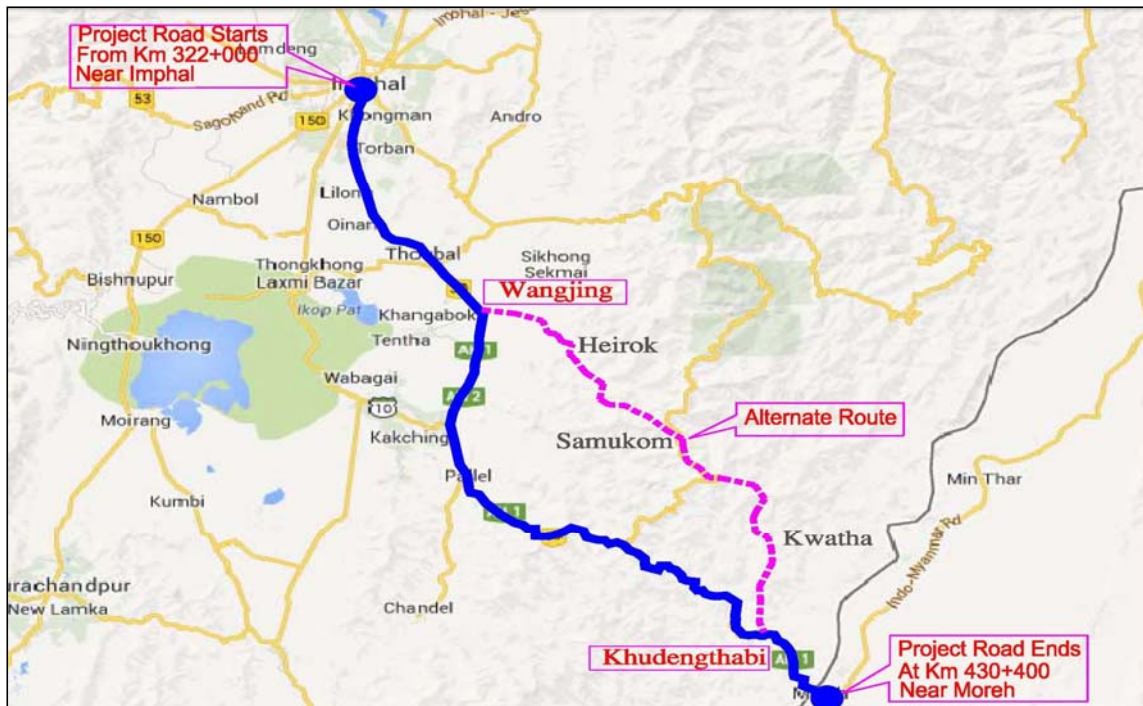


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SHELADIA ASSOCIATES INC., USA

PROJECT:

DETAILED DESIGN FOR INDO MYANMAR ROAD SECTION PROJECT (IMPHAL TO MOREH : AH-01)

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A

REPORT ON

**GEOTECHNICAL INVESTIGATION FOR
PROPOSED STRUCTURE OF INDO
MYANMAR ROAD SECTION FROM
IMPHAL TO MOREH, ADB TA-8116 IND**

For :

**THE GENERAL MANAGER
SHELADIA ASSOCIATES INC. USA
SECUNDERABAD**

By :

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GEOTECH REPORT FOR MAJOR BRIDGE

AT CH: 330+150

**Geotechnical Investigation Report for determination of allowable bearing pressure for
MAJOR BRIDGE at CH. 330+150 of NH-39 under
“DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH,
ADB TA - 8116 IND”**

ABSTRACT

The safe load carrying capacity of the foundation of MAJOR BRIDGE at Ch. 330+150 on NH-39 is recommended as follows:

| Location | | Bore hole Level (m) | Theoretical Scour Level (m) | Scour Depth Below BH (m) | Pile Cap Top Level (m) | Pile Cap Bottom Level (m) | Pile Tip Level (m) | Length of Pile (m) | Vertical Capacity (t) | Lateral Capacity (t) | Uplift Capacity (T) |
|----------|----|------------------------------|-----------------------------------|-----------------------------------|---------------------------------|------------------------------------|--------------------------|--------------------------|-----------------------------|----------------------------|---------------------------|
| 331/1A | A1 | 779.270 | 767.840 | 10.287 | 778.770 | 776.270 | 744.270 | 32 | 200 | 18 | 75 |
| 331/1B | P1 | 768.870 | 761.270 | 5.80 | 770.870 | 768.370 | 726.370 | 42 | 360 | 18 | 140 |
| 331/1C | A2 | 780.070 | 767.840 | 11.087 | 778.770 | 776.270 | 744.270 | 32 | 200 | 18 | 75 |

THE STRATA AT GLANCE AND SILT FACTORS

| Borehole No. | Type of strata | Depth | Weighted mean dia, d_m (mm) | Silt Factor, |
|--------------|--|-------------|-------------------------------|--------------|
| 1 | 2 | 3 | 4 | 5 |
| BH-331/1A | Clayey Sand (SC) mixed with Gravels | 0-3.0m | 1.53 | 2.17 |
| | Highly Plastic Clay (CH) mixed with Sand | 3.0m-15.0m | - | 3.68 |
| | Medium Plastic Clay (CI) mixed with Sand | 15.0m-30.0m | - | >3.68 |
| BH-331/1B | Clayey Sand (SC) mixed with Gravels | 0-4.0m | 1.69 | 2.29 |
| | Highly Plastic Clay (CH) mixed with Sand | 4.0m-18.0m | - | 3.68 |
| | Medium Plastic Clay (CI) mixed with Sand | 18.0m-30.0m | - | >3.68 |
| BH-331/1C | Filled-up Material | 0-1.80m | - | - |
| | Clayey Sand (SC) mixed with Gravels | 1.80m-4.50m | 2.54 | 2.80 |
| | Highly Plastic Clay (CH) mixed with Sand | 4.5m-15.0m | - | 3.34 |
| | Medium Plastic Clay (CI) mixed with Sand | 15.0m-30.0m | - | >3.34 |

Geotechnical Investigation Report
for determination of allowable bearing pressure for
MAJOR BRIDGE at CH. 330+150 on NH-39 under
“Detailed Project for Indo Myanmar Road Section from Imphal to Moreh,
ADB TA - 8116 IND”

1. INTRODUCTION

Geotechnical investigation was carried out for MAJOR BRIDGE at Ch.330+150 on NH-39 under Detailed Project for Indo Myanmar Road Section from Imphal to Moreh, ADB TA - 8116 IND. The Schedule of work and the locations of bore holes were decided by Engineer In-charge of Sheladia Associates, Inc., USA. The locations of boreholes are shown in Key Plan (Fig.A1).

2.0 FIELD INVESTIGATION

2.1 Boring

Three bore holes i.e. BH-331/1A, BH-331/1B & BH-331/1C were made at the locations decided by Engineer In-charge as shown in Key Plan (Fig.A1). Boring was done by power driven rig as per guidelines of IS: 1892:1979 and IRC-78-2000. Boring was done up to the maximum depth of 30.0m. The soil samples were collected as required for laboratory testing.

2.2 Standard Penetration Test (SPT)

Standard penetration test (SPT) was conducted in the bore hole as per IS 2131-1981. The numbers of blows for first 15 cm penetration is considered as seating drive and are not taken into account. The number of blows required for last 30 cm penetration is taken as SPT number (“N” values). If number of blows for last 30 cm penetration exceeds 100, it is said to be the refusal. SPT were conducted at regular interval of 1.5m, starting from the depth of 1.5m from the

ground surface to the depth of exploration/ refusal. The tests results are shown in Table-A1.1 to A1.3.

2.3 Water Table

The water table was observed at the depth of 2.4m.-2.6m from ground surface, at the time of investigation (i.e. December 2013).

3.0 LABORATORY INVESTIGATION

Soil Samples:

The following laboratory tests were conducted on the soil samples obtained from test bore holes:

- a) Natural Moisture content
- b) Specific gravity
- c) Liquid & Plastic Limit
- d) Grain size Analysis
- e) Shear strength test
- f) Bulk density (Dry Density)
- g) Free swell test

Test results are shown in borelogs i.e. Table-A1.1 to A1.3.

4. TYPE OF STRATA

Based on laboratory and field investigation the strata at the site have been described. The bore-log of the strata is presented in Table-A1.1 to A1.3. The strata are as follows:

BH-331/1A

The upper layer of the strata thickness about 3.0m was found to be Clayey Sand (SC) mixed with Gravels. Below this, Highly Plastic Clay (CH) mixed with Sand was found up to the depth of 15.0m. Beyond this, Medium Plastic Clay (CI) mixed with Sand was found up to the depth of exploration i.e. 30.0m. The bore-log is shown in Table-A1.1.

BH-331/1B

The upper layer of the strata thickness about 4.0m was found to be Clayey Sand (SC) mixed with Gravels. Below this, Highly Plastic Clay (CH) mixed with Sand was found up to the depth of 18.0m. Beyond this, Medium Plastic Clay (CI) mixed with Sand was found up to the depth of exploration i.e. 30.0m. The bore-log is shown in Table-A1.2.

BH-331/1C

The upper layer of the strata thickness about 1.8m was found to be Filled-up Material. It is followed by a layer of Clayey Sand (SC) mixed with Gravels was found upto the depth of 4.5m. Below this, Highly Plastic Clay (CH) mixed with Sand was found up to the depth of 15.0m. Beyond this, Medium Plastic Clay (CI) mixed with Sand was found up to the depth of exploration i.e. 30.0m. The bore-log is shown in Table-A1.3.

5.0 FOUNDATION ANALYSIS

Pile foundation has been analyzed. The calculation sheets for safe load carrying capacity bearing capacity in vertical and uplift for different borehole locations are attached as Appendix-A1.1 to Appendix-A1.3. Also the lateral load carrying capacity is given in Appendix-A1.1.1 to Appendix- A1.3.1.

6.0 SILT FACTOR

In order to determine maximum score depth the silt factor of the bad material is required to be determine. The silt factor (f) depends upon the average size of bed material and given by Lacey equation as follows:

$$K_{sf} = 1.76 \sqrt{d_m}$$

Where d_m = the weighted mean diameter in millimeter

Also, in case of soil having $\phi < 15^\circ$ and c (cohesion of soil) $> 0.2 \text{ kg/cm}^2$, ' K_{sf} ' calculated as follows :

$$K_{sf} = F (1 + \sqrt{c}) \text{ where } c \text{ is in kg/cm}^2$$

where $F = 1.50$ for $\phi > 10^\circ$ and $< 15^\circ$
 $= 1.75$ for $\phi > 5^\circ$ and $< 10^\circ$
 $= 2.00$ for $\phi < 5^\circ$

| Borehole No. | Type of strata | Depth | Weighted mean dia, d_m (mm) | Silt Factor, |
|--------------|--|-------------|-------------------------------|--------------|
| 1 | 2 | 3 | 4 | 5 |
| BH-331/1A | Clayey Sand (SC) mixed with Gravels | 0-3.0m | 1.53 | 2.17 |
| | Highly Plastic Clay (CH) mixed with Sand | 3.0m-15.0m | - | 3.68 |
| | Medium Plastic Clay (CI) mixed with Sand | 15.0m-30.0m | - | >3.68 |
| BH-331/1B | Clayey Sand (SC) mixed with Gravels | 0-4.0m | 1.69 | 2.29 |
| | Highly Plastic Clay (CH) mixed with Sand | 4.0m-18.0m | - | 3.68 |
| | Medium Plastic Clay (CI) mixed with Sand | 18.0m-30.0m | - | >3.68 |
| BH-331/1C | Filled-up Material | 0-1.80m | - | - |
| | Clayey Sand (SC) mixed with Gravels | 1.80m-4.50m | 2.54 | 2.80 |
| | Highly Plastic Clay (CH) mixed with Sand | 4.5m-15.0m | - | 3.34 |
| | Medium Plastic Clay (CI) mixed with Sand | 15.0m-30.0m | - | >3.34 |

7.0 CONCLUSION

1. The strata at the site is described in Section 4.0.
2. The water table was observed at the depth of 2.4m.-2.6m from ground surface, at the time of investigation (i.e. December 2013).
3. Safe load carrying capacity has been recommended as follows:

The safe load carrying capacity of the foundation of MAJOR BRIDGE at Ch. 330+150 on NH-39 is recommended as follows:

| Location | | Bore hole Level (m) | Theoretical Scour Level (m) | Scour Depth Below BH (m) | Pile Cap Top Level (m) | Pile Cap Bottom Level (m) | Pile Tip Level (m) | Length of Pile (m) | Vertical Capacity (t) | Lateral Capacity (t) | Uplift Capacity (T) |
|----------|----|---------------------|-----------------------------|--------------------------|------------------------|---------------------------|--------------------|--------------------|-----------------------|----------------------|---------------------|
| 331/1A | A1 | 779.270 | 767.840 | 10.287 | 778.770 | 776.270 | 744.270 | 32 | 200 | 18 | 75 |
| 331/1B | P1 | 768.870 | 761.270 | 5.80 | 770.870 | 768.370 | 726.370 | 42 | 360 | 18 | 140 |
| 331/1C | A2 | 780.070 | 767.840 | 11.087 | 778.770 | 776.270 | 744.270 | 32 | 200 | 18 | 75 |

SCOUR DEPTH CALCULATIONS FOR MAJOR BRIDGE AT CH: 330+150 (Lilong)

| Sl.No | Chainage | Proposed Span Arrangement | Location | HFL (m) | Discharge (Cumecs) | Velocity (m/sec) | Design Discharge 1.3xQ (Cumec) | Silt Factor | Eff. Linear Waterway (m) | Discharge per m width (Cumecs/ | Mean Scour Depth Dsm(m) | Scour depth below HFL(m) | Borehole Level (m) | Min. Bed Level (m) | Theoretic al Scour level (m) | Seismic case | Actual Scour level (m) | Scour depth below BH (m) |
|-------|----------|---------------------------|----------|---------|--------------------|------------------|--------------------------------|-------------|--------------------------|--------------------------------|-------------------------|--------------------------|--------------------|--------------------|------------------------------|--------------|------------------------|--------------------------|
| 1 | 330+150 | 2 x 48.5 | A1 | 779.270 | 2166 | 3.17 | 2815.8 | 3.0 | 93.4 | 30.148 | 9.000 | 11.430 | 779.270 | - | 767.840 | 768.983 | 768.983 | 10.287 |
| | (Lilong) | | P | 779.270 | 2166 | 3.17 | 2815.8 | 3.0 | 93.4 | 30.148 | 9.000 | 18.000 | 768.870 | 768.870 | 761.270 | 763.070 | 763.070 | 5.800 |
| | | | A2 | 779.270 | 2166 | 3.17 | 2815.8 | 3.0 | 93.4 | 30.148 | 9.000 | 11.430 | 780.070 | - | 767.840 | 768.983 | 768.983 | 11.087 |

Pile Capacity Calculations (IS:2911/Part-1/Sec-2)-1979

Bored Cast in Situ Piles

Structure: Major Bridge (Lilong)

Chainage: 330+150

Location: A1

Calculation of Skin friction Resistance

(Existing)

| Item | Layer -I | Layer -II | Layer -III | Layer -IV | Layer -V | Layer -VI | Layer -VII |
|---|---|--------------|-------------|-------------|--------------|--------------|------------|
| Type of strata | Clay | Clay | Clay | Clay | Clay | Clay | Clay |
| Diameter of Pile (D) | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m |
| Length of Pile (L) | 32.0 m | 32 m | 32 m | 32 m | 32 m | 32 m | 32 m |
| Bulk density of the strata (γ) | 16.8 kn/m3 | 17.2 kn/m3 | 17.2 kn/m3 | 17.4 kn/m3 | 17.4 kn/m3 | 17.4 kn/m3 | 17.8 kn/m3 |
| Submerged Unit Weight (γ') | | 7.2 | 7.2 | 7.4 | 7.4 | 7.4 | 7.8 |
| Undrained shear strength (Cu) | 0 kn/m2 | 85 kn/m2 | 120 kn/m2 | 176 kn/m2 | 230 kn/m2 | 250 kn/m2 | 250 kn/m2 |
| Angle of internal friction of soil (φ) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Thickness of soil layer (h) | 10.3 m | 3.2 m | 7.5 m | 6.0 m | 3.0 m | 1.0 m | 3.3 m |
| Effective over burden pressure over the top of strata | 0 kn/m2 | 0 kn/m2 | 23.04 kn/m2 | 77.04 kn/m2 | 121.44 kn/m2 | 143.64 kn/m2 | 151 kn/m2 |
| Effective over burden pressure over the bottom of strata | 0 | 23.04 | 77.04 | 121.44 | 143.64 | 151.04 | 176.8 |
| Adhesion (α) | - | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| K= Coefficient of earth pressure in loose to medium sands = 1 - 3 | | 1 | 1 | 1 | 1 | 1 | 1 |
| Effective over burden pressure Pd = | | 11.52 | 50.04 | 99.24 | 132.54 | 147.34 | 163.9 |
| Angle of wall friction δ=φ | | 0 | 0 | 0 | 0 | 0 | 0 |
| (It is equal to angle of internal friction) | | | | | | | |
| As= 3.142*D*h | | 12.06528 | 28.278 | 22.6224 | 11.3112 | 3.77 | 12.44 |
| (for Granular soils) K x Pd x tanδ x As= | | 0 Kn | 0 Kn | 0 Kn | 0.00 Kn | 0 Kn | 0 Kn |
| (for Cohesive soils) α Cu As= | No skin resistance is considered for this layer | 307.66464 Kn | 1018.008 Kn | 1194.46 Kn | 780.4728 Kn | 282.78 Kn | 933.2 Kn |
| α Cu As= α*Cu*3.142*D*h | | | | | | | |

Skin friction resistance due to cohesive soil layers

$$\sum(\alpha \text{ Cu As}) = 4516.56 \text{ kN}$$

Skin friction resistance due to granular soil layers

$$\sum(K \times Pd \times \tan \delta \times As) = 0 \text{ kN}$$

Negtaive skin friction

$$= 677.484 \text{ kN}$$

Total Skin friction resistance of the pile, qs

$$R_f = \sum(\alpha \text{ Cu As} + K \times Pd \times \tan \delta \times As) = 3839.08$$

Calculation of End bearing resistance

| | |
|--|---|
| Type of bearing strata | Clay |
| C/S area of Pile | 1.131 sqm |
| Length of Pile (L) | 32 m |
| SPT value (N) | |
| Angle of internal friction of soil (φ) | φ 0 |
| Bearing capacity factor | Nc 9 |
| | Nq 17 |
| | Nγ 0 |
| Effective over burden pressure | Pd 0 Kn/m2 |
| Total End bearing resistance of the pile (Qp) | Qp= Ap*(1/2*D*γ*Nr+Pd*Nq)+(Ap*Nc*cp)= 1791.462 kN |
| Ultimate load carrying capacity | Qu= Qs+Qp = 5630.54 |
| Safe load carrying capacity | Qsafe= 2252.2159 kN |
| The Safe load carrying capacity of pile= | 225 t |

The Recommended vertical load carrying capacity is 225t

Ultimate Uplift load carrying capacity is 2687.35 Kn

The Safe Uplift load carrying capacity is

75.276 Tonnes

The Recommended Uplift load carrying capacity is 75.00 Tonnes

Pile Capacity Calculations (IS:2911/Part-1/Sec-2)-1979

Bored Cast in Situ Piles

Structure: Major Bridge (Lilong)

Chainage: 330+150

Location: P1

Calculation of Skin friction Resistance

(Existing)

| Item | Layer -I | Layer -II | Layer -III | Layer -IV | Layer -V | Layer -VI | Layer -VII |
|---|---|------------|--------------|-------------|-------------|------------|-------------|
| Type of strata | Clay | Clay | Clay | Clay | Clay | Clay | Clay |
| Diameter of Pile (D) | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m |
| Length of Pile (L) | 42.0 m | 42 m | 42 m | 42 m | 42 m | 42 m | 42 m |
| Bulk density of the strata (γ) | 16.8 kn/m3 | 17.2 kn/m3 | 17.2 kn/m3 | 17.4 kn/m3 | 17.4 kn/m3 | 17.4 kn/m3 | 17.8 kn/m3 |
| Submerged Unit Weight (γ') | | 7.2 | 7.2 | 7.4 | 7.4 | 7.4 | 7.8 |
| Undrained shear strength (Cu) | 0 kn/m2 | 75 kn/m2 | 120 kn/m2 | 175 kn/m2 | 220 kn/m2 | 260 kn/m2 | 260 kn/m2 |
| Angle of internal friction of soil (φ) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Thickness of soil layer (h) | 6 m | 9.0 m | 9.0 m | 3.0 m | 3.0 m | 3.0 m | 11.3 m |
| Effective over burden pressure over the top of strata | 0 kn/m2 | 0 kn/m2 | 64.8 kn/m2 | 129.6 kn/m2 | 151.8 kn/m2 | 174 kn/m2 | 196.2 kn/m2 |
| Effective over burden pressure over the bottom of strata | 0 | 64.8 | 129.6 | 151.8 | 174 | 196.2 | 284.3 |
| Adhesion (α) | - | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| K= Coefficient of earth pressure in loose to medium sands = 1 - 3 | | 1 | 1 | 1 | 1 | 1 | 1 |
| Effective over burden pressure Pd = | | 32.4 | 97.2 | 140.7 | 162.9 | 185.1 | 240.3 |
| Angle of wall friction δ=φ | | 0 | 0 | 0 | 0 | 0 | 0 |
| (It is equal to angle of internal friction) | | | | | | | |
| As= 3.142*D*h | | 33.9336 | 33.9336 | 11.3112 | 11.3112 | 11.31 | 42.61 |
| (for Granular soils) $K \times Pd \times \tan \delta \times As =$ | | 0 Kn | 0 Kn | 0 Kn | 0.00 Kn | 0 Kn | 0 Kn |
| (for Cohesive soils) $\alpha Cu As =$ | No skin resistance is considered for this layer | 763.506 Kn | 1221.6096 Kn | 593.84 Kn | 746.5392 Kn | 882.27 Kn | 3323 Kn |

Skin friction resistance due to cohesive soil layers

$$\sum (\alpha Cu As) = 7531.00 \text{ kN}$$

Skin friction resistance due to granular soil layers

$$\sum (K \times Pd \times \tan \delta \times As) = 0 \text{ kN}$$

Negtaive skin friction

$$= 188.275 \text{ kN}$$

Total Skin friction resistance of the pile, qs

$$R_f = \sum (\alpha Cu As + K \times Pd \times \tan \delta \times As) = 7342.72$$

Calculation of End bearing resistance

| | |
|--|---|
| Type of bearing strata | Clay |
| C/S area of Pile | 1.131 sqm |
| Length of Pile (L) | 42 m |
| SPT value (N) | |
| Angle of internal friction of soil (φ) | φ 0 |
| Bearing capacity factor | Nc 9 |
| | Nq 17 |
| | Nγ 0 |
| Effective over burden pressure | Pd 0 Kn/m2 |
| Total End bearing resistance of the pile (Qp) | Qp= Ap*(1/2*D*γ*Nr+Pd*Nq)+(Ap*Nc*cp)= 1781.283 kN |
| Ultimate load carrying capacity | Qu= Qs+Qp = 9124.01 |
| Safe load carrying capacity | Qsafe= 3649.602 kN |
| The Safe load carrying capacity of pile= | 365 t |

The Recommended vertical load carrying capacity is 360t

Ultimate Uplift load carrying capacity is 5139.91 Kn

The Safe Uplift load carrying capacity is 1439.75 Kn
143.975 Tonnes

The Recommended Uplift load carrying capacity is 140.00 Tonnes

**DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO
MOREH, ADB TA - 8116 IND**

**ESTIMATION OF LATERAL LOAD CARRYING CAPACITY OF PILES for 1A
(LILONG) MAJOR BRIDGE AT CH: 330+150**

Stipulations of IS:2911 (Part I/Sec.2) - 1979 are followed

| | | |
|--|---|----------------------------|
| Diameter of Pile | = | 1200 mm |
| Strength of Pile Concrete | = | 35 N/mm ² |
| Young's Modulus of Pile Concrete | = | 31500 N/mm ² |
| | = | 31500000 kN/m ² |
| Moment of Inertia of Pile Cross Section | = | 1.02E+11 mm ⁴ |
| | = | 0.1018 m ⁴ |
| Top Layer of sub-soil strata | = | Clay |
| Value of Constant, k1 | = | 7333 kN/m ³ |
| T | = | 4.57 m |
| Unsupported Length, L ₁ | = | 8.000 m |
| L ₁ /T | = | 1.750 |
| L ₁ /T | = | 1.95 |
| L ₁ (Ref Fig.2, Appendix C of IS 2911 (Part 1/Sec.2) - 1979 | = | 8.917 m |
| Cantilever span of pile | = | 16.9 m |
| Lateral Deflection at bottom of pile cap level under unit lateral load | = | 0.000126 m |
| Lateral Deflection at Top of PILE | = | 0.1258 mm |
| Corresponding Deflection at scour level | = | 0.0663 mm |
| Allowable deflection at scour level | = | 12 mm |
| Force that causes 12mm Lateral Deflection at scour level | = | 180.934 kN |
| Thus, Lateral Capacity of INDIVIDUAL PILE | = | 180.934 kN |

NOTE: The recommended lateral load carrying capacity is 18 tonnes

**DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO
MOREH, ADB TA - 8116 IND**

**ESTIMATION OF LATERAL LOAD CARRYING CAPACITY OF PILES for 1B
(LILONG) MAJOR BRIDGE AT CH: 330+150**

Stipulations of IS:2911 (Part I/Sec.2) - 1979 are followed

| | | |
|--|---|------------------------------|
| Diameter of Pile | = | 1200 mm |
| Strength of Pile Concrete | = | 40 N/mm ² |
| Young's Modulus of Pile Concrete | = | 31623 N/mm ² |
| | = | 31622776.6 kN/m ² |
| Moment of Inertia of Pile Cross Section | = | 1.02E+11 mm ⁴ |
| | = | 0.1018 m ⁴ |
| Top Layer of sub-soil strata | = | Clay |
| Value of Constant, k ₁ | = | 4667 kN/m ³ |
| T | = | 5.12 m |
| Unsupported Length, L ₁ | = | 5.300 m |
| L ₁ /T | = | 1.034 |
| L _i /T | = | 2.00 |
| L _i (Ref Fig.2, Appendix C of IS 2911 (Part 1/Sec.2) - 1979 | = | 10.249 m |
| Cantilever span of pile | = | 15.5 m |
| Lateral Deflection at bottom of pile cap level under unit lateral load | = | 0.000097 m |
| Lateral Deflection at Top of PILE | = | 0.0973 mm |
| Corresponding Deflection at scour level | = | 0.0642 mm |
| Allowable deflection at scour level | = | 12 mm |
| Force that causes 12mm Lateral Deflection at scour level | = | 187.035 kN |
| Thus, Lateral Capacity of INDIVIDUAL PILE | = | 187.035 kN |

NOTE: The recommended lateral load carrying capacity is 18 tonnes

**DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO
MOREH, ADB TA - 8116 IND**

**ESTIMATION OF LATERAL LOAD CARRYING CAPACITY OF PILES for 1C
(LILONG) MAJOR BRIDGE AT CH: 330+150**

Stipulations of IS:2911 (Part I/Sec.2) - 1979 are followed

| | | |
|--|---|----------------------------|
| Diameter of Pile | = | 1200 mm |
| Strength of Pile Concrete | = | 35 N/mm ² |
| Young's Modulus of Pile Concrete | = | 31500 N/mm ² |
| | = | 31500000 kN/m ² |
| Moment of Inertia of Pile Cross Section | = | 1.02E+11 mm ⁴ |
| | = | 0.1018 m ⁴ |
| Top Layer of sub-soil strata | = | Clay |
| Value of Constant, k ₁ | = | 7333 kN/m ³ |
| T | = | 4.57 m |
| Unsupported Length, L ₁ | = | 8.000 m |
| L ₁ /T | = | 1.750 |
| L ₁ /T | = | 1.95 |
| L _f (Ref Fig.2, Appendix C of IS 2911 (Part 1/Sec.2) - 1979 | = | 8.917 m |
| Cantilever span of pile | = | 16.9 m |
| Lateral Deflection at bottom of pile cap level under unit lateral load | = | 0.000126 m |
| Lateral Deflection at Top of PILE | = | 0.1258 mm |
| Corresponding Deflection at scour level | = | 0.0663 mm |
| Allowable deflection at scour level | = | 12 mm |
| Force that causes 12mm Lateral Deflection at scour level | = | 180.934 kN |
| Thus, Lateral Capacity of INDIVIDUAL PILE | = | 180.934 kN |

NOTE: The recommended lateral load carrying capacity is 18 tonnes

TABLE-A1.1: RESULT SHEET FOR MINOR BRIDGE AT CH.330+150 ON BH-331/1A

(W.T. = 2.40M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND****Size of Hole : Nx Size****Type of Bit : TC / Diamond****Starting date : 11.12.2013****Completion date : 15.12.2013**

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|-----------------------|-----------|-------|------------------|
| | 15 | 30 | 45 | N | | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 1.0 | 5 | 9 | 13 | 22 | CLAYEY SAND (SC) MIXED WITH GRAVELS | 11.13 | 47.30 | 14.55 | 27.02 | 35.5 | 18.50 | - | 2.72 | - | - | - | 15.0 | - |
| 2.0 | | | | | | | | | | | | | | | | | | |
| 3.0 | 8 | 11 | 14 | 25 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 2.70 | 30.83 | 14.62 | 51.85 | 51.40 | 22.17 | - | 2.68 | - | - | - | 36.4 | - |
| 4.0 | 9 | 11 | 10 | 21 | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | | | | | |
| 6.0 | 3 | 4 | 5 | 9 | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | |
| 8.0 | 3 | 3 | 7 | 10 | | | | | | | | | | | | | | |
| 9.0 | 4 | 6 | 7 | 13 | | | | | | | | | | | | | | |

* = Consolidation Test,

c_c = Compression Index,

DFS = Differential Free Swell,

—v = Water Table,

Sp = Swelling Pressure

TABLE-A1.1: RESULT SHEET FOR MINOR BRIDGE AT CH.330+150 ON BH-331/1A

(W.T. = 2.40M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 11.12.2013

Completion date : 15.12.2013

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 10.0 | 4 | 5 | 10 | 15 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 0.33 | 24.57 | 22.53 | 52.57 | 59.7 | 26.30 | - | 2.71 | - | - | - | 35.0 | |
| 11.0 | | | | | | | | | | | | | | | | | | |
| 12.0 | 5 | 8 | 11 | 19 | | | | | | | | | | | | | | |
| 13.0 | 4 | 9 | 12 | 21 | MEDIUM PLASTIC CLAY (CI) MIXED WITH SAND | 0.40 | 22.36 | 27.03 | 50.21 | 42.8 | 21.50 | - | 2.68 | - | - | - | 24.2 | |
| 14.0 | | | | | | | | | | | | | | | | | | |
| 15.0 | 5 | 10 | 13 | 23 | | | | | | | | | | | | | | |
| 16.0 | 6 | 10 | 14 | 24 | | | | | | | | | | | | | | |
| 17.0 | | | | | | | | | | | | | | | | | | |
| 18.0 | 6 | 9 | 16 | 25 | | | | | | | | | | | | | | |

* = Consolidation Test,

c_c = Compression Index,

DFS = Differential Free Swell,

—v = Water Table,

Sp = Swelling Pressure

TABLE-A1.1: RESULT SHEET FOR MINOR BRIDGE AT CH.330+150 ON BH-331/1A

(W.T. = 2.40M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 11.12.2013

Completion date : 15.12.2013

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 19.0 | 7 | 11 | 16 | 27 | MEDIUM PLASTIC CLAY (CI) MIXED WITH SAND | 0.00 | 31.95 | 14.97 | 53.08 | 38.0 | 21.0 | - | 2.71 | - | - | - | 22.7 | |
| 20.0 | | | | | | | | | | | | | | | | | | |
| 21.0 | 8 | 13 | 17 | 30 | | | | | | | | | | | | | | |
| 22.0 | 9 | 14 | 20 | 34 | | | | | | | | | | | | | | |
| 23.0 | | | | | | | | | | | | | | | | | | |
| 24.0 | 9 | 16 | 22 | 38 | | | | | | | | | | | | | | |
| 25.0 | | | | | | | | | | | | | | | | | | |
| 26.0 | 8 | 16 | 23 | 39 | | | | | | | | | | | | | | |
| 27.0 | 9 | 17 | 25 | 42 | | | | | | | | | | | | | | |

* = Consolidation Test,

c_c = Compression Index,

DFS

= Differential Free Swell,

W = Water Table,

Sp = Swelling Pressure

TABLE-A1.1: RESULT SHEET FOR MINOR BRIDGE AT CH.330+150 ON BH-331/1A

(W.T. = 2.40M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 11.12.2013

Completion date : 15.12.2013

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 28.0 | 10 | 19 | 27 | 46 | MEDIUM PLASTIC CLAY (CI) MIXED WITH SAND | 0.00 | 30.10 | 20.97 | 48.93 | 44.8 | 23.0 | - | - | - | - | - | 19.0 | |
| 29.0 | | | | | | | | | | | | | | | | | | |
| 30.0 | 11 | 21 | 29 | 50 | | | | | | | | | | | | | | |
| 31.0 | | | | | | | | | | | | | | | | | | |
| 32.0 | | | | | | | | | | | | | | | | | | |
| 33.0 | | | | | | | | | | | | | | | | | | |
| 34.0 | | | | | | | | | | | | | | | | | | |
| 36.0 | | | | | | | | | | | | | | | | | | |
| 37.0 | | | | | | | | | | | | | | | | | | |

* = Consolidation Test, c_c = Compression Index, DFS = Differential Free Swell, —v = Water Table, Sp = Swelling Pressure

TABLE-A1.2: RESULT SHEET FOR MINOR BRIDGE AT CH.330+150 ON BH-331/1B

(W.T. = 2.60M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND****Size of Hole : Nx Size****Type of Bit : TC / Diamond****Starting date : 15.12.2013****Completion date : 16.12.2013**

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|-----------------------|-----------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 1.0 | 5 | 8 | 12 | 20 | CLAYEY SAND (SC) MIXED WITH GRAVELS | 14.24 | 52.48 | 11.65 | 21.63 | 38.2 | 18.5 | - | 2.72 | - | - | - | 22.0 | - |
| 2.0 | | | | | | | | | | | | | | | | | | |
| 3.0 | 6 | 9 | 13 | 22 | | | | | | | | | | | | | | |
| 4.0 | 4 | 5 | 6 | 11 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 6.25 | 23.23 | 15.52 | 55.01 | 55.4 | 23.5 | - | 2.69 | - | - | - | 38.0 | - |
| 5.0 | | | | | | | | | | | | | | | | | | |
| 6.0 | 3 | 4 | 6 | 10 | | | | | | | | | | | | | | |
| 7.0 | 3 | 5 | 7 | 12 | | | | | | | | | | | | | | |
| 8.0 | | | | | | | | | | | | | | | | | | |
| 9.0 | 4 | 6 | 8 | 14 | | | | | | | | | | | | | | |

* = Consolidation Test,

c_c = Compression Index,

DFS = Differential Free Swell,

—v = Water Table,

Sp = Swelling Pressure

TABLE-A1.2: RESULT SHEET FOR MINOR BRIDGE AT CH.330+150 ON BH-331/1B

(W.T. = 2.60M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 15.12.2013

Completion date : 16.12.2013

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|--|---|-----------|-----------|-----------|----------------------|-----------------------|--|---------------------|-------------------------------------|-----------------------|-----------|----------|---------------------|
| | 15 | 30 | 45 | N | Soil Descreption | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 10.0 | 5 | 7 | 8 | 15 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 0.40 | 22.15 | 23.24 | 54.22 | 62.0 | 22.10 | - | 2.71 | - | - | - | 41.0 | |
| 11.0 | | | | | | | | | | | | | | | | | | |
| 12.0 | 5 | 7 | 9 | 16 | | | | | | | | | | | | | | |
| 13.0 | 4 | 8 | 10 | 18 | | 0.50 | 29.48 | 14.01 | 56.02 | 58.8 | 23.40 | - | - | - | - | - | 36.0 | |
| 14.0 | | | | | | | | | | | | | | | | | | |
| 15.0 | 6 | 9 | 11 | 20 | | | | | | | | | | | | | | |
| 16.0 | 7 | 10 | 12 | 22 | | | | | | | | | | | | | | |
| 17.0 | | | | | | | | | | | | | | | | | | |
| 18.0 | 8 | 11 | 13 | 24 | | | | | | | | | | | | | | |

* = Consolidation Test,

c_c = Compression Index,

DFS

= Differential Free Swell,

—v = Water Table,

Sp = Swelling Pressure

TABLE-A1.2: RESULT SHEET FOR MINOR BRIDGE AT CH.330+150 ON BH-331/1B**(W.T. = 2.60M)****PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH****ADB TA - 8116 IND****Size of Hole : Nx Size****Type of Bit : TC / Diamond****Starting date : 15.12.2013****Completion date : 16.12.2013**

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Descreption | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 19.0 | 7 | 9 | 15 | 24 | MEDIUM PLASTIC CLAY (CI) MIXED WITH SAND | 0.46 | 26.94 | 15.97 | 56.63 | 39.0 | 21.5 | - | 2.71 | - | - | - | 24.0 | |
| 20.0 | | | | | | | | | | | | | | | | | | |
| 21.0 | 7 | 11 | 15 | 26 | | | | | | | | | | | | | | |
| 22.0 | 8 | 12 | 16 | 28 | | | | | | | | | | | | | | |
| 23.0 | | | | | | | | | | | | | | | | | | |
| 24.0 | 9 | 14 | 28 | 32 | | | | | | | | | | | | | | |
| 25.0 | | | | | | | | | | | | | | | | | | |
| 26.0 | 9 | 16 | 21 | 37 | | | | | | | | | | | | | | |
| 27.0 | 10 | 17 | 23 | 40 | | | | | | | | | | | | | | |

* = Consolidation Test,

c_c = Compression Index,

DFS

= Differential Free Swell,

—v = Water Table,

Sp = Swelling Pressure

TABLE-A1.2: RESULT SHEET FOR MINOR BRIDGE AT CH.330+150 ON BH-331/1B

(W.T. = 2.60M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 15.12.2013

Completion date : 16.12.2013

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 28.0 | 11 | 20 | 24 | 44 | MEDIUM PLASTIC CLAY (CI) MIXED WITH SAND | 1.70 | 27.53 | 21.23 | 49.54 | 42.0 | 20.5 | - | - | - | - | - | 27.0 | |
| 29.0 | | | | | | | | | | | | | | | | | | |
| 30.0 | 12 | 23 | 27 | 50 | | | | | | | | | | | | | | |
| 31.0 | | | | | | | | | | | | | | | | | | |
| 32.0 | | | | | | | | | | | | | | | | | | |
| 33.0 | | | | | | | | | | | | | | | | | | |
| 34.0 | | | | | | | | | | | | | | | | | | |
| 36.0 | | | | | | | | | | | | | | | | | | |
| 37.0 | | | | | | | | | | | | | | | | | | |

* = Consolidation Test,

c_c = Compression Index,

DFS

= Differential Free Swell,

—v = Water Table,

Sp = Swelling Pressure

TABLE-A1.3: RESULT SHEET FOR MINOR BRIDGE AT CH.330+150 ON BH-331/1C

(W.T. = 2.70M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH

ADB TA - 8116 IND

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 30.12.2013

Completion date : 31.12.2013

| Depth (m) | N - value | | | | IS Classification Soil Descreption | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content,% (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|---|-----------|-----------|-----------|----------------------|-----------------------|---|---------------------|-------------------------------------|-----------------------|-----------|----------|---------------------|
| | 15 | 30 | 45 | N | | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | C t/m ² | ø deg. | | |
| 1.0 | 4 | 8 | 9 | 17 | FILLED-UP MATERIAL | | | | | | | | | | | | | |
| 2.0 | | | | | CLAYEY SAND (SC) MIXED WITH GRAVELS | | | | | | | | | | | | | |
| 3.0 | 5 | 8 | 10 | 18 | | 19.67 | 54.83 | 8.93 | 16.58 | 36.50 | 18.00 | - | 2.71 | - | - | - | 21.5 | - |
| 4.0 | 6 | 9 | 12 | 21 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | | | | | |
| 6.0 | 2 | 3 | 3 | 6 | | | | | | | | | | | | | | |
| 7.0 | 2 | 2 | 3 | 5 | | 0.00 | 22.18 | 17.12 | 60.70 | 58.0 | 23.40 | - | 2.68 | - | - | - | 28.9 | - |
| 8.0 | | | | | | | | | | | | | | | | | | |
| 9.0 | 3 | 3 | 4 | 7 | | | | | | | | | | | | | | |

* = Consolidation Test,

c_c = Compression Index,

DFS = Differential Free Swell,

—v = Water Table,

Sp = Swelling Pressure

TABLE-A1.3: RESULT SHEET FOR MINOR BRIDGE AT CH.330+150 ON BH-331/1C

(W.T. = 2.70M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 30.12.2013

Completion date : 31.12.2013

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 10.0 | 3 | 4 | 4 | 8 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 6.40 | 20.93 | 21.80 | 50.87 | 61.3 | 25.5 | - | - | - | - | - | 37.30 | |
| 11.0 | | | | | | | | | | | | | | | | | | |
| 12.0 | 3 | 3 | 5 | 8 | | | | | | | | | | | | | | |
| 13.0 | 2 | 4 | 5 | 9 | MEDIUM PLASTIC CLAY (CI) MIXED WITH SAND | 0.00 | 21.56 | 27.45 | 50.99 | 43.7 | 21.6 | - | 2.71 | - | - | - | 30.50 | |
| 14.0 | | | | | | | | | | | | | | | | | | |
| 15.0 | 3 | 4 | 6 | 10 | | | | | | | | | | | | | | |
| 16.0 | 4 | 5 | 5 | 10 | | | | | | | | | | | | | | |
| 17.0 | | | | | | | | | | | | | | | | | | |
| 18.0 | 4 | 5 | 7 | 12 | | | | | | | | | | | | | | |

* = Consolidation Test,

c_c = Compression Index,

DFS

= Differential Free Swell,

—v = Water Table,

Sp = Swelling Pressure

TABLE-A1.3: RESULT SHEET FOR MINOR BRIDGE AT CH.330+150 ON BH-331/1C

(W.T. = 2.70M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 30.12.2013

Completion date : 31.12.2013

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 19.0 | 5 | 6 | 8 | 14 | MEDIUM PLASTIC CLAY (CI) MIXED WITH SAND | 0.00 | 22.05 | 17.15 | 60.80 | 36.90 | 21.0 | - | 2.72 | - | - | - | 32.0 | - |
| 20.0 | | | | | | | | | | | | | | | | | | |
| 21.0 | 6 | 7 | 10 | 17 | | | | | | | | | | | | | | |
| 22.0 | 7 | 8 | 12 | 20 | | | | | | | | | | | | | | |
| 23.0 | | | | | | | | | | | | | | | | | | |
| 24.0 | 8 | 9 | 13 | 22 | | | | | | | | | | | | | | |
| 25.0 | | | | | | | | | | | | | | | | | | |
| 26.0 | 7 | 10 | 15 | 25 | | | | | | | | | | | | | | |
| 27.0 | 8 | 11 | 16 | 27 | | | | | | | | | | | | | | |

* = Consolidation Test,

c_c = Compression Index,

DFS

= Differential Free Swell,

—v = Water Table,

Sp = Swelling Pressure

TABLE-A1.3: RESULT SHEET FOR MINOR BRIDGE AT CH.330+150 ON BH-331/1C

(W.T. = 2.70M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 30.12.2013

Completion date : 31.12.2013

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 28.0 | 9 | 12 | 19 | 31 | MEDIUM PLASTIC CLAY (CI) MIXED WITH SAND | 0.00 | 24.87 | 22.54 | 52.59 | 47.0 | 21.3 | - | - | - | - | - | 28.0 | |
| 29.0 | | | | | | | | | | | | | | | | | | |
| 30.0 | 9 | 14 | 21 | 35 | | | | | | | | | | | | | | |
| 31.0 | | | | | | | | | | | | | | | | | | |
| 32.0 | | | | | | | | | | | | | | | | | | |
| 33.0 | | | | | | | | | | | | | | | | | | |
| 34.0 | | | | | | | | | | | | | | | | | | |
| 36.0 | | | | | | | | | | | | | | | | | | |
| 37.0 | | | | | | | | | | | | | | | | | | |

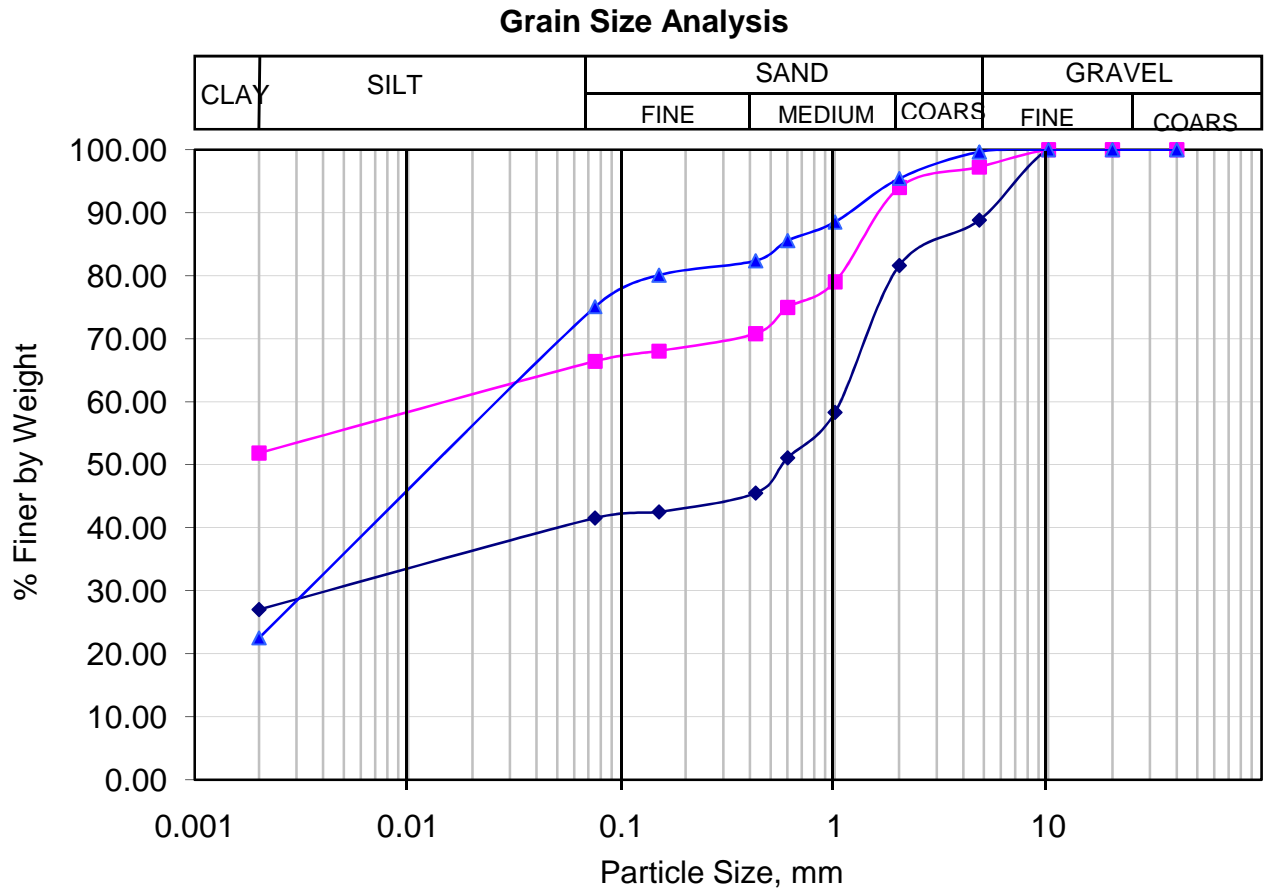
* = Consolidation Test, c_c = Compression Index, DFS = Differential Free Swell, —v = Water Table, Sp = Swelling Pressure

PNT DESIGNS PVT. LTD., KOTA

PROJECT - DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH,
ADB TA - 8116 IND

Determination of Grain Size Analysis Test as per IS:2720-Part 4-1985

MJB AT CH: 330+150 (331/1A)



| Symbol | BH No. | Depth,m | Soil description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|--------|-----------|---------|------------------|------------|----------|----------|----------|
| ◆ | BH-331/1A | 1.50 | SC* | 11.13 | 47.30 | 14.55 | 27.02 |
| ■ | BH-331/1A | 6.00 | CH* | 2.70 | 30.83 | 14.62 | 51.85 |
| ▲ | BH-331/1A | 12.00 | CH* | 0.33 | 24.57 | 22.53 | 52.57 |

SC* = CLAYEY SAND (SC) MIXED WITH GRAVELS

CI* = MEDIUM PLASTIC CLAY (CI) MIXED WITH SAND

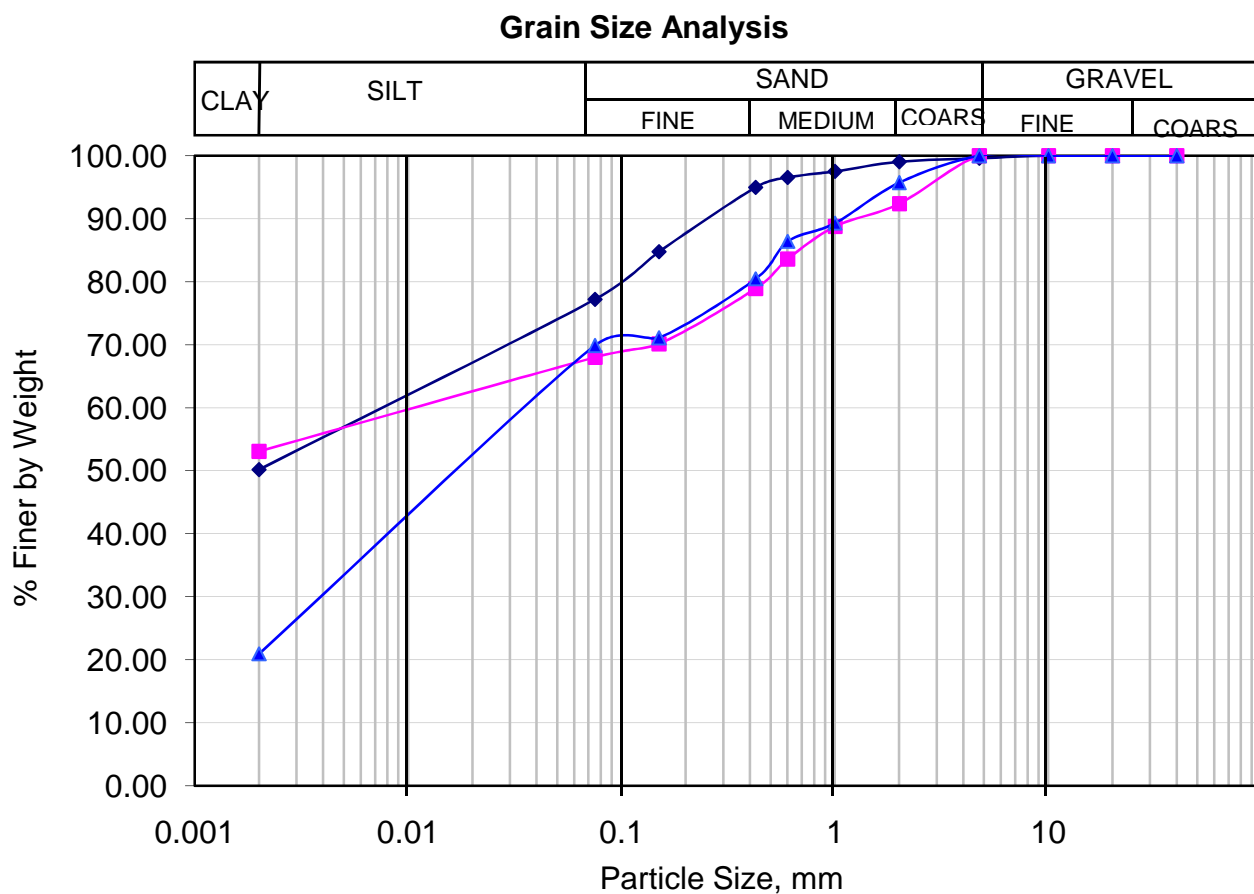
Depth = 1.50 Weighted Mean Dia, d_m = 1.53 mm, $f = 2.17$

PNT DESIGNS PVT. LTD., KOTA

PROJECT - DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH,
ADB TA - 8116 IND

Determination of Grain Size Analysis Test as per IS:2720-Part 4-1985

MJB AT CH: 330+150 (331/1A)



| Symbol | BH No. | Depth,m | Soil description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|--------|-----------|---------|------------------|------------|----------|----------|----------|
| ◆ | BH-331/1A | 18.00 | CI* | 0.40 | 22.36 | 27.03 | 50.21 |
| ■ | BH-331/1A | 22.50 | CI* | 0.00 | 31.95 | 14.97 | 53.08 |
| ▲ | BH-331/1A | 28.50 | CI* | 0.00 | 30.10 | 20.97 | 48.93 |

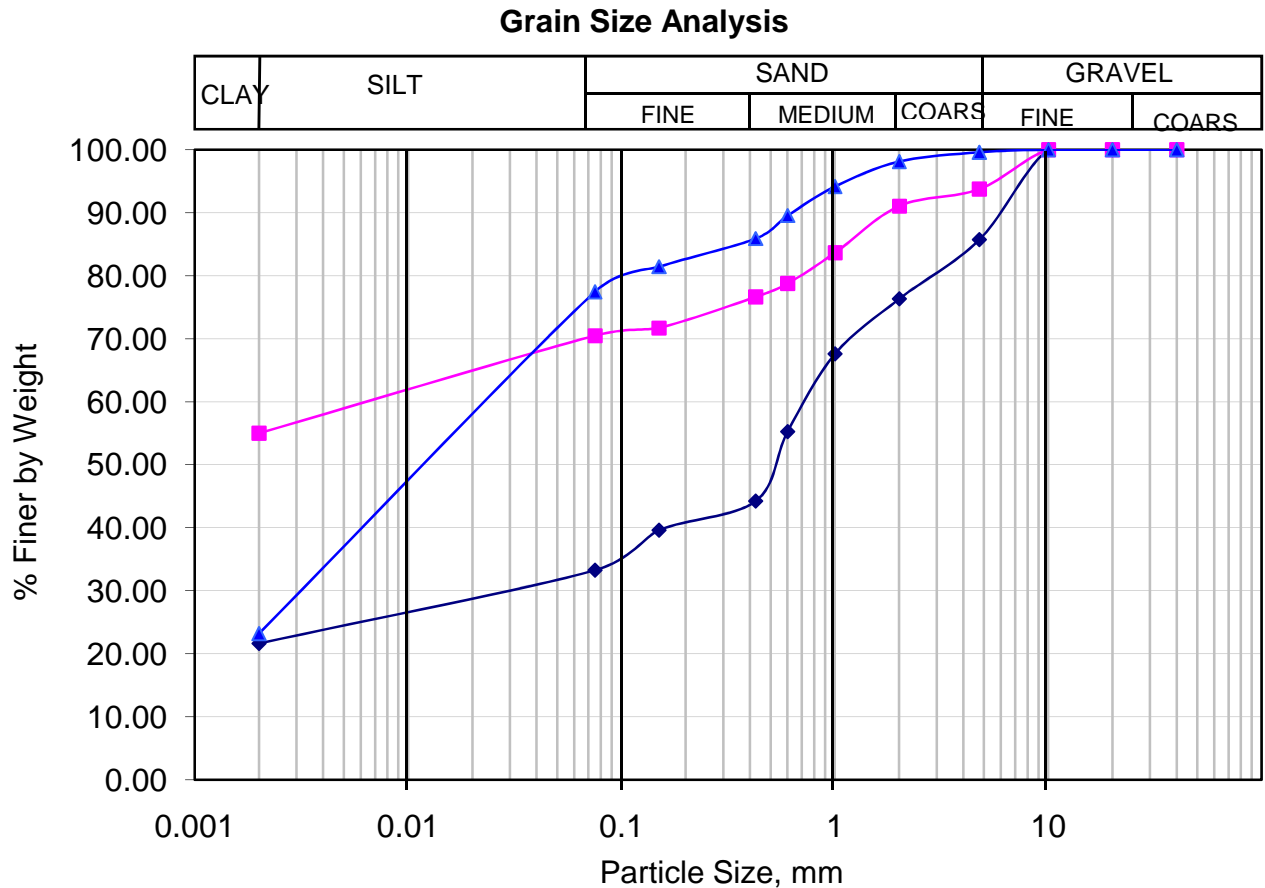
CI* = MEDIUM PLASTIC CLAY (CI) MIXED WITH SAND

PNT DESIGNS PVT. LTD., KOTA

PROJECT - DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH,
ADB TA - 8116 IND

Determination of Grain Size Analysis Test as per IS:2720-Part 4-1985

MJB AT CH: 330+150 (331/1B)



| Symbol | BH No. | Depth,m | Soil description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|--------|-----------|---------|------------------|------------|----------|----------|----------|
| —◆— | BH-331/1B | 3.00 | SC* | 14.24 | 52.48 | 11.65 | 21.63 |
| —■— | BH-331/1B | 7.50 | CH* | 6.25 | 23.23 | 15.52 | 55.01 |
| —▲— | BH-331/1B | 12.00 | CH* | 0.40 | 22.15 | 23.24 | 54.22 |

SC* = CLAYEY SAND (SC) MIXED WITH GRAVELS

CI* = MEDIUM PLASTIC CLAY (CI) MIXED WITH SAND

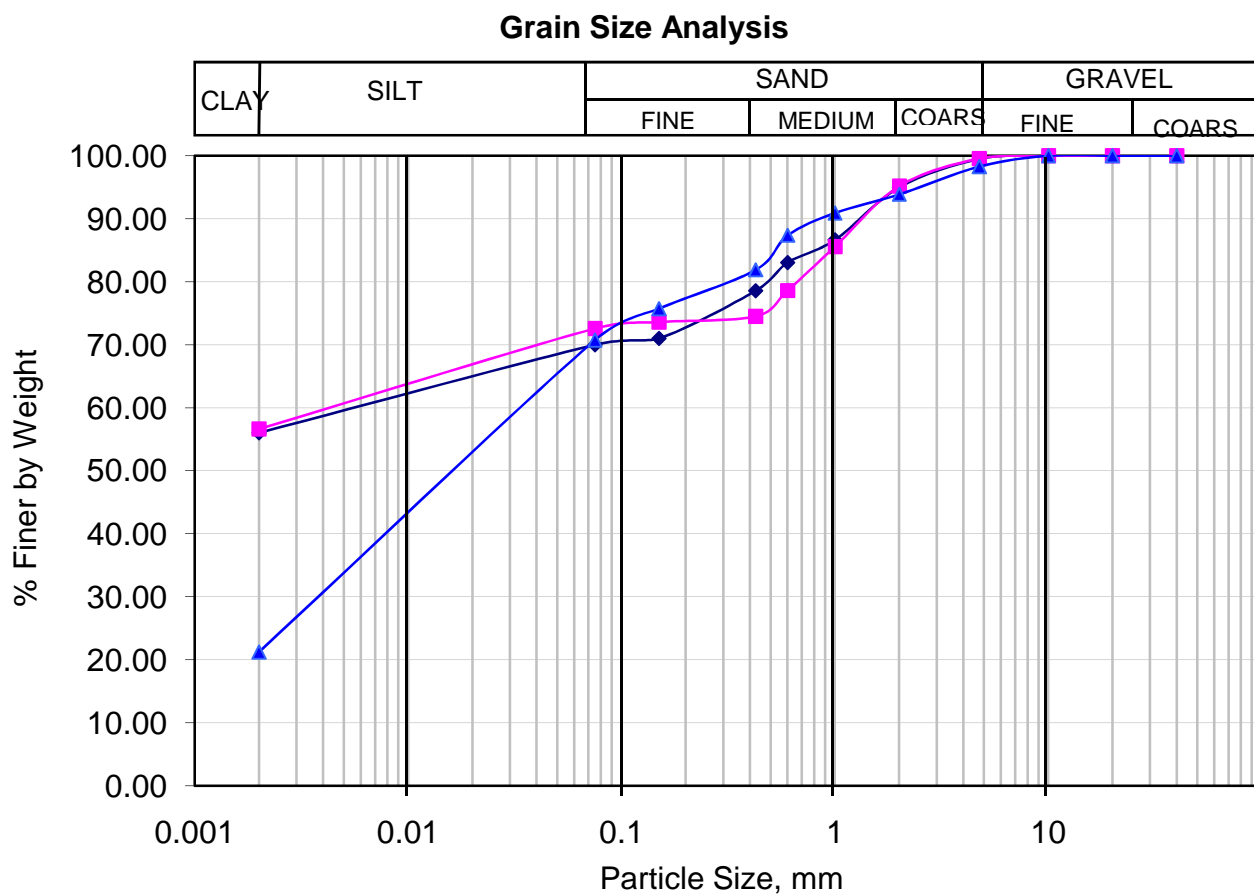
Depth = 3.00 Weighted Mean Dia, d_m = 1.69 mm, $f = 2.29$

PNT DESIGNS PVT. LTD., KOTA

PROJECT - DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH,
ADB TA - 8116 IND

Determination of Grain Size Analysis Test as per IS:2720-Part 4-1985

MJB AT CH: 330+150 (331/1B)



| Symbol | BH No. | Depth,m | Soil description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|--------|-----------|---------|------------------|------------|----------|----------|----------|
| ◆ | BH-331/1B | 18.00 | CI* | 0.50 | 29.48 | 14.01 | 56.02 |
| ■ | BH-331/1B | 22.50 | CI* | 0.46 | 26.94 | 15.97 | 56.63 |
| ▲ | BH-331/1B | 28.50 | CI* | 1.70 | 27.53 | 21.23 | 49.54 |

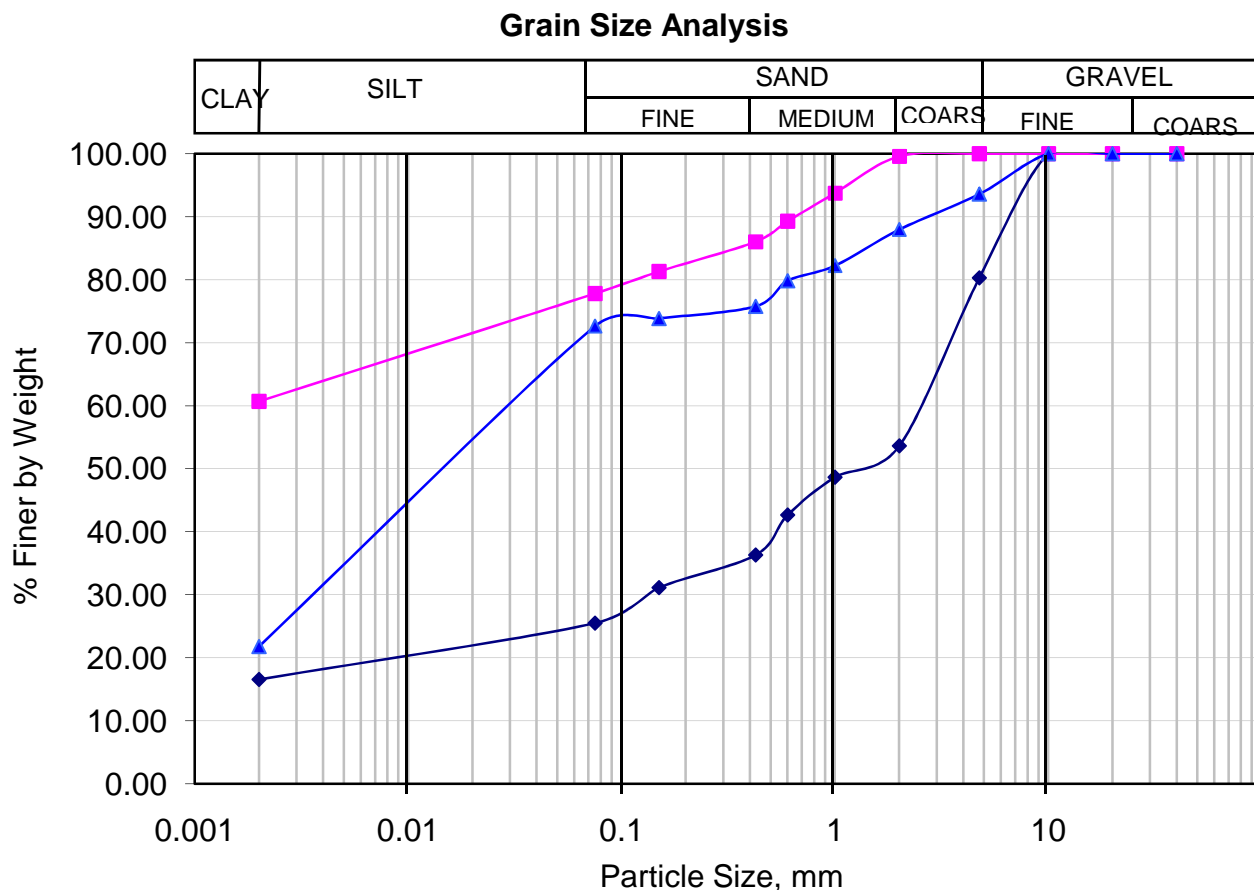
CI* = MEDIUM PLASTIC CLAY (CI) MIXED WITH SAND

PNT DESIGNS PVT. LTD., KOTA

PROJECT - DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH,
ADB TA - 8116 IND

Determination of Grain Size Analysis Test as per IS:2720-Part 4-1985

MJB AT CH: 330+150 (331/1C)



| Symbol | BH No. | Depth,m | Soil description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|--------|-----------|---------|------------------|------------|----------|----------|----------|
| —◆— | BH-331/1C | 3.00 | SC* | 19.67 | 54.83 | 8.93 | 16.58 |
| —■— | BH-331/1C | 7.50 | CH* | 0.00 | 22.18 | 17.12 | 60.70 |
| —▲— | BH-331/1C | 12.00 | CH* | 6.40 | 20.93 | 21.80 | 50.87 |

SC* = CLAYEY SAND (SC) MIXED WITH GRAVELS

CI* = MEDIUM PLASTIC CLAY (CI) MIXED WITH SAND

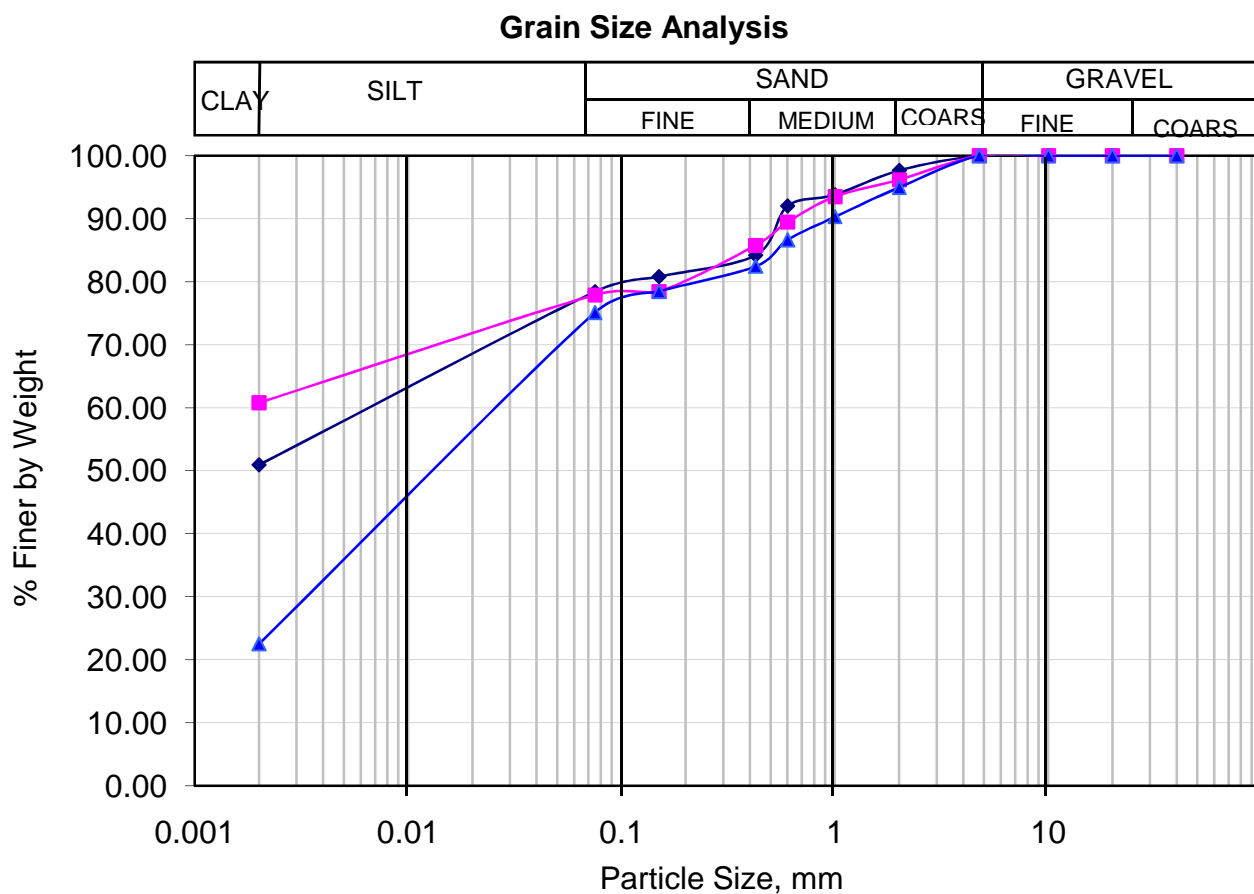
Depth = 3.00 Weighted Mean Dia, d_m = 2.54 mm, $f = 2.80$

PNT DESIGNS PVT. LTD., KOTA

PROJECT - DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH,
ADB TA - 8116 IND

Determination of Grain Size Analysis Test as per IS:2720-Part 4-1985

MJB AT CH: 330+150 (331/1C)



| Symbol | BH No. | Depth,m | Soil description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|--------|-----------|---------|------------------|------------|----------|----------|----------|
| ◆ | BH-331/1C | 18.00 | CI* | 0.00 | 21.56 | 27.45 | 50.99 |
| ■ | BH-331/1C | 22.50 | CI* | 0.00 | 22.05 | 17.15 | 60.80 |
| ▲ | BH-331/1C | 28.50 | CI* | 0.00 | 24.87 | 22.54 | 52.59 |

CI* = MEDIUM PLASTIC CLAY (CI) MIXED WITH SAND

SILT FACTOR CALCULATION BASED ON COHESION OF SOIL
MJB AT CH.330+150

Location : BH-348/1A

Depth : 4.70-15.0m

In order to determine maximum score depth the silt factor of the bad material is required to be determined. The silt factor (K_{sf}) depends upon the average size of bed material and given by Lacey equation as follows:

$$K_{sf} = 1.76 \sqrt{d_m} \quad \dots\dots 1$$

Where d_m = the weighted mean diameter in millimeter

Also, in case of soil having $\phi < 15^\circ$ and c (cohesion of soil) $> 0.2 \text{ kg/cm}^2$, ' K_{sf} ' calculated as follows :

$$K_{sf} = F (1 + \sqrt{c}) \text{ where } c \text{ is in } \text{kg/cm}^2 \quad \dots\dots 2$$

where $F = 1.50$ for $\phi > 10^\circ$ and $< 15^\circ$

$= 1.75$ for $\phi > 5^\circ$ and $< 10^\circ$

$= 2.00$ for $\phi < 5^\circ$

The strata at this location found to be highly plastic clay (CH). The silt factor has been calculated on the basis of undrained cohesion (c) of the soil using equation (2) above. The undrained cohesion has been obtained from SPT data recorded at the site. The calculation of silt factor is as follows :

| | | | |
|--|------------|-----------------------------|------------------|
| Design SPT-value of the Strata (Refusal, $N > 100$) | : | 11.75 | = (9+10+13+15)/4 |
| (below the Founding level) | : | | |
| Cohesion, $C_u = 6 \text{ N (kPa)}$ | : | 70.5 | |
| Angle of shearing resistance (restricted) ϕ | : | 0 | |
| Cohesion, $C_u (\text{kg/cm}^2)$ | : | 0.705 | |
| The silt factor shall be as follows : | : | $K_{sf} = F (1 + \sqrt{c})$ | |
| Where : | F | : 2 | |
| | $K_{sf} =$ | : $2 * (1 + \sqrt{0.705})$ | |
| | | : 3.68 | |

SILT FACTOR CALCULATION BASED ON COHESION OF SOIL
MJB AT CH.330+150

Location : BH-348/1B

Depth : 4.0-18.0m

In order to determine maximum score depth the silt factor of the bad material is required to be determined. The silt factor (K_{sf}) depends upon the average size of bed material and given by Lacey equation as follows:

$$K_{sf} = 1.76 \sqrt{d_m} \quad \dots\dots 1$$

Where d_m = the weighted mean diameter in millimeter

Also, in case of soil having $\phi < 15^\circ$ and c (cohesion of soil) $> 0.2 \text{ kg/cm}^2$, ' K_{sf} ' calculated as follows :

$$K_{sf} = F (1 + \sqrt{c}) \text{ where } c \text{ is in } \text{kg/cm}^2 \quad \dots\dots 2$$

where $F = 1.50$ for $\phi > 10^\circ$ and $< 15^\circ$

$= 1.75$ for $\phi > 5^\circ$ and $< 10^\circ$

$= 2.00$ for $\phi < 5^\circ$

The strata at this location found to be highly plastic clay (CH). The silt factor has been calculated on the basis of undrained cohesion (c) of the soil using equation (2) above. The undrained cohesion has been obtained from SPT data recorded at the site. The calculation of silt factor is as follows :

| | | | |
|--|------------|-----------------------------|-------------------|
| Design SPT-value of the Strata (Refusal, $N > 100$) | : | 11.75 | = (11+10+12+14)/4 |
| (below the Founding level) | : | | |
| Cohesion, $C_u = 6 \text{ N (kPa)}$ | : | 70.5 | |
| Angle of shearing resistance (restricted) ϕ | : | 0 | |
| Cohesion, $C_u (\text{kg/cm}^2)$ | : | 0.705 | |
| The silt factor shall be as follows : | : | $K_{sf} = F (1 + \sqrt{c})$ | |
| Where : | F | : 2 | |
| | $K_{sf} =$ | : $2 * (1 + \sqrt{0.705})$ | |
| | | : 3.68 | |

SILT FACTOR CALCULATION BASED ON COHESION OF SOIL
MJB AT CH.330+150

Location : BH-348/1C

Depth : 4.50-15.0m

In order to determine maximum score depth the silt factor of the bad material is required to be determined. The silt factor (K_{sf}) depends upon the average size of bed material and given by Lacey equation as follows:

$$K_{sf} = 1.76 \sqrt{d_m} \quad \dots\dots 1$$

Where d_m = the weighted mean diameter in millimeter

Also, in case of soil having $\phi < 15^\circ$ and c (cohesion of soil) $> 0.2 \text{ kg/cm}^2$, ' K_{sf} ' calculated as follows :

$$K_{sf} = F (1 + \sqrt{c}) \text{ where } c \text{ is in } \text{kg/cm}^2 \quad \dots\dots 2$$

where $F = 1.50$ for $\phi > 10^\circ$ and $< 15^\circ$

$= 1.75$ for $\phi > 5^\circ$ and $< 10^\circ$

$= 2.00$ for $\phi < 5^\circ$

The strata at this location found to be highly plastic clay (CH). The silt factor has been calculated on the basis of undrained cohesion (c) of the soil using equation (2) above. The undrained cohesion has been obtained from SPT data recorded at the site. The calculation of silt factor is as follows :

| | | | |
|--|---|-----------------------------|--------------------|
| Design SPT-value of the Strata (Refusal, $N > 100$) | : | 7.5 | = (6+5+7+8+9+10)/6 |
| (below the Founding level) | : | | |
| Cohesion, $C_u = 6 \text{ N (kPa)}$ | : | 45 | |
| Angle of shearing resistance (restricted) ϕ | : | 0 | |
| Cohesion, $C_u (\text{kg/cm}^2)$ | : | 0.45 | |
| The silt factor shall be as follows : | : | $K_{sf} = F (1 + \sqrt{c})$ | |
| Where : | : | 2 | |
| $K_{sf} =$ | : | $2 * (1 + \sqrt{0.45})$ | |
| | : | 3.34 | |

SILT FACTOR CALCULATIONS

MJB AT CH: 330+150 (331/1A)

Total Weight of Dry Soil Taken =

300

Depth =

1.5

| Sieve Size in mm | Average Size (mm) | Weight Retained in g | % Weight Retained | Cumulative % Retained | % Finer (N) | Weighted % weight retained |
|------------------|-------------------|----------------------|-------------------|-----------------------|--------------|----------------------------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 = (2X3) |
| 80 | | 0 | 0.00 | 0.00 | 100.00 | 0.000 |
| 40 | | 0 | 0.00 | 0.00 | 100.00 | 0.000 |
| 20 | 30 | 0 | 0.00 | 0.00 | 100.00 | 0.000 |
| 10 | 15 | 0 | 0.00 | 0.00 | 100.00 | 0.000 |
| 4.75 | 7.375 | 33.4 | 11.13 | 11.13 | 88.87 | 82.108 |
| 2 | 3.375 | 21.7 | 7.23 | 18.37 | 81.63 | 24.413 |
| 1 | 1.5 | 69.9 | 23.30 | 41.67 | 58.33 | 34.950 |
| 0.6 | 0.8 | 21.6 | 7.20 | 48.87 | 51.13 | 5.760 |
| 0.425 | 0.5125 | 16.8 | 5.60 | 54.47 | 45.53 | 2.870 |
| 0.15 | 0.2875 | 9 | 3.00 | 57.47 | 42.53 | 0.863 |
| 0.075 | 0.1125 | 2.9 | 0.97 | 58.43 | 41.57 | 0.109 |
| PAN | 0.0375 | 124.7 | 41.57 | 100.00 | 0.00 | 1.559 |
| | | Sum = | 100.00 | | | 152.631 |

Sum of Weighted % Weight retained on each seive

Mean Dia meter, dm = -----

Cummulative % retained

$$dm = 152.630833333333 / 100 = 1.53$$

$$\text{Silt Factor, } f = 1.76 \text{ Sqrt (dm)} = 2.17$$

SILT FACTOR CALCULATIONS

MJB AT CH: 330+150 (331/1B)

Total Weight of Dry Soil Taken =

250

Depth =

3

| Sieve Size in mm | Average Size (mm) | Weight Retained in g | % Weight Retained | Cumulative % Retained | % Finer (N) | Weighted % weight retained |
|------------------|-------------------|----------------------|-------------------|-----------------------|--------------|----------------------------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 = (2X3) |
| 80 | | 0 | 0.00 | 0.00 | 100.00 | 0.000 |
| 40 | | 0 | 0.00 | 0.00 | 100.00 | 0.000 |
| 20 | 30 | 0 | 0.00 | 0.00 | 100.00 | 0.000 |
| 10 | 15 | 0 | 0.00 | 0.00 | 100.00 | 0.000 |
| 4.75 | 7.375 | 35.6 | 14.24 | 14.24 | 85.76 | 105.020 |
| 2 | 3.375 | 23.5 | 9.40 | 23.64 | 76.36 | 31.725 |
| 1 | 1.5 | 21.8 | 8.72 | 32.36 | 67.64 | 13.080 |
| 0.6 | 0.8 | 30.9 | 12.36 | 44.72 | 55.28 | 9.888 |
| 0.425 | 0.5125 | 27.6 | 11.04 | 55.76 | 44.24 | 5.658 |
| 0.15 | 0.2875 | 11.5 | 4.60 | 60.36 | 39.64 | 1.323 |
| 0.075 | 0.1125 | 15.9 | 6.36 | 66.72 | 33.28 | 0.716 |
| PAN | 0.0375 | 83.2 | 33.28 | 100.00 | 0.00 | 1.248 |
| | | Sum = | 100.00 | | | 168.657 |

Sum of Weighted % Weight retained on each seive

Mean Dia meter, $dm = \frac{\text{Sum of Weighted \% Weight retained on each seive}}{\text{Cummulative \% retained}}$

Cummulative % retained

$$dm = 168.657 / 100 = 1.69$$

$$\text{Silt Factor, } f = 1.76 \sqrt{dm} = 2.29$$

SILT FACTOR CALCULATIONS

MJB AT CH: 330+150 (331/1C)

Total Weight of Dry Soil Taken =

300

Depth =

3

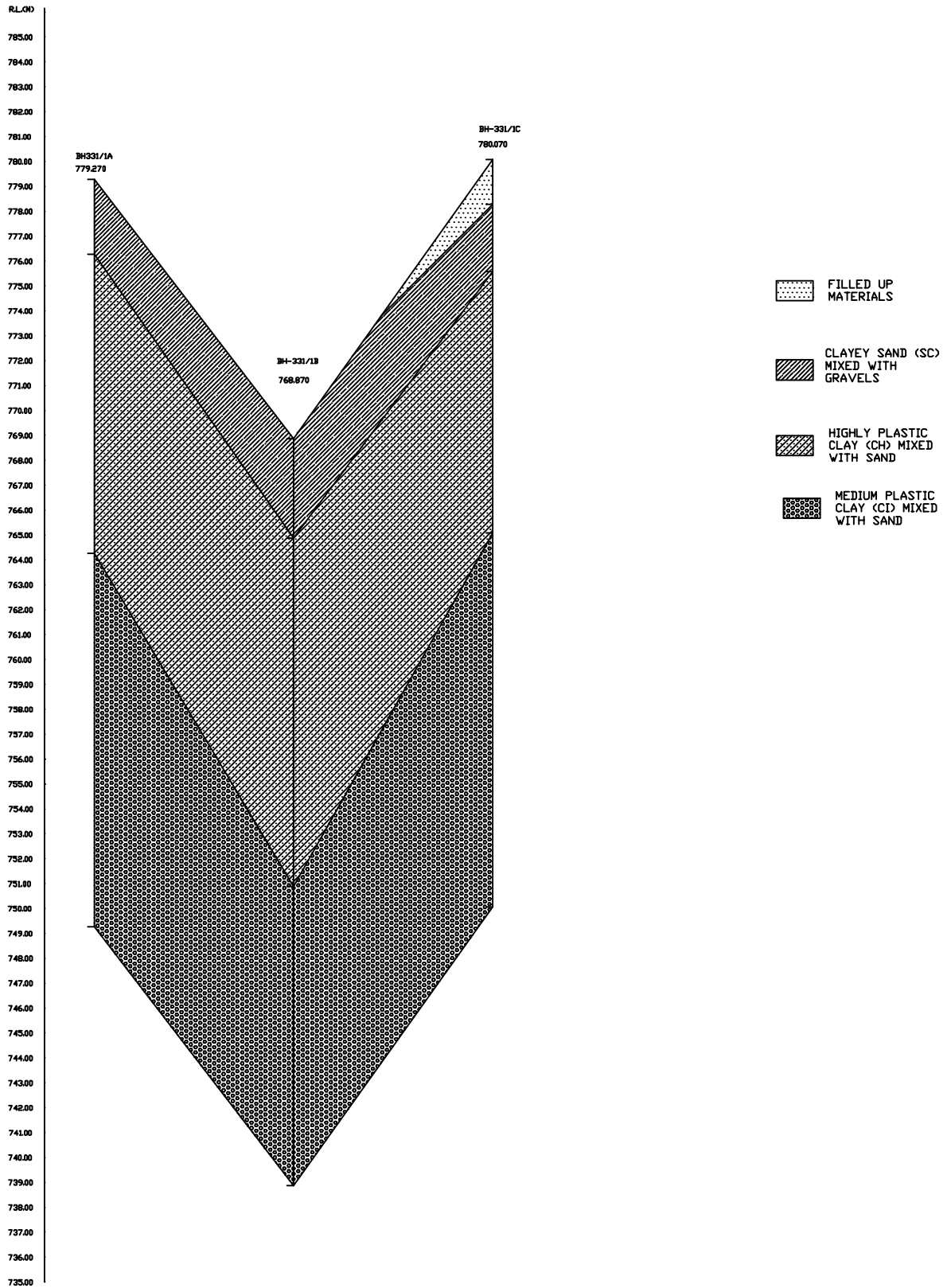
| Sieve Size in mm | Average Size (mm) | Weight Retained in g | % Weight Retained | Cumulative % Retained | % Finer (N) | Weighted % weight retained |
|------------------|-------------------|----------------------|-------------------|-----------------------|--------------|----------------------------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 = (2X3) |
| 80 | | 0 | 0.00 | 0.00 | 100.00 | 0.000 |
| 40 | | 0 | 0.00 | 0.00 | 100.00 | 0.000 |
| 20 | 30 | 0 | 0.00 | 0.00 | 100.00 | 0.000 |
| 10 | 15 | 0 | 0.00 | 0.00 | 100.00 | 0.000 |
| 4.75 | 7.375 | 59 | 19.67 | 19.67 | 80.33 | 145.042 |
| 2 | 3.375 | 80 | 26.67 | 46.33 | 53.67 | 90.000 |
| 1 | 1.5 | 15 | 5.00 | 51.33 | 48.67 | 7.500 |
| 0.6 | 0.8 | 18 | 6.00 | 57.33 | 42.67 | 4.800 |
| 0.425 | 0.5125 | 19 | 6.33 | 63.67 | 36.33 | 3.246 |
| 0.15 | 0.2875 | 15.6 | 5.20 | 68.87 | 31.13 | 1.495 |
| 0.075 | 0.1125 | 16.9 | 5.63 | 74.50 | 25.50 | 0.634 |
| PAN | 0.0375 | 76.5 | 25.50 | 100.00 | 0.00 | 0.956 |
| | | Sum = | 100.00 | | | 253.673 |

Sum of Weighted % Weight retained on each seive

Mean Dia meter, dm = -----

Cummulative % retained

$$\begin{aligned}
 dm &= 253.6725 / 100 &= & 2.54 \\
 \text{Silt Factor, } f &= 1.76 \text{ Sqrt } (dm) &= & 2.80
 \end{aligned}$$

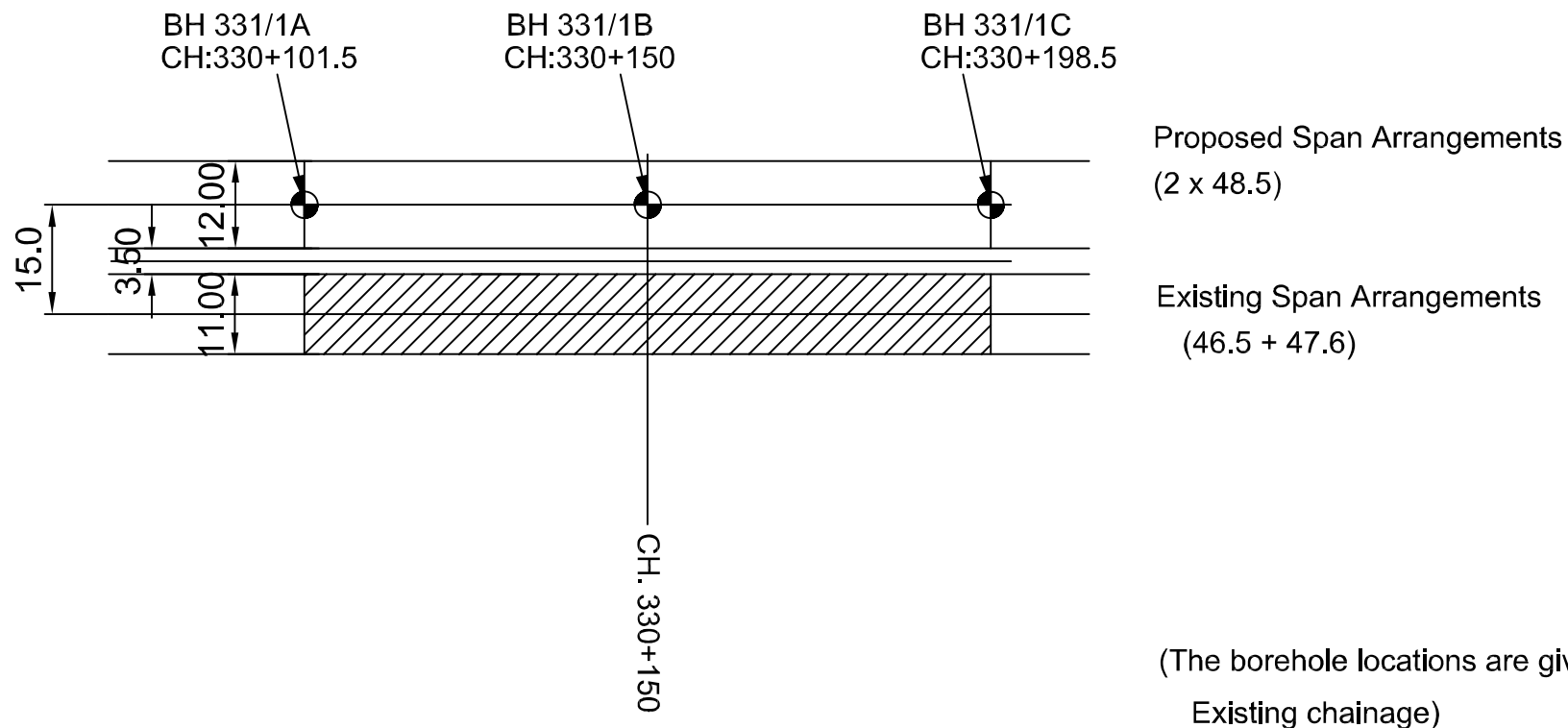


PROFILE : MAJOR BRIDGE AT CH.330+150
SOIL / ROCK PROFILE ALONG BH-331/1A, BH-331/1B,
& BH-331/1C

← IMPHAL

MOREH →

BOREHOLE LOCATION PLAN FOR MAJOR BRIDGE AT CH: 330+150 (Lilong)



(The borehole locations are given for
Existing chainage)

LEGEND:



Borehole Location



Existing Bridge

PROJECT

DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION
FROM IMPHAL TO MOREH, ADB TA - 8116 IND

Design Consultant :

SHELADIA ASSOCIATES INC., USA



Amsri Shamira, Flat No: 206 & 207,
S D Road, Old Lancer Lanes,
Secunderabad - 500 003, AP.

GEOTECH REPORT FOR MAJOR BRIDGE

AT CH: 341+780

**Geotechnical Investigation Report for determination of allowable bearing pressure for
MAJOR BRIDGE at CH. 341+780 of NH-39 under
“DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH,
ADB TA - 8116 IND”**

ABSTRACT

The safe load carrying capacity of the foundation of MAJOR BRIDGE at Ch. 341+780 on NH-39 is recommended as follows:

| Location | | Bore hole Level (m) | Theoretical Scour Level (m) | Scour Depth Below Borehole (m) | Pile Cap Top Level (m) | Pile Cap Bottom Level (m) | Pile Tip Level (m) | Length of Pile (m) | Vertical Capacity (t) | Lateral Capacity (t) | Uplift Capacity (T) |
|----------|----|------------------------------|-----------------------------------|--|---------------------------------|---------------------------------|-----------------------|--------------------------|-----------------------------|----------------------------|---------------------------|
| 342/1A | A1 | 776.267 | 768.479 | 6.535 | 778.510 | 776.710 | 744.710 | 32 | 230 | 20 | 80 |
| 342/1B | P1 | 771.267 | 761.277 | 8.017 | 770.657 | 768.157 | 726.157 | 42 | 350 | 20 | 150 |
| 342/1C | A2 | 776.267 | 768.479 | 6.535 | 778.510 | 776.710 | 744.710 | 32 | 230 | 20 | 80 |

THE STRATA AT GLANCE AND SILT FACTORS

| Borehole No. | Type of strata | Depth | Weighted mean dia, d_m (mm) | Silt Factor, |
|--------------|--|-------------|-------------------------------|--------------|
| 1 | 2 | 3 | 4 | 5 |
| BH-342/1A | Filled-up Material | 0.0 - 2.1m | - | - |
| | Highly Plastic Clay (CH) mixed with Sand | 2.1 - 30.0m | - | 3.47 |
| BH-342/1B | Filled-up Material | 0.0 - 2.8m | - | - |
| | Highly Plastic Clay (CH) mixed with Sand | 2.8 - 27.0m | | 3.58 |
| BH-342/1C | Filled-up Material | 0-1.0m | - | - |
| | Highly Plastic Clay (CH) mixed with Sand | 1.0-30.0m | | 3.48 |

Geotechnical Investigation Report
for determination of allowable bearing pressure for
MAJOR BRIDGE at CH. 341+780 on NH-39 under
“Detailed Project for Indo Myanmar Road Section from Imphal to Moreh,
ADB TA - 8116 IND”

1. INTRODUCTION

Geotechnical investigation was carried out for MAJOR BRIDGE at Ch.341+780 on NH-39 under Detailed Project for Indo Myanmar Road Section from Imphal to Moreh, ADB TA - 8116 IND. The Schedule of work and the locations of bore holes were decided by Engineer In-charge of Sheladia Associates, Inc., USA. The locations of boreholes are shown in Key Plan (Fig.A2).

2.0 FIELD INVESTIGATION

2.1 Boring

Three bore holes i.e. BH-342/1A, BH-342/1B & BH-342/1C were made at the locations decided by Engineer In-charge as shown in Key Plan (Fig.A2). Boring was done by power driven rig as per guidelines of IS: 1892:1979 and IRC-78-2000. Boring was done up to the maximum depth of 30.0m. The soil samples were collected as required for laboratory testing.

2.2 Standard Penetration Test (SPT)

Standard penetration test (SPT) was conducted in the bore hole as per IS 2131-1981. The numbers of blows for first 15 cm penetration is considered as seating drive and are not taken into account. The number of blows required for last 30 cm penetration is taken as SPT number (“N” values). If number of blows for last 30 cm penetration exceeds 100, it is said to be the refusal. SPT were

conducted at regular interval of 1.5m, starting from the depth of 1.5m from the ground surface to the depth of exploration/ refusal. The tests results are shown in Table-A2.1 to A2.3.

2.3 Water Table

The water table was observed at the depth of 2.3m.-2.8m from ground surface, at the time of investigation (i.e. Dec-Jan 2013-14).

3.0 LABORATORY INVESTIGATION

Soil Samples:

The following laboratory tests were conducted on the soil samples obtained from test bore holes:

- a) Natural Moisture content
- b) Specific gravity
- c) Liquid & Plastic Limit
- d) Grain size Analysis
- e) Shear strength test
- f) Bulk density (Dry Density)
- g) Free swell test

Test results are shown in borelogs i.e. Table-A2.1 to A2.3.

4. TYPE OF STRATA

Based on laboratory and field investigation the strata at the site have been described. The bore-log of the strata is presented in Table-A2.1 to A2.3. The strata are as follows:

BH-342/1A

The upper layer of the strata thickness about 2.1m was found to be Filled-up Material. Below this, Highly Plastic Clay (CH) mixed with Gravels was found up to the depth of exploration i.e. 30.0m. The bore-log is shown in Table-A2.1.

BH-342/1B

The upper layer of the strata thickness about 2.8m was found to be Filled-up Material. Below this, Highly Plastic Clay (CH) mixed with Gravels was found up to the depth of exploration i.e. 27.0m. The bore-log is shown in Table-A2.2.

BH-342/1C

The upper layer of the strata thickness about 1.0m was found to be Filled-up Material. Below this, Highly Plastic Clay (CH) mixed with Gravels was found up to the depth of exploration i.e. 30.0m. The bore-log is shown in Table-A2.3.

5.0 FOUNDATION ANALYSIS

Pile foundation has been analyzed. The calculation sheets for safe load carrying capacity bearing capacity in vertical and uplift for different borehole locations are attached as Appendix-A2.1 to Appendix-A2.3. Also the lateral load carrying capacity is given in Appendix-A2.1.1 to Appendix- A2.3.1.

6.0 SILT FACTOR

In order to determine maximum score depth the silt factor of the bad material is required to be determine. The silt factor (f) depends upon the average size of bed material and given by Lacey equation as follows:

$$K_{sf} = 1.76 \sqrt{d_m}$$

Where d_m = the weighted mean diameter in millimeter

Also, in case of soil having $\phi < 15^\circ$ and c (cohesion of soil) $> 0.2 \text{ kg/cm}^2$, ' K_{sf} ' calculated as follows :

$$K_{sf} = F (1 + \sqrt{c}) \text{ where } c \text{ is in kg/cm}^2$$

where $F = 1.50$ for $\phi > 10^\circ$ and $< 15^\circ$

$$= 1.75 \text{ for } \phi > 5^0 \text{ and } < 10^0$$

$$= 2.00 \text{ for } \phi < 5^0$$

| orehole No. | Type of strata | Depth | Weighted mean dia, d_m (mm) | Silt Factor, |
|-------------|--|-------------|-------------------------------|--------------|
| 1 | 2 | 3 | 4 | 5 |
| BH-342/1A | Filled-up Material | 0.0 - 2.1m | - | - |
| | Highly Plastic Clay (CH) mixed with Sand | 2.1 - 30.0m | - | 3.47 |
| BH-342/1B | Filled-up Material | 0.0 - 2.8m | - | - |
| | Highly Plastic Clay (CH) mixed with Sand | 2.8 - 27.0m | | 3.58 |
| BH-342/1C | Filled-up Material | 0-1.0m | - | - |
| | Highly Plastic Clay (CH) mixed with Sand | 1.0-30.0m | | 3.48 |

7.0 CONCLUSION

1. The strata at the site is described in Section 4.0.
2. The water table was observed at the depth of 2.3m.-2.8m from ground surface, at the time of investigation (i.e. Dec-Jan 2013-14).
3. Safe load carrying capacity has been recommended as follows:

| Location | | Bore hole Level (m) | Theoretical Scour Level (m) | Scour Depth Below Borehole (m) | Pile Cap Top Level (m) | Pile Cap Bottom Level (m) | Pile Tip Level (m) | Length of Pile (m) | Vertical Capacity (t) | Lateral Capacity (t) | Uplift Capacity (T) |
|----------|----|---------------------|-----------------------------|--------------------------------|------------------------|---------------------------|--------------------|--------------------|-----------------------|----------------------|---------------------|
| 342/1A | A1 | 776.267 | 768.479 | 6.535 | 778.510 | 776.710 | 744.710 | 32 | 230 | 20 | 80 |
| 342/1B | P1 | 771.267 | 761.277 | 8.017 | 770.657 | 768.157 | 726.157 | 42 | 350 | 20 | 150 |
| 342/1C | A2 | 776.267 | 768.479 | 6.535 | 778.510 | 776.710 | 744.710 | 32 | 230 | 20 | 80 |

SCOUR DEPTH CALCULATIONS FOR MAJOR BRIDGE AT CH: 341+780 (Thoubal)

| Sl.No | Chainage | Proposed Span Arrangement | Location | HFL (m) | Discharge (Cumecs) | Velocity (m/sec) | Design Discharge 1.3xQ (Cumec) | Silt Factor | Eff. Linear Waterway (m) | Discharge per m width (Cumecs/ | Mean Scour Depth Dsm(m) | Scour depth below HFL(m) | Borehole Level (m) | Min. Bed Level (m) | Theoretic al Scour level (m) | Seismic case | Actual Scour level (m) | Scour depth below BH (m) |
|-------|-----------|---------------------------|----------|---------|--------------------|------------------|--------------------------------|-------------|--------------------------|--------------------------------|-------------------------|--------------------------|--------------------|--------------------|------------------------------|--------------|------------------------|--------------------------|
| 2 | 341+780 | 2 x 34.5 | A1 | 781.010 | 1741 | 3.8 | 2263.3 | 3.0 | 65.4 | 34.607 | 9.867 | 12.531 | 776.267 | - | 768.479 | 769.732 | 769.732 | 6.535 |
| | (Thoubal) | | P | 781.010 | 1741 | 3.8 | 2263.3 | 3.0 | 65.4 | 34.607 | 9.867 | 19.733 | 771.267 | 771.267 | 761.277 | 763.250 | 763.250 | 8.017 |

Pile Capacity Calculations (IS:2911/Part-1/Sec-2)-1979

Bored Cast in Situ Piles

Structure: Major Bridge (Thoubal)

Chainage: 341+780

Location: A1

Calculation of Skin friction Resistance

(Existing)

| Item | Layer -I | Layer -II | Layer -III | Layer -IV | Layer -V | Layer -VI | Layer -VII |
|---|---|------------|-------------|-------------|-------------|------------|-------------|
| Type of strata | Clay | Clay | Clay | Clay | Clay | Clay | Clay |
| Diameter of Pile (D) | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m |
| Length of Pile (L) | 32.0 m | 32 m | 32 m | 32 m | 32 m | 32 m | 32 m |
| Bulk density of the strata (γ) | 16.8 kn/m3 | 17.2 kn/m3 | 17.2 kn/m3 | 17.4 kn/m3 | 17.4 kn/m3 | 17.4 kn/m3 | 17.8 kn/m3 |
| Submerged Unit Weight (γ') | | 7.2 | 7.2 | 7.4 | 7.4 | 7.4 | 7.8 |
| Undrained shear strength (Cu) | 0 kn/m2 | 75 kn/m2 | 120 kn/m2 | 176 kn/m2 | 230 kn/m2 | 250 kn/m2 | 250 kn/m2 |
| Angle of internal friction of soil (φ) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Thickness of soil layer (h) | 6.5 m | 7.0 m | 7.5 m | 6.0 m | 3.0 m | 1.0 m | 3.3 m |
| Effective over burden pressure over the top of strata | 0 kn/m2 | 0 kn/m2 | 50.4 kn/m2 | 104.4 kn/m2 | 148.8 kn/m2 | 171 kn/m2 | 178.4 kn/m2 |
| Effective over burden pressure over the bottom of strata | 0 | 50.4 | 104.4 | 148.8 | 171 | 178.4 | 204.1 |
| Adhesion (α) | - | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| K= Coefficient of earth pressure in loose to medium sands = 1 - 3 | | 1 | 1 | 1 | 1 | 1 | 1 |
| Effective over burden pressure Pd = | | 25.2 | 77.4 | 126.6 | 159.9 | 174.7 | 191.3 |
| Angle of wall friction δ=φ | | 0 | 0 | 0 | 0 | 0 | 0 |
| (It is equal to angle of internal friction) | | | | | | | |
| As= 3.142*D*h | | 26.3928 | 28.278 | 22.6224 | 11.3112 | 3.77 | 12.44 |
| (for Granular soils) $K \times Pd \times \tan \delta \times As =$ | | 0 Kn | 0 Kn | 0 Kn | 0.00 Kn | 0 Kn | 0 Kn |
| (for Cohesive soils) $\alpha Cu As =$ | No skin resistance is considered for this layer | 593.838 Kn | 1018.008 Kn | 1194.46 Kn | 780.4728 Kn | 282.78 Kn | 933.2 Kn |

Skin friction resistance due to cohesive soil layers

$$\sum (\alpha Cu As) = 4802.74 \text{ kN}$$

Skin friction resistance due to granular soil layers

$$\sum (K \times Pd \times \tan \delta \times As) = 0 \text{ kN}$$

Negtaive skin friction

$$= 720.410 \text{ kN}$$

Total Skin friction resistance of the pile, qs

$$R_f = \sum (\alpha Cu As + K \times Pd \times \tan \delta \times As) = 4082.33$$

Calculation of End bearing resistance

| | |
|--|---|
| Type of bearing strata | Clay |
| C/S area of Pile | 1.131 sqm |
| Length of Pile (L) | 32 m |
| SPT value (N) | |
| Angle of internal friction of soil (φ) | φ 0 |
| Bearing capacity factor | Nc 9 |
| | Nq 17 |
| | Nγ 0 |
| Effective over burden pressure | Pd 0 Kn/m2 |
| Total End bearing resistance of the pile (Qp) | Qp= Ap*(1/2*D*γ*Nr+Pd*Nq)+(Ap*Nc*cp)= 1791.462 kN |
| Ultimate load carrying capacity | Qu= Qs+Qp = 5873.79 |
| Safe load carrying capacity | Qsafe= 2349.5148 kN |
| The Safe load carrying capacity of pile= | 235 t |

The Recommended vertical load carrying capacity is 230t

Ultimate Uplift load carrying capacity is 2857.63 Kn

The Safe Uplift load carrying capacity is 800.456 Kn
80.0456 Tonnes

The Recommended Uplift load carrying capacity is 80.00 Tonnes

DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH, ADB TA - 8116 IND

Pile Capacity Calculations (IS:2911/Part-1/Sec-2)-1979

Bored Cast in Situ Piles

Structure: Major Bridge (Thoubal)

Chainage: 341+780

Location: 1B

Calculation of Skin friction Resistance

| Item | Layer -I | Layer -II | Layer -III | Layer -IV | Layer -V | Layer -VI | Layer -VII |
|--|---|------------|-------------|------------|-------------|-----------|------------|
| Type of strata | Clay | Clay | Clay | Clay | Clay | Clay | Clay |
| Diameter of Pile (D) | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m |
| Length of Pile (L) | 42.0 m | 42 m | 42 m | 42 m | 42 m | 42 m | 42 m |
| Bulk density of the strata (γ) | | | | | | | |
| Submerged Unit Weight (γ') (Minimum) | | 10 | 10 | 10 | 10 | 10 | 10 |
| Undrained shear strength (C_u) | 0 kn/m2 | 75 kn/m2 | 120 kn/m2 | 176 kn/m2 | 230 kn/m2 | 250 kn/m2 | 260 kn/m2 |
| Angle of internal friction of soil (ϕ) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Thickness of soil layer (h) | 8 m | 5.5 m | 7.5 m | 6.0 m | 3.0 m | 1.0 m | 13.3 m |
| Effective over burden pressure over the top of strata | 0 kn/m2 | 0 kn/m2 | 55 kn/m2 | 130 kn/m2 | 190 kn/m2 | 220 kn/m2 | 230 kn/m2 |
| Effective over burden pressure over the bottom of strata | 0 | 55 | 130 | 190 | 220 | 230 | 363 |
| Adhesion (α) | - | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| K= Coefficient of earth pressure in loose to medium sands = 1 - 3 | | 1 | 1 | 1 | 1 | 1 | 1 |
| Effective over burden pressure P_d = | | 27.5 | 92.5 | 160 | 205 | 225 | 296.5 |
| Angle of wall friction $\delta = \phi$ | | 0 | 0 | 0 | 0 | 0 | 0 |
| (It is equal to angle of internal friction) | | | | | | | |
| $A_s = 3.142 \cdot D \cdot h$ | | 20.7372 | 28.278 | 22.6224 | 11.3112 | 3.77 | 50.15 |
| (for Granular soils) $K \times P_d \times \tan \delta \times A_s =$ | | 0 Kn | 0 Kn | 0 Kn | 0.00 Kn | 0 Kn | 0 Kn |
| (for Cohesive soils) $\alpha C_u A_s = \alpha \cdot C_u \cdot 3.142 \cdot D \cdot h$ | No skin resistance is considered for this layer | 466.587 Kn | 1018.008 Kn | 1194.46 Kn | 780.4728 Kn | 282.78 Kn | 3911 Kn |

Skin friction resistance due to cohesive soil layers

$$\sum (\alpha C_u A_s) = 7653.72 \text{ kN}$$

Skin friction resistance due to granular soil layers

$$\sum (K \times P_d \times \tan \delta \times A_s) = 0 \text{ kN}$$

Negtaive skin friction

$$= 0.000 \text{ kN}$$

Total Skin friction resistance of the pile, q_s

$$R_f = \sum (\alpha C_u A_s + K \times P_d \times \tan \delta \times A_s) = 7653.72$$

Calculation of End bearing resistance

| | |
|--|--|
| Type of bearing strata | Clay |
| C/S area of Pile | 1.131 sqm |
| Length of Pile (L) | 42 m |
| SPT value (N) | |
| Angle of internal friction of soil (ϕ) | ϕ 0 |
| Bearing capacity factor | N_c 9 |
| | N_q 17 |
| | N_y 0 |
| Effective over burden pressure | P_d 0 Kn/m2 |
| Total End bearing resistance of the pile (Q_p) | $Q_p = A_p \cdot (1/2 \cdot D \cdot \gamma \cdot N_r + P_d \cdot N_q) + (A_p \cdot N_c \cdot C_p) = 1791.462 \text{ kN}$ |
| Ultimate load carrying capacity | $Q_u = Q_s + Q_p = 9445.19$ |
| Safe load carrying capacity | $Q_{safe} = 3778.0741 \text{ kN}$ |
| The Safe load carrying capacity of pile= | 378 t |

The Recommended vertical load carrying capacity is 350t

Ultimate Uplift load carrying capacity is 5357.61 Kn

The Safe Uplift load carrying capacity is 1500.73 Kn

150.073 Tonnes

The Recommended Uplift load carrying capacity is 150.00 Tonnes

DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH, ADB TA - 8116 IND

Pile Capacity Calculations (IS:2911/Part-1/Sec-2)-1979

Bored Cast in Situ Piles

Structure: Major Bridge (Thoubal)

Chainage: 341+780

Location: 1C

Calculation of Skin friction Resistance

| Item | Layer -I | Layer -II | Layer -III | Layer -IV | Layer -V | Layer -VI | Layer -VII |
|---|---|------------|-------------|------------|-------------|-----------|------------|
| Type of strata | Clay | Clay | Clay | Clay | Clay | Clay | Clay |
| Diameter of Pile (D) | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m |
| Length of Pile (L) | 32.0 m | 32 m | 32 m | 32 m | 32 m | 32 m | 32 m |
| Bulk density of the strata (γ) | | 10 | 10 | 10 | 10 | 10 | 10 |
| Submerged Unit Weight (γ') (Minimum) | | 75 kn/m2 | 120 kn/m2 | 176 kn/m2 | 230 kn/m2 | 250 kn/m2 | 250 kn/m2 |
| Undrained shear strength (C_u) | 0 kn/m2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Angle of internal friction of soil (ϕ) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Thickness of soil layer (h) | 6.5 m | 7.0 m | 7.5 m | 6.0 m | 3.0 m | 1.0 m | 3.3 m |
| Effective over burden pressure over the top of strata | 0 kn/m2 | 0 kn/m2 | 70 kn/m2 | 145 kn/m2 | 205 kn/m2 | 235 kn/m2 | 245 kn/m2 |
| Effective over burden pressure over the bottom of strata | 0 | 70 | 145 | 205 | 235 | 245 | 278 |
| Adhesion (α) | - | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| K= Coefficient of earth pressure in loose to medium sands = 1 - 3 | | 1 | 1 | 1 | 1 | 1 | 1 |
| Effective over burden pressure P_d = | | 35 | 107.5 | 175 | 220 | 240 | 261.5 |
| Angle of wall friction $\delta = \phi$ | | 0 | 0 | 0 | 0 | 0 | 0 |
| (It is equal to angle of internal friction) | | | | | | | |
| $A_s = 3.142 \cdot D \cdot h$ | | 26.3928 | 28.278 | 22.6224 | 11.3112 | 3.77 | 12.44 |
| (for Granular soils) $K \times P_d \times \tan \delta \times A_s =$ | | 0 Kn | 0 Kn | 0 Kn | 0.00 Kn | 0 Kn | 0 Kn |
| (for Cohesive soils) $\alpha \times C_u \times A_s =$ | No skin resistance is considered for this layer | 593.838 Kn | 1018.008 Kn | 1194.46 Kn | 780.4728 Kn | 282.78 Kn | 933.2 Kn |

Skin friction resistance due to cohesive soil layers

$$\sum (\alpha C_u A_s) = 4802.74 \text{ kN}$$

Skin friction resistance due to granular soil layers

$$\sum (K \times P_d \times \tan \delta \times A_s) = 0 \text{ kN}$$

Negtaive skin friction

$$= 720.410 \text{ kN}$$

Total Skin friction resistance of the pile, q_s

$$R_f = \sum (\alpha C_u A_s + K \times P_d \times \tan \delta \times A_s) = 4082.33$$

Calculation of End bearing resistance

| | |
|--|--|
| Type of bearing strata | Clay |
| C/S area of Pile | 1.131 sqm |
| Length of Pile (L) | 32 m |
| SPT value (N) | |
| Angle of internal friction of soil (ϕ) | ϕ 0 |
| Bearing capacity factor | N_c 9 |
| | N_q 17 |
| | N_γ 0 |
| Effective over burden pressure | P_d 0 Kn/m2 |
| Total End bearing resistance of the pile (Q_p) | $Q_p = A_p \cdot (1/2 \cdot D \cdot \gamma \cdot N_r + P_d \cdot N_q) + (A_p \cdot N_c \cdot C_p) = 1791.462 \text{ kN}$ |
| Ultimate load carrying capacity | $Q_u = Q_s + Q_p = 5873.79$ |
| Safe load carrying capacity | $Q_{safe} = 2349.5148 \text{ kN}$ |
| The Safe load carrying capacity of pile= | 235 t |

The Recommended vertical load carrying capacity is 230t

Ultimate Uplift load carrying capacity is 2857.63 Kn

The Safe Uplift load carrying capacity is

800.456 Kn

80.0456 Tonnes

The Recommended Uplift load carrying capacity is 80.00 Tonnes

**DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO
MOREH, ADB TA - 8116 IND**

**ESTIMATION OF LATERAL LOAD CARRYING CAPACITY OF PILES for 1A
(THOUBAL) MAJOR BRIDGE AT CH: 341+780**

| | | |
|--|---|----------------------------|
| Stipulations of IS:2911 (Part I/Sec.2) - 1979 are followed | | |
| Diameter of Pile | = | 1200 mm |
| Strength of Pile Concrete | = | 35 N/mm ² |
| Young's Modulus of Pile Concrete | = | 31500 N/mm ² |
| | = | 31500000 kN/m ² |
| Moment of Inertia of Pile Cross Section | = | 1.02E+11 mm ⁴ |
| | = | 0.1018 m ⁴ |
| Top Layer of sub-soil strata | = | Clay |
| Value of Constant, k ₁ | = | 5333 kN/m ³ |
| T | = | 4.95 m |
| Unsupported Length, L ₁ | = | 4.300 m |
| L ₁ /T | = | 0.868 |
| L _i /T | = | 2.00 |
| L _i (Ref Fig.2, Appendix C of IS 2911 (Part 1/Sec.2) - 1979 | = | 9.903 m |
| Cantilever span of pile | = | 14.2 m |
| Lateral Deflection at bottom of pile cap level under unit lateral load | = | 0.000074 m |
| Lateral Deflection at Top of PILE | = | 0.0745 mm |
| Corresponding Deflection at scour level | = | 0.0519 mm |
| Allowable deflection at scour level | = | 12 mm |
| Force that causes 12mm Lateral Deflection at scour level | = | 231.103 kN |
| Thus, Lateral Capacity of INDIVIDUAL PILE | = | 231.103 kN |

NOTE: The recommended lateral load carrying capacity is 20 tonnes

**DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO
MOREH, ADB TA - 8116 IND**

**ESTIMATION OF LATERAL LOAD CARRYING CAPACITY OF PILES for 1B
(THOUBAL) MAJOR BRIDGE AT CH: 341+780**

Stipulations of IS:2911 (Part I/Sec.2) - 1979 are followed

| | | |
|--|---|----------------------------|
| Diameter of Pile | = | 1200 mm |
| Strength of Pile Concrete | = | 35 N/mm ² |
| Young's Modulus of Pile Concrete | = | 31500 N/mm ² |
| | = | 31500000 kN/m ² |
| Moment of Inertia of Pile Cross Section | = | 1.02E+11 mm ⁴ |
| | = | 0.1018 m ⁴ |
| Top Layer of sub-soil strata | = | Clay |
| Value of Constant, k ₁ | = | 5667 kN/m ³ |
| T | = | 4.88 m |
| Unsupported Length, L ₁ | = | 5.700 m |
| L ₁ /T | = | 1.169 |
| L _i /T | = | 1.98 |
| L _i (Ref Fig.2, Appendix C of IS 2911 (Part 1/Sec.2) - 1979 | = | 9.657 m |
| Cantilever span of pile | = | 15.4 m |
| Lateral Deflection at bottom of pile cap level under unit lateral load | = | 0.000094 m |
| Lateral Deflection at Top of PILE | = | 0.0941 mm |
| Corresponding Deflection at scour level | = | 0.0592 mm |
| Allowable deflection at scour level | = | 12 mm |
| Force that causes 12mm Lateral Deflection at scour level | = | 202.736 kN |
| Thus, Lateral Capacity of INDIVIDUAL PILE | = | 202.736 kN |

NOTE: The recommended lateral load carrying capacity is 20 tonnes

**DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO
MOREH, ADB TA - 8116 IND**

**ESTIMATION OF LATERAL LOAD CARRYING CAPACITY OF PILES for 1C
(THOUBAL) MAJOR BRIDGE AT CH: 341+780**

Stipulations of IS:2911 (Part I/Sec.2) - 1979 are followed

| | | |
|--|---|----------------------------|
| Diameter of Pile | = | 1200 mm |
| Strength of Pile Concrete | = | 35 N/mm ² |
| Young's Modulus of Pile Concrete | = | 31500 N/mm ² |
| | = | 31500000 kN/m ² |
| Moment of Inertia of Pile Cross Section | = | 1.02E+11 mm ⁴ |
| | = | 0.1018 m ⁴ |
| Top Layer of sub-soil strata | = | Clay |
| Value of Constant, k ₁ | = | 5333 kN/m ³ |
| T | = | 4.95 m |
| Unsupported Length, L ₁ | = | 4.300 m |
| L ₁ /T | = | 0.868 |
| L ₁ /T | = | 2.00 |
| L _f (Ref Fig.2, Appendix C of IS 2911 (Part 1/Sec.2) - 1979 | = | 9.903 m |
| Cantilever span of pile | = | 14.2 m |
| Lateral Deflection at bottom of pile cap level under unit lateral load | = | 0.000074 m |
| Lateral Deflection at Top of PILE | = | 0.0745 mm |
| Corresponding Deflection at scour level | = | 0.0519 mm |
| Allowable deflection at scour level | = | 12 mm |
| Force that causes 12mm Lateral Deflection at scour level | = | 231.103 kN |
| Thus, Lateral Capacity of INDIVIDUAL PILE | = | 231.103 kN |

NOTE: The recommended lateral load carrying capacity is 20 tonnes

TABLE-A2.1: RESULT SHEET FOR MINOR BRIDGE AT CH.341+780 ON BH-342/1A

(W.T. = 1.50M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND****Size of Hole : Nx Size****Type of Bit : TC / Diamond****Starting date : 30.12.2013****Completion date : 31.12.2013**

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|-----------------------|-----------|-------|------------------|
| | 15 | 30 | 45 | N | | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 1.0 | 8 | 9 | 12 | 21 | FILLED-UP MATERIAL | | | | | | | | | | | | | |
| 2.0 | | | | | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 0.00 | 23.20 | 26.88 | 49.92 | 55.5 | 19.20 | - | 2.71 | - | - | - | 35.0 | - |
| 3.0 | 2 | 3 | 3 | 6 | | | | | | | | | | | | | | |
| 4.0 | 3 | 3 | 4 | 7 | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | | | | | |
| 6.0 | 3 | 4 | 5 | 9 | | | | | | | | | | | | | | |
| 7.0 | | | | | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 2.43 | 26.00 | 15.74 | 55.82 | 59.60 | 25.60 | - | - | - | - | - | 33.6 | - |
| 8.0 | 3 | 4 | 5 | 9 | | | | | | | | | | | | | | |
| 9.0 | 4 | 5 | 6 | 11 | | | | | | | | | | | | | | |

* = Consolidation Test,

c_c = Compression Index,

DFS = Differential Free Swell,

—v = Water Table,

Sp = Swelling Pressure

TABLE-A2.1: RESULT SHEET FOR MINOR BRIDGE AT CH.341+780 ON BH-342/1A

(W.T. = 1.50M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 30.12.2013

Completion date : 31.12.2013

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 10.0 | 4 | 5 | 7 | 12 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 1.53 | 21.93 | 22.96 | 53.57 | 60.4 | 22.3 | - | 2.71 | - | - | - | 34.30 | |
| 11.0 | | | | | | | | | | | | | | | | | | |
| 12.0 | 5 | 6 | 8 | 14 | | | | | | | | | | | | | | |
| 13.0 | | | | | | | | | | | | | | | | | | |
| 14.0 | 5 | 7 | 11 | 18 | | | | | | | | | | | | | | |
| 15.0 | 6 | 8 | 11 | 19 | | | | | | | | | | | | | | |
| 16.0 | | | | | | | | | | | | | | | | | | |
| 17.0 | 6 | 7 | 13 | 20 | | | | | | | | | | | | | | |
| 18.0 | | | | | | | | | | | | | | | | | | |
| | | | | | | 1.27 | 31.60 | 13.43 | 53.71 | 57.6 | 21.0 | - | - | - | - | - | 36.00 | |
| | 6 | 8 | 14 | 22 | | | | | | | | | | | | | | |

* = Consolidation Test,

c_c = Compression Index,

DFS

= Differential Free Swell,

—v = Water Table,

Sp = Swelling Pressure

TABLE-A2.1: RESULT SHEET FOR MINOR BRIDGE AT CH.341+780 ON BH-342/1A

(W.T. = 1.50M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 30.12.2013

Completion date : 31.12.2013

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 19.0 | 7 | 9 | 16 | 25 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 0.80 | 25.64 | 16.18 | 57.38 | 52.50 | 20.5 | - | 2.72 | - | - | - | 29.0 | |
| 20.0 | | | | | | | | | | | | | | | | | | |
| 21.0 | 8 | 9 | 17 | 26 | | | | | | | | | | | | | | |
| 22.0 | 8 | 10 | 19 | 29 | | | | | | | | | | | | | | |
| 23.0 | | | | | | | | | | | | | | | | | | |
| 24.0 | 8 | 11 | 20 | 31 | | | | | | | | | | | | | | |
| 25.0 | | | | | | | | | | | | | | | | | | |
| 26.0 | 9 | 12 | 23 | 35 | | | | | | | | | | | | | | |
| 27.0 | 9 | 13 | 26 | 39 | | | | | | | | | | | | | | |

* = Consolidation Test,

c_c = Compression Index,

DFS

= Differential Free Swell,

W = Water Table,

Sp = Swelling Pressure

TABLE-A2.1: RESULT SHEET FOR MINOR BRIDGE AT CH.341+780 ON BH-342/1A

(W.T. = 1.50M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 30.12.2013

Completion date : 31.12.2013

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Descreption | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 28.0 | 8 | 14 | 27 | 41 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 0.00 | 27.08 | 21.88 | 51.04 | 55.0 | 21.0 | - | - | - | - | - | 34.9 | |
| 29.0 | | | | | | | | | | | | | | | | | | |
| 30.0 | 8 | 15 | 28 | 43 | | | | | | | | | | | | | | |
| 31.0 | | | | | | | | | | | | | | | | | | |
| 32.0 | | | | | | | | | | | | | | | | | | |
| 33.0 | | | | | | | | | | | | | | | | | | |
| 34.0 | | | | | | | | | | | | | | | | | | |
| 36.0 | | | | | | | | | | | | | | | | | | |
| 37.0 | | | | | | | | | | | | | | | | | | |

* = Consolidation Test, c_c = Compression Index, DFS = Differential Free Swell, —v = Water Table, Sp = Swelling Pressure

TABLE-A2.2: RESULT SHEET FOR MINOR BRIDGE AT CH.341+780 ON BH-342/1B

(W.T. = 2.50M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND****Size of Hole : Nx Size****Type of Bit : TC / Diamond****Starting date : 18.12.2013****Completion date : 20.12.2013**

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|-----------------------|-----------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 1.0 | 5 | 8 | 12 | 20 | FILLED-UP MATERIAL | | | | | | | | | | | | | |
| 2.0 | | | | | | | | | | | | | | | | | | |
| 3.0 | 3 | 4 | 4 | 8 | | 4.32 | 30.32 | 22.88 | 42.48 | 54.8 | 24.3 | - | 2.68 | - | - | - | 28.0 | - |
| 4.0 | | | | | | | | | | | | | | | | | | |
| 5.0 | 3 | 4 | 5 | 9 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | | | | | | | | | | | | | |
| 6.0 | 2 | 4 | 6 | 10 | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | |
| 8.0 | 3 | 5 | 7 | 12 | | | | | | | | | | | | | | |
| 9.0 | 4 | 5 | 8 | 13 | | 2.93 | 26.38 | 15.55 | 55.15 | 60.50 | 25.4 | - | - | - | - | - | 30.5 | - |

* = Consolidation Test, c_c = Compression Index, DFS = Differential Free Swell, —v = Water Table, Sp = Swelling Pressure

TABLE-A2.2: RESULT SHEET FOR MINOR BRIDGE AT CH.341+780 ON BH-342/1B

(W.T. = 2.50M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 18.12.2013

Completion date : 20.12.2013

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 10.0 | 5 | 6 | 9 | 15 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 2.63 | 23.28 | 22.23 | 51.87 | 62.7 | 20.60 | - | 2.71 | - | - | - | 34.3 | |
| 11.0 | | | | | | | | | | | | | | | | | | |
| 12.0 | 4 | 7 | 10 | 17 | | | | | | | | | | | | | | |
| 13.0 | | | | | | | | | | | | | | | | | | |
| 14.0 | 6 | 8 | 11 | 19 | | | | | | | | | | | | | | |
| 15.0 | 6 | 9 | 11 | 20 | | | | | | | | | | | | | | |
| 16.0 | | | | | | | | | | | | | | | | | | |
| 17.0 | 7 | 9 | 12 | 21 | | | | | | | | | | | | | | |
| 18.0 | 8 | 10 | 14 | 24 | | 4.50 | 25.78 | 24.40 | 45.32 | 59.5 | 24.00 | - | - | - | - | - | 32.7 | |

* = Consolidation Test,

c_c = Compression Index,

DFS = Differential Free Swell,

—v = Water Table,

Sp = Swelling Pressure

TABLE-A2.2: RESULT SHEET FOR MINOR BRIDGE AT CH.341+780 ON BH-342/1B

(W.T. = 2.50M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 18.12.2013

Completion date : 20.12.2013

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 19.0 | 9 | 12 | 16 | 28 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 3.95 | 28.48 | 14.87 | 52.71 | 54.30 | 23.80 | - | 2.68 | - | - | - | 39.5 | |
| 20.0 | | | | | | | | | | | | | | | | | | |
| 21.0 | 10 | 15 | 20 | 35 | | | | | | | | | | | | | | |
| 22.0 | 12 | 18 | 21 | 39 | | | | | | | | | | | | | | |
| 23.0 | | | | | | | | | | | | | | | | | | |
| 24.0 | 13 | 21 | 24 | 45 | | | | | | | | | | | | | | |
| 25.0 | | | | | | | | | | | | | | | | | | |
| 26.0 | 14 | 23 | 30 | 53 | | | | | | | | | | | | | | |
| 27.0 | 15 | 28 | 32 | 60 | | 7.80 | 25.50 | 13.34 | 53.36 | 60.60 | 22.30 | - | - | - | - | - | 35.5 | |

* = Consolidation Test,

c_c = Compression Index,

DFS

= Differential Free Swell,

—v =

Water Table,

Sp = Swelling Pressure

TABLE-A2.3: RESULT SHEET FOR MINOR BRIDGE AT CH.341+780 ON BH-342/1C

(W.T. = 2.00M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH

ADB TA - 8116 IND

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 01.01.2014

Completion date : 02.01.2014

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 1.0 | | | | | FILLED-UP MATERIAL | | | | | | | | | | | | | |
| 2.0 | 2 | 3 | 3 | 6 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 1.80 | 26.54 | 25.08 | 46.58 | 57.1 | 21.4 | - | 2.71 | - | - | - | 30.2 | - |
| 3.0 | 3 | 4 | 4 | 8 | | | | | | | | | | | | | | |
| 4.0 | 3 | 4 | 5 | 9 | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | | | | | |
| 6.0 | 3 | 4 | 6 | 10 | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | |
| 8.0 | 3 | 5 | 6 | 11 | | | | | | | | | | | | | | |
| 9.0 | 4 | 5 | 6 | 11 | | 3.95 | 29.58 | 14.62 | 51.85 | 62.80 | 22.9 | - | - | - | - | - | 33.8 | - |

* = Consolidation Test, c_c = Compression Index, DFS = Differential Free Swell, —v = Water Table, Sp = Swelling Pressure

TABLE-A2.3: RESULT SHEET FOR MINOR BRIDGE AT CH.341+780 ON BH-342/1C

(W.T. = 2.00M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 01.01.2014

Completion date : 02.01.2014

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 10.0 | 4 | 5 | 7 | 12 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 0.20 | 22.38 | 23.23 | 54.19 | 59.3 | 24.6 | - | 2.73 | - | - | - | 29.60 | |
| 11.0 | | | | | | | | | | | | | | | | | | |
| 12.0 | 5 | 6 | 7 | 13 | | | | | | | | | | | | | | |
| 13.0 | 5 | 6 | 8 | 14 | | | | | | | | | | | | | | |
| 14.0 | | | | | | | | | | | | | | | | | | |
| 15.0 | 6 | 7 | 9 | 16 | | | | | | | | | | | | | | |
| 16.0 | | | | | | | | | | | | | | | | | | |
| 17.0 | 5 | 8 | 9 | 17 | | | | | | | | | | | | | | |
| 18.0 | 6 | 9 | 10 | 19 | | 5.00 | 23.40 | 25.06 | 46.54 | 60.2 | 23.5 | - | - | - | - | - | 39.00 | |

* = Consolidation Test,

c_c = Compression Index,

DFS

= Differential Free Swell,

—v = Water Table,

Sp = Swelling Pressure

TABLE-A2.3: RESULT SHEET FOR MINOR BRIDGE AT CH.341+780 ON BH-342/1C

(W.T. = 2.00M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 01.01.2014

Completion date : 02.01.2014

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 19.0 | 6 | 9 | 11 | 20 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 1.70 | 30.83 | 14.84 | 52.63 | 64.70 | 22.0 | - | 2.68 | - | - | - | 30.0 | |
| 20.0 | | | | | | | | | | | | | | | | | | |
| 21.0 | 7 | 9 | 12 | 21 | | | | | | | | | | | | | | |
| 22.0 | 7 | 10 | 13 | 23 | | | | | | | | | | | | | | |
| 23.0 | | | | | | | | | | | | | | | | | | |
| 24.0 | 8 | 10 | 14 | 24 | | | | | | | | | | | | | | |
| 25.0 | | | | | | | | | | | | | | | | | | |
| 26.0 | 8 | 11 | 15 | 26 | | | | | | | | | | | | | | |
| 27.0 | 9 | 12 | 16 | 28 | | | | | | | | | | | | | | |

* = Consolidation Test,

c_c = Compression Index,

DFS

= Differential Free Swell,

—v = Water Table,

Sp = Swelling Pressure

TABLE-A2.3: RESULT SHEET FOR MINOR BRIDGE AT CH.341+780 ON BH-342/1C

(W.T. = 2.00M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH

ADB TA - 8116 IND

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 01.01.2014

Completion date : 02.01.2014

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 28.0 | 9 | 13 | 18 | 31 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | 1.16 | 23.36 | 22.64 | 52.84 | 53.5 | 21.0 | - | - | - | - | - | 35.1 | |
| 29.0 | | | | | | | | | | | | | | | | | | |
| 30.0 | 10 | 15 | 24 | 39 | | | | | | | | | | | | | | |
| 31.0 | | | | | | | | | | | | | | | | | | |
| 32.0 | | | | | | | | | | | | | | | | | | |
| 33.0 | | | | | | | | | | | | | | | | | | |
| 34.0 | | | | | | | | | | | | | | | | | | |
| 36.0 | | | | | | | | | | | | | | | | | | |
| 37.0 | | | | | | | | | | | | | | | | | | |

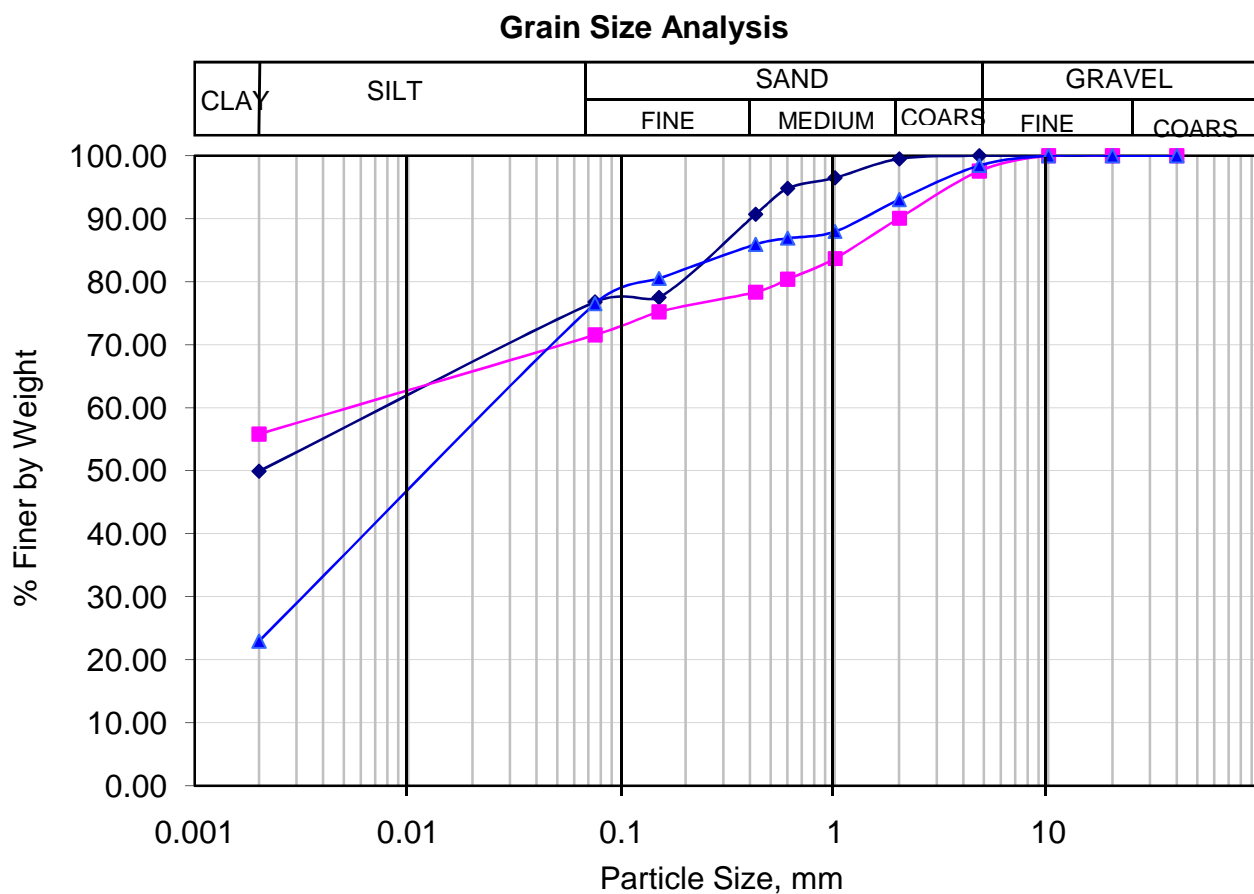
* = Consolidation Test, c_c = Compression Index, DFS = Differential Free Swell, —v = Water Table, Sp = Swelling Pressure

PNT DESIGNS PVT. LTD., KOTA

PROJECT - DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH,
ADB TA - 8116 IND

Determination of Grain Size Analysis Test as per IS:2720-Part 4-1985

MJB AT CH: 341+780 (342/1A)



| Symbol | BH No. | Depth,m | Soil description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|--------|-----------|---------|------------------|------------|----------|----------|----------|
| ◆ | BH-342/1A | 3.00 | CH* | 0.00 | 23.20 | 26.88 | 49.92 |
| ■ | BH-342/1A | 9.00 | CH* | 2.43 | 26.00 | 15.74 | 55.82 |
| ▲ | BH-342/1A | 12.00 | CH* | 1.53 | 21.93 | 22.96 | 53.57 |

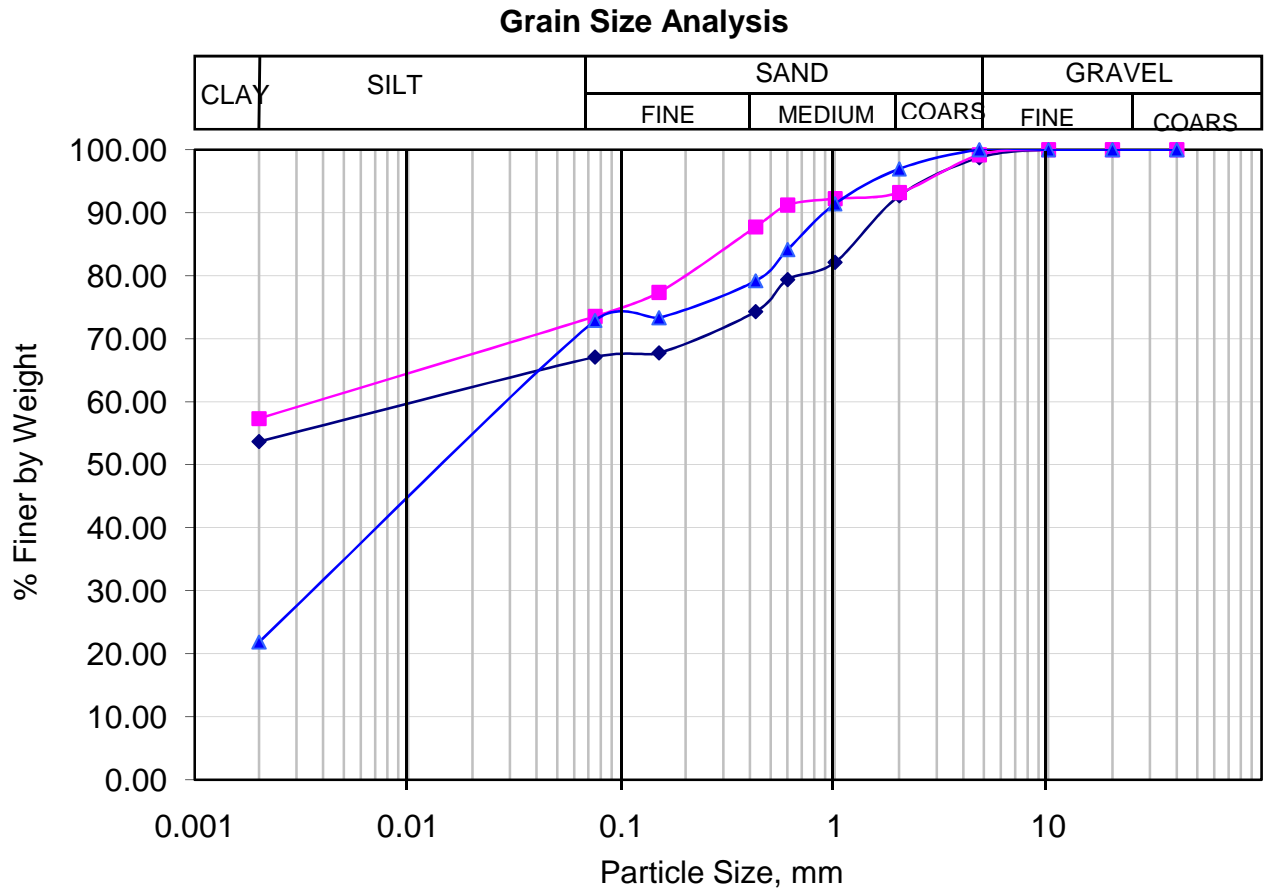
CH* = HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND

PNT DESIGNS PVT. LTD., KOTA

PROJECT - DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH,
ADB TA - 8116 IND

Determination of Grain Size Analysis Test as per IS:2720-Part 4-1985

MJB AT CH: 341+780 (342/1A)



| Symbol | BH No. | Depth,m | Soil description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|--------|-----------|---------|------------------|------------|----------|----------|----------|
| —◆— | BH-342/1A | 18.00 | CH* | 1.27 | 31.60 | 13.43 | 53.71 |
| —■— | BH-342/1A | 22.50 | CH* | 0.80 | 25.64 | 16.18 | 57.38 |
| —▲— | BH-342/1A | 28.50 | CH* | 0.00 | 27.08 | 21.88 | 51.04 |

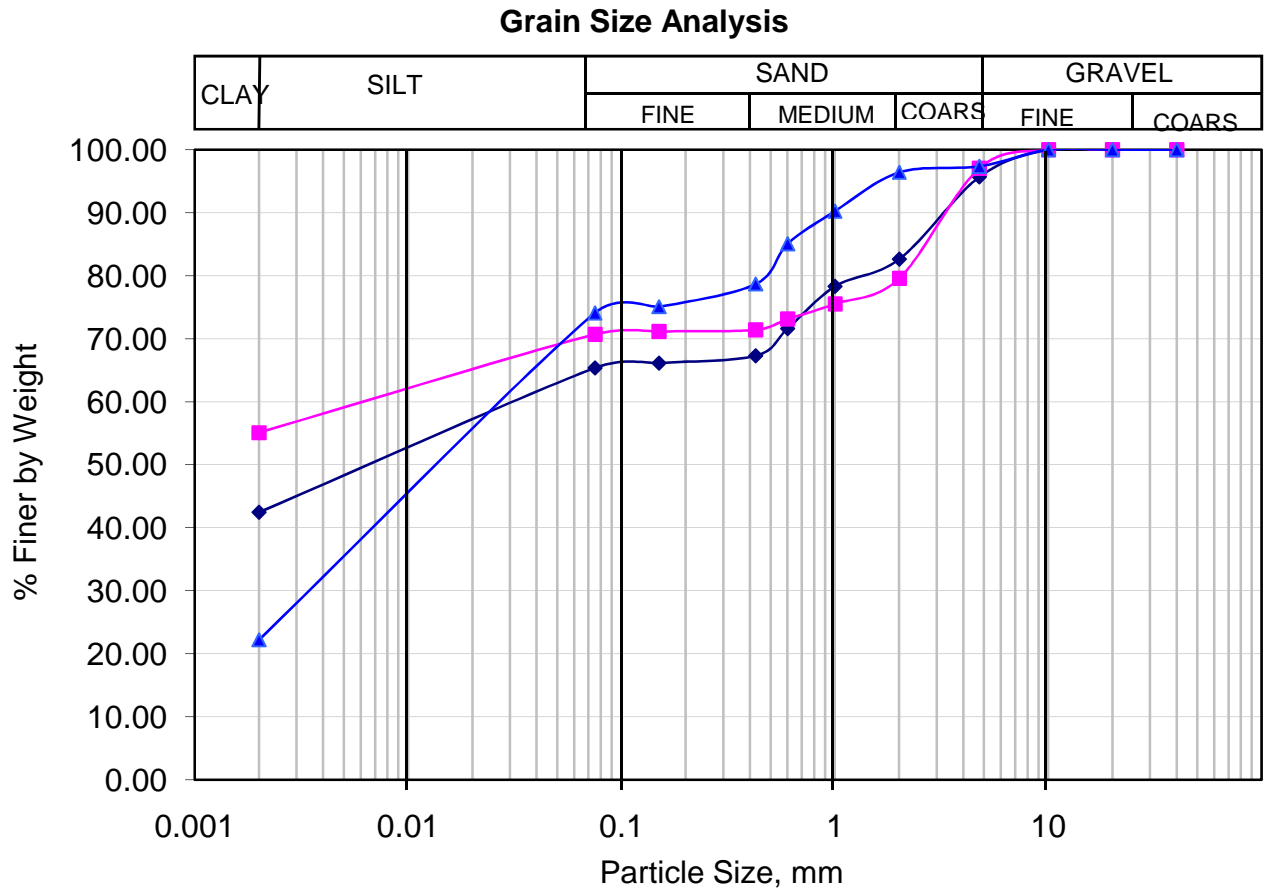
CH* = HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND

PNT DESIGNS PVT. LTD., KOTA

PROJECT - DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH,
ADB TA - 8116 IND

Determination of Grain Size Analysis Test as per IS:2720-Part 4-1985

MJB AT CH: 341+780 (342/1B)



| Symbol | BH No. | Depth,m | Soil description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|--------|-----------|---------|------------------|------------|----------|----------|----------|
| —◆— | BH-342/1B | 3.00 | CH* | 4.32 | 30.32 | 22.88 | 42.48 |
| —■— | BH-342/1B | 9.00 | CH* | 2.93 | 26.38 | 15.55 | 55.15 |
| —▲— | BH-342/1B | 12.00 | CH* | 2.63 | 23.28 | 22.23 | 51.87 |

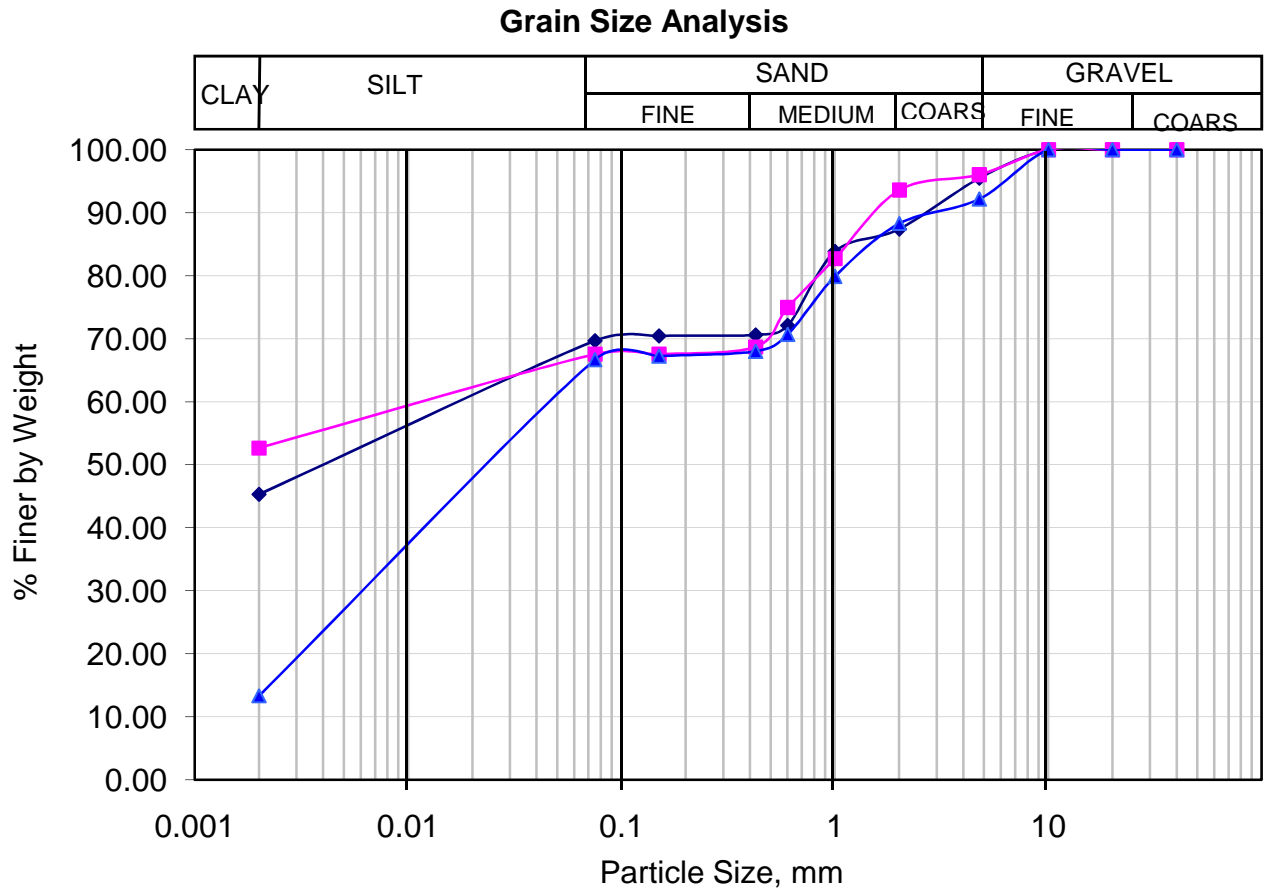
CH* = HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND

PNT DESIGNS PVT. LTD., KOTA

PROJECT - DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH,
ADB TA - 8116 IND

Determination of Grain Size Analysis Test as per IS:2720-Part 4-1985

MJB AT CH: 341+780 (342/1B)



| Symbol | BH No. | Depth,m | Soil description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|--------|-----------|---------|------------------|------------|----------|----------|----------|
| ◆ | BH-342/1B | 18.00 | CH* | 4.50 | 25.78 | 24.40 | 45.32 |
| ■ | BH-342/1B | 22.50 | CH* | 3.95 | 28.48 | 14.87 | 52.71 |
| ▲ | BH-342/1B | 27.00 | CH* | 7.80 | 25.50 | 13.34 | 53.36 |

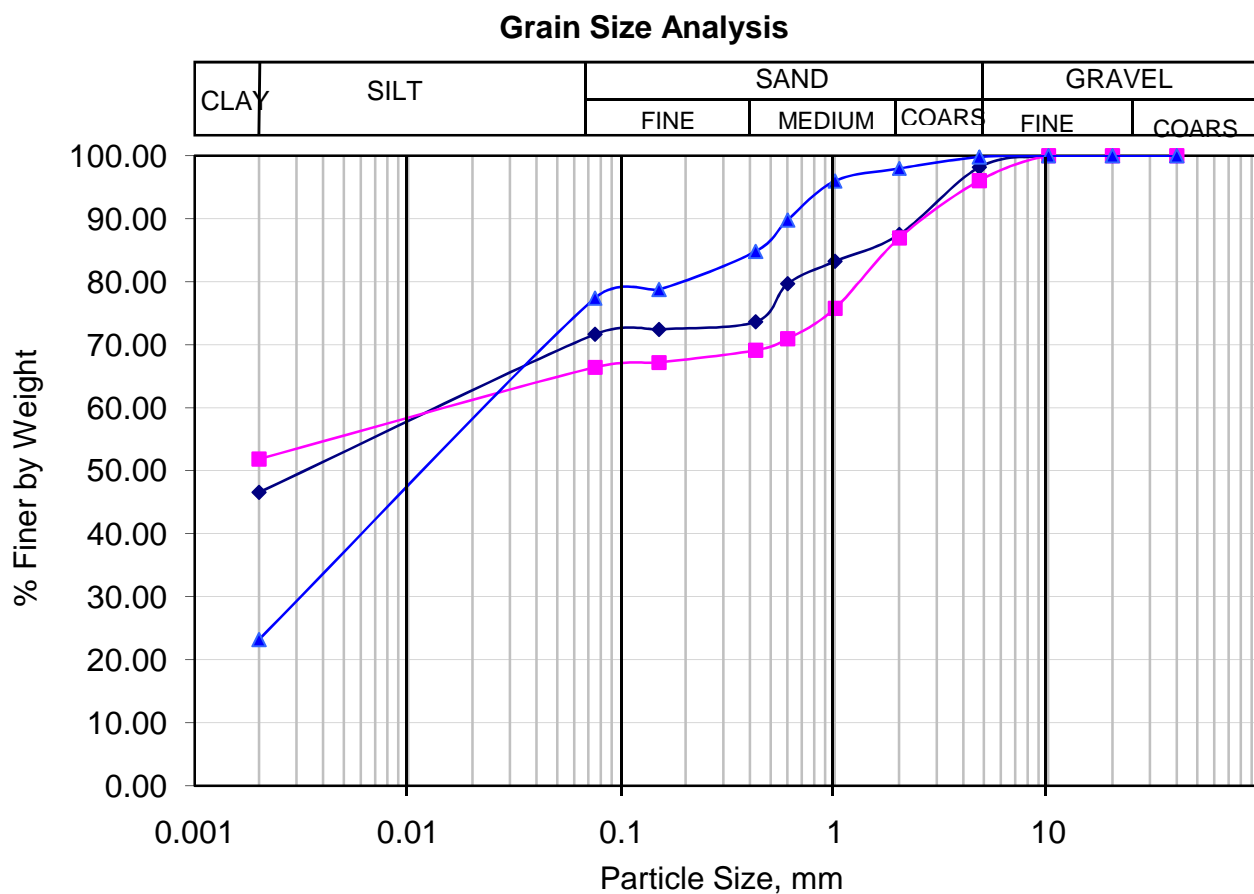
CH* = HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND

PNT DESIGNS PVT. LTD., KOTA

PROJECT - DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH,
ADB TA - 8116 IND

Determination of Grain Size Analysis Test as per IS:2720-Part 4-1985

MJB AT CH: 341+780 (342/1C)



| Symbol | BH No. | Depth,m | Soil description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|--------|-----------|---------|------------------|------------|----------|----------|----------|
| ◆ | BH-342/1C | 1.50 | CH* | 1.80 | 26.54 | 25.08 | 46.58 |
| ■ | BH-342/1C | 9.00 | CH* | 3.95 | 29.58 | 14.62 | 51.85 |
| ▲ | BH-342/1C | 12.00 | CH* | 0.20 | 22.38 | 23.23 | 54.19 |

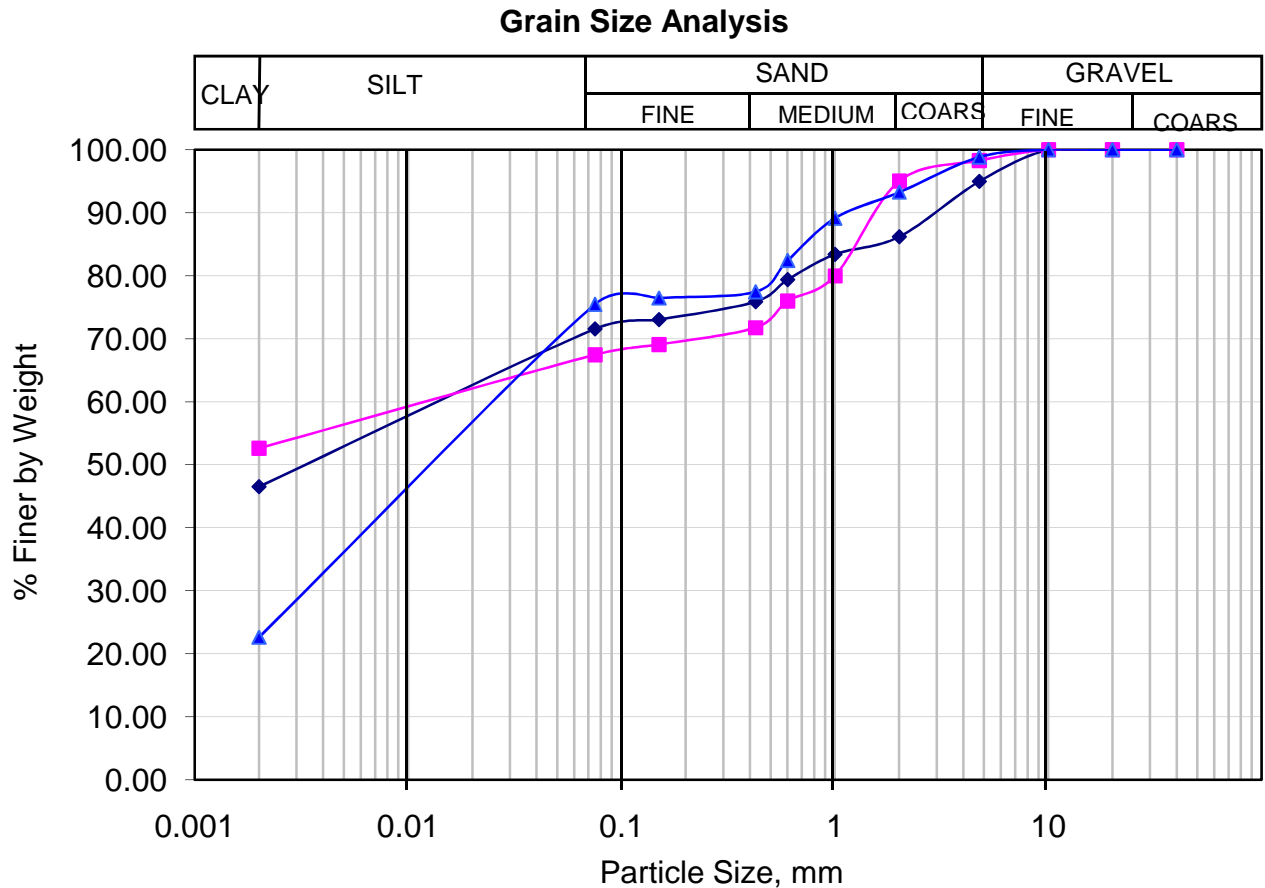
CH* = HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND

PNT DESIGNS PVT. LTD., KOTA

PROJECT - DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH,
ADB TA - 8116 IND

Determination of Grain Size Analysis Test as per IS:2720-Part 4-1985

MJB AT CH: 341+780 (342/1C)



| Symbol | BH No. | Depth,m | Soil description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|--------|-----------|---------|------------------|------------|----------|----------|----------|
| —◆— | BH-342/1C | 18.00 | CH* | 5.00 | 23.40 | 25.06 | 46.54 |
| —■— | BH-342/1C | 22.50 | CH* | 1.70 | 30.83 | 14.84 | 52.63 |
| —▲— | BH-342/1C | 28.50 | CH* | 1.16 | 23.36 | 22.64 | 52.84 |

CH* = HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND

DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH, ADB TA - 8116 IND

SILT FACTOR CALCULATION BASED ON COHESION OF SOIL MJB AT CH.341+780

Location : BH-342/1A

Depth : 2.10-30.0m

In order to determine maximum score depth the silt factor of the bad material is required to be determined. The silt factor (K_{sf}) depends upon the average size of bed material and given by Lacey equation as follows:

$$K_{sf} = 1.76 \sqrt{d_m} \quad \dots\dots 1$$

Where d_m = the weighted mean diameter in millimeter

Also, in case of soil having $\phi < 15^\circ$ and c (cohesion of soil) $> 0.2 \text{ kg/cm}^2$, ' K_{sf} ' calculated as follows :

$$K_{sf} = F (1 + \sqrt{c}) \text{ where } c \text{ is in } \text{kg/cm}^2 \quad \dots\dots 2$$

where $F = 1.50$ for $\phi > 10^\circ$ and $< 15^\circ$

$= 1.75$ for $\phi > 5^\circ$ and $< 10^\circ$

$= 2.00$ for $\phi < 5^\circ$

The strata at this location found to be highly plastic clay (CH). The silt factor has been calculated on the basis of undrained cohesion (c) of the soil using equation (2) above. The undrained cohesion has been obtained from SPT data recorded at the site. The calculation of silt factor is as follows :

| | | | |
|--|---|----------------------------------|---------------------|
| Design SPT-value of the Strata (Refusal, $N > 100$) | : | 9 | = (6+7+9+9+11+12)/6 |
| (below the Founding level) | : | | |
| Cohesion, $C_u = 6 \text{ N (kPa)}$ | : | 54 | |
| Angle of shearing resistance (restricted) ϕ | : | 0 | |
| Cohesion, $C_u (\text{kg/cm}^2)$ | : | 0.54 | |
| The silt factor shall be as follows : | : | $K_{sf} = F (1 + \sqrt{c})$ | |
| Where : | : | 2 | |
| | : | $K_{sf} = 2 * (1 + \sqrt{0.54})$ | |
| | : | 3.47 | |

DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH, ADB TA - 8116 IND

SILT FACTOR CALCULATION BASED ON COHESION OF SOIL MJB AT CH.341+780

Location : BH-342/1B

Depth : 2.80-27.0m

In order to determine maximum score depth the silt factor of the bad material is required to be determined. The silt factor (K_{sf}) depends upon the average size of bed material and given by Lacey equation as follows:

$$K_{sf} = 1.76 \sqrt{d_m} \quad \dots\dots 1$$

Where d_m = the weighted mean diameter in millimeter

Also, in case of soil having $\phi < 15^\circ$ and c (cohesion of soil) $> 0.2 \text{ kg/cm}^2$, ' K_{sf} ' calculated as follows :

$$K_{sf} = F (1 + \sqrt{c}) \text{ where } c \text{ is in } \text{kg/cm}^2 \quad \dots\dots 2$$

where $F = 1.50$ for $\phi > 10^\circ$ and $< 15^\circ$

$= 1.75$ for $\phi > 5^\circ$ and $< 10^\circ$

$= 2.00$ for $\phi < 5^\circ$

The strata at this location found to be highly plastic clay (CH). The silt factor has been calculated on the basis of undrained cohesion (c) of the soil using equation (2) above. The undrained cohesion has been obtained from SPT data recorded at the site. The calculation of silt factor is as follows :

| | | | |
|--|------------|-----------------------------|--------------------|
| Design SPT-value of the Strata (Refusal, $N > 100$) | : | 10.4 | = (8+9+10+12+13)/5 |
| (below the Founding level) | : | | |
| Cohesion, $C_u = 6 \text{ N (kPa)}$ | : | 62.4 | |
| Angle of shearing resistance (restricted) ϕ | : | 0 | |
| Cohesion, $C_u \text{ (kg/cm}^2\text{)}$ | : | 0.624 | |
| The silt factor shall be as follows : | : | $K_{sf} = F (1 + \sqrt{c})$ | |
| Where : | F | : 2 | |
| | $K_{sf} =$ | : $2 * (1 + \sqrt{0.624})$ | |
| | | : 3.58 | |

SILT FACTOR CALCULATION BASED ON COHESION OF SOIL
MJB AT CH.341+780

Location : BH-342/1C

Depth : 1.0-30.0m

In order to determine maximum score depth the silt factor of the bad material is required to be determined. The silt factor (K_{sf}) depends upon the average size of bed material and given by Lacey equation as follows:

$$K_{sf} = 1.76 \sqrt{d_m} \quad \dots\dots 1$$

Where d_m = the weighted mean diameter in millimeter

Also, in case of soil having $\phi < 15^\circ$ and c (cohesion of soil) $> 0.2 \text{ kg/cm}^2$, ' K_{sf} ' calculated as follows :

$$K_{sf} = F (1 + \sqrt{c}) \text{ where } c \text{ is in } \text{kg/cm}^2 \quad \dots\dots 2$$

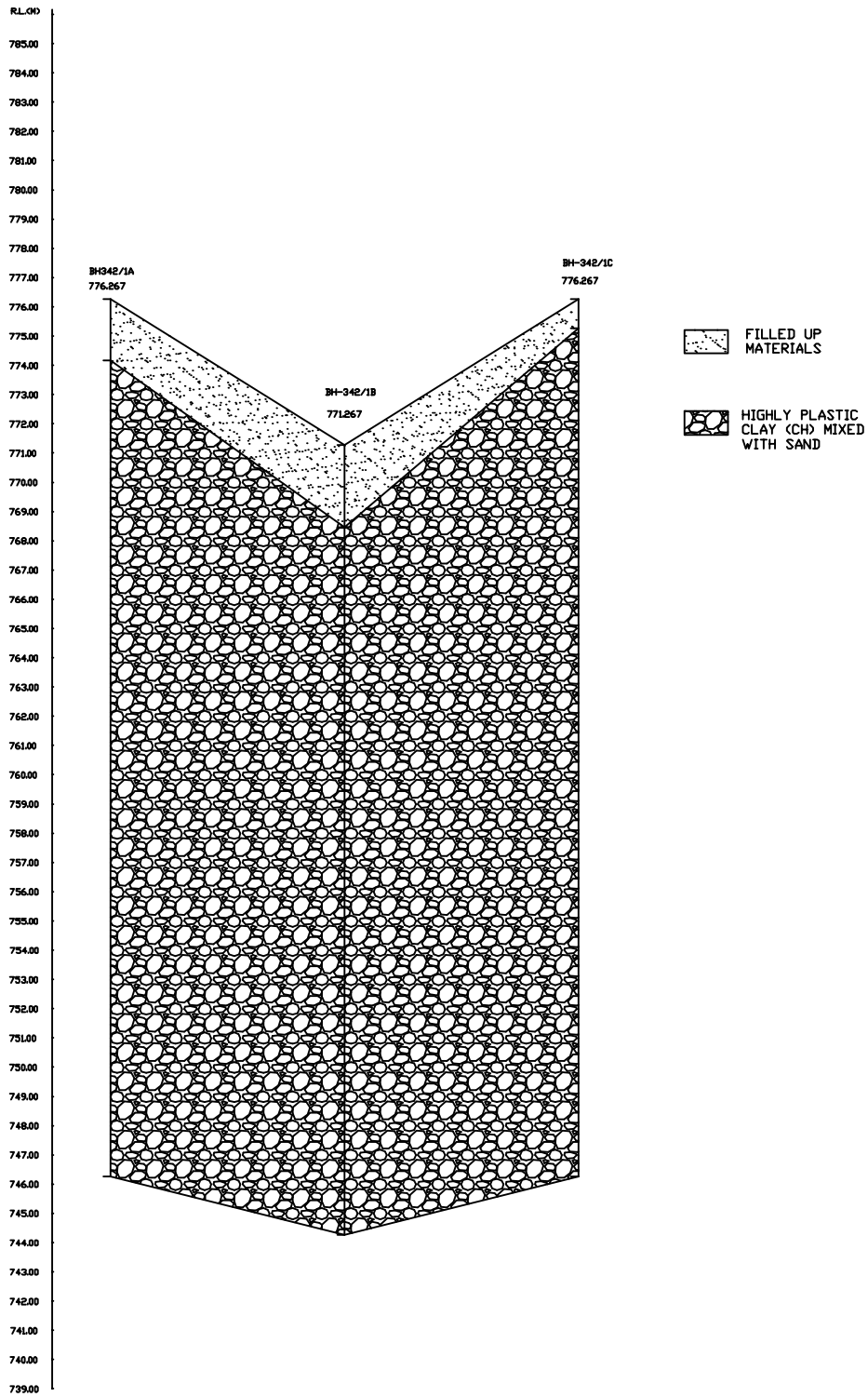
where $F = 1.50$ for $\phi > 10^\circ$ and $< 15^\circ$

$= 1.75$ for $\phi > 5^\circ$ and $< 10^\circ$

$= 2.00$ for $\phi < 5^\circ$

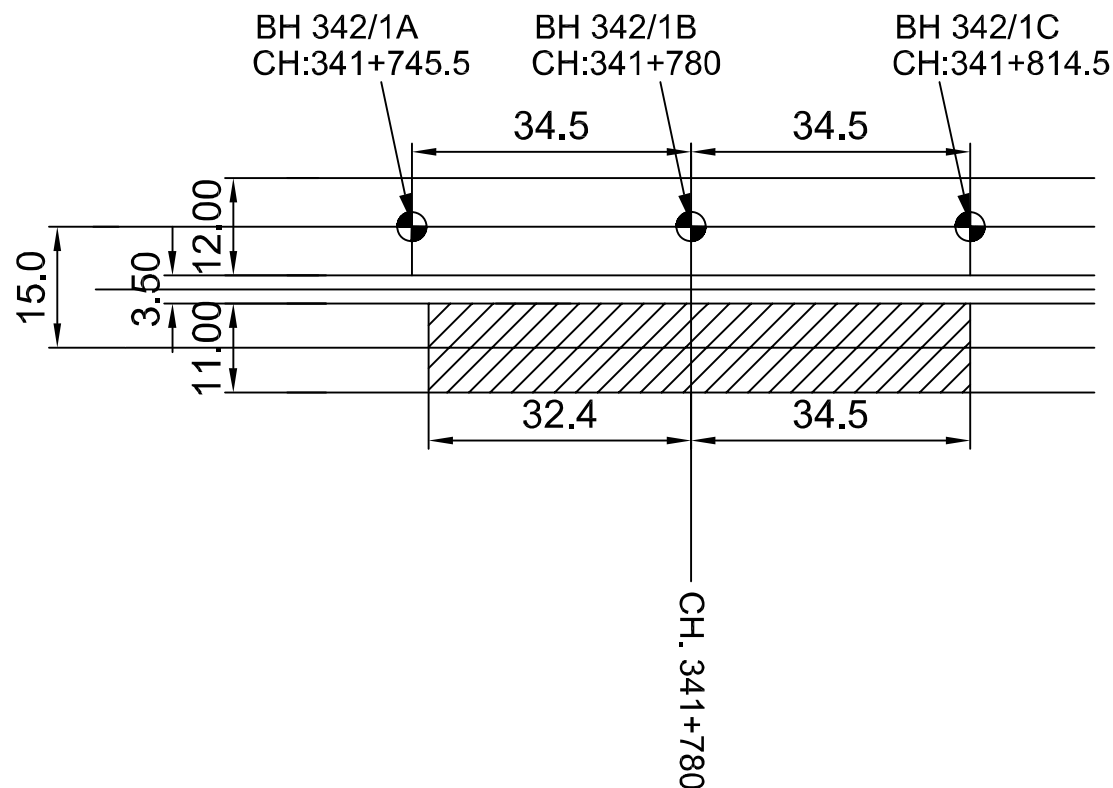
The strata at this location found to be highly plastic clay (CH). The silt factor has been calculated on the basis of undrained cohesion (c) of the soil using equation (2) above. The undrained cohesion has been obtained from SPT data recorded at the site. The calculation of silt factor is as follows :

| | | | |
|--|------------|-----------------------------|----------------------|
| Design SPT-value of the Strata (Refusal, $N > 100$) | : | 9.17 | = (6+8+9+10+11+11)/6 |
| (below the Founding level) | : | | |
| Cohesion, $C_u = 6 \text{ N (kPa)}$ | : | 55 | |
| Angle of shearing resistance (restricted) ϕ | : | 0 | |
| Cohesion, $C_u (\text{kg/cm}^2)$ | : | 0.55 | |
| The silt factor shall be as follows : | : | $K_{sf} = F (1 + \sqrt{c})$ | |
| Where : | F | : 2 | |
| | $K_{sf} =$ | : $2 * (1 + \sqrt{0.55})$ | |
| | | : 3.48 | |



PROFILE : MAJOR BRIDGE AT CH. 341+780
SOIL / ROCK PROFILE ALONG BH-342/1A, BH-342/1B
& BH-342/1C

BOREHOLE LOCATION PLAN FOR MAJOR BRIDGE AT CH: 341+780 (Thoubal)



Proposed Span Arrangements
(2 x 34.5)

Existing Span Arrangements
(32.42 + 34.5)

(The borehole locations are given for
Existing chainage)

LEGEND:



Borehole Location



Existing Bridge

PROJECT

DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION
FROM IMPHAL TO MOREH, ADB TA - 8116 IND

Design Consultant :

SHELADIA ASSOCIATES INC., USA



Amsrl Shamira, Flat No: 206 & 207,
S D Road, Old Lancer Lanes,
Secunderabad - 500 003, AP.

GEOTECH REPORT FOR MAJOR BRIDGE

AT CH: 365+822

**Geotechnical Investigation Report for determination of allowable bearing pressure for MAJOR
BRIDGE at CH. 365+550 of NH-39**

under

**“DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH,
ADB TA - 8116 IND”**

ABSTRACT

The safe load carrying capacity of the foundation of MAJOR BRIDGE at Ch. 365+550 on NH-39 is recommended as follows:

| Location | | Bore hole/ogl Level (m) | Theoretical Scour Level (m) | Scour Depth Below BH (m) | Pile Cap Top Level (m) | Pile Cap Bottom Level (m) | Pile Tip Level (m) | Length of Pile (m) | Vertical Capacity (t) | Lateral Capacity (t) | Uplift Capacity (T) |
|----------|----|----------------------------------|-----------------------------------|-----------------------------------|---------------------------------|------------------------------------|--------------------------|--------------------------|-----------------------------|----------------------------|---------------------------|
| 366/1A | A1 | 783.179 | 777.200 | 5.98 | 782.679 | 780.179 | 748.179 | 32 | 250 | 25 | 90 |
| | P1 | 781.179 | 772.062 | 9.1 | 780.679 | 778.679 | 743.679 | 35 | 250 | 15 | 95 |

THE STRATA AT GLANCE AND SILT FACTORS

| Borehole No. | Type of strata | Depth | Weighted mean dia, d_m (mm) | Silt Factor |
|--------------|--|------------|-------------------------------|-------------|
| 1 | 2 | 3 | 4 | 5 |
| BH-366/1A | Filled-up Material | 3.0 - 9.0m | - | 3.68 |
| | Highly Plastic Clay (CH) mixed with Sand | 10.0-15.0m | - | 3.77 |

Geotechnical Investigation Report
for determination of allowable bearing pressure for
MAJOR BRIDGE at CH. 365+550 on NH-39 under
“Detailed Project for Indo Myanmar Road Section from Imphal to Moreh,
ADB TA - 8116 IND”

1. INTRODUCTION

Geotechnical investigation was carried out for MAJOR BRIDGE at Ch.365+550 on NH-39 under Detailed Project for Indo Myanmar Road Section from Imphal to Moreh, ADB TA - 8116 IND. The Schedule of work and the locations of bore holes were decided by Engineer In-charge of Sheladia Associates, Inc., USA. The locations of boreholes are shown in Key Plan (Fig.C4).

2.0 FIELD INVESTIGATION

2.1 Boring

One bore hole i.e. BH-366/1A was made at the locations decided by Engineer In-charge as shown in Key Plan (Fig.C4). Boring was done by power driven rig as per guidelines of IS: 1892:1979 and IRC-78-2000. Boring was done up to the maximum depth of 15.0m. The soil samples were collected as required for laboratory testing.

2.2 Standard Penetration Test (SPT)

Standard penetration test (SPT) was conducted in the bore hole as per IS 2131-1981. The numbers of blows for first 15 cm penetration is considered as seating drive and are not taken into account. The number of blows required for last 30 cm penetration is taken as SPT number (“N” values). If number of blows for last 30 cm penetration exceeds 100, it is said to be the refusal. SPT were conducted at regular interval of 1.5m, starting from the depth of 1.5m from the

ground surface to the depth of exploration/ refusal. The tests results are shown in Table-C4.1.

2.3 Water Table

The water table was observed at the depth of 1.8m from ground surface, at the time of investigation (i.e. January 2014).

3.0 LABORATORY INVESTIGATION

Soil Samples:

The following laboratory tests were conducted on the soil samples obtained from test bore holes:

- a) Natural Moisture content
- b) Specific gravity
- c) Liquid & Plastic Limit
- d) Grain size Analysis
- e) Shear strength test
- f) Bulk density (Dry Density)
- g) Free swell test

Test results are shown in bore log i.e. Table-C4.1.

4. TYPE OF STRATA

Based on laboratory and field investigation the strata at the site have been described. The bore-log of the strata is presented in Table-C4.1. The strata are as follows:

BH-366/1A

The upper layer of the strata thickness about 1.5m was found to be Filled-up Material. Below this, Highly Plastic Clay (CH) mixed with Sand was found up to the depth of exploration i.e. 15.0m. The bore-log is shown in Table-C4.1.

5.0 FOUNDATION ANALYSIS

Pile foundation has been analyzed. The calculation sheets for safe load carrying capacity bearing capacity in vertical and uplift for different borehole locations are attached as Appendix-C4.1.

6.0 SILT FACTOR

In order to determine maximum scour depth the silt factor of the bed material is required to be determined. The silt factor (f) depends upon the average size of bed material and given by Lacey equation as follows:

$$K_{sf} = 1.76 \sqrt{d_m}$$

Where d_m = the weighted mean diameter in millimeter

Also, in case of soil having $\phi < 15^\circ$ and c (cohesion of soil) $> 0.2 \text{ kg/cm}^2$, ' K_{sf} ' calculated as follows :

$$K_{sf} = F (1 + \sqrt{c}) \text{ where } c \text{ is in kg/cm}^2$$

where F = 1.50 for $\phi > 10^\circ$ and $< 15^\circ$
= 1.75 for $\phi > 5^\circ$ and $< 10^\circ$
= 2.00 for $\phi < 5^\circ$

| Borehole No. | Type of strata | Depth | Weighted mean dia, d_m (mm) | Silt Factor |
|--------------|--|------------|-------------------------------|-------------|
| 1 | 2 | 3 | 4 | 5 |
| BH-366/1A | Filled-up Material | 3.0 - 9.0m | - | 3.68 |
| | Highly Plastic Clay (CH) mixed with Sand | 10.0-15.0m | - | 3.77 |

7.0 CONCLUSION

1. The strata at the site is described in Section 4.0.
2. The water table was observed at the depth of 1.8m from ground surface, at the time of investigation (i.e. January 2014).
3. Safe load carrying capacity has been recommended as follows:

| Location | | Bore hole/ogl Level (m) | Theoretical Scour Level (m) | Scour Depth Below BH (m) | Pile Cap Top Level (m) | Pile Cap Bottom Level (m) | Pile Tip Level (m) | Length of Pile (m) | Vertical Capacity (t) | Lateral Capacity (t) | Uplift Capacity (T) |
|----------|----|-------------------------|-----------------------------|--------------------------|------------------------|---------------------------|--------------------|--------------------|-----------------------|----------------------|---------------------|
| 366/1A | A1 | 783.179 | 777.200 | 5.98 | 782.679 | 780.179 | 748.179 | 32 | 250 | 25 | 90 |
| | P1 | 781.179 | 772.062 | 9.1 | 780.679 | 778.679 | 743.679 | 35 | 250 | 15 | 95 |

SCOUR DEPTH CALCULATIONS FOR MINOR BRIDGE AT CH: 365+550 (Pallel)

| Si.No | Chainage | Proposed Span Arrangement | Location | HFL (m) | Discharge (Cumecs) | Velocity (m/sec) | Design Discharge 1.3xQ (Cumec) | Silt Factor | Eff. Linear Waterway (m) | Discharge per m width (Cumecs/ | Mean Scour Depth Dsm(m) | Scour depth below HFL(m) | Borehole Level (m) | Min. Bed Level (m) | Theoretic al Scour level (m) | Seismic Scour Level (m) | Actual Scour level (m) | Scour depth below BH (m) |
|-------|----------|---------------------------|----------|---------|--------------------|------------------|--------------------------------|-------------|--------------------------|--------------------------------|-------------------------|--------------------------|--------------------|--------------------|------------------------------|-------------------------|------------------------|--------------------------|
| 3 | 365+550 | 3 x 24 | A1 | 786.140 | 1078 | 4.5 | 1401.4 | 3.0 | 67.2 | 20.854 | 7.039 | 8.940 | 783.179 | - | 777.200 | 778.094 | 777.200 | 5.979 |
| | (Pallel) | | P | 786.140 | 1078 | 4.5 | 1401.4 | 3.0 | 67.2 | 20.854 | 7.039 | 14.078 | 781.179 | 781.179 | 772.062 | 773.469 | 772.062 | 9.117 |

Pile Capacity Calculations (IS:2911/Part-1/Sec-2)-1979

Bored Cast in Situ Piles

Structure: Major Bridge (Parallel)

Chainage: 365+550

Location: A1

Calculation of Skin friction Resistance

(Existing)

| Item | Layer -I | Layer -II | Layer -III | Layer -IV | Layer -V | Layer -VI | Layer -VII |
|---|---|------------|-------------|------------|-------------|-------------|-------------|
| Type of strata | Clay | Clay | Clay | Clay | Clay | Clay | Clay |
| Diameter of Pile (D) | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m |
| Length of Pile (L) | 32.0 m | 32 m | 32 m | 32 m | 32 m | 32 m | 32 m |
| Bulk density of the strata (γ) | 16.8 kn/m3 | 17.2 kn/m3 | 17.2 kn/m3 | 17.4 kn/m3 | 17.4 kn/m3 | 17.4 kn/m3 | 17.8 kn/m3 |
| Submerged Unit Weight (γ') | | 7.2 | 7.2 | 7.4 | 7.4 | 7.4 | 7.8 |
| Undrained shear strength (Cu) | 0 kn/m2 | 75 kn/m2 | 120 kn/m2 | 176 kn/m2 | 230 kn/m2 | 240 kn/m2 | 250 kn/m2 |
| Angle of internal friction of soil (φ) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Thickness of soil layer (h) | 6 m | 7.5 m | 7.5 m | 6.0 m | 3.0 m | 2.0 m | 2.3 m |
| Effective over burden pressure over the top of strata | 0 kn/m2 | 0 kn/m2 | 54 kn/m2 | 108 kn/m2 | 152.4 kn/m2 | 174.6 kn/m2 | 189.4 kn/m2 |
| Effective over burden pressure over the bottom of strata | 0 | 54 | 108 | 152.4 | 174.6 | 189.4 | 207.3 |
| Adhesion (α) | - | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| K= Coefficient of earth pressure in loose to medium sands = 1 - 3 | | 1 | 1 | 1 | 1 | 1 | 1 |
| Effective over burden pressure Pd = | | 27 | 81 | 130.2 | 163.5 | 182 | 198.4 |
| Angle of wall friction δ=φ | | 0 | 0 | 0 | 0 | 0 | 0 |
| (It is equal to angle of internal friction) | | | | | | | |
| As= 3.142*D*h | | 28.278 | 28.278 | 22.6224 | 11.3112 | 7.54 | 8.672 |
| (for Granular soils) K x Pd x tanδ x As= | | 0 Kn | 0 Kn | 0 Kn | 0.00 Kn | 0 Kn | 0 Kn |
| (for Cohesive soils) α Cu As= α*Cu*3.142*D*h | No skin resistance is considered for this layer | 636.255 Kn | 1018.008 Kn | 1194.46 Kn | 780.4728 Kn | 542.94 Kn | 650.4 Kn |

Skin friction resistance due to cohesive soil layers

$$\sum(\alpha \text{ Cu As})= 4822.53 \text{ kN}$$

Skin friction resistance due to granular soil layers

$$\sum(K \times Pd \times \tan \delta \times As)= 0 \text{ kN}$$

Negtaive skin friction

$$= 241.127 \text{ kN}$$

Total Skin friction resistance of the pile, qs

$$R_f = \sum(\alpha \text{ Cu As} + K \times Pd \times \tan \delta \times As) = 4581.40$$

Calculation of End bearing resistance

| | |
|--|---|
| Type of bearing strata | Clay |
| C/S area of Pile | 1.131 sqm |
| Length of Pile (L) | 32 m |
| SPT value (N) | |
| Angle of internal friction of soil (φ) | φ 0 |
| Bearing capacity factor | Nc 9 |
| | Nq 17 |
| | Nγ 0 |
| Effective over burden pressure | Pd 0 Kn/m2 |
| Total End bearing resistance of the pile (Qp) | Qp= Ap*(1/2*D*γ*Nr+Pd*Nq)+(Ap*Nc*cp)= 1791.462 kN |
| Ultimate load carrying capacity | Qu= Qs+Qp = 6372.87 |
| Safe load carrying capacity | Qsafe= 2549.1462 kN |
| The Safe load carrying capacity of pile= | 255 t |

The Recommended vertical load carrying capacity is 250t

Ultimate Uplift load carrying capacity is 3206.98 Kn

The Safe Uplift load carrying capacity is 898.314 Kn
89.8314 Tonnes

The Recommended Uplift load carrying capacity is 85.00 Tonnes

Pile Capacity Calculations (IS:2911/Part-1/Sec-2)-1979

Bored Cast in Situ Piles

Calculation of Skin friction Resistance

Structure: Major Bridge (Parallel)

Chainage: 365+550

Location: P1

(Existing)

| Item | Layer -I | Layer -II | Layer -III | Layer -IV | Layer -V | Layer -VI | Layer -VII |
|---|---|------------------------|-------------------------|-------------------------|--------------------------|--------------------------|-------------------------|
| Type of strata | Clay | Clay | Clay | Clay | Clay | Clay | Clay |
| Diameter of Pile (D) | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m | 1.2 m |
| Length of Pile (L) | 34.5 m | 34.5 m | 34.5 m | 34.5 m | 34.5 m | 34.5 m | 34.5 m |
| Bulk density of the strata (γ) | 16.8 kn/m ³ | 17.2 kn/m ³ | 17.2 kn/m ³ | 17.4 kn/m ³ | 17.4 kn/m ³ | 17.4 kn/m ³ | 17.8 kn/m ³ |
| Submerged Unit Weight (γ') | | 7.2 | 7.2 | 7.4 | 7.4 | 7.4 | 7.8 |
| Undrained shear strength (Cu) | 0 kn/m ² | 75 kn/m ² | 120 kn/m ² | 176 kn/m ² | 230 kn/m ² | 240 kn/m ² | 250 kn/m ² |
| Angle of internal friction of soil (φ) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Thickness of soil layer (h) | 9.2 m | 4.3 m | 7.5 m | 6.0 m | 3.0 m | 2.0 m | 4.8 m |
| Effective over burden pressure over the top of strata | 0 kn/m ² | 0 kn/m ² | 30.96 kn/m ² | 84.96 kn/m ² | 129.36 kn/m ² | 151.56 kn/m ² | 166.4 kn/m ² |
| Effective over burden pressure over the bottom of strata | 0 | 30.96 | 84.96 | 129.36 | 151.56 | 166.36 | 203.8 |
| Adhesion (α) | - | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| K= Coefficient of earth pressure in loose to medium sands = 1 - 3 | | 1 | 1 | 1 | 1 | 1 | 1 |
| Effective over burden pressure Pd = | | 15.48 | 57.96 | 107.16 | 140.46 | 158.96 | 185.1 |
| Angle of wall friction δ=φ | | 0 | 0 | 0 | 0 | 0 | 0 |
| (It is equal to angle of internal friction) | | | | | | | |
| As= 3.142*D*h | | 16.21272 | 28.278 | 22.6224 | 11.3112 | 7.54 | 18.1 |
| (for Granular soils) K x Pd x tanδ x As= | | 0 Kn | 0 Kn | 0 Kn | 0.00 Kn | 0 Kn | 0 Kn |
| (for Cohesive soils) α Cu As= | No skin resistance is considered for this layer | 364.7862 Kn | 1018.008 Kn | 1194.46 Kn | 780.4728 Kn | 542.94 Kn | 1357 Kn |

Skin friction resistance due to cohesive soil layers

$$\sum(\alpha \text{ Cu As}) = 5258.01 \text{ kN}$$

Skin friction resistance due to granular soil layers

$$\sum(K \times Pd \times \tan \delta \times As) = 0 \text{ kN}$$

Negtaive skin friction

$$= 262.901 \text{ kN}$$

Total Skin friction resistance of the pile, qs

$$R_f = \sum(\alpha \text{ Cu As} + K \times Pd \times \tan \delta \times As) = 4995.11$$

Calculation of End bearing resistance

Type of bearing strata Clay
C/S area of Pile 1.131 sqm
Length of Pile (L) 34.5 m
SPT value (N)
Angle of internal friction of soil (φ) 0
Bearing capacity factor Nc 9
Nq 17
Ny 0

Effective over burden pressure Pd 0 Kn/m²

Total End bearing resistance of the pile (Qp) Qp= Ap*(1/2*D*γ*Nr+Pd*Nq)+(Ap*Nc*cp)= 1791.462 kN

Ultimate load carrying capacity Qu= Qs+Qp = 6786.57

Safe load carrying capacity Qsafe= 2714.629 kN

The Safe load carrying capacity of pile= 271 t

The Recommended vertical load carrying capacity is 250t

Ultimate Uplift load carrying capacity is 3496.58 Kn

The Safe Uplift load carrying capacity is 979.433 Kn

97.9433 Tonnes

The Recommended Uplift load carrying capacity is 95.00 Tonnes

**ESTIMATION OF LATERAL LOAD CARRYING CAPACITY OF PILES for A1
(PALLEAL) MAJOR BRIDGE AT CH: 365+550**

Stipulations of IS:2911 (Part I/Sec.2) - 1979 are followed

| | | |
|--|---|----------------------------|
| Diameter of Pile | = | 1200 mm |
| Strength of Pile Concrete | = | 35 N/mm ² |
| Young's Modulus of Pile Concrete | = | 31500 N/mm ² |
| | = | 31500000 kN/m ² |
| Moment of Inertia of Pile Cross Section | = | 1.02E+11 mm ⁴ |
| | = | 0.1018 m ⁴ |
| Top Layer of sub-soil strata | = | Clay |
| Value of Constant, k ₁ | = | 6000 kN/m ³ |
| T | = | 4.81 m |
| Unsupported Length, L ₁ | = | 3.200 m |
| L ₁ /T | = | 0.666 |
| L _i /T | = | 2.08 |
| L _i (Ref Fig.2, Appendix C of IS 2911 (Part 1/Sec.2) - 1979 | = | 10.001 m |
| Cantilever span of pile | = | 13.2 m |
| Lateral Deflection at bottom of pile cap level under unit lateral load | = | 0.000060 m |
| Lateral Deflection at Top of PILE | = | 0.0598 mm |
| Corresponding Deflection at scour level | = | 0.0453 mm |
| Allowable deflection at scour level | = | 12 mm |
| Force that causes 12mm Lateral Deflection at scour level | = | 264.943 kN |
| Thus, Lateral Capacity of INDIVIDUAL PILE | = | 264.943 kN |

NOTE: The recommended lateral load carrying capacity is 25 tonnes

**ESTIMATION OF LATERAL LOAD CARRYING CAPACITY OF PILES for P1
(PALLEAL) MAJOR BRIDGE AT CH: 365+550**

Stipulations of IS:2911 (Part I/Sec.2) - 1979 are followed

| | | |
|--|---|----------------------------|
| Diameter of Pile | = | 1200 mm |
| Strength of Pile Concrete | = | 35 N/mm ² |
| Young's Modulus of Pile Concrete | = | 31500 N/mm ² |
| | = | 31500000 kN/m ² |
| Moment of Inertia of Pile Cross Section | = | 1.02E+11 mm ⁴ |
| | = | 0.1018 m ⁴ |
| Top Layer of sub-soil strata | = | Clay |
| Value of Constant, k ₁ | = | 5333 kN/m ³ |
| T | = | 4.95 m |
| Unsupported Length, L ₁ | = | 6.700 m |
| L ₁ /T | = | 1.353 |
| L _i /T | = | 1.98 |
| L _i (Ref Fig.2, Appendix C of IS 2911 (Part 1/Sec.2) - 1979 | = | 9.804 m |
| Cantilever span of pile | = | 16.5 m |
| Lateral Deflection at bottom of pile cap level under unit lateral load | = | 0.000117 m |
| Lateral Deflection at Top of PILE | = | 0.1168 mm |
| Corresponding Deflection at scour level | = | 0.0694 mm |
| Allowable deflection at scour level | = | 12 mm |
| Force that causes 12mm Lateral Deflection at scour level | = | 172.885 kN |
| Thus, Lateral Capacity of INDIVIDUAL PILE | = | 172.885 kN |

NOTE: The recommended lateral load carrying capacity is 15 tonnes

TABLE-C4.1: RESULT SHEET FOR MAJOR BRIDGE AT CH.365+822 ON BH-366/1A

(W.T. = 1.80M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH

ADB TA - 8116 IND

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 29.12.2013

Completion date : 29.12.2013

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|--------------------|--------|-------|------------------|
| | 15 | 30 | 45 | N | | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 1.0 | 7 | 8 | 12 | 20 | FILLED-UP MATERIAL | | | | | | | | | | | | | |
| 2.0 | 8 | 9 | 9 | 18 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | | | | | | | | | | | | | |
| 3.0 | 2 | 3 | 3 | 6 | | 2.80 | 26.82 | 14.08 | 56.30 | 56.20 | 25.0 | - | 2.69 | - | - | - | 43.0 | - |
| 4.0 | 3 | 4 | 4 | 8 | | | | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | | | | | | | | |
| 6.0 | 3 | 4 | 5 | 9 | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | |
| 8.0 | 4 | 5 | 5 | 10 | | | | | | | | | | | | | | |
| 9.0 | 5 | 6 | 7 | 13 | | 0.82 | 24.64 | 16.40 | 58.14 | 63.50 | 23.0 | - | - | - | - | - | 38.0 | - |

* = Consolidation Test,

c_c = Compression Index,

DFS = Differential Free Swell,

—v = Water Table,

Sp = Swelling Pressure

TABLE-C4.1: RESULT SHEET FOR MAJOR BRIDGE AT CH.365+822 ON BH-366/1A

(W.T. = 1.80M)

PROJECT : DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH**ADB TA - 8116 IND**

Size of Hole : Nx Size

Type of Bit : TC / Diamond

Starting date : 29.12.2013

Completion date : 29.12.2013

| Depth (m) | N - value | | | | IS Classification | Sieve Size Analysis with hydrometer test | | | | Atterberg Limits | | Natural Moisture content, % (Sr, %) | Specific Gravity | Bulk Density (t/m ³) | Shear Parameter | | DFS % | * C _c |
|-----------|-----------|----|----|----|---|--|--------|--------|--------|------------------|-----------------|-------------------------------------|------------------|----------------------------------|-----------------------|-----------|-------|------------------|
| | 15 | 30 | 45 | N | Soil Description | Gravel % | Sand % | Silt % | Clay % | Liquid Limit % | Plastic Limit % | | | | c t/m ² | ø deg. | | |
| 10.0 | 5 | 6 | 8 | 14 | HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND | | | | | | | | | | | | | |
| 11.0 | | | | | | | | | | | | | | | | | | |
| 12.0 | 6 | 7 | 9 | 16 | | | | | | | | | | | | | | |
| 13.0 | | | | | | | | | | | | | | | | | | |
| 14.0 | 7 | 8 | 10 | 18 | | 1.00 | 28.32 | 14.14 | 56.54 | 53.0 | 19.5 | - | 2.71 | - | - | - | 40.0 | - |
| 15.0 | 8 | 9 | 11 | 20 | | | | | | | | | | | | | | |
| 16.0 | | | | | | | | | | | | | | | | | | |
| 17.0 | | | | | | | | | | | | | | | | | | |
| 18.0 | | | | | | | | | | | | | | | | | | |

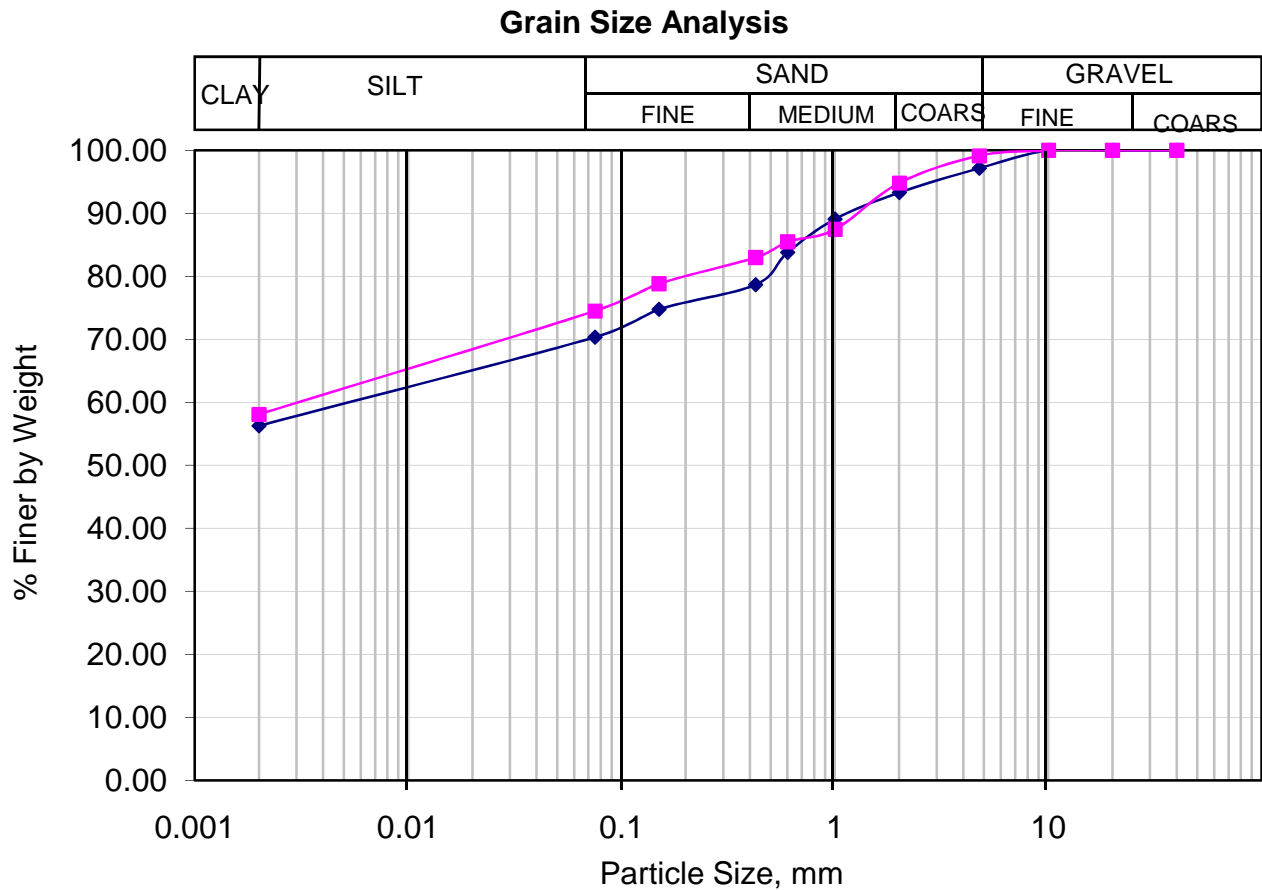
* = Consolidation Test, c_c = Compression Index, DFS = Differential Free Swell, —v = Water Table, Sp = Swelling Pressure

PNT DESIGNS PVT. LTD., KOTA

PROJECT - DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH, ADB TA - 8116 IND

Determination of Grain Size Analysis Test as per IS:2720-Part 4-1985

MAJOR BRIDGE AT CH: 365+822 (366/1A)



| Symbol | BH No. | Depth,m | Soil description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|--------|-----------|---------|------------------|------------|----------|----------|----------|
| | BH-366/1A | 3.00 | CH* | 2.80 | 26.82 | 14.08 | 56.30 |
| | BH-366/1A | 9.00 | CH* | 0.82 | 24.64 | 16.40 | 58.14 |

CH* = HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND

SILT FACTOR CALCULATION BASED ON COHESION OF SOIL
MJB AT CH.365+550

Location : BH-366/1A

Depth : 3.00-9.0m

In order to determine maximum score depth the silt factor of the bad material is required to be determined. The silt factor (K_{sf}) depends upon the average size of bed material and given by Lacey equation as follows:

$$K_{sf} = 1.76 \sqrt{d_m} \quad \dots\dots 1$$

Where d_m = the weighted mean diameter in millimeter

Also, in case of soil having $\phi < 15^\circ$ and c (cohesion of soil) $> 0.2 \text{ kg/cm}^2$, ' K_{sf} ' calculated as follows :

$$K_{sf} = F (1 + \sqrt{c}) \text{ where } c \text{ is in } \text{kg/cm}^2 \quad \dots\dots 2$$

where $F = 1.50$ for $\phi > 10^\circ$ and $< 15^\circ$

$= 1.75$ for $\phi > 5^\circ$ and $< 10^\circ$

$= 2.00$ for $\phi < 5^\circ$

The strata at this location found to be highly plastic clay (CH). The silt factor has been calculated on the basis of undrained cohesion (c) of the soil using equation (2) above. The undrained cohesion has been obtained from SPT data recorded at the site. The calculation of silt factor is as follows :

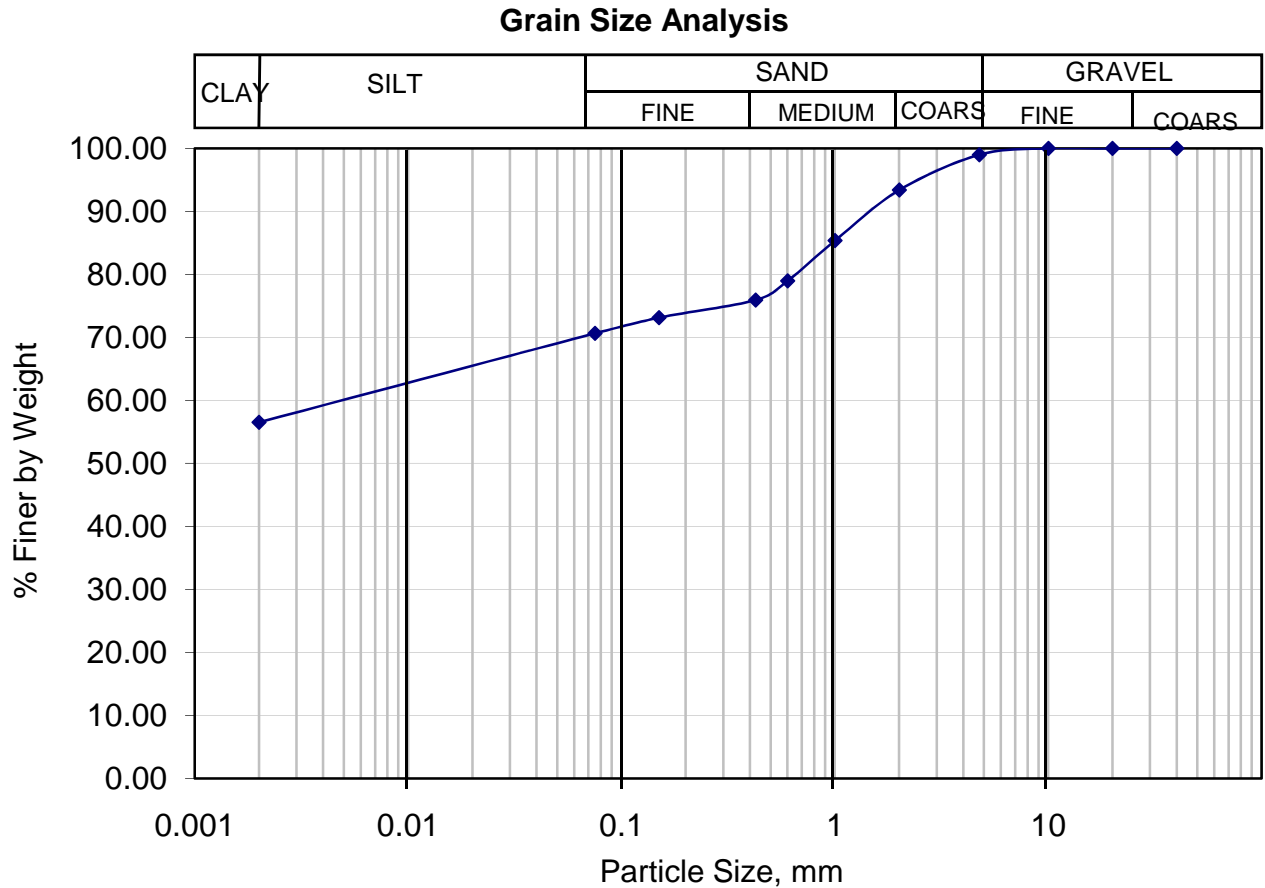
| | | | |
|--|------------|-----------------------------|---------------------|
| Design SPT-value of the Strata (Refusal, $N > 100$) | : | 12.4 | = (9+10+13+14+16)/5 |
| (below the Founding level) | : | | |
| Cohesion, $C_u = 6 \text{ N (kPa)}$ | : | 74.4 | |
| Angle of shearing resistance (restricted) ϕ | : | 0 | |
| Cohesion, $C_u \text{ (kg/cm}^2\text{)}$ | : | 0.705 | |
| The silt factor shall be as follows : | : | $K_{sf} = F (1 + \sqrt{c})$ | |
| Where : | F | : 2 | |
| | $K_{sf} =$ | : $2 * (1 + \sqrt{0.705})$ | |
| | | : 3.68 | |

PNT DESIGNS PVT. LTD., KOTA

PROJECT - DETAILED PROJECT FOR INDO MYANMAR ROAD SECTION FROM IMPHAL TO MOREH, ADB TA - 8116 IND

Determination of Grain Size Analysis Test as per IS:2720-Part 4-1985

MAJOR BRIDGE AT CH: 365+822 (366/1A)



| Symbol | BH No. | Depth,m | Soil description | Gravel (%) | Sand (%) | Silt (%) | Clay (%) |
|--------|-----------|---------|------------------|------------|----------|----------|----------|
| —◆— | BH-366/1A | 13.50 | CH* | 1.00 | 28.32 | 14.14 | 56.54 |

CH* = HIGHLY PLASTIC CLAY (CH) MIXED WITH SAND

SILT FACTOR CALCULATION BASED ON COHESION OF SOIL
MJB AT CH.365+550

Location : BH-366/1A

Depth : 9.00 - 13.5m

In order to determine maximum score depth the silt factor of the bad material is required to be determined. The silt factor (K_{sf}) depends upon the average size of bed material and given by Lacey equation as follows:

$$K_{sf} = 1.76 \sqrt{d_m} \quad \dots\dots 1$$

Where d_m = the weighted mean diameter in millimeter

Also, in case of soil having $\phi < 15^\circ$ and c (cohesion of soil) $> 0.2 \text{ kg/cm}^2$, ' K_{sf} ' calculated as follows :

$$K_{sf} = F (1 + \sqrt{c}) \text{ where } c \text{ is in } \text{kg/cm}^2 \quad \dots\dots 2$$

where $F = 1.50$ for $\phi > 10^\circ$ and $< 15^\circ$

$= 1.75$ for $\phi > 5^\circ$ and $< 10^\circ$

$= 2.00$ for $\phi < 5^\circ$

The strata at this location found to be highly plastic clay (CH). The silt factor has been calculated on the basis of undrained cohesion (c) of the soil using equation (2) above. The undrained cohesion has been obtained from SPT data recorded at the site. The calculation of silt factor is as follows :

| | | | |
|--|------------|-----------------------------|-------------------|
| Design SPT-value of the Strata (Refusal, $N > 100$) | : | 17.0 | = (14+16+18+20)/4 |
| (below the Founding level) | : | | |
| Cohesion, $C_u = 6 \text{ N (kPa)}$ | : | 102.0 | |
| Angle of shearing resistance (restricted) ϕ | : | 0 | |
| Cohesion, $C_u \text{ (kg/cm}^2\text{)}$ | : | 0.785 | |
| The silt factor shall be as follows : | : | $K_{sf} = F (1 + \sqrt{c})$ | |
| Where : | F | : 2 | |
| | $K_{sf} =$ | : $2 * (1 + \sqrt{0.785})$ | |
| | | : 3.77 | |