for the first 15 cm penetration were not taken into account. This was considered as seating drive. The numbers of blows for next 30 cm penetration were designated as SPT 'N' value. Wherever the total penetration was less than 45 cm, the number of blows & the depth penetrated is incorporated in respective bore logs. Disturbed soil samples obtained from standard split spoon sampler for all the above standard penetration tests were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded and carefully transported to the laboratory for testing.

**4.3.2 Undisturbed** soil samples were collected from the bore hole at every 3.00 m interval in depth & at change of strata as per sampling specifications. These sampling tubes after retrieval from the bore hole was properly waxed and sealed at both ends. These were carefully labeled and transported to the laboratory for testing. Undisturbed soil samples wherever slipped during lifting, were duly marked in the field bore logs as well as in the soil profile.

**4.3.3 Disturbed soil** samples were also collected from the bore hole at suitable depths/intervals to supplement the boring records. These samples were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded & carefully transported to the laboratory for testing.





## REPORT ON SUB SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-83+424.

**4.3.4** The depth of ground water table was checked / measured in all bore holes.

**4.3.5** Summary of bore holes:

Table I

RL of bore hole top	Depth of Bore hole(M)	Water level during the time of field work( M)
897.4	20.0	Not encountered

### 5.0 LABORATORY INVESTIGATIONS:

**5.1** The following laboratory tests were conducted on selected soil samples recovered from bore hole / test locations: -

- (a) Bulk density and Moisture content
- (b) Sieve analysis
- (c) Hydrometer analysis
- (d) Liquid limit & Plastic limits
- (e) Specific gravity
- (f) Shear test on remolded and saturated disturbed soil samples
- (g) Determination of void ratio..

All the above laboratory tests were carried out as per relevant Indian Standards. All the soil samples were identified and classified as per IS: 1498-1970.

### 6.0 FINDING OF GEOTECHNICAL INVESTIGATION:

The study of bore logs/results of laboratory and other field tests are tabulated through different tables as annexure.

### 7.0 Analysis of liquefaction potential

It is analysed through Seed and Idriss ( 1982) approach

Liquefaction is generally occurs in fine to medium sand within a depth of 10.0M from ground surface. With increasing overburden pressure the chances of liquefaction usually decrease. ( CI 13.5.1, Theory and practice of Foundation design NN Som, S.C. Das, Prentice hall of India Pvt Ltd Publisher) . **As the area is mostly bouldery/ Shale probability of liquefaction is almost nil.**





## REPORT ON SUB SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-83+424.

### 8.0 CALCULATION OF BEARING CAPACITY

#### (A) Calculation of Net Safe Bearing Capacity based on shear Criteria

IS: 6403-1981 recommends the following equation to calculate the net Safe Bearing Capacity  $q_s$  based on Hansen's Bearing Capacity analysis:

$$q_s = 1/F \{ C N_c S_c d_c i_c + q (N_q - 1) S_q d_q i_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma \times R_w \}$$

Where, C = Cohesion of soil.

$\gamma$  = Saturated Density of soil

B = Width of footing = 2.0 m (assumed)

$R_w$  = Water table correction factor depending upon position of water table with respect to founding level

Q = Effective surcharge at footing level =  $\gamma D$  (D = depth of footing)

$N_c, N_q, N_\gamma$  = Bearing capacity factor

$S_c, S_q, S_\gamma$  = Shape factor

$d_c, d_q, d_\gamma$  = depth factor

$i_c, i_q, i_\gamma$  = inclination factors

F = Factor of safety = 3.0

#### B) Calculation of safe bearing pressure based on tolerable settlement.

The safe bearing pressure is to be found out from the elastic settlement consideration and is found from the following equation given I.S. 8009 (part-1) 1976

$$S_f = S_{oed} = (H_f / (1 + e_o)) C_c \log_{10} (p_o + \Delta p) / p_o$$

$S_f$  = Final settlement in mm

$S_{oed}$  = Settlement computed from one dimensional test

$H_f$  = Thickness of soil layer in m

$e_o$  = Initial void ratio at mid height of of layer

$C_c$  = Compression Index

$p_o$  = Initial effective pressure at mid height of layer

$\Delta p$  = pressure increment

For the computation of settlement of foundation founded at certain depth, a correction should be applied to the calculated  $S_f$  in the form of a depth factor to be read from Fig:12 of I.S. 8009 (part-1) 1976.

Corrected settlement  $S_{fd} = S_f \times \text{depth factor}$

Depth factor is dependent on the following

- i. D= Depth of footing
- ii. L= Length of footing
- iii. B= Width of footing



## REPORT ON SUB SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-83+424.

**Table I Safe Bearing Capacity at different depth**

Foundation Depth below ground level (M)	RL of founding level	Recommended net safe bearing Capacity (M ton/sqm)
3.0	894.400	55.69
4.0	893.400	69.30
5.0	892.400	82.94
6.0	891.400	96.61
7.0	890.400	110.32
8.0	889.400	124.06
9.0	888.400	137.83
10.0	887.400	151.63

### 9.0 CONCLUSION AND RECOMMENDATION

Soil at this site is of boulder strata upto a depth of 10.5m of bouldery strata after that it is of weathered rock.





# BORE LOG CUM LABORATORY TEST RESULT

Name of Project: Construction of RCC Bridge at KM – 83+424

Boring method: Rotary Drilling

Date Commenced: 12-05-2016

Date completed: 14-05-2016

BH: 2

DEPTH OF WATER TABLE=Not Encountered

Depth in meters below reference	Types of Sample	Observed N-Value	Group Symbol	Visual description of soil	% Gravel > 75mm	% Sand 4.75-0.075 mm	Silt 0.075-0.002	% Clay < 0.002 mm	Field density, gms/cm <sup>3</sup>	Specific Gravity	Void Ratio	Water absorption (%)	Uniaxial compressive Strength MPa (U D)	Shear Parameter		Compression Index Cc
														Cohesion 'c' Kg/cm <sup>2</sup>	Angle of shearing resistance (Φ°)	
0.00-1.50				Sand.	1.50M											
1.50-3.0				Bouldery strata	10.50M	Core recovery= 14.67%			2.22	2.67					36	
3.00-4.50						RQD= Nil										
4.50-6.0						Core recovery= 12.67%										
6.00-7.5						RQD= Nil			2.24	2.67					39	
7.50-9.0						Core recovery= 13.33%										
9.00-10.5						RQD= Nil										
10.50-12.0						Core recovery= 22.00%										
12.00-13.5				Weathered Rock.	20.0M	RQD= Nil			2.30	2.67					39	
13.50-15.0						Core recovery= 18.00%										
15.00-16.5						RQD= Nil										
16.50-18.0						Core recovery= 18.67%										
18.00-19.5						RQD= Nil										
19.5-20.0						Non Coring Rock Strata			2.33	2.67					40	
						Non Coring Rock Strata										
						Non Coring Rock Strata			2.37	2.67					40	
						Non Coring Rock Strata										
						Non Coring Rock Strata										
						Non Coring Rock Strata										
						Non Coring Rock Strata										
						Non Coring Rock Strata										
						Non Coring Rock Strata										

U: Undisturbed Sample::

D: Disturbed Sample::

P: Standard Penetration test::

DS: Direct shear test::

R=Refusal, N-value>100



ANNEX II

SBC calculation

Abutment Right bank BH1

Depth	Cohesion(c) (kg/Sqcm)	Angle of Shearing	Relative density	
	0	36	62	

Relative Density  $ID > 70.00$  ( General shear condition )

Relative Density  $ID < 20.00$  ( local shear condition )

Corresponding to  $ID = 62.00$  Intermediate shear condition

**FAILURE TYPE :** Intermediate shear

**DESIGN ANGLE OF SHEARING RESISTANCE :**

Angle of Shearing Resistance of End Bearing Soil Layer ( $\phi$ )

For General shear	For Local Shear
36	25

Depth of foundn(M)  $D_f = 10$

<b>Soil parameter</b>			
C=	0 kg/scm=	0 t/sqm	$\gamma_{sub}$ ( ton/m <sup>3</sup> ) = 1
$\phi$ =	36	General	
		Bearing capacity factor	
		Nc	Nq Ny
$\phi$ =	36	50.6	37.8 41.1
<b>Width(B)M=</b> 6		<b>Length L =</b> 6	
<b>Shape Factor</b>			
Sc=	1.3	Sq=	1.2
(square and circular)		(square and circular)	
Sc = $1 + 0.2 \times B/L$ =	1.2	Sq = $1 + 0.2 \times B/L$ =	1.20
( Rectangle )		( Rectangle )	
Sc ( to be adopted )=	1.3	Sq ( to be adopted )=	1.2
		Sy=	(square ) 0.8
		Sy=	(circular) 0.6
		Sy = $1 - 0.4 \times B/L$ =	0.6
		( Rectangle )	
		Sy(to be adopted)=	0.8
<b>Depth Factor</b>			
$d_c = (1 + 0.2(D_f/B) \tan(45 + \phi/2))$		$d_q = d_y = 1 + 0.1(D_f/B) \tan(45 + \phi/2)$ for $\phi > 10$	
= 1.52		1.26	
		$d_q = d_y = 1$ for $\phi < 10$	



$$dq=dy=(\text{to be adopted}) \quad 1.04$$

#### Inclination factor

$$i_c=i_q=i_y = (1 - \alpha/90) \\ = 1$$

$$\text{Water table correction factor } R_w = 0.5$$

$$q_d = \{ s_c d_c i_c c N_c + s_q d_q i_q \gamma D (N_q - 1) + 0.5 s_y d_y i_y \gamma B N_y R_w \}$$

$$q_s = 1/F \{ s_c d_c i_c c N_c + s_q d_q i_q \gamma D (N_q - 1) + 0.5 s_y d_y i_y \gamma B N_y R_w \}$$

$$q_d = 510.56 \text{ ton/sqm}$$

$$\text{Depth of foundn(M)} D_f = 10.0$$

#### Soil parameter

$$C = 0 \text{ kg/scm} = 0 \text{ t/sqm} \quad \gamma_{\text{sub}} (\text{ton/m}^3) = 1$$

$$\phi = 36^\circ \text{ , shear condition} \quad \text{Local}$$

$$\text{Angle of shearing resistance for local failure} = \phi_m = \tan^{-1} 2/3 \tan \phi$$

		Bearing capacity factor		
$\phi$		$N_c$	$N_q$	$N_y$
$\phi_m$	25	20.72	10.66	10.88

$$\text{Width(B)} M = 6 \quad \text{Length } L = 6$$

#### Shape Factor

$S_c = 1.3$ (square and circular)	$S_q = 1.2$ (square and circular)	$S_y = 0.8$ (square) $S_y = 0.6$ (circular)
$S_c = 1 + 0.2 \times B/L = 1.2$ ( Rectangle)	$S_q = 1 + 0.2 \times B/L = 1.20$ ( Rectangle)	$S_y = 1 - 0.4 \times B/L = 0.6$ ( Rectangle)
$S_c (\text{to be adopted}) = 1.3$	$S_q (\text{to be adopted}) = 1.2$	$S_y (\text{to be adopted}) = 0.8$

#### Depth Factor

$$d_c = (1 + 0.2(D_f/B) \tan(45 + \phi/2))$$

$$dq=dy = 1 + 0.1(D_f/B) \tan(45 + \phi/2) \text{ for } \phi > 10^\circ$$

$$= 1.52 \quad 1.26$$

$$dq=dy = 1 \text{ for } \phi < 10^\circ$$

$$dq=dy = (\text{to be adopted}) \quad 1.26$$



Inclination factor

$$i_c = i_q = i_\gamma = (1 - \alpha/90)$$
$$= 1$$

Water table correction factor  $R_w =$

0.5

$$q_d = (2/3 \times s_c \times d_c \times i_c \times c \times N_c + s_q \times d_q \times i_q \times \gamma \times D \times (N_q - 1) + 0.5 \times s_\gamma \times d_\gamma \times i_\gamma \times \gamma \times B \times N_\gamma \times R_w)$$

$$q_s = 1/F \times (2/3 \times s_c \times d_c \times i_c \times c \times N_c + s_q \times d_q \times i_q \times \gamma \times D \times (N_q - 1) + s_\gamma \times d_\gamma \times i_\gamma \times \gamma \times B \times N_\gamma \times R_w)$$

$$q_d = 162.68 \text{ ton/sqm}$$

corresponding to  $ID > 70$  General shear failure  
 $UBC(\text{gen}) = 510.56 \text{ Ton/sqm}$

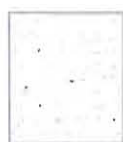
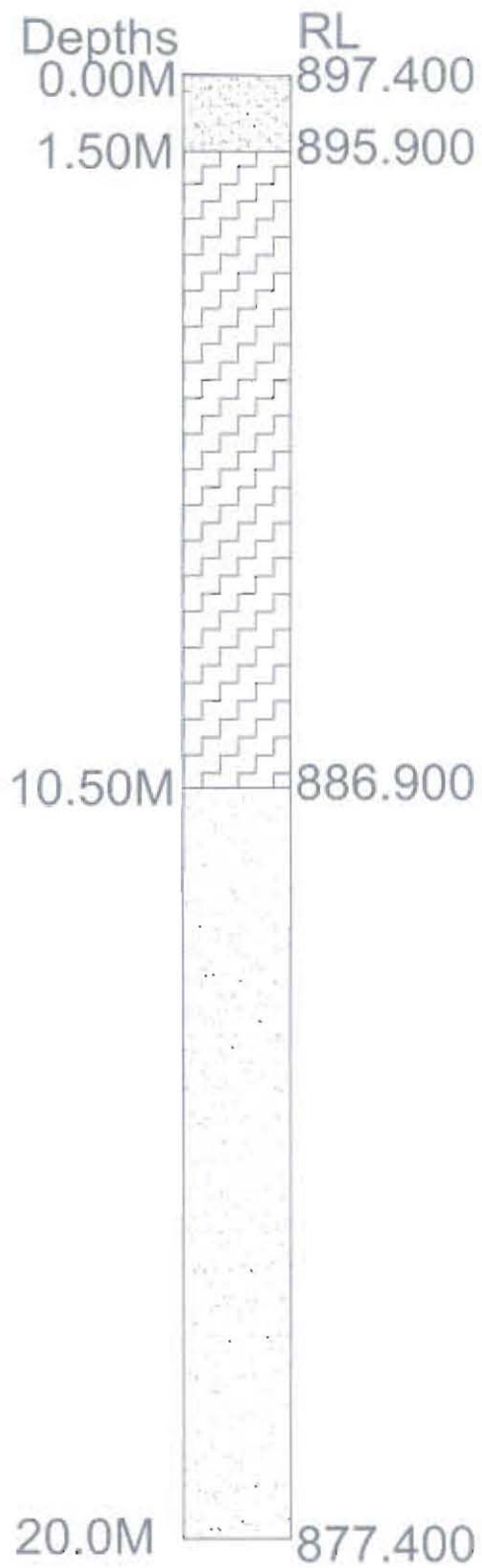
Corresponding to  $ID < 20$  Local Shear failure  
 $UBC(\text{Loc}) = 162.68 \text{ Ton/sqm}$

Corresponding to  $ID = 62.00$   
To be interpolated between General and local shear failure condition

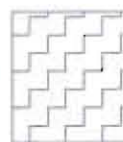
NET ULTIMATE LOAD BEARING CAPACITY ( $Q_{nu}$ ) = 454.90 Ton/sqm  
For ( $ID = 162.680109$ )

Safe bearing capacity 151.63  
(FOS = 3)





sand/Weathered  
Rock



Rock

Fig1: Cross-section & subsoil profile



**SSI REPORT FOR  
CONSTRUCTION OF RCC BRIDGE  
AT  
KM – 90+816**





## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-90+816.

### 1. INTRODUCTION:

**1.1** This report presented herein deals with the field and laboratory investigations carried out by us to access the nature of sub-strata and to evaluate the soil parameters required for design of foundations proposed to be constructed for proposed bridge.

**1.2** Client's help is gratefully acknowledged in providing bore hole locations, close supervision and checking during boring, sampling, various testing operations and cooperation and guidance during finalization of report.

**1.3** The work of Geotechnical Investigation was awarded to RELIANT FOUNDATIONS PVT LTD., H-7, BYE LANE NO.1 (A.NORTH), PANJABARI ROAD, SIXMILE, GUWAHATI-22 for the project construction of bridge.

**1.4** This report is based upon the results of field, laboratory tests conducted on selected soil/rock samples collected from three bore hole up to the depth of 9.45 M each and interpretation of results were done as per IRC 78-2000 and pertinent IS code of practices.

### 2. GEOLOGICAL BACKGROUND :

**GEOLOGICAL BACKGROUND :** Arunachal Pradesh, the 'Land of the rising sun' is located towards the northeastern tip of India. It presents a breathtaking beautiful landscape with towering snowclad peaks, steep precipitous gorges, lush green valleys and innumerable streams. The state is bound by neighboring countries like China (Tibet), Bhutan and Myanmar towards North, West and East respectively. Arunachal Pradesh lies between 26°28' and 29°30' N and 91°30' and 97°25' E. It occupies an area of 83,578 sq. kms. Arunachal Pradesh is largely inaccessible rugged terrain with dense impenetrable forests, unpredictable climatic conditions and poor road communications. Thus, it is geologically, a rather lesser known region. Arunachal Pradesh consists of four physiographic domains viz. a) Himalayan range, b) Trans-Himalayan range c) Naga-Patkoi range and d) Brahmaputra plain. Each domain has a distinctive geological and tectonic history.

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## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-90+816.

documentation of the geological information was made mostly by the British military expeditions during the early part of the

nineteenth century prior to establishment of the GSI in 1851. This excludes the meticulous records of the earthquakes which are available since the middle of the last century.

### 3. SCOPE OF WORK:

The scope of work provided to us for this project was limited to the following:-

**3.1** Mobilizing necessary plant, equipments and personnel to the project site, setting up the equipment, carrying out the field investigations on land and demobilization on completion of work.

**3.2** Making 150 mm nominal diameter bore holes at the site in all types of soil using suitable approved method of boring to be given at site by the Engineer-in-Charge. Refusal shall mean when SPT field 'N' value reaches 50 for 30 cm or less penetration of SPT sampler.

**3.2.1** Conducting standard penetration tests in the bore holes at 1.50 m interval in depth as per specifications / instructions of Engineer-in-Charge.

**3.2.2** Collecting undisturbed soil samples from bore holes at 3.0m interval or every change of strata, whichever is earlier as per specifications.

**3.2.3** Collecting disturbed soil samples from bore hole at regular interval and at every identifiable change of strata to supplement the boring records.

**3.2.4** Recording the depth of ground water table in all the bore hole if observed up to the depth of exploration during boring work as per specifications & withdrawing the casing pipe.

**3.3** Conducting the following laboratory tests on selected disturbed / undisturbed soil samples collected from bore hole / test locations :-

(a) Bulk density and Moisture content

(b) Sieve analysis

(c) Hydrometer analysis

(d) Liquid limit & Plastic limits

(e) Specific gravity

(f) Shear test on undisturbed and remoulded saturated disturbed soil samples

(g) Determination of void ratio.





## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-90+816.

**3.4** Preparation and submission of report in three copies.

### **4.0 FIELD INVESTIGATIONS:**

**4.1** Necessary plant, equipment and personnel for conducting the requisite field work were mobilized to the site.

**4.2** one number borehole was first marked on the ground surface as per the layout given to us by the Engineer-in-Charge.

**4.3** Bore hole was bored at this site using rotary drilling method as per IS: 1892-1979.

**4.3.1 Standard penetration** tests were conducted in the above bore hole at every 1.50 m interval & at change of strata as per specifications / instructions of Engineer-in-Charge. The bore was cleaned up to the desired depths. Standard split spoon sampler attached to lower end of 'A' drill rods was driven in the bore holes by means of standard hammer of 63.5 Kg. falling freely from a height of 75 cm. The sampler was driven 45 cm as per specifications & the numbers of blows required for each 15 cm penetration were recorded. The numbers of blows for the first 15 cm penetration were not taken into account. This was considered as seating drive. The numbers of blows for next 30 cm penetration were designated as SPT 'N' value. Wherever the total penetration was less than 45 cm, the number of blows & the depth penetrated is incorporated in respective bore logs. Disturbed soil samples obtained from standard split spoon sampler for all the above standard penetration tests were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded and carefully transported to the laboratory for testing.

**4.3.2 Undisturbed** soil samples were collected from the bore hole at every 3.00 m interval in depth & at change of strata as per sampling specifications. These sampling tubes after retrieval from the bore hole was properly waxed and sealed at both ends. These were carefully labeled and transported to the laboratory for testing. Undisturbed soil samples wherever slipped during lifting, were duly marked in the field bore logs as well as in the soil profile.

**4.3.3 Disturbed** soil samples were also collected from the bore hole at suitable depths/intervals to supplement the boring records. These samples were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded & carefully transported to the laboratory for testing.

**4.3.4** The depth of ground water table was checked / measured in all bore holes.







## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-90+816.

### 4.3.5 Summary of bore holes:

Table I

RL of bore hole top	Depth of Bore hole(M)	Water level during the time of field work( M)
798.521	10.0	Not encountered

### 5.0 LABORATORY INVESTIGATIONS:

**5.1** The following laboratory tests were conducted on selected soil samples recovered

from bore hole / test locations: -

- (a) Bulk density and Moisture content
- (b) Sieve analysis
- (c) Hydrometer analysis
- (d) Liquid limit & Plastic limits
- (e) Specific gravity
- (f) Shear test on remolded and saturated disturbed soil samples
- (g) Determination of void ratio..

All the above laboratory tests were carried out as per relevant Indian Standards. All the soil samples were identified and classified as per IS: 1498-1970.

### 6.0 FINDING OF GEOTECHNICAL INVESTIGATION:

The study of bore logs/results of laboratory and other field tests are tabulated through different tables as annexure.

### 7.0 Analysis of liquefaction potential

It is analysed through Seed and Idriss ( 1982) approach

Liquefaction is generally occurs in fine to medium sand within a depth of 10.0M from ground surface. With increasing overburden pressure the chances of liquefaction usually decrease. ( CI 13.5.1, Theory and practice of Foundation design NN Som, S.C. Das, Prentice hall of India Pvt Ltd Publisher) . As the area is mostly bouldery/ Shale probability of liquefaction is almost nil.



## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-90+816.

### 8.0 CALCULATION OF BEARING CAPACITY

#### (A) Calculation of Net Safe Bearing Capacity based on shear Criteria

[S: 6403-1981] recommends the following equation to calculate the net Safe Bearing Capacity 'q<sub>s</sub>' based on Hansen's Bearing Capacity analysis:

$$q_s = 1/F \{ C N_c S_c d_c i_c + q (N_q - 1) S_q d_q i_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma \times R_w \}$$

Where, C = Cohesion of soil.

$\gamma$  = Saturated Density of soil

B = Width of footing = 2.0 m (assumed)

R<sub>w</sub> = Water table correction factor depending upon position of water table with respect to founding level

Q = Effective surcharge at footing level =  $\gamma D$  (D = depth of footing)

N<sub>c</sub>, N<sub>q</sub>, N<sub>γ</sub> = Bearing capacity factor

S<sub>c</sub>, S<sub>q</sub>, S<sub>γ</sub> = Shape factor

d<sub>c</sub>, d<sub>q</sub>, d<sub>γ</sub> = depth factor

i<sub>c</sub>, i<sub>q</sub>, i<sub>γ</sub> = inclination factors

F = Factor of safety = 3.0

#### B) Calculation of safe bearing pressure based on tolerable settlement.

The safe bearing pressure is to be found out from the elastic settlement consideration and is found from the following equation given I.S. 8009 (part-1) 1976

$$S_f = S_{ecd} = (H_f / (1 + e_0)) C_c \log_{10} (p_0 + \Delta p) / p_0$$

S<sub>f</sub> = Final settlement in mm

S<sub>ecd</sub> = Settlement computed from one dimensional test

H<sub>f</sub> = Thickness of soil layer in m

e<sub>0</sub> = Initial void ratio at mid height of of layer

C<sub>c</sub> = Compression Index

p<sub>0</sub> = Initial effective pressure at mid height of layer

Δp = pressure increment

For the computation of settlement of foundation founded at certain depth, a correction should be applied to the calculated S<sub>f</sub> in the form of a depth factor to be read from Fig:12 of I.S. 8009 (part-1) 1976.

Corrected settlement S<sub>fd</sub> = S<sub>f</sub> x depth factor

Depth factor is dependent on the following

- i. D = Depth of footing
- ii. L = Length of footing
- iii. B = Width of footing





## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-90+816.

Here the safe bearing capacity of soil for open foundation is calculated based foundation on rock.

### As per IS 12070 -1987

The safe bearing pressure should be estimated from the following equation

$$q_s = q_c \times N_i$$

$N_i$  = Discontinuity factor = 0.1 ( Minimum value)

Depth 3.0 M

Uniaxial compressive strength,  $q_c$  = 7.5 MPa

$$q_s = q_c \times N_i$$

$$= 7.5 \times 0.1 = 0.75 \text{ MPa} = 75 \text{ Ton/sqm}$$

**Table1 Safe Bearing Capacity at different depth**

Foundation Depth below ground level (M)	RL of founding level	Recommended net safe bearing Capacity (M ton/sqm)
3.0	795.521	75.0
4.0	794.521	75.0
5.0	793.521	75.0
6.0	792.521	95.0
7.0	791.521	95.0
8.0	790.521	95.0
9.0	789.521	95.0
10.0	788.521	95.0

### 9.0 CONCLUSION AND RECOMMENDATION

Sub soil at this site is of rocky type . Safe bearing capacity for open foundation is shown in above table.



# BORE LOG CUM LABORATORY TEST RESULT

Name of Project: Construction of RCC Bridge at KM – 90+816

Boring method: Rotary Drilling

Date Commenced: 30-05-2016

Date completed: 31-05-2016

DEPTH OF WATER TABLE=Not Encountered

Depth in meters below reference	Types of Sample	Observed N-Value	Group Symbol	Visual description of soil	% Gravel >.75mm	% Sand 4.75-0.075 mm	Silt 0.075-0.002	% Clay < 0.002 mm	Field density, gms/cm <sup>3</sup>	Specific Gravity	Void Ratio	Water absorption (%)	Uniaxial compressive Strength MPa (U D)	Shear Parameter		Compression Index Cc
														Cohesion 'c' Kg/cm <sup>2</sup>	Angle of shearing resistance (Φ°)	
0.0-3.0	P	R		Bouldery strata 3.00M	Core recovery= 8.00% RQD= Nil				2.29	2.67		2.2			36	
3.00-4.50	P	R		Rocky strata    10.0M	Core recovery= 9.33% RQD= Nil				2.30	2.67		2.3	7.6			
4.50-6.0	P	R			Core recovery= 12.00% RQD= Nil											
6.00-7.5	P	R			Core recovery= 16.00% RQD= Nil				2.31	2.69		3.0	9.5			
7.50-9.0	P	R			Core recovery= 24.00% RQD= 14.6%											
9.0-10.0	P	R			Core recovery= 32.00% RQD= 21%				2.36	2.69		3.1	15.6			

U: Undisturbed Sample::

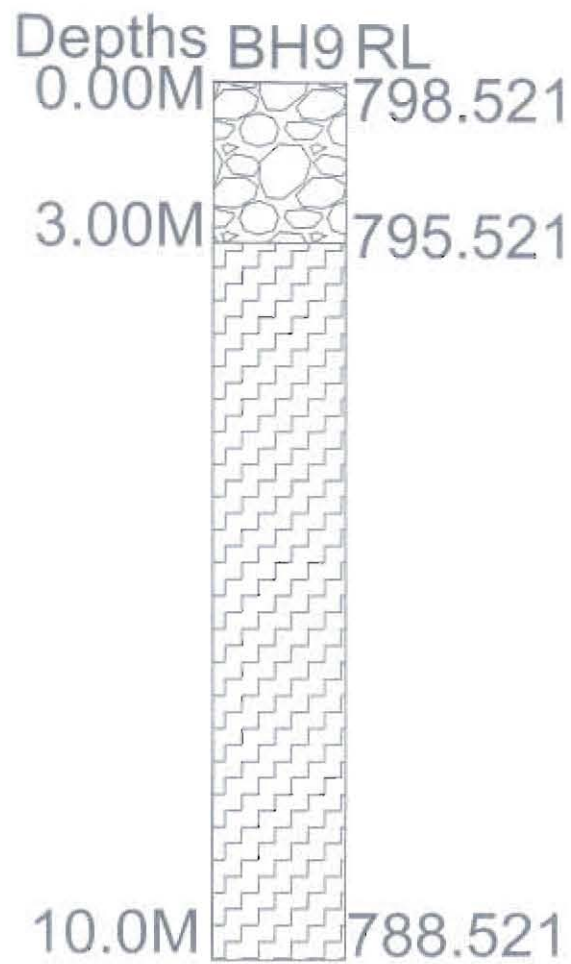
D: Disturbed Sample::

P: Standard Penetration test::

DS: Direct shear test::

R=Refusal, N-value>100





Bouldery



Rock

Fig1:Cross-section & subsoil profile





**SSI REPORT FOR  
CONSTRUCTION OF RCC BRIDGE  
AT  
KM – 108+546**

A handwritten signature in blue ink is written over a faint circular stamp. The signature appears to be 'Shah' or similar. The stamp is mostly illegible but seems to contain some text around the perimeter.



## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-108+546.

### 1. INTRODUCTION:

**1.1** This report presented herein deals with the field and laboratory investigations carried out by us to access the nature of sub-strata and to evaluate the soil parameters required for design of foundations proposed to be constructed for proposed bridge.

**1.2** Client's help is gratefully acknowledged in providing bore hole locations, close supervision and checking during boring, sampling, various testing operations and cooperation and guidance during finalization of report.

**1.3** The work of Geotechnical Investigation was awarded to RELIANT FOUNDATIONS PVT LTD., H-7, BYE LANE NO.1 (A.NORTH), PANJABARI ROAD, SIXMILE, GUWAHATI-22 for the project construction of bridge.

**1.4** This report is based upon the results of field, laboratory tests conducted on selected soil/rock samples collected from three bore hole up to the depth of 8.45 M each and interpretation of results were done as per IRC 78-2000 and pertinent IS code of practices.

### 2. GEOLOGICAL BACKGROUND :

**GEOLOGICAL BACKGROUND :** Arunachal Pradesh, the 'Land of the rising sun' is located towards the northeastern tip of India. It presents a breathtaking beautiful landscape with towering snowclad peaks, steep precipitous gorges, lush green valleys and innumerable streams. The state is bound by neighboring countries like China (Tibet), Bhutan and Myanmar towards North, West and East respectively. Arunachal Pradesh lies between 26°28' and 29°30' N and 91°30' and 97°25' E. It occupies an area of 83,578 sq. kms. Arunachal Pradesh is largely inaccessible rugged terrain with dense impenetrable forests, unpredictable climatic conditions and poor road communications. Thus, it is geologically, a rather lesser known region. Arunachal Pradesh consists of four physiographic domains viz. a) Himalayan range, b) Trans-Himalayan range c) Naga-Patkoï range and d) Brahmaputra plain. Each domain has a distinctive geological and tectonic history.

**LANDSLIDES AND SIESMOTECTONICS:** The region is prone to earthquake. Since the middle of the nineteenth century, there had been at least two major earthquakes (1897 and 1950), which are among the most destructive earthquakes in human history. The mountainous tracts of the region are inhabited by people of diverse ethnic groups and cultural affinities lured by the pioneering spirit of man in quest of the unknown, be it geographical or geological. The earliest reference of the region is found in the Mahabharata and



## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-108+546.

documentation of the geological information was made mostly by the British military expeditions during the early part of the

nineteenth century prior to establishment of the GSI in 1851. This excludes the meticulous records of the earthquakes which are available since the middle of the last century.

### 3. SCOPE OF WORK:

The scope of work provided to us for this project was limited to the following:-

**3.1** Mobilizing necessary plant, equipments and personnel to the project site, setting up the equipment, carrying out the field investigations on land and demobilization on completion of work.

**3.2** Making 150 mm nominal diameter bore holes at the site in all types of soil using suitable approved method of boring to be given at site by the Engineer-in-Charge. Refusal shall mean when SPT field 'N' value reaches 50 for 30 cm or less penetration of SPT sampler.

**3.2.1** Conducting standard penetration tests in the bore holes at 1.50 m interval in depth as per specifications / instructions of Engineer-in-Charge.

**3.2.2** Collecting undisturbed soil samples from bore holes at 3.0m interval or every change of strata, whichever is earlier as per specifications.

**3.2.3** Collecting disturbed soil samples from bore hole at regular interval and at every identifiable change of strata to supplement the boring records.

**3.2.4** Recording the depth of ground water table in all the bore hole if observed up to the depth of exploration during boring work as per specifications & withdrawing the casing pipe.

**3.3** Conducting the following laboratory tests on selected disturbed / undisturbed soil samples collected from bore hole / test locations :-

(a) Bulk density and Moisture content

(b) Sieve analysis

(c) Hydrometer analysis

(d) Liquid limit & Plastic limits

(e) Specific gravity

(f) Shear test on undisturbed and remoulded saturated disturbed soil samples



## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-108+546.

(g) Determination of void ratio.

**3.4** Preparation and submission of report in three copies.

### **4.0 FIELD INVESTIGATIONS:**

**4.1** Necessary plant, equipment and personnel for conducting the requisite field work were mobilized to the site.

**4.2** one number borehole was first marked on the ground surface as per the layout given to us by the Engineer-in-Charge.

**4.3** Bore hole was bored at this site using rotary drilling method as per IS: 1892-1979.

**4.3.1 Standard penetration** tests were conducted in the above bore hole at every 1.50 m interval & at change of strata as per specifications / instructions of Engineer-in-Charge. The bore was cleaned up to the desired depths. Standard split spoon sampler attached to lower end of 'A' drill rods was driven in the bore holes by means of standard hammer of 63.5 Kg. falling freely from a height of 75 cm. The sampler was driven 45 cm as per specifications & the numbers of blows required for each 15 cm penetration were recorded. The numbers of blows for the first 15 cm penetration were not taken into account. This was considered as seating drive. The numbers of blows for next 30 cm penetration were designated as SPT 'N' value. Wherever the total penetration was less than 45 cm. the number of blows & the depth penetrated is incorporated in respective bore logs. Disturbed soil samples obtained from standard split spoon sampler for all the above standard penetration tests were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded and carefully transported to the laboratory for testing.

**4.3.2 Undisturbed** soil samples were collected from the bore hole at every 3.00 m interval in depth & at change of strata as per sampling specifications. These sampling tubes after retrieval from the bore hole was properly waxed and sealed at both ends. These were carefully labeled and transported to the laboratory for testing. Undisturbed soil samples wherever slipped during lifting, were duly marked in the field bore logs as well as in the soil profile.

**4.3.3 Disturbed** soil samples were also collected from the bore hole at suitable depths/intervals to supplement the boring records. These samples were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded & carefully transported to the laboratory for testing.







## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-108+546.

**4.3.4** The depth of ground water table was checked / measured in all bore holes.

**4.3.5** Summary of bore holes:

Table I

Borehole Location	RL of bore hole top	Depth of Bore hole(M)	Water level during the time of field work( M)
ABT1	694.8	8.5	Not encountered
ABT2	701.1	6.5	Not encountered

### 5.0 LABORATORY INVESTIGATIONS:

**5.1** The following laboratory tests were conducted on selected soil samples recovered

from bore hole / test locations: -

- (a) Bulk density and Moisture content
- (b) Sieve analysis
- (c) Hydrometer analysis
- (d) Liquid limit & Plastic limits
- (e) Specific gravity
- (f) Shear test on remolded and saturated disturbed soil samples
- (g) Determination of void ratio..

All the above laboratory tests were carried out as per relevant Indian Standards. All the soil samples were identified and classified as per IS: 1498-1970.

### 6.0 FINDING OF GEOTECHNICAL INVESTIGATION:

The study of bore logs/results of laboratory and other field tests are tabulated through different tables as annexure.

### 7.0 Analysis of liquefaction potential

It is analysed through Seed and Idriss ( 1982) approach

Liquefaction is generally occurs in fine to medium sand within a depth of 10.0M from ground surface. With increasing overburden pressure the chances of liquefaction usually decrease. ( CI 13.5.1, Theory and practice







## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-108+546.

of Foundation design NN Som, S.C. Das, Prentice hall of India Pvt Ltd Publisher) . As the area is mostly bouldery/ Shale probability of liquefaction is almost nil.

### 8.0 CALCULATION OF BEARING CAPACITY

#### (A) Calculation of Net Safe Bearing Capacity based on shear Criteria

IS: 6403-1981 recommends the following equation to calculate the net Safe Bearing Capacity ' $q_s$ ' based on Hansen's Bearing Capacity analysis:

$$q_s = 1/F \{ C N_c S_c d_c i_c + q (N_q - 1) S_q d_q i_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma \times R_w \}$$

Where,  $C$  = Cohesion of soil.

$\gamma$  = Saturated Density of soil

$B$  = Width of footing = 2.0 m (assumed)

$R_w$  = Water table correction factor depending upon position of water table with respect to founding level

$Q$  = Effective surcharge at footing level =  $\gamma D$  ( $D$  = depth of footing)

$N_c, N_q, N_\gamma$  = Bearing capacity factor

$S_c, S_q, S_\gamma$  = Shape factor

$d_c, d_q, d_\gamma$  = depth factor

$i_c, i_q, i_\gamma$  = inclination factors

$F$  = Factor of safety = 3.0

#### B) Calculation of safe bearing pressure based on tolerable settlement.

The safe bearing pressure is to be found out from the elastic settlement consideration and is found from the following equation given I.S. 8009 (part-I) 1976

$$S_f = S_{oed} = (H_t / (1 + e_0)) C_c \log_{10} (p_0 + \Delta p) / p_u$$

$S_f$  = Final settlement in mm

$S_{oed}$  = Settlement computed from one dimensional test

$H_t$  = Thickness of soil layer in m

$e_0$  = Initial void ratio at mid height of of layer

$C_c$  = Compression Index

$p_0$  = Initial effective pressure at mid height of layer

$\Delta p$  = pressure increment

For the computation of settlement of foundation founded at certain depth, a correction should be applied to the calculated  $S_f$  in the form of a depth factor to be read from Fig:12 of I.S. 8009 (part-I) 1976.

Corrected settlement  $S_{fd} = S_f \times \text{depth factor}$

Depth factor is dependent on the following

- i.  $D$  = Depth of footing
- ii.  $L$  = Length of footing
- iii.  $B$  = Width of footing





## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-108+546.

Here the safe bearing capacity of soil for open foundation is calculated based foundation on rock.

### As per IS 12070 -1987

The safe bearing pressure should be estimated from the following equation

$$q_s = q_c \times N_i$$

$N_i$  = Discontinuity factor = 0.1 ( Minimum value)

Depth 3.0 M

Uniaxial compressive strength,  $q_c$  = 8.5 MPa

$$q_s = q_c \times N_i$$

$$= 8.5 \times 0.1 = 0.85 \text{ MPa} = 85 \text{ Ton/sqm}$$

**Table I Safe Bearing Capacity at different depth**

Foundation Depth below ground level (M)	RL of founding level	Recommended net safe bearing Capacity (M ton/sqm)
3.0	700.1	85.0
4.0	699.1	85.0
5.0	698.1	85.0
6.0	697.10	95.0
7.0	696.10	95.0
8.0	695.10	95.0
9.0	694.10	120.0
10.0	693.10	120.0

### 9.0 CONCLUSION AND RECOMMENDATION

Sub soil at this site is of rocky type . Safe bearing capacity for open foundation is shown in above table.



# BORE LOG CUM LABORATORY TEST RESULT

Name of Project: Construction of RCC Bridge at KM – 108+546

Boring method: Rotary Drilling

Date Commenced: 16-05-2016

Date completed: 17-05-2016

LOCATION: ABT1

DEPTH OF WATER TABLE=Not Encountered

Depth in meters below reference	Types of Sample	Observed N-Value	Group Symbol	Visual description of soil	% Gravel > 75mm	% Sand 4.75-0.075 mm	Silt 0.075-0.002	% Clay < 0.002 mm	Field density, gms/cm <sup>3</sup>	Specific Gravity	Void Ratio	Water absorption (%)	Uniaxial compressive Strength MPa (U D)	Shear Parameter		Compression Index C <sub>c</sub>
														Cohesion 'c' Kg/cm <sup>2</sup>	Angle of shearing resistance (Φ°)	
0-1.5	P	R		Bouldery strata  3.0m	Core recovery= 6.5% RQD= Nil											
1.50-3.0	P	R			Core recovery= 6.67% RQD= Nil				2.20	2.67		3.9			38	
3.00-4.50	P	R		Rocky strata.  8.5M	Core recovery= 10.00% RQD= Nil											
4.50-6.0	P	R			Core recovery= 12.67% RQD= Nil				2.26	2.67		2.4	8.5			
6.00-7.5	P	R			Core recovery= 14.00% RQD= 8.2%											
7.50-8.5	P	R			Core recovery= 21.33% RQD= 12.6%				2.39	2.67		2.0	12.0			

U: Undisturbed Sample::

D: Disturbed Sample::

P: Standard Penetration test::

DS: Direct shear test::

R=Refusal, N-value>100



# BORE LOG CUM LABORATORY TEST RESULT

Name of Project: Construction of RCC Bridge at KM – 108+546

Boring method: Rotary Drilling

Date Commenced: 18-05-2016

Date completed: 19-05-2016

LOCATION: ABT 2

DEPTH OF WATER TABLE=Not Encountered

Depth in meters below reference	Types of Sample	Observed N-Value	Group Symbol	Visual description of soil	% Gravel > .75mm	% Sand 4.75-0.075 mm	Silt 0.075-0.002	% Clay < 0.002 mm	Field density, gms/cm <sup>3</sup>	Specific Gravity	Void Ratio	Water absorption (%)	Uniaxial compressive Strength MPa (U D)	Shear Parameter		Compression Index C <sub>c</sub>
														Cohesion 'c' Kg/cm <sup>2</sup>	Angle of shearing resistance (Φ°)	
0-2.0	P	R		Bouldery strata 2.00M	Core recovery= 7.6% RQD= Nil											
2.0-3.0	P	R		Hard Rock.    6.5M	Core recovery= 9.33% RQD= Nil				2.34	2.67		2.1	8.9			
3.00-4.50	P	R			Core recovery= 15.33% RQD= 10.3%											
4.50-6.0	P	R			Core recovery= 16.67% RQD= 10.2%				2.37	2.67		2.4	14.2			
6.00-6.5	P	R			Core recovery= 22.00% RQD= NIL											

U: Undisturbed Sample::

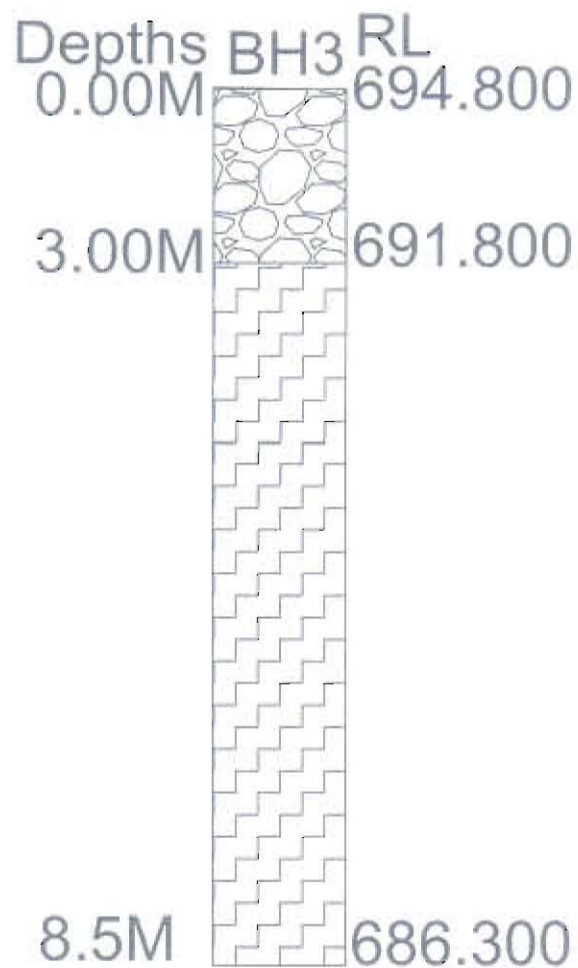
D: Disturbed Sample::

P: Standard Penetration test::

DS: Direct shear test::

R=Refusal, N-value>100





BOULDERY

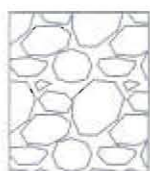
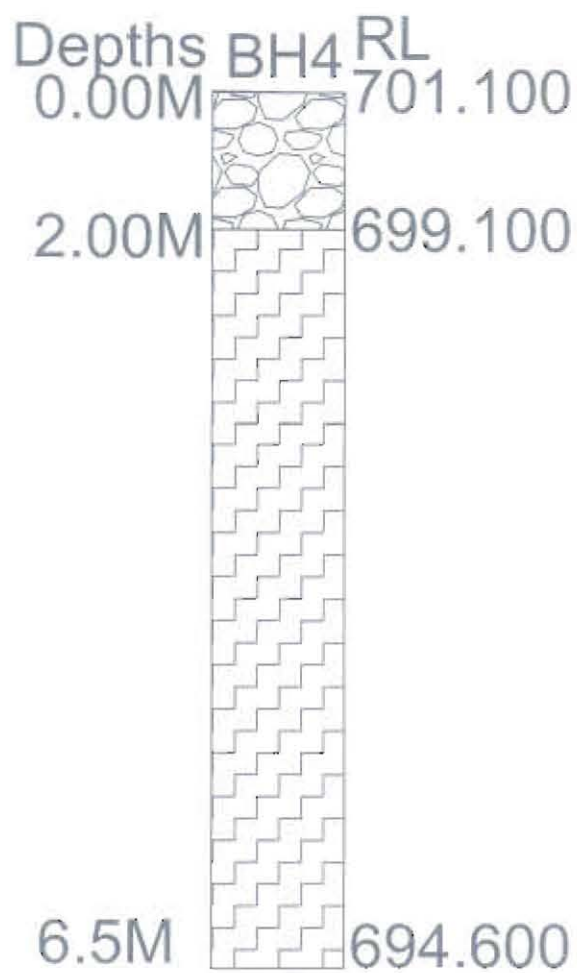


Rock

Fig1:Cross-section & subsoil profile







Bouldery



Rock

Fig1:Cross-section & subsoil profile

REVIEW  
And

**SSI REPORT FOR  
CONSTRUCTION OF RCC BRIDGE  
AT  
KM – 122+100**





## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-122+100.

### 1. INTRODUCTION:

**1.1** This report presented herein deals with the field and laboratory investigations carried out by us to access the nature of sub-strata and to evaluate the soil parameters required for design of foundations proposed to be constructed for proposed bridge.

**1.2** Client's help is gratefully acknowledged in providing bore hole locations, close supervision and checking during boring, sampling, various testing operations and cooperation and guidance during finalization of report.

**1.3** The work of Geotechnical Investigation was awarded to RELIANT FOUNDATIONS PVT LTD., H-7, BYE LANE NO.1 (A.NORTH), PANJABARI ROAD, SIXMILE, GUWAHATI-22 for the project construction of bridge.

**1.4** This report is based upon the results of field, laboratory tests conducted on selected soil/rock samples collected from three bore hole up to the depth of 15.45 M each and interpretation of results were done as per IRC 78-2000 and pertinent IS code of practices.

### 2. GEOLOGICAL BACKGROUND :

**GEOLOGICAL BACKGROUND :** Arunachal Pradesh, the 'Land of the rising sun' is located towards the northeastern tip of India. It presents a breathtaking beautiful landscape with towering snowclad peaks, steep precipitous gorges, lush green valleys and innumerable streams. The state is bound by neighboring countries like China (Tibet), Bhutan and Myanmar towards North, West and East respectively. Arunachal Pradesh lies between 26°28' and 29°30' N and 91°30' and 97°25' E. It occupies an area of 83,578 sq. kms. Arunachal Pradesh is largely inaccessible rugged terrain with dense impenetrable forests, unpredictable climatic conditions and poor road communications. Thus, it is geologically, a rather lesser known region. Arunachal Pradesh consists of four physiographic domains viz. a) Himalayan range, b) Trans-Himalayan range c) Naga-Patkoil range and d) Brahmaputra plain. Each domain has a distinctive geological and tectonic history.

**LANDSLIDES AND SIESMOTECTONICS:** The region is prone to earthquake. Since the middle of the nineteenth century, there had been at least two major earthquakes (1897 and 1950), which are among the most destructive earthquakes in human history. The mountainous tracts of the region are inhabited by people of diverse ethnic groups and cultural affinities lured by the pioneering spirit of man in quest of the unknown, be it geographical or geological. The earliest reference of the region is found in the Mahabharata and





## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-122+100.

documentation of the geological information was made mostly by the British military expeditions during the early part of the

nineteenth century prior to establishment of the GSI in 1851. This excludes the meticulous records of the earthquakes which are available since the middle of the last century.

### 3. SCOPE OF WORK:

The scope of work provided to us for this project was limited to the following:-

**3.1** Mobilizing necessary plant, equipments and personnel to the project site, setting up the equipment, carrying out the field investigations on land and demobilization on completion of work.

**3.2** Making 150 mm nominal diameter bore holes at the site in all types of soil using suitable approved method of boring to be given at site by the Engineer-in-Charge. Refusal shall mean when SPT field 'N' value reaches 50 for 30 cm or less penetration of SPT sampler.

**3.2.1** Conducting standard penetration tests in the bore holes at 1.50 m interval in depth as per specifications / instructions of Engineer-in-Charge.

**3.2.2** Collecting undisturbed soil samples from bore holes at 3.0m interval or every change of strata, whichever is earlier as per specifications.

**3.2.3** Collecting disturbed soil samples from bore hole at regular interval and at every identifiable change of strata to supplement the boring records.

**3.2.4** Recording the depth of ground water table in all the bore hole if observed up to the depth of exploration during boring work as per specifications & withdrawing the casing pipe.

**3.3** Conducting the following laboratory tests on selected disturbed / undisturbed soil samples collected from bore hole / test locations :-

(a) Bulk density and Moisture content

(b) Sieve analysis

(c) Hydrometer analysis

(d) Liquid limit & Plastic limits

(e) Specific gravity

(f) Shear test on undisturbed and remoulded saturated disturbed soil samples

(g) Determination of void ratio.







## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-122+100.

**3.4** Preparation and submission of report in three copies.

### **4.0 FIELD INVESTIGATIONS:**

**4.1** Necessary plant, equipment and personnel for conducting the requisite field work were mobilized to the site.

**4.2** one number borehole was first marked on the ground surface as per the layout given to us by the Engineer-in-Charge.

**4.3** Bore hole was bored at this site using rotary drilling method as per IS: 1892-1979.

**4.3.1 Standard penetration** tests were conducted in the above bore hole at every 1.50 m interval & at change of strata as per specifications / instructions of Engineer-in-Charge. The bore was cleaned up to the desired depths. Standard split spoon sampler attached to lower end of 'A' drill rods was driven in the bore holes by means of standard hammer of 63.5 Kg. falling freely from a height of 75 cm. The sampler was driven 45 cm as per specifications & the numbers of blows required for each 15 cm penetration were recorded. The numbers of blows for the first 15 cm penetration were not taken into account. This was considered as seating drive. The numbers of blows for next 30 cm penetration were designated as SPT 'N' value. Wherever the total penetration was less than 45 cm, the number of blows & the depth penetrated is incorporated in respective bore logs. Disturbed soil samples obtained from standard split spoon sampler for all the above standard penetration tests were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded and carefully transported to the laboratory for testing.

**4.3.2 Undisturbed** soil samples were collected from the bore hole at every 3.00 m interval in depth & at change of strata as per sampling specifications. These sampling tubes after retrieval from the bore hole was properly waxed and sealed at both ends. These were carefully labeled and transported to the laboratory for testing. Undisturbed soil samples wherever slipped during lifting, were duly marked in the field bore logs as well as in the soil profile.

**4.3.3 Disturbed soil** samples were also collected from the bore hole at suitable depths/intervals to supplement the boring records. These samples were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded & carefully transported to the laboratory for testing.

**4.3.4** The depth of ground water table was checked / measured in all bore holes.



## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-122+100.

### 4.3.5 Summary of bore holes:

Table I

RL of bore hole top	Depth of Bore hole(M)	Water level during the time of field work( M)
735.50	15.0	Not encountered

## 5.0 LABORATORY INVESTIGATIONS:

**5.1** The following laboratory tests were conducted on selected soil samples recovered

from bore hole / test locations: -

- (a) Bulk density and Moisture content
- (b) Sieve analysis
- (c) Hydrometer analysis
- (d) Liquid limit & Plastic limits
- (e) Specific gravity
- (f) Shear test on remolded and saturated disturbed soil samples
- (g) Determination of void ratio..

All the above laboratory tests were carried out as per relevant Indian Standards. All the soil samples were identified and classified as per IS: 1498-1970.

## 6.0 FINDING OF GEOTECHNICAL INVESTIGATION:

The study of bore logs/results of laboratory and other field tests are tabulated through different tables as annexure.

## 7.0 Analysis of liquefaction potential

It is analysed through Seed and Idriss ( 1982) approach

Liquefaction is generally occurs in fine to medium sand within a depth of 10.0M from ground surface. With increasing overburden pressure the chances of liquefaction usually decrease. ( CI 13.5.1, Theory and practice of Foundation design NN Som, S.C. Das, Prentice hall of India Pvt Ltd Publisher) . **As the area is mostly bouldery/ Shale probability of liquefaction is almost nil.**





## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-122+100.

### 8.0 CALCULATION OF BEARING CAPACITY

#### (A) Calculation of Net Safe Bearing Capacity based on shear Criteria

IS: 6403-1981 recommends the following equation to calculate the net Safe Bearing Capacity ' $q_s$ ' based on Hansen's Bearing Capacity analysis:

$$q_s = 1/F \{ C N_c S_c d_c i_c + q (N_q - 1) S_q d_q i_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma \times R_w \}$$

Where,  $C$  = Cohesion of soil.

$\gamma$  = Saturated Density of soil

$B$  = Width of footing = 2.0 m (assumed)

$R_w$  = Water table correction factor depending upon position of water table with respect to founding level

$Q$  = Effective surcharge at footing level =  $\gamma D$  ( $D$  = depth of footing)

$N_c, N_q, N_\gamma$  = Bearing capacity factor

$S_c, S_q, S_\gamma$  = Shape factor

$d_c, d_q, d_\gamma$  = depth factor

$i_c, i_q, i_\gamma$  = inclination factors

$F$  = Factor of safety = 3.0

#### B) Calculation of safe bearing pressure based on tolerable settlement.

The safe bearing pressure is to be found out from the elastic settlement consideration and is found from the following equation given I.S. 8009 (part-1) 1976

$$S_f = S_{oes} = (H / (1 + e_0)) C_c \log_{10} (p_0 + \Delta p) / p_0$$

$S_f$  = Final settlement in mm

$S_{oes}$  = Settlement computed from one dimensional test

$H$  = Thickness of soil layer in m

$e_0$  = Initial void ratio at mid height of of layer

$C_c$  = Compression Index

$p_0$  = Initial effective pressure at mid height of layer

$\Delta p$  = pressure increment

For the computation of settlement of foundation founded at certain depth, a correction should be applied to the calculated  $S_f$  in the form of a depth factor to be read from Fig:12 of I.S. 8009 (part-1) 1976.

Corrected settlement  $S_{fd} = S_f \times \text{depth factor}$

Depth factor is dependent on the following

- i.  $D$  = Depth of footing
- ii.  $L$  = Length of footing
- iii.  $B$  = Width of footing

#### As per IS 12070 -1987

The safe bearing pressure should be estimated from the following equation

$$q_s = q_c \times N_i$$



## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-122+100.

$N_i$  = Discontinuity factor = 0.1 ( Minimum value)

Depth 3.0 M

Uniaxial compressive strength,  $q_c$  = 90.0 MPa

$q_s = q_c \times N_i$

=  $9.0 \times 0.1 = 0.90 \text{ MPa} = 90 \text{ Ton/sqm}$

**Table I Safe Bearing Capacity at different depth**

Foundation Depth below ground level (M)	RL of founding level	Recommended net safe bearing Capacity (M ton/sqm)
3.0	732.500	90.0
4.0	731.500	90.0
5.0	730.500	90.0
6.0	729.500	90.0
7.0	728.500	90.0
8.0	727.50	120.0
9.0	726.500	120.0
10.0	725.500	120.0

### 9.0 CONCLUSION AND RECOMMENDATION

Sub soil at this site is of rocky type . Safe bearing capacity for open foundation is shown in above table.





# BORE LOG CUM LABORATORY TEST RESULT

Name of Project: Construction of RCC Bridge at KM – 122+100.

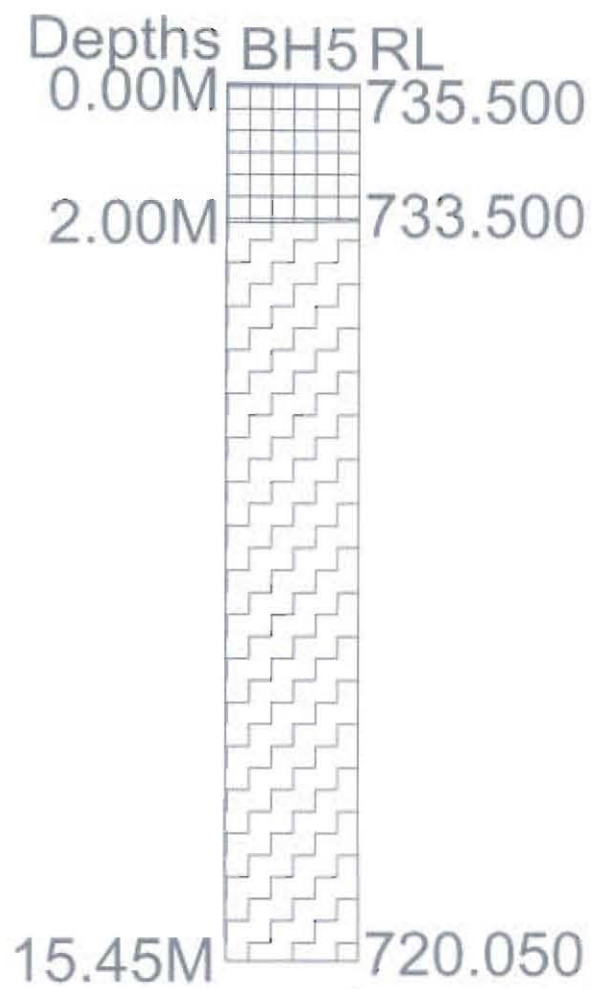
Boring method: Rotary Drilling      Date Commenced: 20-05-2016      Date completed: 22-05-2016

DEPTH OF WATER TABLE=Not Encountered

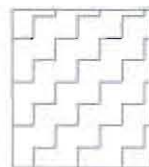
Depth in meters below reference	Group Symbol	Visual description of soil	% Gravel > .75mm Core recovery=      RQD= Nil	% Sand 4.75-0.075 mm	Silt 0.075-0.002	% Clay < 0.002 mm	Field density, gms/cm <sup>3</sup>	Specific Gravity	Void Ratio	Water absorption (%)	Uniaxial compressive Strength MPa (U D)	Shear Parameter Cohesion c' Kg/cm <sup>2</sup> Angle of shearing resistance (φ°)	Compression Index Cc
0.0-2.0		Shale.	Core recovery= 21.33% RQD= Nil				2.28	2.67		2.2			
2.00-4.50		Rocky strata	Core recovery= 18.67% RQD= Nil										
4.50-6.0			Core recovery= 10.33% RQD= Nil				2.29	2.67		3.5	9.3		
6.00-7.50			Core recovery= 12.00% RQD= Nil										
7.50-9.0			Core recovery= 18.00% RQD= 12.5%				2.34	2.67		3.0	12.8		
9.00-10.5			Core recovery= 15.67% RQD= 10.9%										
10.50-12.0			Core recovery= 18.67% RQD= 11.5%				2.33	2.67		2.6	17.2		
12.00-13.50			Core recovery= 28.00% RQD= 15.6%										
13.50-15.0		15.0M	Core recovery= 29.33% RQD= 14.8%				2.38	2.67		2.4	20.3		

U: Undisturbed Sample::      D: Disturbed Sample::      P: Standard Penetration test::      DS: Direct shear test::      R=Refusal, N-value>100

*Shub*



Shale



Rocky  
Strata

Fig1:Cross-section & subsoil profile



**SSI REPORT FOR  
CONSTRUCTION OF RCC BRIDGE  
AT  
KM – 125+294**

*Shah*



## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-125+294.

### 1. INTRODUCTION:

**1.1** This report presented herein deals with the field and laboratory investigations carried out by us to access the nature of sub-strata and to evaluate the soil parameters required for design of foundations proposed to be constructed for proposed bridge.

**1.2** Client's help is gratefully acknowledged in providing bore hole locations, close supervision and checking during boring, sampling, various testing operations and cooperation and guidance during finalization of report.

**1.3** The work of Geotechnical Investigation was awarded to RELIANT FOUNDATIONS PVT LTD., H-7, BYE LANE NO.1 (A.NORTH), PANJABARI ROAD, SIXMILE, GUWAHATI-22 for the project construction of bridge.

**1.4** This report is based upon the results of field, laboratory tests conducted on selected soil/rock samples collected from three bore hole up to the depth of 9.45 M each and interpretation of results were done as per IRC 78-2000 and pertinent IS code of practices.

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## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-125+294.

documentation of the geological information was made mostly by the British military expeditions during the early part of the

nineteenth century prior to establishment of the GSI in 1851. This excludes the meticulous records of the earthquakes which are available since the middle of the last century.

### 3. SCOPE OF WORK:

The scope of work provided to us for this project was limited to the following:-

**3.1** Mobilizing necessary plant, equipments and personnel to the project site, setting up the equipment, carrying out the field investigations on land and demobilization on completion of work.

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(d) Liquid limit & Plastic limits

(e) Specific gravity

(f) Shear test on undisturbed and remoulded saturated disturbed soil samples

(g) Determination of void ratio.





## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-125+294.

**3.4** Preparation and submission of report in three copies.

### **4.0 FIELD INVESTIGATIONS:**

**4.1** Necessary plant, equipment and personnel for conducting the requisite field work were mobilized to the site.

**4.2** one number borehole was first marked on the ground surface as per the layout given to us by the Engineer-in-Charge.

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**4.3.4** The depth of ground water table was checked / measured in all bore holes.





## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-125+294.

### 4.3.5 Summary of bore holes:

Table I

RL of bore hole top	Depth of Bore hole(M)	Water level during the time of field work( M)
812.600	10.0	Not encountered

### 5.0 LABORATORY INVESTIGATIONS:

**5.1** The following laboratory tests were conducted on selected soil samples recovered

from bore hole / test locations: -

- (a) Bulk density and Moisture content
- (b) Sieve analysis
- (c) Hydrometer analysis
- (d) Liquid limit & Plastic limits
- (e) Specific gravity
- (f) Shear test on remolded and saturated disturbed soil samples
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All the above laboratory tests were carried out as per relevant Indian Standards. All the soil samples were identified and classified as per IS: 1498-1970.

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It is analysed through Seed and Idriss ( 1982) approach

Liquefaction is generally occurs in fine to medium sand within a depth of 10.0M from ground surface. With increasing overburden pressure the chances of liquefaction usually decrease. ( CI 13.5.1, Theory and practice of Foundation design NN Som, S.C. Das, Prentice hall of India Pvt Ltd Publisher) . **As the area is mostly bouldery/ Shale probability of liquefaction is almost nil.**



## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-125+294.

### 8.0 CALCULATION OF BEARING CAPACITY

#### (A) Calculation of Net Safe Bearing Capacity based on shear Criteria

IS: 6403-1981 recommends the following equation to calculate the net Safe Bearing Capacity ' $q_s$ ' based on Hansen's Bearing Capacity analysis:

$$q_s = 1/F \{ C N_c S_c d_c i_c + q (N_q - 1) S_q d_q i_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma \times R_w \}$$

Where,  $C$  = Cohesion of soil.

$\gamma$  = Saturated Density of soil

$B$  = Width of footing = 2.0 m (assumed)

$R_w$  = Water table correction factor depending upon position of water table with respect to founding level

$Q$  = Effective surcharge at footing level =  $\gamma D$  ( $D$  = depth of footing)

$N_c, N_q, N_\gamma$  = Bearing capacity factor

$S_c, S_q, S_\gamma$  = Shape factor

$d_c, d_q, d_\gamma$  = depth factor

$i_c, i_q, i_\gamma$  = inclination factors

$F$  = Factor of safety = 3.0

#### B) Calculation of safe bearing pressure based on tolerable settlement.

The safe bearing pressure is to be found out from the elastic settlement consideration and is found from the following equation given I.S. 8009 (part-1) 1976

$$S_f = S_{\text{mod}} = (H_f / (1 + e_0)) C_c \log_{10} (p_0 + \Delta p) / p_0$$

$S_f$  = Final settlement in mm

$S_{\text{mod}}$  = Settlement computed from one dimensional test

$H_f$  = Thickness of soil layer in m

$e_0$  = Initial void ratio at mid height of of layer

$C_c$  = Compression Index

$p_0$  = Initial effective pressure at mid height of layer

$\Delta p$  = pressure increment

For the computation of settlement of foundation founded at certain depth, a correction should be applied to the calculated  $S_f$  in the form of a depth factor to be read from Fig:12 of I.S. 8009 (part-1) 1976.

Corrected settlement  $S_{fd} = S_f \times \text{depth factor}$

Depth factor is dependent on the following

- i.  $D$  = Depth of footing
- ii.  $L$  = Length of footing
- iii.  $B$  = Width of footing







## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-125+294.

### Bearing capacity for foundation resting on rock

#### As per IS 12070 -1987

The safe bearing pressure should be estimated from the following equation

$$q_s = q_c \times N_i$$

$N_i$  = Discontinuity factor = 0.1 ( Minimum value)

Depth 3.0 M

Uniaxial compressive strength,  $q_c$  = 65.0 MPa

$$q_s = q_c \times N_i$$

$$= 65 \times 0.1 = 6.5 \text{ MPa} = 65 \text{ Ton/sqm}$$

**Table I Safe Bearing Capacity at different depth**

Foundation Depth below ground level (M)	RL of founding level	Recommended net safe bearing Capacity (M ton/sqm)
3.0	732.500	65.0
4.0	731.500	65.0
5.0	730.500	100.0
6.0	729.500	100.0
7.0	728.500	100.0
8.0	727.50	100.0
9.0	726.500	100.0
10.0	725.500	100.0

### 9.0 CONCLUSION AND RECOMMENDATION

Sub soil at this site is of rocky type . Safe bearing capacity for open foundation is shown in above table.



# BORE LOG CUM LABORATORY TEST RESULT

Name of Project: Construction of RCC Bridge at KM – 125+294

Boring method: Rotary Drilling

Date Commenced: 23-05-2016

Date completed: 24-05-2016

BH: 6

DEPTH OF WATER TABLE=Not Encountered

Depth in meters below reference	Visual description of soil	% Gravel > 75mm	% Sand 4.75-0.075 mm	Silt 0.075-0.002	% Clay < 0.002 mm	Field density, gms/cm <sup>3</sup>	Specific Gravity	Void Ratio	Water absorption (%)	Uniaxial compressive Strength MPa (U D)	Shear Parameter		Compression Index Cc
											Cohesion 'c' Kg/cm <sup>2</sup>	Angle of shearing resistance (Φ°)	
0.0-2.0	Bouldery strata 2.0M					2.20						36	
2.00-3.00	Rocky strata 10.0M	Core recovery= 9.33% RQD= Nil				2.28	2.67		2.5	6.5			
3.00-4.50		Core recovery= 8.67% RQD= Nil											
4.50-6.0		Core recovery= 14.00% RQD= Nil				2.32	2.67		3.1	10.7			
6.00-7.5		Core recovery= 15.33% RQD= Nil											
7.50-9.0		Core recovery= 22.67% RQD= 14.6%				2.36	2.70		3.6	12.6			
9.00-10.0		Core recovery= 30.00% RQD= 11.6%											

U: Undisturbed Sample::

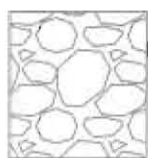
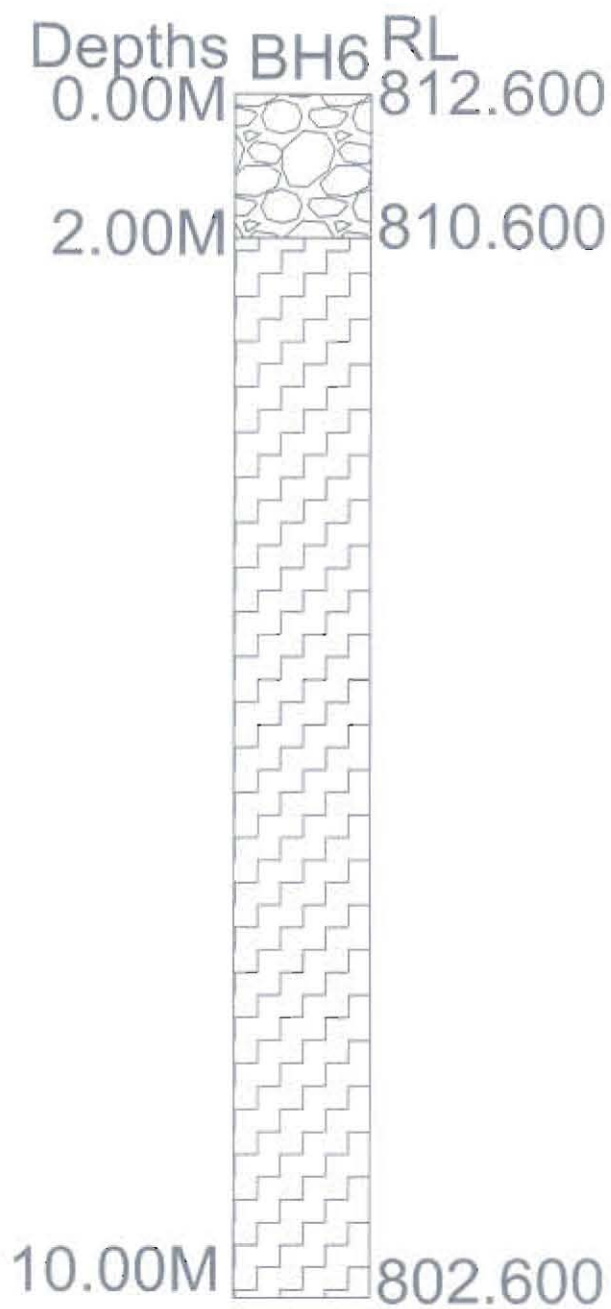
D: Disturbed Sample::

P: Standard Penetration test::

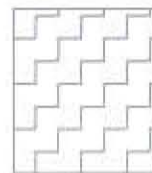
DS: Direct shear test::

R=Refusal, N-value>100





Gravelly



ROCK

Fig1:Cross-section & subsoil profile



**SSI REPORT FOR  
CONSTRUCTION OF RCC BRIDGE  
AT  
KM – 132+117**





## REPORT ON SOIL INVESTIGATION WORK FOR CONSTRUCTION OF BRIDGE AT CH-132+117.

### 1. INTRODUCTION:

**1.1** This report presented herein deals with the field and laboratory investigations carried out by us to access the nature of sub-strata and to evaluate the soil parameters required for design of foundations proposed to be constructed for proposed bridge.

**1.2** Client's help is gratefully acknowledged in providing bore hole locations, close supervision and checking during boring, sampling, various testing operations and cooperation and guidance during finalization of report.

**1.3** The work of Geotechnical Investigation was awarded to RELIANT FOUNDATIONS PVT LTD., H-7, BYE LANE NO.1 (A.NORTH), PANJABARI ROAD, SIXMILE, GUWAHATI-22 for the project construction of bridge.

**1.4** This report is based upon the results of field, laboratory tests conducted on selected soil/rock samples collected from three bore hole up to the depth of 7.95 M each and interpretation of results were done as per IRC 78-2000 and pertinent IS code of practices.

### 2. GEOLOGICAL BACKGROUND :

**GEOLOGICAL BACKGROUND :** Arunachal Pradesh, the 'Land of the rising sun' is located towards the northeastern tip of India. It presents a breathtaking beautiful landscape with towering snowclad peaks, steep precipitous gorges, lush green valleys and innumerable streams. The state is bound by neighboring countries like China (Tibet), Bhutan and Myanmar towards North, West and East respectively. Arunachal Pradesh lies between 26°28' and 29°30' N and 91°30' and 97°25' E. It occupies an area of 83,578 sq. kms. Arunachal Pradesh is largely inaccessible rugged terrain with dense impenetrable forests, unpredictable climatic conditions and poor road communications. Thus, it is geologically, a rather lesser known region. Arunachal Pradesh consists of four physiographic domains viz. a) Himalayan range, b) Trans-Himalayan range c) Naga-Patkoï range and d) Brahmaputra plain. Each domain has a distinctive geological and tectonic history.

**LANDSLIDES AND SIESMOTECTONICS:** The region is prone to earthquake. Since the middle of the nineteenth century, there had been at least two major earthquakes (1897 and 1950), which are among the most destructive earthquakes in human history. The mountainous tracts of the region are inhabited by people of diverse ethnic groups and cultural affinities lured by the pioneering spirit of man in quest of the unknown, be it geographical or geological. The earliest reference of the region is found in the Mahabharata and







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documentation of the geological information was made mostly by the British military expeditions during the early part of the

nineteenth century prior to establishment of the GSI in 1851. This excludes the meticulous records of the earthquakes which are available since the middle of the last century.

### 3. SCOPE OF WORK:

The scope of work provided to us for this project was limited to the following:-

**3.1** Mobilizing necessary plant, equipments and personnel to the project site, setting up the equipment, carrying out the field investigations on land and demobilization on completion of work.

**3.2** Making 150 mm nominal diameter bore holes at the site in all types of soil using suitable approved method of boring to be given at site by the Engineer-in-Charge. Refusal shall mean when SPT field 'N' value reaches 50 for 30 cm or less penetration of SPT sampler.

**3.2.1** Conducting standard penetration tests in the bore holes at 1.50 m interval in depth as per specifications / instructions of Engineer-in-Charge.

**3.2.2** Collecting undisturbed soil samples from bore holes at 3.0m interval or every change of strata, whichever is earlier as per specifications.

**3.2.3** Collecting disturbed soil samples from bore hole at regular interval and at every identifiable change of strata to supplement the boring records.

**3.2.4** Recording the depth of ground water table in all the bore hole if observed up to the depth of exploration during boring work as per specifications & withdrawing the casing pipe.

**3.3** Conducting the following laboratory tests on selected disturbed / undisturbed soil samples collected from bore hole / test locations :-

(a) Bulk density and Moisture content

(b) Sieve analysis

(c) Hydrometer analysis

(d) Liquid limit & Plastic limits

(e) Specific gravity

(f) Shear test on undisturbed and remoulded saturated disturbed soil samples

(g) Determination of void ratio.





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**3.4** Preparation and submission of report in three copies.

### **4.0 FIELD INVESTIGATIONS:**

**4.1** Necessary plant, equipment and personnel for conducting the requisite field work were mobilized to the site.

**4.2** one number borehole was first marked on the ground surface as per the layout given to us by the Engineer-in-Charge.

**4.3** Bore hole was bored at this site using rotary drilling method as per IS: 1892-1979.

**4.3.1 Standard penetration** tests were conducted in the above bore hole at every 1.50 m interval & at change of strata as per specifications / instructions of Engineer-in-Charge. The bore was cleaned up to the desired depths. Standard split spoon sampler attached to lower end of 'A' drill rods was driven in the bore holes by means of standard hammer of 63.5 Kg. falling freely from a height of 75 cm. The sampler was driven 45 cm as per specifications & the numbers of blows required for each 15 cm penetration were recorded. The numbers of blows for the first 15 cm penetration were not taken into account. This was considered as seating drive. The numbers of blows for next 30 cm penetration were designated as SPT 'N' value. Wherever the total penetration was less than 45 cm, the number of blows & the depth penetrated is incorporated in respective bore logs. Disturbed soil samples obtained from standard split spoon sampler for all the above standard penetration tests were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded and carefully transported to the laboratory for testing.

**4.3.2 Undisturbed** soil samples were collected from the bore hole at every 3.00 m interval in depth & at change of strata as per sampling specifications. These sampling tubes after retrieval from the bore hole was properly waxed and sealed at both ends. These were carefully labeled and transported to the laboratory for testing. Undisturbed soil samples wherever slipped during lifting, were duly marked in the field bore logs as well as in the soil profile.

**4.3.3 Disturbed** soil samples were also collected from the bore hole at suitable depths/intervals to supplement the boring records. These samples were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded & carefully transported to the laboratory for testing.

**4.3.4** The depth of ground water table was checked / measured in all bore holes.





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### 4.3.5 Summary of bore holes:

Table I

RL of bore hole top	Depth of Bore hole(M)	Water level during the time of field work( M)
840.80	8.0	Not encountered

### 5.0 LABORATORY INVESTIGATIONS:

**5.1** The following laboratory tests were conducted on selected soil samples recovered from bore hole / test locations: -

- (a) Bulk density and Moisture content
- (b) Sieve analysis
- (c) Hydrometer analysis
- (d) Liquid limit & Plastic limits
- (e) Specific gravity
- (f) Shear test on remolded and saturated disturbed soil samples
- (g) Determination of void ratio..

All the above laboratory tests were carried out as per relevant Indian Standards. All the soil samples were identified and classified as per IS: 1498-1970.

### 6.0 FINDING OF GEOTECHNICAL INVESTIGATION:

The study of bore logs/results of laboratory and other field tests are tabulated through different tables as annexure.

### 7.0 Analysis of liquefaction potential

It is analysed through Seed and Idriss ( 1982) approach

Liquefaction is generally occurs in fine to medium sand within a depth of 10.0M from ground surface. With increasing overburden pressure the chances of liquefaction usually decrease. ( CI 13.5.1, Theory and practice of Foundation design NN Som, S.C. Das, Prentice hall of India Pvt Ltd Publisher) . As the area is mostly bouldery probability of liquefaction is almost nil.







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### 8.0 CALCULATION OF BEARING CAPACITY

#### (A) Calculation of Net Safe Bearing Capacity based on shear Criteria

IS: 6403-1981 recommends the following equation to calculate the net Safe Bearing Capacity  $q_s$  based on Hansen's Bearing Capacity analysis:

$$q_s = 1/F \{ C N_c S_c d_c i_c + q (N_q - 1) S_q d_q i_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma \times R_w \}$$

Where,  $C$  = Cohesion of soil.

$\gamma$  = Saturated Density of soil

$B$  = Width of footing = 2.0 m (assumed)

$R_w$  = Water table correction factor depending upon position of water table with respect to founding level

$Q$  = Effective surcharge at footing level =  $\gamma D$  ( $D$  = depth of footing)

$N_c, N_q, N_\gamma$  = Bearing capacity factor

$S_c, S_q, S_\gamma$  = Shape factor

$d_c, d_q, d_\gamma$  = depth factor

$i_c, i_q, i_\gamma$  = inclination factors

$F$  = Factor of safety = 3.0

#### B) Calculation of safe bearing pressure based on tolerable settlement.

The safe bearing pressure is to be found out from the elastic settlement consideration and is found from the following equation given I.S. 8009 (part-I) 1976

$$S_f = S_{oed} = (H_f / (1 + e_o)) C_c \log_{10} (p_o + \Delta p) / p_o$$

$S_f$  = Final settlement in mm

$S_{oed}$  = Settlement computed from one dimensional test

$H_f$  = Thickness of soil layer in m

$e_o$  = Initial void ratio at mid height of of layer

$C_c$  = Compression Index

$p_o$  = Initial effective pressure at mid height of layer

$\Delta p$  = pressure increment

For the computation of settlement of foundation founded at certain depth, a correction should be applied to the calculated  $S_f$  in the form of a depth factor to be read from Fig:12 of I.S. 8009 (part-I) 1976.

Corrected settlement  $S_{fd} = S_f \times \text{depth factor}$

Depth factor is dependent on the following

- i.  $D$  = Depth of footing
- ii.  $L$  = Length of footing
- iii.  $B$  = Width of footing



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### Bearing capacity for foundation resting on rock

#### As per IS 12070 -1987

The safe bearing pressure should be estimated from the following equation

$$q_s = q_c \times N_i$$

$N_i$  = Discontinuity factor = 0.1 ( Minimum value)

Depth 3.0 M

Uniaxial compressive strength,  $q_c$  = 75.0 MPa

$$q_s = q_c \times N_i$$

$$= 75 \times 0.1 = 0.75 \text{ MPa} = 75 \text{ Ton/sqm}$$

**Table I Safe Bearing Capacity at different depth**

Foundation Depth below ground level (M)	RL of founding level	Recommended net safe bearing Capacity (M ton/sqm)
3.0	837.80	65.0
4.0	836.80	65.0
5.0	835.80	65.0
6.0	834.80	65.0
7.0	833.80	100.0
8.0	832.80	100.0

### 9.0 CONCLUSION AND RECOMMENDATION

Sub soil at this site is of rocky type . Safe bearing capacity for open foundation is shown in above table.





# BORE LOG CUM LABORATORY TEST RESULT

Name of Project: Construction of RCC Bridge at KM – 132+117.

Boring method: Rotary drilling Date Commenced: 26-05-2016

Date completed: 27-05-2016

DEPTH OF WATER TABLE=Not Encountered

Depth in meters below reference	Types of Sample	Observed N-Value	Group Symbol	Visual description of soil	% Gravel > .75mm	% Sand 4.75-0.075 mm	Silt 0.075-0.002	% Clay < 0.002 mm	Field density, gms/cm <sup>3</sup>	Specific Gravity	Void Ratio	Water absorption (%)	Uniaxial compressive Strength MPa (U D)	Shear Parameter		Compression Index C <sub>c</sub>
														Cohesion 'c' Kg/cm <sup>2</sup>	Angle of shearing resistance (Φ°)	
0-2.50	P	R		Soft Rock.	Core recovery= 10.0% RQD= Nil				2.24	2.66		2.3	5.2			
2.5-4.50	P	R		Hard Rock	Core recovery= 11.33% RQD= Nil											
4.50-6.00	P	R			Core recovery= 18.00% RQD= 14.3%				2.25	2.67		3.7	7.6			
6.00-7.50	P	R			Core recovery= 21.33% RQD= 12.6%											
7.50-8.00	P	R			Core recovery= 28.00% RQD= 16.8%				2.32	2.67		4.1	10.9			

U: Undisturbed Sample::

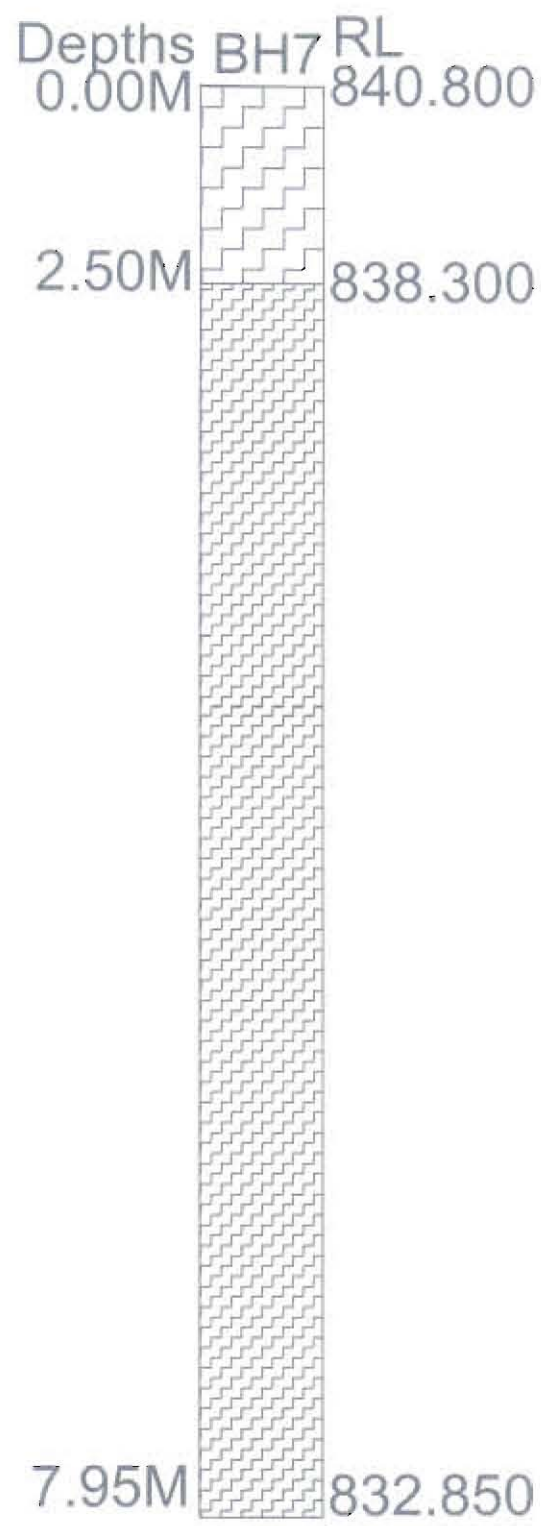
D: Disturbed Sample::

P: Standard Penetration test::

DS: Direct shear test::

R=Refusal, N-value>100





 Soft rock  Hard Rock

Fig1: Cross-section & subsoil profile





Site Photographs

*Handwritten signature*



Site Photographs

