राष्ट्रीय राजमार्ग एवं अवसंरचना विकास निगम लिमिटेड
सड़क परिवहन और राजमार्ग मंत्रालय, भारत सरकार
प्रथम तल, टावर ए, वर्ल्ड ट्रेड सेंटर, नौरोजी नगर, नई दिल्ली–110029,
National Highways & Infrastructure Development Corporation Limited
Ministry of Road Transport & Highways, Government of India
First Floor, Tower A, World Trade Centre, Nauroji Nagar, New Delhi-110029, Tel: +91 11 26768950, www.nhidcl.com
CIN: U45400DL2014GOI269062
(भारत सरकार का उद्यम) (A Government of India Enterprise)

NHIDCL/Sikkim&W.B./DPR/NH-717A&NH-717B/2023/Part-I/238471/3600 07.08.2026

To
All Prospective Bidders

Subject: " Widening and Up-gradation of existing carriageway into 2-lane with paved shoulder configuration from Rhenock (existing Km 0.000) to Rongli Bazaar (existing Km 15.300) along NH-717B in the State of Sikkim on EPC mode"- **Corrigendum-03.**

Tender ID: 2026_NHIDC_914279_1

Corrigendum-03

1. The Existing provisions and modified provisions are as hereunder:

<table>
<tr><th>Sl No.</th><th>Refer Clauses of the RFP/ DCA</th><th>Existing Provisions</th><th>Modified Provisions</th></tr>
<tr><td>i.</td><td>Section 7-Data Sheet Clause 5.1 Data</td><td>5.1 Definition (2.2.2.2 (iii)

b.
(i) Cross-sectional Area of proposed Tunnel (in case of Tunnel)- NA

(ii) Length of Tunnel to be constructed -NA</td><td>5.1 Definition 2.2.2.2 (ii)

b.
(i) Cross-sectional Area of proposed Tunnel (in case of Tunnel)- 101 sqm

(ii) Length of Tunnel to be constructed - 550 m</td></tr>
<tr><td>ii.</td><td>Annex -I (Schedule-B), Clause 11- Hazardous Locations</td><td>The safety barriers (Thrie Beam Crash Barriers along with reflectors) shall be provided at the following hazardous locations:
<table>
<tr><th>Sl. No.</th><th>Location stretches from (km) to (km)</th><th>LHS/RHS</th><th>Remarks</th></tr>
<tr><td>1</td><td>km 00+000 to km 7+560</td><td></td><td></td></tr>
</table></td><td>The safety barriers, i.e., Thrie Beam Crash Barriers along with reflectors, shall be provided. In addition, Bamboo Crash Barriers shall be installed over a total length of 5 km, forming part of the overall length of the safety barriers. The safety barriers shall be provided at the following hazardous locations:
<table>
<tr><th>Sl. No.</th><th>Location stretches from (km) to (km)</th><th>LHS/RHS</th><th>Remarks</th></tr>
</table></td></tr>
</table>

		2 km 7+670 to km 11+200 3 km 11+750 to km 13+690 4 km 13+740 to km 14+514	At Valley side	Except at culvert locations.
iii.	Annex-I (Schedule-D), Clause 3 - Technical Specification	-		**In addition to existing Technical Specification, following technical specification are also added:** • **Tunnel:** • Design Fire Scenario & Fire Load Consideration: Major HGV / Semi-trailer incident scenario with rapid fire growth (t^2 fire curve / standard HC fire curve), as per IRC SP:91, NFPA 502, PIARC. • Design Fire Size (MW): 50 MW *(Heavy goods/mixed traffic expected),* as per IRC:SP:91/NFPA 502. • Jet Fan Fire Rating & Operation Duration: 400°C for 2 hours (Class F400

1	km 00+000 to km 7+560		
2	km 7+670 to km 11+200	At Valley side	Except at culvert locations.
3	km 11+750 to km 13+690		
4	km 13+740 to km 14+514		

			rating per EN 12101-3 / NFPA 502). • Jet Fan Operational Philosophy : Manual • CO, NO, Visibility / Smoke Level Permissible Limits **CO Limit:** <50 ppm (normal), <100 ppm **NO2 Limit:** 1.0 ppm **Visibility / Extinction Coefficient (K):** K < 0.003 m-1(congested traffic) **Emergency Evacuation Visibility:** 10 m - 15 m • Electrical Power Supply: Primary Source: 11 kV / 33 kV State Electricity Grid connection from nearest substation. Backup Source: DG Set with 100% redundancy for critical loads. Point of Connection: Main Control Room / Substation near tunnel portal. • Electrical - Distribution: Transformer: 11kV/0.415kV, dry-type CRT transformer (150-250 kVA rating). HT/LT Panels: Indoor Air-Insulated HT Panel (11kV VCB) & Main LT Distribution Panel equipped with Automatic Transfer Switch (ATS) for seamless grid-to-DG changeover. • Fire hydrant System:

			A dry riser / semi-wet hydrant line running along the tunnel wall with hose connections at 100m intervals is recommended for fire brigade connection. • **Bamboo Crash Barrier:** <u>Bahu-Balli Bamboo Crash Barrier (Kooch Kavach)</u> (Providing and fixing of Bahu-Balli Bamboo Crash Barrier (Kooch Kavach) which comprising of bamboo beam clubbing of 4 bamboo beam rail having 3 beam rail of 80mm (+10mm) external dia each in back and 1 beam rail of 100mm (±10mm) external dia and wall thickness of 10mm to be fixed on the vertical post with a spacer of 110 mm external dia and 300 mm long to fix on clubbing of 3 bamboo poles having 90mm (±10mm) external dia each and 0.85m above road/ground level, spacing of 1.80 m. height Bahu-Balli bamboo vertical post center to center or post to post at 1.60 m and 0.95 m below ground/road level including excavation, beam and post tied with 8mm 19 deg * 6 core) GI Wire rope with clamps and Aluminum ferul locking all steel parts and fitments with M10 Nuts & Bolts to be galvanised by hot dip process, all fittings conform to 4.8 grade steel, all nuts & bolts should be welded at the end. All bamboo poles, beams & spacer by using Bamboo spacies of Bambusa Balcoaa or Bambusa Bambos are well seasoned, treated with VPI and HDPE coating thickness 1.5 mm (+0.5mm). End

			portion of bamboo crash barrier shall be flared outside by 1.25 m., department side shall be terminated by trailing terminal (TT) arrangement as shown in figure 9.13 of the IRC:SP:73-2018, end portion of bamboo crash barrier shall be flared outside by 0.35 m. distance of 6.40 m. in last section, fixing of white retro-reflective tape (made of Class-C Microprismetic Grade sheeting of Type-XI) 50mm wide on front member of beam and 100mm wide on front post etc. complete as per drawing annexed herewith & as directed by Engineer-in-Charge.
iv.	2.2.2.2 (ii)	In addition to above, the bidder must also possess experience of works completed in last 10 years including any 5 items (in a minimum length of 250 m or in a minimum area of 1300 sqmt.) mentioned below: a. Installation of Self Drilling Hollow Soil/Rock Anchors/ pre-stressed anchors in hilly/ mountainous terrain. b. Supply & fixing of High Tensile Rolled Cable Net or High Strength Steel wire mesh /Synthetic Geomat in hilly/mountainous terrain. c. Installation of soil nails, steel mesh and ground anchors. d. Application of shotcrete in hilly/mountainous terrain e. Supply and fixing of double twisted mesh in hilly/mountainous terrain f. installation of High Tensile Rope Net System or High tensile steel	In addition to above, the bidder must also possess experience of works completed in last 10 years including any 5 items (in a minimum length of 250 m or in a minimum area of 1300 sqmt.) mentioned below: a. Installation of Self Drilling Hollow Soil/Rock Anchors/ pre-stressed anchors in hilly/ mountainous terrain. b. Supply & fixing of High Tensile Rolled Cable Net or High Strength Steel wire mesh /Synthetic Geomat in hilly/mountainous terrain. c. Installation of soil nails, steel mesh and ground anchors. d. Application of shotcrete in hilly/mountainous terrain e. Supply and fixing of double twisted mesh in hilly/mountainous terrain f. installation of High Tensile Rope Net System or High tensile steel

		wire mess and hydraulically applied erosion control products g. Multi stand pre-stressed cable anchors h. Rapid slope consolidator i. Mechanically bonded Geotextile j. Gabion wall k. RCC or RR work in slope/ sinking zones l. Micro-piling m. Sub-surface drainage pipes n. Rock Fall Barrier	wire mess and hydraulically applied erosion control products g. Multi stand pre-stressed cable anchors h. Rapid slope consolidator i. Mechanically bonded Geotextile j. Gabion wall k. RCC or RR **or Plum concrete** work in slope/ sinking zones l. Micro-piling m. Sub-surface drainage pipes n. Rock Fall Barrier
v.	Table 1.3.1 of Schedule-H (B.1-Reconstruction/New realignment/bypass (Flexible pavement)) : Col (3)	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length or 500 m length, whichever is less.	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length or 500 m length, whichever is less, and subject to the safe disposal of excavated muck at the dumping site arranged by the Contractor.
vi.	Drawings	-	Typical Drawing of Bamboo Crash Barrier attached.

2. The Geotechnical Report and Hydrology Report are enclosed herewith as part of this Corrigendum for the information of the prospective bidders.

Remaining provisions shall remain unchanged.

Yours faithfully,

(Ankush Mehta)
General Manager (Tech.)

Date : 19/09/2024 **Report No.- 10281**

GEOTECHNICAL INVESTIGATION REPORT

FOR

CONSULTANCY SERVICES FOR PREPARATION OF DPR AND PROVIDING SERVICES FOR PRE-CONSTRUCTION ACTIVITIES IN RESPECT OF "WIDENING AND UP-GRADATION OF EXISTING CARRIAGEWAY INTO 2L+PS CONFIGURATION FROM LAVAMORE (KM 61.10) TO START OF PEDONG BYPASS (KM 79.700) AND FROM RESHI(KM 96.254) .TO RHENOCK (KM 101.554) ALONG NH-717A & FROM RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300) ALONG NH-717B IN THE STATES OF SIKKIM AND WB".

RESHI TO RONGLI, SIKKAM.

CLIENT:

NATIONAL HIGHWAY & INFRASTRUCTURE DEVELOPMENT CORP. LTD.

SUBMITTED TO:

M/S DSD INFRATECH MANAGEMENT PVT. LTD

511, TOWER B, ITHUM, PLOT-A40, SECTOR-62, NOIDA, UTTAR PRADESH.

PREPARED AND SUBMITTED BY:

KUNIKA GEOTECHNICAL SERVICES PVT LTD

(AN IS0 9001-2015 CERTIFIED COMPANY)

B – 141, FIRST FLOOR, SECTOR - 69, NOIDA, UTTAR PRADESH

kgsindia@yahoo.com kgsindia2@gmail.com Ph. No. 08750787882, 7011416334

REPORT ON
GEOTECHNICAL INVESTIGATION
FOR
RESHI TO RONGLI, SIKKAM.

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REPORT ON
GEOTECHNICAL INVESTIGATION
FOR
RESHI TO RONGLI, SIKKAM.

1.0 INTRODUCTION:

1.1 The client, **NHIDCL**, has undertaken a project of "Consultancy Services For Preparation Of DPR And Providing Services For Pre-Construction Activities in Respect of "Widening And Up-Gradation Of Existing Carriageway into 2L+PS Configuration From Lavamore (Km 61.10) To Start Of Pedong Bypass (Km 79.700) And From Reshi(Km 96.254) .To Rhenock (Km 101.554) Along NH-717A & From Rhenock (Km 0.00) To Rongli Bazaar (Km 15.300) Along NH-717B in the States Of Sikkim and WB".

1.2 **National Highway & Infrastructure Development Corp. Ltd.**, have entrusted the work to **M/s Xplorer Consultancy Services Pvt. Ltd. in joint venture DSD Infratech Management Pvt. Ltd.**

1.3 **M/s DSD Infratech Management Pvt. Ltd.** have entrusted the work of sub soil investigation at structure locations to **M/s Kunika Geotechnical Services Pvt Ltd, (KGSPL),** B – 141, First Floor, Sector - 69, Noida, Uttar Pradesh.

1.4 KGSPL carried out the field - work during August, 2024. Field identification tests and some in situ strength tests as well as laboratory tests on soil & Rock samples were carried out.

1.5 All the field work and laboratory tests were conducted as per the IS specifications and instructions of client. This report is based on the data collected during the field work and laboratory testing on collected soil samples.

2.0 DETAILS OF SITE :

2.1 The details of the site & test location for the proposed project are shown in the figure. The proposed Project site is between **Reshi to Rongli, Sikkam.**

3.0 SCOPE OF WORK:

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

3.1 Mobilizing necessary plant, equipment and personnel to the project site, setting up the equipment, shifting of the equipment from one test location to another location, carrying out the field investigations on land and demobilization on completion of work.

3.2.2 Making NX Size diameter bore holes at various locations in all types of soil or rock stratum using suitable approved method of boring at the specified locations to be given at site by the Engineer-in-Charge up to desired depths

3.2.3 Conducting standard penetration tests in the bore holes at 1.50 m interval in depth & at every change of strata, whichever is earlier as per specifications / instructions of Engineer-in-Charge.

3.2.4 Collecting undisturbed soil samples from bore holes at 3.00 m interval in depth or at every change of strata, whichever is earlier as per specifications.

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

3.2.6 Collecting Rock core samples from the borehole at regular intervals.

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

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

1. **Soil Samples**
   - (a) Sieve Analysis.
   - (b) Hydrometer Analysis
   - (c) Specific Gravity
   - (d) Moisture Content
   - (e) Dry Density
   - (f) Atterberg Limits
   - (g) Direct Shear Test
   - (h) Triaxial Shear Test
   - (i) Consolidation Test

2. **Rock Samples**
   (a) Density Tests
   (b) Water Absorption and Porosity
   (c) Determination of Specific Gravity
   (d) Unconfined Compression Test
   (e) Carry out Point Load Index.

3.4 Preparation and submission of report in three copies.

4.0 FIELD INVESTIGATIONS:

4.1 Necessary plant, equipment and personnel for conducting the requisite field work were mobilized to the site. These were shifted from one test location to another location during execution of the field work and demobilized on satisfactory completion of the entire field work.

4.2 Fourteen bore holes carried out were first marked on the ground surface as per the layout given to us by the Engineer-in-Charge.

4.3 All bore holes were bored at this site as per IS: 1892-1979. Casing as required was used to retain the bore holes.

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

4.3.3 When rebound or refusal was resulted during SPT attempt, the drilling bit was changed to TC (tungsten carbide) or diamond and core recovery, RQD (rock quality designation) both were measured.

4.3.4 Undisturbed soil samples were collected from the bore hole at every 3.00 m interval

in depth & at change of strata as per sampling specifications, in thin walled sampling tubes of 100 mm dia and 450 mm length fitted to an adopter with ball and socket arrangement. These sampling tubes after retrieval from the bore holes were properly waxed and sealed at both ends. These were carefully labeled and transported to the laboratory for testing. Undisturbed soil samples wherever slipped during lifting, were duly marked in the field bore logs as well as in the soil profile.

4.3.5 Rock cores were also collected from the boreholes at suitable depths/intervals to supplement the boring records. These samples were collected in core boxes of suitable sizes. These samples were properly sealed, labeled, recorded & carefully transported to the laboratory for testing.

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

4.3.7 The depth of ground water table was checked / measured in the bore hole during the boring activity.

4.3.8 **Summary of Borehole:**

Sr. No.	Chainage (Km)	No. of Bore Hole	Easting	Northing	Depth of Borehole , (m)	Depth of Water table , (m)
Viaduct - 3						
1	7+560	A1	662904.537	3008567.517	15.0	Not Met
2	7+585	P1	662912.034	3008591.746	15.0	Not Met
3	7+615	P2	662930.199	3008614.187	15.0	Not Met
4	7+645	P3	662958.355	3008625.758	15.0	Not Met
5	7+670	A2	662983.075	3008625.233	15.0	Not Met
TUNNEL						
6	11+200	1	665368.471	3010018.846	25.0	Not Met
7	11+750	2	665890.161	3010147.076	25.0	Not Met

Sr. No.	Chainage (Km)	No. of Bore Hole	Easting	Northing	Depth of Borehole , (m)	Depth of Water table , (m)
STEEL COMPOSIT MNB - 4						
8	13+690	A1	667544.833	3009655.405	15.0	Not Met
9	13+740	A2	667590.536	3009635.825	15.0	Not Met

5.0 LABORATORY INVESTIGATIONS:

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

5.1 GRAIN SIZE ANALYSIS

For this purpose an oven dry pulverized soil sample is sieved through the set of sieves 20mm, 10mm, 4.75mm, 2.0mm, 1.0mm, 600micron, 300micron, 150micron and 75micron. The amounts of soil retained on each sieve are noted down. The % retained, cumulative % retained and % passing are computed by these retained weights. If the % passing 75 micron sieve is appreciable, Hydrometer method is used to find the % fraction of particle sizes from 75micron to 2micron.

5.2 LIQUID LIMIT

For liquid limit, Casagrande apparatus is used. For this test air dry soil sample passing 425micron is taken and mixed with distilled water to give a stiff and homogeneous paste and is left for sufficient time for maturing in an air tight container. A portion of the above paste is kept in the cup of Casagrande apparatus, a groove is cut with groove cutting tool and blows are imparted by turning the handle at the rate of 2 revolutions per second. The numbers of blows are counted till the continuous contact of the bottom of the groove occurs. Few quantity of soil from the close portion of the groove after the contact occurs, are taken and its water content is determined by oven drying method.

The liquid limit (w_L) is computed by the equation.

$w_L = w_N(n/25)e$

Where w_N =water content (% corresponding to n blows)

e=0.092 for soils with w_L <50

=0.12 for soils with w_L >50

5.3 PLASTIC LIMIT

For this test sample is prepared in the same way as for liquid limit test. A ball is formed of sub sample weighting about 5 gm. This ball is rolled between the fingers of one hand and the glass plate with pressure sufficient to reduce the mass into a thread of about 3mm in 5 to 10 complete forward and back movements. When a diameter of 3mm is reached, soil is again remolded into a ball. The process of rolling and remolding is repeated until the thread a start just crumbing at a diameter of 3mm.The crumbled thread is immediately transferred to an air tight container for determination of its moisture content by oven drying method.

This water content is termed as plastic limit. (w_p)

5.4 PLASTICITY INDEX

The plasticity index Ip is given by
$I_p = w_L - w_p$

5.5 WATER CONTENT

For this test the soil sample of known quantity (w_m) is taken in a container.

The container with this soil sample is placed in an oven for drying at 105-110ºc for 16-24 hours. After drying the dry sample is again weighed to determine the dry weight of sample (w_d)

The moisture content is computed by the following equation:

$w_N = (w_m - w_d)/ w_d$

5.6 DRY DENSITY & BULK DENSITY

For determination of bulk density, a sample of known volume 'V' is extracted from the undisturbed sample. Its bulk weight 'W' and moisture content 'w_N' is determined

by oven drying method.

The bulk density is determined by following equation

γ_b = W/V and dry density $\gamma_d = \gamma_b /(1+ w_N)$

5.7 SPECIFIC GRAVITY

The specific gravity of soil sample is determined by density bottle method. For this test 5-10g (w_2) sample of oven dry, cool soil is taken in 50ml capacity density bottle and its weight is noted down. The soil is covered with distilled water and left for sufficient period for suitable soaking. The entrapped air is removed by vacuum. The soil in bottle is filled full with water and its weight is noted down as w_3. The mass of empty bottle (w_1) and bottle with full distilled water also noted (w_4).

The specific gravity is found by the following equation.

$G=w_2-w_1/[(w_2-w_1)-(w_3-w_4)]$

5.8 DIRECT SHEAR TEST

For this test shear box test apparatus is used. The prepared specimen from remolded/undisturbed sample is placed carefully in the box. The plain grid is kept on top of the specimen with its serrations at right angles to the direction of shear. The upper porous stone is placed on the grid and loading pad on the stone. The box with specimen is gently placed in the container (water jacket). The specimen is submerged with water. The container is mounted with the shear box and the specimen inside, on the shearing machine. The upper part of the box is so adjusted that it touches the proving ring. The jack is brought forward to bear up against the box container. The proving ring dial gauge is set to read zero.

The steel ball is placed in the recess of the loading pad. The loading yoke is set in contact with the steel ball on the loading pad. Vertical displacement dial gauge to read zero in contact with the top of the yoke. The normal load is applied and any change in thickness of specimen is recorded. Shear displacement dial gauge is also set to read zero.

The locking screw is now removed and two parts of the shear box are separated by advancing the spacing screws. The specimen is sheared at constant rate of strain. The readings of the proving ring dial gauge are noted down every 15 seconds for the first one minute and then every 30 seconds thereafter. The reading of change in the thickness dial gauge and shear displacement dial gauge are also recorded at the same

time interval. The test is continued until the specimen fails. The specimen is assumed to fail when the proving ring dial gauge starts receding or at shear displacement of approximately 15% of the length takes place.

The soil is removed from the box and test is repeated on the identical specimen under increased normal load. For consolidated undrained test the specimen is prepared and set in the apparatus as above and after submergence, the specimen is allowed to consolidate fully under normal loads. The specimen is then sheared as in undrained test. At the end of the test, the specimen is removed and its final water content is determined. The test is repeated on other identical specimen in similar way under increasing normal loads. For drained test, after completion of consolidation under a particular normal load, specimen is sheared at a slow rate to allow the pore water pressure inside the specimen may be drained out ie completely dissipated. Final water content of failed specimen is determined. The test is repeated on other identical specimen after consolidation under increasing normal loads.

6.0 TYPE AND DEPTH OF FOUNDATIONS:

Based upon the results of field investigations, laboratory test results & considering the structure going to construct, the following type of foundations have been analyzed herein below : -

- **OPEN SHALLOW FOUNDATIONS ON SOIL STRATA**:

The allowable bearing capacity of sub-soil strata for Open foundation has been computed from shear and settlement failure considerations.

Allowable Bearing Capacity (As per IS:6403)

The net intensity of loading which the foundation will carry without undergoing settlement in excess of the permissible value for the structure under consideration but not exceeding net safe bearing capacity.

Net Safe Bearing Capacity from Shear consideration

For Clayey Soil ($\phi = 0$)

The values are computed from unconfined compressive strength UCS, using the following equation;

$q_d = C\ N_c\ S_c\ d_c$ - Refer IS:6403, Clause 5.3

Where

q_d = Net Ultimate bearing capacity

A factor of safety of 2.5 is used.

Considering $\phi = 0$, $N_c = 5.14$

Thus the equation is simplified as

$q_{(Net\ safe)} = 1 / 2.5 \times C \times 5.14\ S_c\ d_c$

= 2.056 C Sc dc

For C - ϕ Soils

Refer IS: 6403 – 1981, Clause 5.1

General Shear Failure

q_d = C N_c Sc dc + γ D (N_q – 1) S_q d_q + 0.5 γ B Nγ Sγ dγ W ’

Local Shear Failure

$q_{d'}$ = 2/3C N'_c Sc dc + γ D (N'_q – 1) S_q d_q + 0.5 γ B Nγ’ Sγ dγ W ’

Where

qd and qd’ are net ultimate bearing capacity for general and local shear failure

Net safe bearing capacity = 1 / 2.5 x Net ultimate bearing capacity

Bearing capacity factor shall be determined for ϕ for general shear failure and ϕ’ = $\tan^{-1}(0.67 \tan\phi)$ for local shear failure.

Shape and depth factors shall be determined as per IS: 6403-1981.

For cohesion less soil with e_o value less than 0.55, values are computed for General shear failure, for e_o values between 0. 55 to 0.75 the values are computed by linear interpolation between local and general shear failure, and for eo value greater than 0.75 the values are computed for local shear failure.

For footing resting on multilayer deposit, Bowls recommends that the ultimate bearing capacity of footing be determined using average values of cohesion, C_{av} and angle of shearing resistance, ϕ_{av}. The average values are computed over a depth H below the base of footing,

Where

H = 0.5 B tan (45 + ϕ/2)

Safe Bearing pressure from settlement Consideration.

For normal consolidated clay

Sf = Sc + Si
Sc = λ Soed
Si = $pB(1-\mu^2)$ I /E; will be negligible
μ = poison’s ratio,
Soed = $\Sigma(h_I C_c /(1 + e_0)) \log_{10} ((\Delta p' + p_0') / p_0'))$

(Reference: clause 9.2.2.2 IS 8009 (Part I))

Where;

h_I = thickness of soil layer (m)
C_c = Compression index
e_0 = Initial void ratio
p_0' = effective overburden pressure (t/sqm)
Δp' = net increase in pressure at centre of cohesive soil layer

For pre compressed clays

S_1 = Sc (for fully saturated clays)
Sc = λ Soed; λ is taken from table – 1, IS: 8009 (Part – 1), 0.7
Soed = $\Sigma m_v h_I \Delta p$

(Reference: clause 9.2.2.3 IS 8009 (Part I))

Where;

h_I = thickness of soil layer (m)
m_v = Coefficient of volume compression
Δp = net increase in pressure at center of cohesive soil layer

If clays are lightly over consolidated, then the above method may be adopted but if the clay is heavily over consolidated, it may not be necessary to compute the settlement.

If the soil deposits consist of several regular soil layers in the influence zone, the settlement of each layer below the foundation shall be computed and summed to obtain the total settlement.

The settlement contribution by non cohesive / partially cohesive soil layer shall be estimated by the methods in clause 9.1, IS: 8009 (Part I); De Beer Marten method shall be used.

De Beer and Martens' Procedure

S_2 = $(2.303 / C_i) \log_{10} ((\Delta p + p_0') / p_0')) hi$
h_I = thickness of soil layer (m)
C_i = a constant of compressibility = $3/2 (C_{kd} / p_0')$
C_{kd} = average static cone resistance
p_0' = effective overburden pressure (t/sqm)
Δp = net increase in pressure at centre of non cohesive/ partially cohesive soil layer

Total settlement = $S_1 + S_2$

For purely non-cohesive soils

Settlement shall be determined for unit pressure for a specified width of footing based on Corrected SPT values between the level of base of footing and the depth equal to 1.5 to 2.0 times the width of footing. Corrections shall be applied as applicable. Refer; IS: 8009 (Part-1).

- **<u>OPEN SHALLOW FOUNDATIONS ON ROCK STRATA</u>**:

Estimation of Bearing Capacity by Various Methods

(1) For Sound Rock (As per IS: 12070 – 1987)

Where the rock is sound the strength of the foundation rock is generally much in excess of the design requirements, provided the walls of the discontinuities are closed and they are favorably oriented with respect to the applied forces. The investigations should, therefore, be concentrated on:

i) The identification and mapping of all discontinuities in the rock mass within the zone of influence of the foundation including the determination of the aperture (opening) of discontinuities;
ii) An evaluation of the mechanical properties of these discontinuities, frictional resistance, compressibility and strength of infilling material ; and
iii) The identification and evaluation of the strength of the rock material according to relevant Indian Standard.

In case of rock mass with favorable characteristics that is, rock surface is parallel to the base of the foundation, the load has no tangential component, the rock mass has no open discontinuities). The safe bearing pressure should be estimated from the equation:

$q_s = q_c \times N_j$

Where

q_s = Safe bearing pressure (gross),

q_c = Average uniaxial compressive strength of rock cores,

N_j = Empirical coefficient depending on the spacing of discontinuities

Spacing of Discontinuities, cm	N_j
300	0.40
100-300	0.25
30-100	0.10

Note - Equation includes a factor of safety of 3

(2) **For Non-Homogeneous And unsound Rocks** (As per IRS – Bridge Sub-structure & Foundation Code)

A factor of safety of 6 to 8 on unconfined compression strength should normally be adequate to cover such rock deficiencies in fixing the allowable bearing pressure.

In the case of badly disintegrated rocks or very soft varieties of rock where the core recovery during boring is found to be less than 35% and test cylinders are not available, the allowable bearing pressure may be assessed by adopting methods prescribed for soil.

(3) PRESUMTIVE VALUES

For preliminary design these presumptive values may be taken based on the assessment of experienced engineering geologist taking in consideration the various characteristics of rock mass.

Normally as per IRC: 78, allowable bearing pressure exceeding 2MPa (200T/m2) shall not be adopted.

As per IS: 12070, Net safe bearing pressures for massive crystalline bedrock may be taken as high as 1000 T/m2 for preliminary design and as low as 30 T/m2 for soft shale.

Based on our assessment of the rock condition, a suitable value of net allowable bearing pressure has been selected.

(4) ANALYSIS OF SAFE BEARING PRESSURE FROM THE RMR SYSTEM:

Analysis has been carried out using the RMR also known as Geo-mechanics classification by considering various parameters such as uniaxial compressive strength, RQD, spacing and condition of discontinuities and ground water condition. The correlation between the RMR value and allowable pressure has been given in Table-3, IS: 12070. This will ensure settlement of raft foundation up to 6.0m to be less than 12mm.

TABLE - 3 (IS: 12070) NET SAFE BEARING PRESSURE BASED ON RMR

Classification No.	I	II	III	IV	V
Description of rock	Very good	Good	Fair	Poor	Very poor
RMR	100 - 81	80 - 61	60 - 41	40 - 21	20 - 0
qns (T/m2)	600 - 448	440 - 288	280 - 141	135 - 48	45 - 30

The RMR for use in Table 3 should be the average within a depth below foundation level equal to the width of foundation, provided the RMR is fairly uniform within the depth. If the upper part of the rock, within a depth of about one fourth of the width of foundation, is of lower quality the value of this part should be used or the inferior rock should be removed. Since these values are based on limiting the settlement, they should not be increased if the foundation is embedded into the rock.

CORRECTIONS TO BE APPLIED

For getting the allowable bearing pressure the safe bearing pressure obtained from 7.2.3 shall be multiplied with the correction factors according to the geological condition as per IS: 12070 Clause 9.2

For submerged conditions - correction factor of 0.50 to 0.75 depending upon the aperture of joints.

For orientation of joints - correction factor of 0.50 to 1.00 depending upon the orientation of joints

➢ Pile foundation: Pile Capacity Calculations as per IRC -78 2014

Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance. The ultimate load carrying capacity will be calculated from one of the two approaches given below: Where cores of the rock can be taken and unconfined compressive strength directly established using standard method of testing, the approach described in method 1 will be used. In situations where strata is highly fragmented, where RQD is nil or (CR+RQD)/2 is less than 30 percent, or where strata is not classified as a granular or clayey soil, or when the crushing strength is less than 10 MPa, the approach described in method 2 will be used. Also, for weak rock like chalk, mud stone, clay stone, shale and other

intermediate rocks, method 2 is applicable.

Method-1

$$Q_a = (K_{Sp} \times q_c \times d_f \times A_b)/F_1 + (C_{us} \times A_s)/F_2$$

Where,

Q_a = Allowable capacity of Pile

q_c = Average Unconfined compressive strength of rock for twice the least lateral dimensions of pile MPa

d_f = Depth factor = 1+0.4 (Length of socket/Diameter of socket)

A_b = Cross-sectional area of base of pile

C_{us} = Ultimate shear strength along socket length=0.225 Sqrt (qc) or Restricted to 3.0 MPa

A_s = Surface area of socket in m^2 (πDL)

L = Length of socket into rock-top 300mm rock surface neglected, m

F1 = Factor of safety for end bearing resistance (FOS=6)

F2 = Factor of safety for side socket resistance (FOS=3)

K_{sp} = An empirical co-efficient whose value ranges from 0.3 to 1.2 as per the table below for the rocks where core recovery is reported,

(CR+RQD)/2	K_{sp}
30%	0.3
100%	1.2

Method-2

This method is applicable when cores and/or core testing result are not available, or when geo- material is highly fragmented. The shear strength of geo-material is obtained from its correlation with extrapolated SPT values for 300 mm of penetration as given in table below:

Shear Strength/Consistency	Moderately Weak	Weak	Very Weak
Approx. N Value	300-200	200-100	100-60
Shear Strength/Cohesion in MPa	3.3-1.9	1.9-0.7	0.7-0.4

$Q_a = (C_{ub} \times N_c \times A_b)/F_1 + (C_{us} \times A_s)/F_2$

Where

C_{ub} - Average shear strength below base of pile, for the depth equal to twice the diameter/least lateral dimension of pile, based on average 'N' value of this region.

C_{us} - Ultimate shear strength along socket length, to be obtained from table, based on average 'N' value of socket portion. This shall be restricted to shear capacity of concrete of the pile, to be taken as 3.0 MPa for M 35 concrete in confined condition, which for other strengths of concrete can be modified by a factor Sqrt (fck/35) Intermediate values cub and cus can be interpolated linearly.

L = Length of socket.

N = 9

Q_a = Allowable capacity of pile

F_1 = Factor of safety for end bearing resistance (FOS=6)

F_2 = Factor of safety for side socket resistance (FOS=3)

Note: The allowable end bearing component after dividing by factor of safety shall be restricted to 5 MPa.

Moment Carrying Capacity:

$$L_s = \frac{2H}{\sigma_1 D} + \sqrt{\frac{4H^2}{\sigma_1{}^2 D^2} + \frac{6M}{\sigma_1 D}}$$

where

Ls = Socket length

H = Horizontal force at top of the socket

M - Moment at the top of the socket

D = Diameter of the pile.

σ_1 = Permissible compressive strength in rock which is leaser of 30 kg/sq cm or 0.33qc

Pile Capacity: As per IRC 78 (Part-2) - 2020

Characteristic Pile resistance (capacity) of the pile Q_{uc} is determine by calculating the end bearing and skin reaction along the pile surface based on soil parameters. The

calculation of characteristic pile resistance or ultimate pile resistance (Q_{uc}) is calculated as per IRC 78-2014. The characteristic capacity thus arrived shall be further divided by respective partial factor for ground resistance GR as per Table 5 of IRC 78 (Part-2) – 2020 for soil & Table 9 of IRC 78 (Part-2) – 2020 for rock strata as below:

$$Q_{Rd} = Q_{ubc}/\gamma_b + Q_{ufc}/\gamma_s$$

Where

Q_{ubc} = Characteristic base resistance
Q_{ufc} = Characteristic shaft resistance
Q_{Rd} = Reduced capacity of pile based on partial factor for ground resistance.

The Ultimate design resistance or capacity of pile,
$Q_{ud} = Q_{rd}/M$

Where M = Model Factor

Recommended Foundations

Based upon the results of field investigations, laboratory test results & considering the structure going to construct, the following type of foundations have been analyzed herein below : -

1) Cast in-situ Pile Foundation

Type of foundation (s)	Diameter of Pile,(m)	Rock socketing(m)
Pile Foundation	1.20m	3D

7.0 FINDING OF GEOTECHNICAL INVESTIGATION:

The study of bore logs/results of laboratory and other field tests as above from ground level reveal that:-

8.0 RECOMMENDATIONS

Type of Foundation: Bored Cast in situ RCC Pile

Depending on the field and laboratory observations of subsoil strata, test results and the

type of structures proposed at site, the most feasible soil-foundation system is recommended as normal bored cast in situ R.C.C. piles foundations of 1.0m & 1.2m diameter at different depths with cut-off level of 1.80m depth below existing Ground level.

The safe load capacity of piles as per **Working Stress Method** are as follows:

Chainage, Km	Bore Hole No.	Dia. of piles, (m)	Cut-off level below EGL(m)	Length of piles below cut-off level (m)	Length of Socketing, (m)	Pile Capacity, (T)	
						In compression	In lateral
Viaduct - 3							
7+560	A1	1.2	1.8	13.2	3.6	365.0	50
7+585	P1	1.2	1.8	13.2	3.6	362.0	50
7+615	P2	1.2	1.8	13.2	3.6	354.0	50
7+645	P3	1.2	1.8	13.2	3.6	353.0	50
7+670	A2	1.2	1.8	13.2	3.6	354.0	50
STEEL COMPOSIT MNB - 4							
13+690	A1	1.2	1.8	13.2	3.6	358.0	50
13+740	A2	1.2	1.8	13.2	3.6	362.0	50

Type of Foundation: Open Foundation

The net safe bearing capacity/ Allowable Pressure Intensity for **open foundation** are given in following table.

Chainage (Km)	Depth of foundation below existing ground surface (m)	Size of Foundation (m)	Net Safe Bearing Capacity/ Allowable Pressure Intensity (T/m^2)
			Recommended
Viaduct - 3			
7+560, A1	3.0	8.0 x 8.0	19.7
	4.0	8.0 x 8.0	23.7
7+585, P1	3.0	8.0 x 8.0	20.0
	4.0	8.0 x 8.0	24.0
7+615, P2	3.0	8.0 x 8.0	20.5
	4.0	8.0 x 8.0	24.6
7+645, P3	3.0	8.0 x 8.0	19.7
	4.0	8.0 x 8.0	23.6
7+670, A2	3.0	8.0 x 8.0	20.7
	4.0	8.0 x 8.0	24.8
STEEL COMPOSIT MNB - 4			
13+690, A1	3.0	10.0 x 10.0	33.8
	4.0	10.0 x 10.0	39.8
13+740, A2	3.0	10.0 x 10.0	33.4
	4.0	10.0 x 10.0	39.3

9.0 CLOSURE

We appreciate the opportunity to submit this Geotechnical Investigation Report. The above recommendations have been made on the basis of in situ tests and laboratory tests conducted on the samples collected from the boreholes bored at the locations given by the client. If during excavation, any unusual or abnormal features are noticed, these may be brought to the attention of geotechnical consultant before proceeding with construction work for further suggestions.

For KUNIKA GEOTECHNICAL SERVICES PVT LTD

SAMIR PANDEY
(DIRECTOR)

KUNIKA GEOTECHNICAL SERVICES PVT LTD

CHAINAGE (Km). - 7.560, A1 | **DATE STARTED : 03.08.2024** | **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. | **DATE COMPLETED : 04.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 15.00 m | **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS													
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	WS	NIL	NIL	NIL	1.65	--	--	--	--	--	--	--	--	--	--	0.0	27.8
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50	Completely Weathered Rock.	--	Core	6.0	4.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	5.0	3.33	NIL	--	--	--	--	--	--	--	--	--	--	--	0.0	29.0
	6.00	7.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	7.0	4.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50		--	Core	10.0	6.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	10.50	12.00	1.50		--	Core	31.0	20.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50	Fracture Sandstone.	--	Core	38.0	25.33	NIL	2.504	2.48	0.95	1.05	2.69	7.81	2.75	60.50	--	--	--	--	--
	13.50	15.00	1.50		--	Core	42.0	28.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--

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CHAINAGE (Km). - 7.585, P1 **DATE STARTED : 04.08.2024** **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. **DATE COMPLETED : 05.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 15.00 m **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	WS	NIL	NIL	NIL	1.64	--	--	--	--	--	--	--	--	--	--	0.0	28.0
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50	Completely Weathered Rock.	--	Core	4.0	2.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	6.0	4.00	NIL	--	--	--	--	--	--	--	--	--	--	--	0.0	29.2
	6.00	7.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	7.0	4.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50		--	Core	8.0	5.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	10.50	12.00	1.50		--	Core	34.0	22.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50	Fracture Sandstone.	--	Core	41.0	27.33	NIL	2.512	2.49	0.90	1.10	2.70	7.78	2.70	59.40	--	--	--	--	--
	13.50	15.00	1.50		--	Core	39.0	26.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--

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CHAINAGE (Km). - 7.615, P2 **DATE STARTED : 05.08.2024** **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. **DATE COMPLETED : 06.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 15.00 m **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	Core	5.0	5.00	NIL	1.65	--	--	--	--	--	--	--	--	--	--	0.0	28.2
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50	Completely Weathered Rock.	--	Core	6.0	4.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	4.0	2.67	NIL	--	--	--	--	--	--	--	--	--	--	--	0.0	29.6
	6.00	7.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	9.0	6.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	10.50	12.00	1.50		--	Core	29.0	19.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50	Fracture Sandstone.	--	Core	38.0	25.33	NIL	2.521	2.50	0.85	1.12	2.71	7.75	2.60	57.20	--	--	--	--	--
	13.50	15.00	1.50		--	Core	45.0	30.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--

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CHAINAGE (Km). - 7.645, P3 | **DATE STARTED : 06.08.2024** | **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. | **DATE COMPLETED : 07.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 15.00 m | **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	Core	3.0	3.00	NIL	1.63	--	--	--	--	--	--	--	--	--	--	0.0	27.9
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50	Completely Weathered Rock.	--	Core	5.0	3.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	7.0	4.67	NIL	--	--	--	--	--	--	--	--	--	--	--	0.0	29.6
	6.00	7.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	10.0	6.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	10.50	12.00	1.50		--	Core	32.0	21.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50	Fracture Sandstone.	--	Core	35.0	23.33	NIL	2.494	2.47	0.96	1.10	2.72	9.19	2.58	56.76	--	--	--	--	--
	13.50	15.00	1.50		--	Core	37.0	24.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--

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CHAINAGE (Km). - 7.670, A2 | **DATE STARTED : 07.08.2024** | **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. | **DATE COMPLETED : 08.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 15.00 m | **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	WS	NIL	NIL	NIL	1.65	--	--	--	--	--	--	--	--	--	--	0.0	28.3
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50	Completely Weathered Rock.	--	Core	7.0	4.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	9.0	6.00	NIL	--	--	--	--	--	--	--	--	--	--	--	0.0	29.6
	6.00	7.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	6.0	4.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	10.50	12.00	1.50		--	Core	35.0	23.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50	Fracture Sandstone.	--	Core	41.0	27.33	NIL	2.501	2.48	0.85	0.98	2.71	8.49	2.60	57.20	--	--	--	--	--
	13.50	15.00	1.50		--	Core	46.0	30.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--

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CHAINAGE (Km). - 11.200, Tunnel Start. **DATE STARTED : 20.08.2024** **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. **DATE COMPLETED : 22.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 25.00 m **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00	Completely Weathered Rock.	Refusal	WS	NIL	NIL	NIL	1.72	--	--	--	--	--	--	--	--	--	--	0.0	31.6
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	9.0	6.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	6.00	7.50	1.50		--	Core	12.0	8.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	16.0	10.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50	Fracture Sandstone.	--	Core	18.0	12.00	NIL	2.514	2.49	0.95	1.15	2.69	7.43	3.30	72.60	--	--	--	--	--
	10.50	12.00	1.50		--	Core	23.0	15.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50		--	Core	33.0	22.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	13.50	15.00	1.50		--	Core	48.0	32.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	15.00	16.50	1.50		--	Core	57.0	38.00	8.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	16.50	18.00	1.50	Hard Sandstone.	--	Core	64.0	42.67	10.0	2.546	2.53	0.65	0.95	2.72	6.99	11.40	250.80	--	--	--	--	--
	18.00	19.50	1.50			Core	78.0	52.00	14.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	19.50	21.00	1.50		--	Core	86.0	57.33	18.6	--	--	--	--	--	--	--	--	--	--	--	--	--
	21.00	22.50	1.50	Fine-Grained Quartzite Rock	--	Core	80.0	53.33	20.6	2.561	2.55	0.45	0.75	2.73	6.59	12.60	277.20	--	--	--	--	--
	22.50	24.00	1.50			Core	85.0	56.67	26.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	24.00	25.00	1.00		--	Core	82.0	82.00	42.0	--	--	--	--	--	--	--	--	--	--	--	--	--

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CHAINAGE (Km). - 11.750, Tunnel End. **DATE STARTED : 15.08.2024** **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. **DATE COMPLETED : 18.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 25.00 m **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50	Completely Weathered Rock.	--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	WS	NIL	NIL	NIL	1.73	--	--	--	--	--	--	--	--	--	--	0.0	32.0
	1.50	3.00	1.50		--	Core	8.0	5.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50		--	Core	12.0	8.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	10.0	6.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	6.00	7.50	1.50	Fracture Sandstone.	--	Core	18.0	12.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	24.0	16.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50		--	Core	31.0	20.67	NIL	2.524	2.51	0.55	0.95	2.71	7.38	3.50	77.00	--	--	--	--	--
	10.50	12.00	1.50		--	Core	48.0	32.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50	Hard Sandstone.	--	Core	42.0	28.00	8.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	13.50	15.00	1.50		--	Core	58.0	38.67	12.6	--	--	--	--	--	--	--	--	--	--	--	--	--
	15.00	16.50	1.50		--	Core	69.0	46.00	14.6	2.539	2.52	0.76	0.92	2.72	7.35	10.30	226.60	--	--	--	--	--
	16.50	18.00	1.50		--	Core	65.0	43.33	22.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	18.00	19.50	1.50	Fine-Grained Quartzite Rock		Core	76.0	50.67	30.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	19.50	21.00	1.50		--	Core	70.0	46.67	27.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	21.00	22.50	1.50		--	Core	80.0	53.33	34.0	2.539	2.52	0.76	0.92	2.72	7.35	11.70	257.40	--	--	--	--	--
	22.50	24.00	1.50			Core	75.0	50.00	36.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	24.00	25.00	1.00		--	Core	82.0	82.00	58.0	--	--	--	--	--	--	--	--	--	--	--	--	--

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CHAINAGE (Km). - 13.690, A1 | **DATE STARTED : 08.08.2024** | **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. | **DATE COMPLETED : 09.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 15.00 m | **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50	Completely Weathered Rock.	--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	WS	NIL	NIL	NIL	1.72	--	--	--	--	--	--	--	--	--	--	0.0	31.9
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50		--	Core	4.0	2.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	5.0	3.33	NIL	--	--	--	--	--	--	--	--	--	--	--	0.0	33.1
	6.00	7.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	7.0	4.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50	Fracture Sandstone.	--	Core	31.0	20.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	10.50	12.00	1.50		--	Core	38.0	25.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50		--	Core	42.0	28.00	NIL	2.512	2.49	0.90	1.10	2.70	7.78	2.62	57.64	--	--	--	--	--
	13.50	15.00	1.50		--	Core	39.0	26.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--

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CHAINAGE (Km). - 13.740, A2 | **DATE STARTED : 09.08.2024** | **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. | **DATE COMPLETED : 10.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 15.00 m | **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	Core	3.0	3.00	NIL	1.73	--	--	--	--	--	--	--	--	--	--	0.0	31.7
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50	Completely Weathered Rock.	--	Core	6.0	4.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	4.0	2.67	NIL	--	--	--	--	--	--	--	--	--	--	--	0.0	32.8
	6.00	7.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	10.0	6.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50		--	Core	27.0	18.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	10.50	12.00	1.50		--	Core	36.0	24.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50	Fracture Sandstone.	--	Core	39.0	26.00	NIL	2.519	2.50	0.75	0.97	2.71	7.75	2.70	59.40	--	--	--	--	--
	13.50	15.00	1.50		--	Core	42.0	28.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--

BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS 6403-1981

LOCATION : Reshi to Rongli, Sikkam.

CHAINAGE (Km). - 7.560, A1

The bearing capacity equation is as follows :

$$q_{net\ safe} = (1/FS)\{cNc\zeta_c d_c i_c + q(N_q-1)\zeta_q d_q i_q + 0.5B\gamma N_\gamma \zeta_\gamma d_\gamma i_\gamma R_w\}$$

where:

$q_{net\ safe}$ =	safe net bearing capacity	c =	cohesion intercept
q =	overburden pressure	B =	Foundation width
γ =	Bulk density of soil below founding level		
R_w =	Water table correction factor		
N_c, N_q, N_γ =	bearing capacity factors, which are a function of ϕ		
d_c, d_q, d_γ =	Depth factors		
$\zeta_c, \zeta_q, \zeta_\gamma$ =	Shape factors		
i_c, i_q, i_γ =	inclination factors		

Soil parameters :

c = 0.00 T/m^2 ϕ = 27.8 degrees GENERAL SHEAR FAILURE

c' = 0.00 T/m^2 ϕ'= 19.4 degrees LOCAL SHEAR FAILURE

General Shear Failure : N_c = 25.42 N_q = 14.40 N_γ = 16.24

Local Shear Failure : N_c' = 14.25 N_q' = 6.01 N_γ' = 4.93

Inclination of Foundation to vertical : 0 degrees

Inclination Factors $i_c = i_q$ = 1.00 i_γ = 1.00

Factor of safety = 2.5 as per IS 1904-1986

Design Water Table depth = Not Met

R_w factor: Constant value(**V**) for worst condition or calculate(**C**) based on WT Depth ? : C

Depth factor to be considered ? N

Bulk Density Profile

Depth, m From	Depth, m To	γ T/m^3
0.0	10.0	1.65

FAILURE CRITERIA : **Local** **SHEAR FAILURE**

Foundation Dimensions B, m	Foundation Dimensions L, m	FOUN-DATION SHAPE	Depth,m	R_w	Shape Factors ζ_c	Shape Factors ζ_q	Shape Factors ζ_γ	Depth factors (GSF) d_c	Depth factors (GSF) d_q	Depth factors (GSF) d_γ	Depth factors (LSF) d_c'	Depth factors (LSF) $d_{q'}$	Depth factors (LSF) d_γ'	$q_{net\ safe}$, T/m^2 GSF	$q_{net\ safe}$, T/m^2 LSF	Safe Net Bearing Capacity T/m^2
8.0	**8.0**	*Rectangle*	**3.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		19.7	**19.7**
8.0	**8.0**	*Rectangle*	**4.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		23.7	**23.7**

BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS 6403-1981

LOCATION : Reshi to Rongli, Sikkam.

CHAINAGE (Km). - 7.585, P1

The bearing capacity equation is as follows :

$$q_{net\ safe} = (1/FS)\{cNc\zeta_c d_c i_c + q(N_q-1)\zeta_q d_q i_q + 0.5B\gamma N_\gamma \zeta_\gamma d_\gamma i_\gamma R_w\}$$

where:

$q_{net\ safe}$ =	safe net bearing capacity	c =	cohesion intercept
q =	overburden pressure	B =	Foundation width
γ =	Bulk density of soil below founding level		
R_w =	Water table correction factor		
N_c, N_q, N_γ =	bearing capacity factors, which are a function of ϕ		
d_c, d_q, d_γ =	Depth factors		
$\zeta_c, \zeta_q, \zeta_\gamma$ =	Shape factors		
i_c, i_q, i_γ =	inclination factors		

Soil parameters :

c = 0.00 T/m^2 ϕ = 28.0 degrees GENERAL SHEAR FAILURE

c' = 0.00 T/m^2 ϕ'= 19.5 degrees LOCAL SHEAR FAILURE

General Shear Failure : N_c = 25.80 N_q = 14.72 N_γ = 16.72

Local Shear Failure : N_c' = 14.39 N_q' = 6.10 N_γ' = 5.03

Inclination of Foundation to vertical : 0 degrees

Inclination Factors $i_c = i_q$ = 1.00 i_γ = 1.00

Factor of safety = 2.5 as per IS 1904-1986

Design Water Table depth = Not Met

R_w factor: Constant value(**V**) for worst condition or calculate(**C**) based on WT Depth ? : C

Depth factor to be considered ? N

Bulk Density Profile

Depth, m From	Depth, m To	γ T/m^3
0.0	10.0	1.64

FAILURE CRITERIA : **Local** **SHEAR FAILURE**

Foundation Dimensions B, m	Foundation Dimensions L, m	FOUN-DATION SHAPE	Depth,m	R_w	Shape Factors ζ_c	Shape Factors ζ_q	Shape Factors ζ_γ	Depth factors (GSF) d_c	Depth factors (GSF) d_q	Depth factors (GSF) d_γ	Depth factors (LSF) d_c'	Depth factors (LSF) $d_{q'}$	Depth factors (LSF) d_γ'	$q_{net\ safe}$, T/m^2 GSF	$q_{net\ safe}$, T/m^2 LSF	Safe Net Bearing Capacity T/m^2
8.0	**8.0**	*Rectangle*	**3.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		20.0	**20.0**
8.0	**8.0**	*Rectangle*	**4.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		24.0	**24.0**

BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS 6403-1981

LOCATION : Reshi to Rongli, Sikkam.

CHAINAGE (Km). - 7.615, P2

The bearing capacity equation is as follows :

$$q_{net\ safe} = (1/FS)\{cNc\zeta_c d_c i_c + q(N_q-1)\zeta_q d_q i_q + 0.5B\gamma N_\gamma \zeta_\gamma d_\gamma i_\gamma R_w\}$$

where:

$q_{net\ safe}$ =	safe net bearing capacity	c =	cohesion intercept
q =	overburden pressure	B =	Foundation width
γ =	Bulk density of soil below founding level		
R_w =	Water table correction factor		
N_c, N_q, N_γ =	bearing capacity factors, which are a function of ϕ		
d_c, d_q, d_γ =	Depth factors		
$\zeta_c, \zeta_q, \zeta_\gamma$ =	Shape factors		
i_c, i_q, i_γ =	inclination factors		

Soil parameters :

c = 0.00 T/m^2 ϕ = 28.2 degrees GENERAL SHEAR FAILURE

c' = 0.00 T/m^2 ϕ'= 19.7 degrees LOCAL SHEAR FAILURE

General Shear Failure : N_c = 26.20 N_q = 15.05 N_γ = 17.21

Local Shear Failure : N_c' = 14.53 N_q' = 6.19 N_γ' = 5.14

Inclination of Foundation to vertical : 0 degrees

Inclination Factors $i_c = i_q$ = 1.00 i_γ = 1.00

Factor of safety = 2.5 as per IS 1904-1986

Design Water Table depth = Not Met

R_w factor: Constant value(**V**) for worst condition or calculate(**C**) based on WT Depth ? : C

Depth factor to be considered ? N

Bulk Density Profile

Depth, m		γ
From	To	T/m^3
0.0	10.0	1.65

FAILURE CRITERIA : **Local** **SHEAR FAILURE**

Foundation Dimensions		FOUN-DATION SHAPE	Depth,m	R_w	Shape Factors			Depth factors (GSF)			Depth factors (LSF)			$q_{net\ safe}$, T/m^2		Safe Net Bearing Capacity T/m^2
B, m	L, m				ζ_c	ζ_q	ζ_γ	d_c	d_q	d_γ	d_c'	$d_{q'}$	d_γ'	GSF	LSF	
8.0	**8.0**	*Rectangle*	**3.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		20.5	**20.5**
8.0	**8.0**	*Rectangle*	**4.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		24.6	**24.6**

BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS 6403-1981

LOCATION : Reshi to Rongli, Sikkam.

CHAINAGE (Km). - 7.645, P3

The bearing capacity equation is as follows :

$$q_{net\ safe} = (1/FS)\{cNc\zeta_c d_c i_c + q(N_q-1)\zeta_q d_q i_q + 0.5B\gamma N_\gamma \zeta_\gamma d_\gamma i_\gamma R_w\}$$

where:

$q_{net\ safe}$ =	safe net bearing capacity	c =	cohesion intercept
q =	overburden pressure	B =	Foundation width
γ =	Bulk density of soil below founding level		
R_w =	Water table correction factor		
N_c, N_q, N_γ =	bearing capacity factors, which are a function of ϕ		
d_c, d_q, d_γ =	Depth factors		
$\zeta_c, \zeta_q, \zeta_\gamma$ =	Shape factors		
i_c, i_q, i_γ =	inclination factors		

Soil parameters :

c = 0.00 T/m^2 ϕ = 27.9 degrees GENERAL SHEAR FAILURE

c' = 0.00 T/m^2 ϕ'= 19.4 degrees LOCAL SHEAR FAILURE

General Shear Failure : N_c = 25.61 N_q = 14.56 N_γ = 16.48

Local Shear Failure : N_c' = 14.32 N_q' = 6.06 N_γ' = 4.98

Inclination of Foundation to vertical : 0 degrees

Inclination Factors $i_c = i_q$ = 1.00 i_γ = 1.00

Factor of safety = 2.5 as per IS 1904-1986

Design Water Table depth = Not Met

R_w factor: Constant value(**V**) for worst condition or calculate(**C**) based on WT Depth ? : C

Depth factor to be considered ? N

Bulk Density Profile

Depth, m From	Depth, m To	γ T/m^3
0.0	10.0	1.63

FAILURE CRITERIA : **Local** **SHEAR FAILURE**

Foundation Dimensions B, m	Foundation Dimensions L, m	FOUN-DATION SHAPE	Depth,m	R_w	Shape Factors ζ_c	Shape Factors ζ_q	Shape Factors ζ_γ	Depth factors (GSF) d_c	Depth factors (GSF) d_q	Depth factors (GSF) d_γ	Depth factors (LSF) d_c'	Depth factors (LSF) $d_{q'}$	Depth factors (LSF) d_γ'	$q_{net\ safe}$, T/m^2 GSF	$q_{net\ safe}$, T/m^2 LSF	Safe Net Bearing Capacity T/m^2
8.0	**8.0**	*Rectangle*	**3.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		19.7	**19.7**
8.0	**8.0**	*Rectangle*	**4.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		23.6	**23.6**

BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS 6403-1981

LOCATION : Reshi to Rongli, Sikkam.

CHAINAGE (Km). - 7.670, A2

The bearing capacity equation is as follows :

$$q_{net\ safe} = (1/FS)\{cNc\zeta_c d_c i_c + q(N_q-1)\zeta_q d_q i_q + 0.5B\gamma N_\gamma \zeta_\gamma d_\gamma i_\gamma R_w\}$$

where:

$q_{net\ safe}$ =	safe net bearing capacity	c =	cohesion intercept
q =	overburden pressure	B =	Foundation width
γ =	Bulk density of soil below founding level		
R_w =	Water table correction factor		
N_c, N_q, N_γ =	bearing capacity factors, which are a function of ϕ		
d_c, d_q, d_γ =	Depth factors		
$\zeta_c, \zeta_q, \zeta_\gamma$ =	Shape factors		
i_c, i_q, i_γ =	inclination factors		

Soil parameters :

c = 0.00 T/m^2 ϕ = 28.3 degrees GENERAL SHEAR FAILURE

c' = 0.00 T/m^2 ϕ'= 19.7 degrees LOCAL SHEAR FAILURE

General Shear Failure : N_c = 26.40 N_q = 15.21 N_γ = 17.46

Local Shear Failure : N_c' = 14.60 N_q' = 6.24 N_γ' = 5.20

Inclination of Foundation to vertical : 0 degrees

Inclination Factors $i_c = i_q$ = 1.00 i_γ = 1.00

Factor of safety = 2.5 as per IS 1904-1986

Design Water Table depth = Not Met

R_w factor: Constant value(**V**) for worst condition or calculate(**C**) based on WT Depth ? : C

Depth factor to be considered ? N

Bulk Density Profile

Depth, m From	Depth, m To	γ T/m^3
0.0	10.0	1.65

FAILURE CRITERIA : **Local** **SHEAR FAILURE**

Foundation Dimensions B, m	Foundation Dimensions L, m	FOUN-DATION SHAPE	Depth,m	R_w	Shape Factors ζ_c	Shape Factors ζ_q	Shape Factors ζ_γ	Depth factors (GSF) d_c	Depth factors (GSF) d_q	Depth factors (GSF) d_γ	Depth factors (LSF) d_c'	Depth factors (LSF) $d_{q'}$	Depth factors (LSF) d_γ'	$q_{net\ safe}$, T/m^2 GSF	$q_{net\ safe}$, T/m^2 LSF	Safe Net Bearing Capacity T/m^2
8.0	**8.0**	*Rectangle*	**3.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		20.7	**20.7**
8.0	**8.0**	*Rectangle*	**4.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		24.8	**24.8**

BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS 6403-1981

LOCATION : Reshi to Rongli, Sikkam.

CHAINAGE (Km). - 13.690, A1

The bearing capacity equation is as follows :

$$q_{net\ safe} = (1/FS)\{cNc\zeta_c d_c i_c + q(N_q-1)\zeta_q d_q i_q + 0.5B\gamma N_\gamma \zeta_\gamma d_\gamma i_\gamma R_w\}$$

where:

$q_{net\ safe}$ =	safe net bearing capacity	c =	cohesion intercept
q =	overburden pressure	B =	Foundation width
γ =	Bulk density of soil below founding level		
R_w =	Water table correction factor		
N_c, N_q, N_γ =	bearing capacity factors, which are a function of ϕ		
d_c, d_q, d_γ =	Depth factors		
$\zeta_c, \zeta_q, \zeta_\gamma$ =	Shape factors		
i_c, i_q, i_γ =	inclination factors		

Soil parameters :

c = 0.00 T/m^2 ϕ = 31.9 degrees GENERAL SHEAR FAILURE

c' = 0.00 T/m^2 ϕ'= 22.5 degrees LOCAL SHEAR FAILURE

General Shear Failure : N_c = 35.19 N_q = 22.91 N_γ = 29.76

Local Shear Failure : N_c' = 17.50 N_q' = 8.26 N_γ' = 7.69

Inclination of Foundation to vertical : 0 degrees

Inclination Factors $i_c = i_q$ = 1.00 i_γ = 1.00

Factor of safety = 2.5 as per IS 1904-1986

Design Water Table depth = Not Met

R_w factor: Constant value(**V**) for worst condition or calculate(**C**) based on WT Depth ? : C

Depth factor to be considered ? N

Bulk Density Profile

Depth, m From	Depth, m To	γ T/m^3
0.0	10.0	1.72

FAILURE CRITERIA : **Local** **SHEAR FAILURE**

Foundation Dimensions B, m	Foundation Dimensions L, m	FOUN-DATION SHAPE	Depth,m	R_w	Shape Factors ζ_c	Shape Factors ζ_q	Shape Factors ζ_γ	Depth factors (GSF) d_c	Depth factors (GSF) d_q	Depth factors (GSF) d_γ	Depth factors (LSF) d_c'	Depth factors (LSF) $d_{q'}$	Depth factors (LSF) d_γ'	$q_{net\ safe}$, T/m^2 GSF	$q_{net\ safe}$, T/m^2 LSF	Safe Net Bearing Capacity T/m^2
10.0	**10.0**	*Rectangle*	**3.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		33.8	**33.8**
10.0	**10.0**	*Rectangle*	**4.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		39.8	**39.8**

BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS 6403-1981

LOCATION : Reshi to Rongli, Sikkam.

CHAINAGE (Km). - 13.740, A2

The bearing capacity equation is as follows :

$$q_{net\ safe} = (1/FS)\{cNc\zeta_c d_c i_c + q(N_q-1)\zeta_q d_q i_q + 0.5B\gamma N_\gamma \zeta_\gamma d_\gamma i_\gamma R_w\}$$

where:

$q_{net\ safe}$ =	safe net bearing capacity	c =	cohesion intercept
q =	overburden pressure	B =	Foundation width
γ =	Bulk density of soil below founding level		
R_w =	Water table correction factor		
N_c, N_q, N_γ =	bearing capacity factors, which are a function of ϕ		
d_c, d_q, d_γ =	Depth factors		
$\zeta_c, \zeta_q, \zeta_\gamma$ =	Shape factors		
i_c, i_q, i_γ =	inclination factors		

Soil parameters :

c = 0.00 T/m^2 ϕ = 31.7 degrees GENERAL SHEAR FAILURE

c' = 0.00 T/m^2 ϕ'= 22.4 degrees LOCAL SHEAR FAILURE

General Shear Failure : N_c = 34.61 N_q = 22.38 N_γ = 28.88

Local Shear Failure : N_c' = 17.31 N_q' = 8.13 N_γ' = 7.52

Inclination of Foundation to vertical : 0 degrees

Inclination Factors $i_c = i_q$ = 1.00 i_γ = 1.00

Factor of safety = 2.5 as per IS 1904-1986

Design Water Table depth = Not Met

R_w factor: Constant value(**V**) for worst condition or calculate(**C**) based on WT Depth ? : C

Depth factor to be considered ? N

Bulk Density Profile

Depth, m From	Depth, m To	γ T/m^3
0.0	10.0	1.73

FAILURE CRITERIA : **Local** **SHEAR FAILURE**

Foundation Dimensions B, m	Foundation Dimensions L, m	FOUN-DATION SHAPE	Depth,m	R_w	Shape Factors ζ_c	Shape Factors ζ_q	Shape Factors ζ_γ	Depth factors (GSF) d_c	Depth factors (GSF) d_q	Depth factors (GSF) d_γ	Depth factors (LSF) d_c'	Depth factors (LSF) $d_{q'}$	Depth factors (LSF) d_γ'	$q_{net\ safe}$, T/m^2 GSF	$q_{net\ safe}$, T/m^2 LSF	Safe Net Bearing Capacity T/m^2
10.0	**10.0**	*Rectangle*	**3.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		33.4	**33.4**
10.0	**10.0**	*Rectangle*	**4.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		39.3	**39.3**

Pile Capacity Calculation in Rock (As per Method 1, Appendix-5 of IRC:78-2014) :

CH - 7.560, A1

Bed Level =	100.00	m
Cut Off Level =	98.20	m
Top Level of Rock =	88.60	m
Pile Tip Level =	85.00	m
Length of Pile below Cut Off =	13.20	m
Length of Pile Socket =	3.60	m
Diameter of Pile =	1.2	m
Grade of Concrete for Pile =	35.0	
Core Recovery, CR =	24	%
Rock Quality Designation, RQD =	0	%

Refer Clause 709.3.1 of IRC:78-2014 & Appendix-5, 9.1 (Method 1)

Q_u = $R_e + R_{af}$ = $K_{sp} * q_c * d_f * A_b + C_{us} * A_s$

Q_{allow} = $(R_e/3) + (R_{af}/6)$

Q_u =	Ultimate Capacity of Pile
Q_{allow} =	Allowable Capacity of Pile
R_e =	Ultimate End Bearing
R_{af} =	Ultimate Side Socket Shear
K_{sp} =	An empirical coefficient
q_c =	Average UCS of rock
d_f =	Depth factor
A_b =	Cross Sectional area of pile
C_{us} =	Ultimate Shear Strength along socket length of pile
A_s =	Surface area of socket

(CR+RQD)/2 =	12	%	
K_{sp} =	0.1		
q_c =	60.5	t/m^2	
d_f =	1.2		
A_b =	1.131	m^2	
C_{us} =	1.75	Mpa	
A_s =	12.441	m^2	(Neglecting top 300mm of top rock)
Factor of Safety for End Bearing =	3		
Factor of Safety for Socket resistance =	6		
Allowable End Bearing Stress =	2.42	t/m^2	
Allowable End Bearing Capacity =	2.7	t	
Allowable Socket resistance =	362.9	t	
Q_{allow} =	365.6	t	

Pile Capacity Calculation in Rock (As per Method 1, Appendix-5 of IRC:78-2014) :

CH - 7.585, P1

Bed Level =	100.00	m
Cut Off Level =	98.20	m
Top Level of Rock =	88.60	m
Pile Tip Level =	85.00	m
Length of Pile below Cut Off =	13.20	m
Length of Pile Socket =	3.60	m
Diameter of Pile =	1.2	m
Grade of Concrete for Pile =	35.0	
Core Recovery, CR =	25	%
Rock Quality Designation, RQD =	0	%

Refer Clause 709.3.1 of IRC:78-2014 & Appendix-5, 9.1 (Method 1)

Q_u = $R_e + R_{af}$ = $K_{sp} * q_c * d_f * A_b + C_{us} * A_s$

Q_{allow} = $(R_e/3) + (R_{af}/6)$

Q_u =	Ultimate Capacity of Pile
Q_{allow} =	Allowable Capacity of Pile
R_e =	Ultimate End Bearing
R_{af} =	Ultimate Side Socket Shear
K_{sp} =	An empirical coefficient
q_c =	Average UCS of rock
d_f =	Depth factor
A_b =	Cross Sectional area of pile
C_{us} =	Ultimate Shear Strength along socket length of pile
A_s =	Surface area of socket

(CR+RQD)/2 =	12.5	%	
K_{sp} =	0.1		
q_c =	59.4	t/m^2	
d_f =	1.2		
A_b =	1.131	m^2	
C_{us} =	1.73	Mpa	
A_s =	12.441	m^2	(Neglecting top 300mm of top rock)
Factor of Safety for End Bearing =	3		
Factor of Safety for Socket resistance =	6		
Allowable End Bearing Stress =	2.376	t/m^2	
Allowable End Bearing Capacity =	2.7	t	
Allowable Socket resistance =	359.6	t	
Q_{allow} =	362.2	t	

Pile Capacity Calculation in Rock (As per Method 1, Appendix-5 of IRC:78-2014) :

CH - 7.615, P2

Bed Level =	100.00	m
Cut Off Level =	98.20	m
Top Level of Rock =	88.60	m
Pile Tip Level =	85.00	m
Length of Pile below Cut Off =	13.20	m
Length of Pile Socket =	3.60	m
Diameter of Pile =	1.2	m
Grade of Concrete for Pile =	35.0	
Core Recovery, CR =	24	%
Rock Quality Designation, RQD =	0	%

Refer Clause 709.3.1 of IRC:78-2014 & Appendix-5, 9.1 (Method 1)

$Q_u = R_e + R_{af} = K_{sp} * q_c * d_f * A_b + C_{us} * A_s$

$Q_{allow} = (R_e/3) + (R_{af}/6)$

Q_u =	Ultimate Capacity of Pile
Q_{allow} =	Allowable Capacity of Pile
R_e =	Ultimate End Bearing
R_{af} =	Ultimate Side Socket Shear
K_{sp} =	An empirical coefficient
q_c =	Average UCS of rock
d_f =	Depth factor
A_b =	Cross Sectional area of pile
C_{us} =	Ultimate Shear Strength along socket length of pile
A_s =	Surface area of socket

(CR+RQD)/2 =	12	%	
K_{sp} =	0.1		
q_c =	57	t/m^2	
d_f =	1.2		
A_b =	1.131	m^2	
C_{us} =	1.70	Mpa	
A_s =	12.441	m^2	(Neglecting top 300mm of top rock)
Factor of Safety for End Bearing =	3		
Factor of Safety for Socket resistance =	6		
Allowable End Bearing Stress =	2.28	t/m^2	
Allowable End Bearing Capacity =	2.6	t	
Allowable Socket resistance =	352.2	t	
Q_{allow} =	354.8	t	

Pile Capacity Calculation in Rock (As per Method 1, Appendix-5 of IRC:78-2014) :

CH - 7.645, P3

Bed Level =	100.00	m
Cut Off Level =	98.20	m
Top Level of Rock =	88.60	m
Pile Tip Level =	85.00	m
Length of Pile below Cut Off =	13.20	m
Length of Pile Socket =	3.60	m
Diameter of Pile =	1.2	m
Grade of Concrete for Pile =	35.0	
Core Recovery, CR =	23	%
Rock Quality Designation, RQD =	0	%

Refer Clause 709.3.1 of IRC:78-2014 & Appendix-5, 9.1 (Method 1)

$Q_u = R_e + R_{af} = K_{sp} * q_c * d_f * A_b + C_{us} * A_s$

$Q_{allow} = (R_e/3) + (R_{af}/6)$

Q_u =	Ultimate Capacity of Pile
Q_{allow} =	Allowable Capacity of Pile
R_e =	Ultimate End Bearing
R_{af} =	Ultimate Side Socket Shear
K_{sp} =	An empirical coefficient
q_c =	Average UCS of rock
d_f =	Depth factor
A_b =	Cross Sectional area of pile
C_{us} =	Ultimate Shear Strength along socket length of pile
A_s =	Surface area of socket

(CR+RQD)/2 =	11.5	%	
K_{sp} =	0.1		
q_c =	56.5	t/m^2	
d_f =	1.2		
A_b =	1.131	m^2	
C_{us} =	1.69	Mpa	
A_s =	12.441	m^2	(Neglecting top 300mm of top rock)
Factor of Safety for End Bearing =	3		
Factor of Safety for Socket resistance =	6		
Allowable End Bearing Stress =	2.26	t/m^2	
Allowable End Bearing Capacity =	2.6	t	
Allowable Socket resistance =	350.7	t	
Q_{allow} =	353.2	t	

Pile Capacity Calculation in Rock (As per Method 1, Appendix-5 of IRC:78-2014) :

CH - 7.670, A2

Bed Level =	100.00	m
Cut Off Level =	98.20	m
Top Level of Rock =	88.60	m
Pile Tip Level =	85.00	m
Length of Pile below Cut Off =	13.20	m
Length of Pile Socket =	3.60	m
Diameter of Pile =	1.2	m
Grade of Concrete for Pile =	35.0	
Core Recovery, CR =	27	%
Rock Quality Designation, RQD =	0	%

Refer Clause 709.3.1 of IRC:78-2014 & Appendix-5, 9.1 (Method 1)

Q_u = $R_e + R_{af}$ = $K_{sp} * q_c * d_f * A_b + C_{us} * A_s$

Q_{allow} = $(R_e/3) + (R_{af}/6)$

Q_u =	Ultimate Capacity of Pile
Q_{allow} =	Allowable Capacity of Pile
R_e =	Ultimate End Bearing
R_{af} =	Ultimate Side Socket Shear
K_{sp} =	An empirical coefficient
q_c =	Average UCS of rock
d_f =	Depth factor
A_b =	Cross Sectional area of pile
C_{us} =	Ultimate Shear Strength along socket length of pile
A_s =	Surface area of socket

(CR+RQD)/2 =	13.5	%	
K_{sp} =	0.1		
q_c =	57	t/m^2	
d_f =	1.2		
A_b =	1.131	m^2	
C_{us} =	1.70	Mpa	
A_s =	12.441	m^2	(Neglecting top 300mm of top rock)
Factor of Safety for End Bearing =	3		
Factor of Safety for Socket resistance =	6		
Allowable End Bearing Stress =	2.28	t/m^2	
Allowable End Bearing Capacity =	2.6	t	
Allowable Socket resistance =	352.2	t	
Q_{allow} =	354.8	t	

Pile Capacity Calculation in Rock (As per Method 1, Appendix-5 of IRC:78-2014) :

CH - 13.690, A1

Bed Level =	100.00	m
Cut Off Level =	98.20	m
Top Level of Rock =	88.60	m
Pile Tip Level =	85.00	m
Length of Pile below Cut Off =	13.20	m
Length of Pile Socket =	3.60	m
Diameter of Pile =	1.2	m
Grade of Concrete for Pile =	35.0	
Core Recovery, CR =	22	%
Rock Quality Designation, RQD =	0	%

Refer Clause 709.3.1 of IRC:78-2014 & Appendix-5, 9.1 (Method 1)

$Q_u = R_e + R_{af} = K_{sp} * q_c * d_f * A_b + C_{us} * A_s$

$Q_{allow} = (R_e/3) + (R_{af}/6)$

Q_u =	Ultimate Capacity of Pile
Q_{allow} =	Allowable Capacity of Pile
R_e =	Ultimate End Bearing
R_{af} =	Ultimate Side Socket Shear
K_{sp} =	An empirical coefficient
q_c =	Average UCS of rock
d_f =	Depth factor
A_b =	Cross Sectional area of pile
C_{us} =	Ultimate Shear Strength along socket length of pile
A_s =	Surface area of socket

(CR+RQD)/2 =	11	%	
K_{sp} =	0.1		
q_c =	58.3	t/m^2	
d_f =	1.2		
A_b =	1.131	m^2	
C_{us} =	1.72	Mpa	
A_s =	12.441	m^2	(Neglecting top 300mm of top rock)
Factor of Safety for End Bearing =	3		
Factor of Safety for Socket resistance =	6		
Allowable End Bearing Stress =	2.332	t/m^2	
Allowable End Bearing Capacity =	2.6	t	
Allowable Socket resistance =	356.2	t	
Q_{allow} =	358.9	t	

Pile Capacity Calculation in Rock (As per Method 1, Appendix-5 of IRC:78-2014) :

CH - 13.740, A2

Bed Level =	100.00	m
Cut Off Level =	98.20	m
Top Level of Rock =	88.60	m
Pile Tip Level =	85.00	m
Length of Pile below Cut Off =	13.20	m
Length of Pile Socket =	3.60	m
Diameter of Pile =	1.2	m
Grade of Concrete for Pile =	35.0	
Core Recovery, CR =	22.6	%
Rock Quality Designation, RQD =	0	%

Refer Clause 709.3.1 of IRC:78-2014 & Appendix-5, 9.1 (Method 1)

$Q_u = R_e + R_{af} = K_{sp} * q_c * d_f * A_b + C_{us} * A_s$

$Q_{allow} = (R_e/3) + (R_{af}/6)$

Q_u =	Ultimate Capacity of Pile
Q_{allow} =	Allowable Capacity of Pile
R_e =	Ultimate End Bearing
R_{af} =	Ultimate Side Socket Shear
K_{sp} =	An empirical coefficient
q_c =	Average UCS of rock
d_f =	Depth factor
A_b =	Cross Sectional area of pile
C_{us} =	Ultimate Shear Strength along socket length of pile
A_s =	Surface area of socket

(CR+RQD)/2 =	11.3	%	
K_{sp} =	0.1		
q_c =	59.4	t/m^2	
d_f =	1.2		
A_b =	1.131	m^2	
C_{us} =	1.73	Mpa	
A_s =	12.441	m^2	(Neglecting top 300mm of top rock)
Factor of Safety for End Bearing =	3		
Factor of Safety for Socket resistance =	6		
Allowable End Bearing Stress =	2.376	t/m^2	
Allowable End Bearing Capacity =	2.7	t	
Allowable Socket resistance =	359.6	t	
Q_{allow} =	362.2	t	

CH NO 7 + 560

CH NO 7 + 585

CH NO 7 + 615

CH NO 13 + 690

CH NO 11 + 200

CH NO 11 + 750

CH NO 13 +740

CH NO 7 + 645

CH NO 7 + 670

KUNIKA GEOTECHNICAL SERVICES PVT LTD

ISO 9001:2015

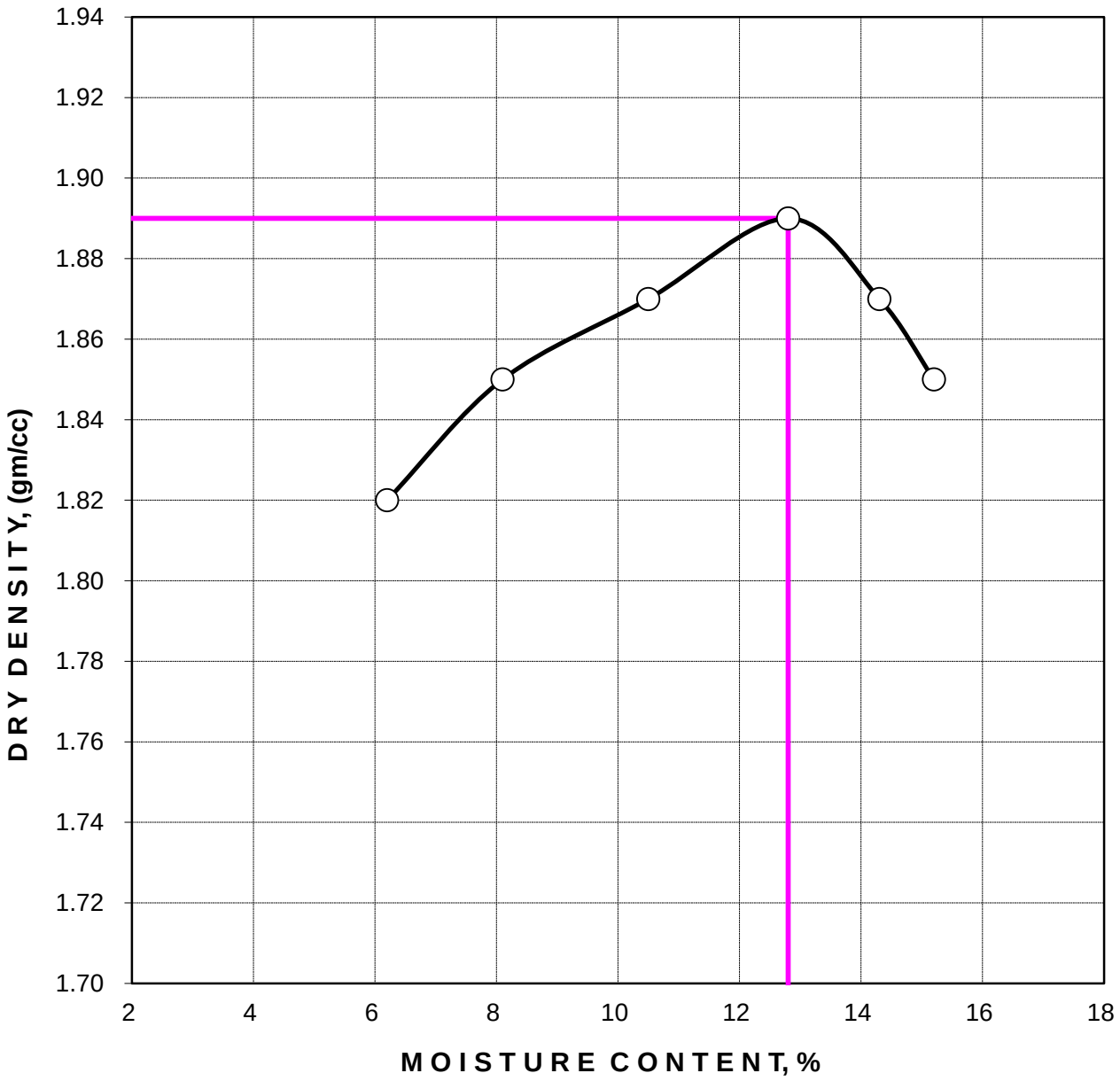
SUMMARY OF CBR TESTS

Project	**"Consultancy Services for Preparation of Detailed Project Report and providing services for pre-construction activities in respect of "Widening and Up-gradation of existing carriageway into 2-lane with paved shoulder configuration from Lavamore (Km 61.10) to Start of Pedong Bypass (Km 79.700) and from Reshi (Km 96.254) to Rhenock (Km 101.554) along NH-717A & from Rhenock (Km 0.00) to Rongli Bazaar (Km 15.300) along NH-717B in the States of Sikkim and West Bengal".**
Location	**Sikkim**
Sample Collected by	**Client**

Chainage in Km	Depth (m)	Sample Type	Description of Sample	Grain Size Analysis (IS : 2720 - Part-4 : 1985)				Soil Classification (IS : 1498-1970)	Atterberg Limits (IS : 2720 - Part-5 : 1985)			Modified Procter Compaction Test IS : 2720 (Part 8) - 1970		Lab CBR (IS : 2720 - Part-16 : 1987)					
												M.D.D, g/cc	O.M.C, %	Un-Soaked C.B.R (%)			Soaked C.B.R (%)		
				Gravel %	Sand %	Silt %	Clay %		Liquid Limits (%)	Plastic Limits (%)	Plasticity Index (%)			I - energy level	II - energy level	III - energy level	I - energy level	II - energy level	III - energy level
0.000	0.00 - 1.00	DS	Greyish Coarse Silty Sand with Gravels	20.3	53.2	26.5	0.0	SM	Non Plasticity			1.89	12.8	8.4	12.3	18.3	5.1	7.8	12.5
5.000	0.00 - 1.00	DS	Greyish Coarse Silty Sand with Gravels	21.6	55.7	22.7	0.0	SM	Non Plasticity			1.90	13.2	7.7	11.6	17.6	4.9	8.1	12.1
6.300	0.00 - 1.00	DS	Greyish Coarse Silty Sand with Gravels	24.4	47.8	27.8	0.0	SM	Non Plasticity			1.91	12.5	10.4	14.3	20.3	5.4	9.3	15.3
10.000	0.00 - 1.00	DS	Greyish Coarse Silty Sand with Gravels	17.6	58.4	24.0	0.0	SM	Non Plasticity			1.92	13.4	8.8	12.7	18.7	5.2	8.2	12.4
14.950	0.00 - 1.00	DS	Greyish Coarse Silty Sand with Gravels	23.6	41.2	35.2	0.0	SM	Non Plasticity			1.90	12.8	9.4	13.3	19.4	5.1	9.0	14.2
97.000	0.00 - 1.00	DS	Greyish Coarse Silty Sand with Gravels	16.5	61.3	22.2	0.0	SM	Non Plasticity			1.93	11.7	8.5	12.4	18.4	5.7	9.3	13.6
98.150	0.00 - 1.00	DS	Greyish Coarse Silty Sand with Gravels	17.8	58.8	23.4	0.0	SM	Non Plasticity			1.91	12.9	9.2	13.1	19.2	6.1	10.0	14.3

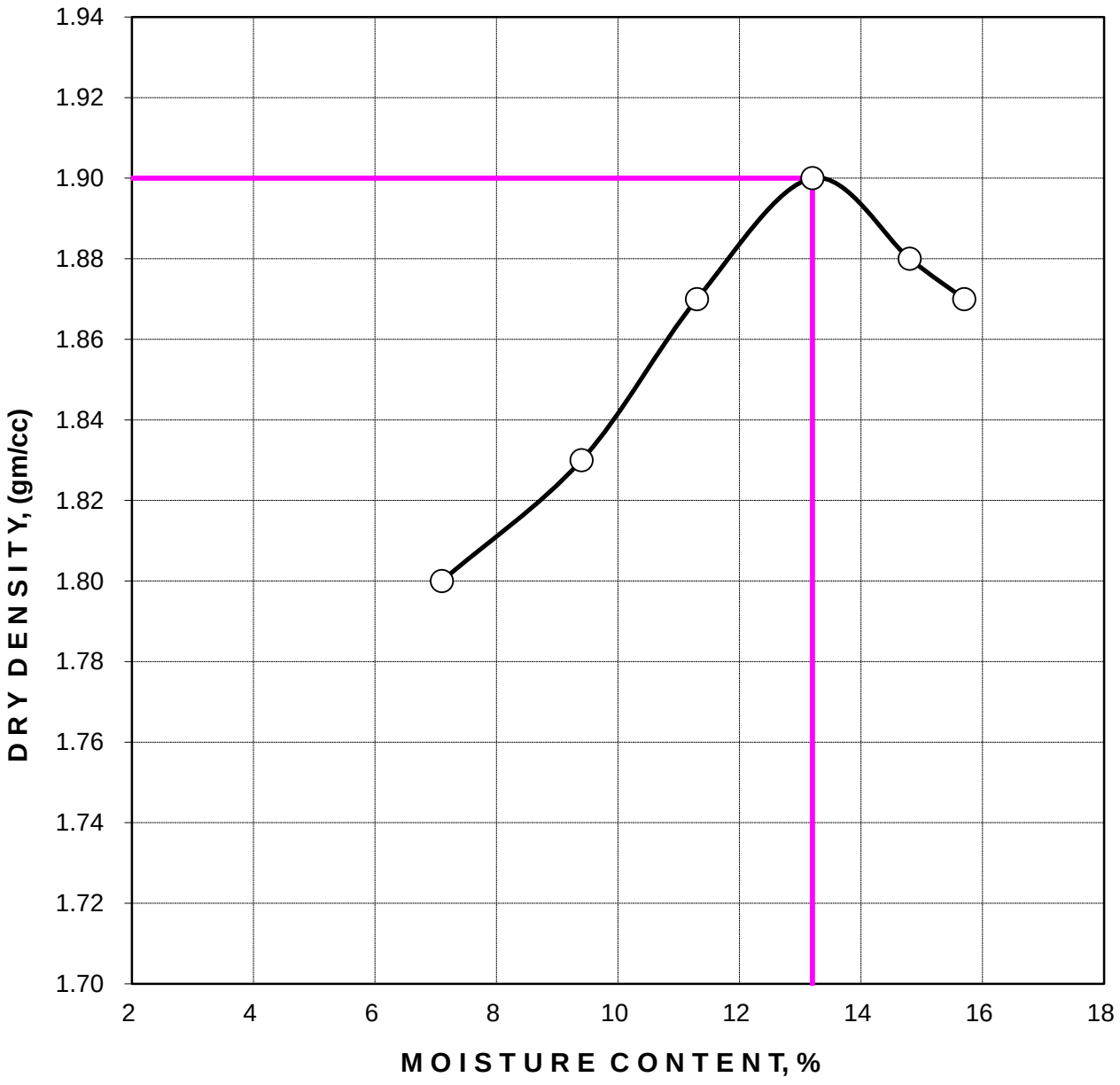
PROCTOR COMPACTION TEST

SAMPLE DETAILS		TEST RESULTS	
Location	0.00 Km	Maximum Dry Density, gm/cc :	1.89
Sample Depth	1.00 Meter	Optimum Moisture Content, % :	12.80



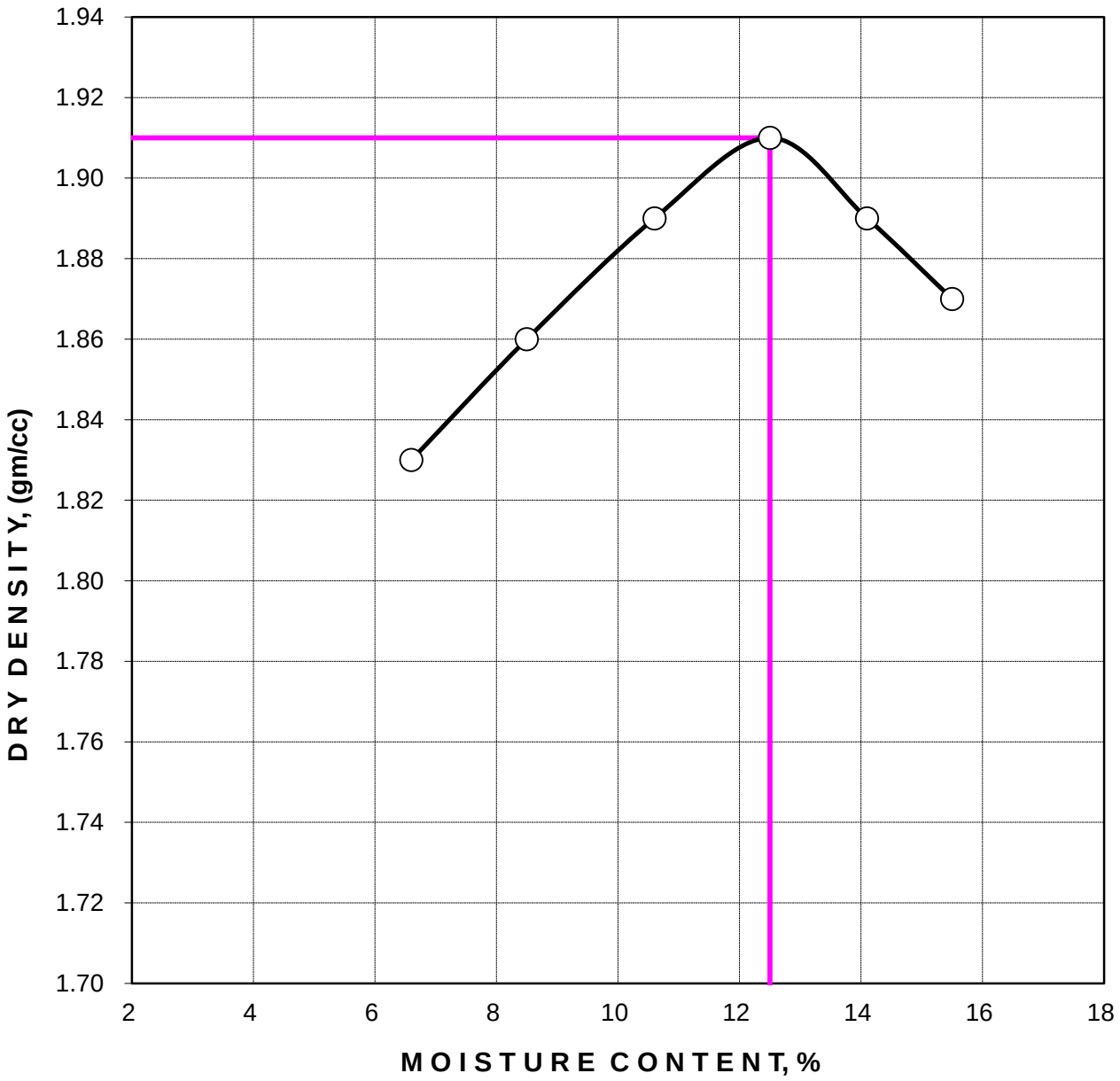
PROCTOR COMPACTION TEST

SAMPLE DETAILS		TEST RESULTS	
Location	5.00 Km	Maximum Dry Density, gm/cc :	1.90
Sample Depth	1.00 Meter	Optimum Moisture Content, % :	13.20



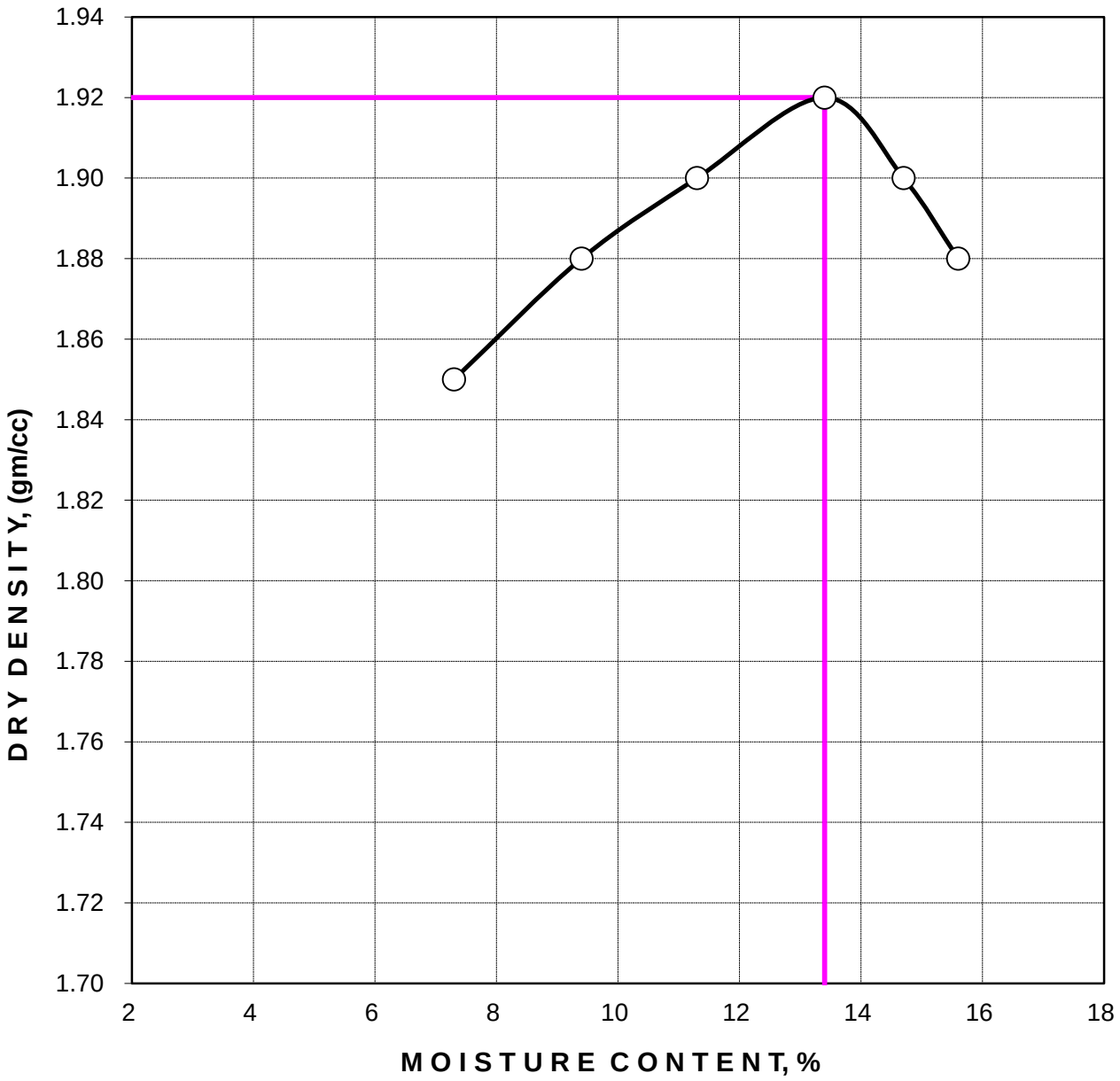
PROCTOR COMPACTION TEST

SAMPLE DETAILS		TEST RESULTS	
Location	6.30 Km	Maximum Dry Density, gm/cc :	1.91
Sample Depth	1.00 Meter	Optimum Moisture Content, % :	12.50



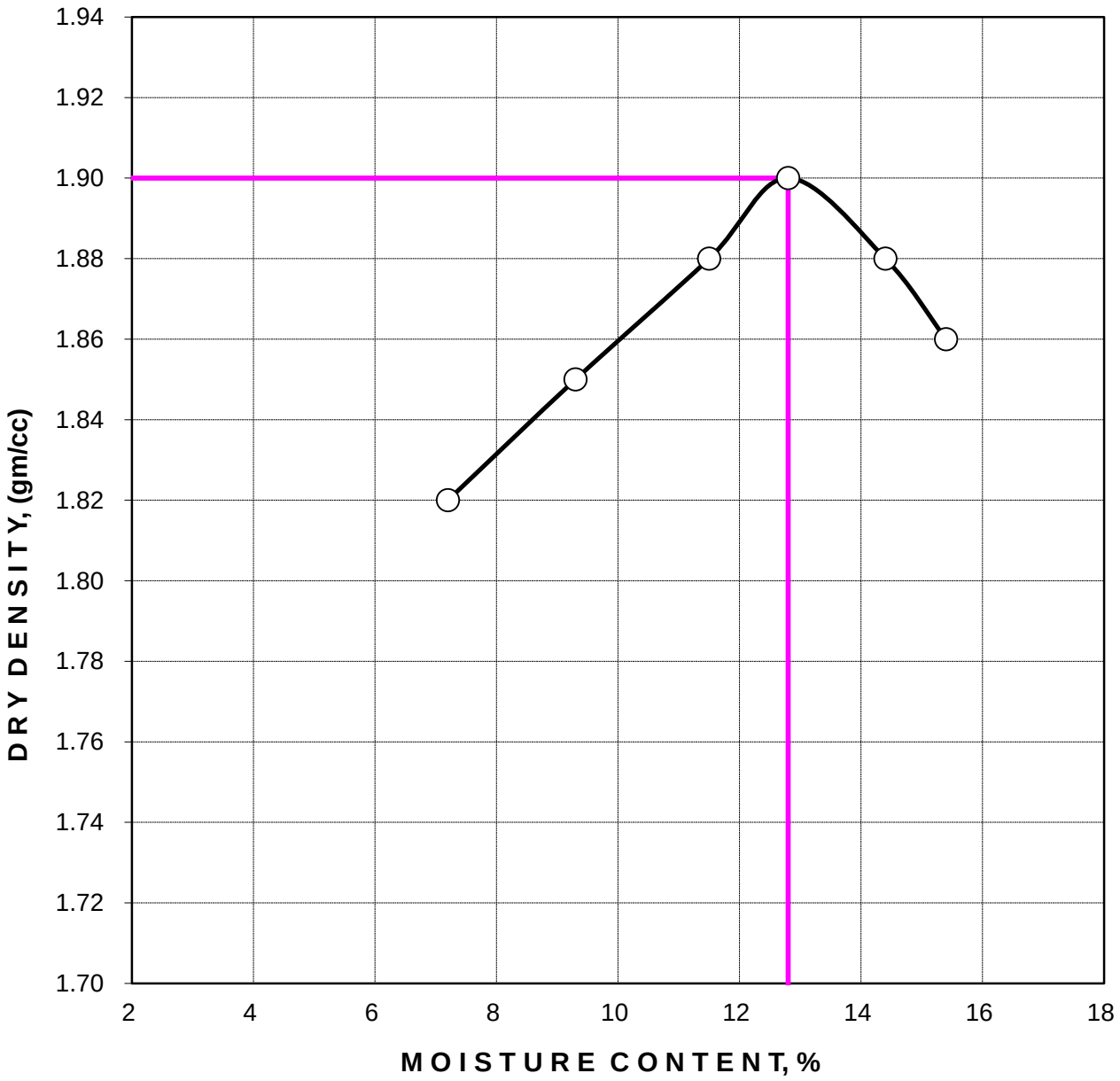
PROCTOR COMPACTION TEST

SAMPLE DETAILS		TEST RESULTS	
Location	10.00 Km	Maximum Dry Density, gm/cc :	1.92
Sample Depth	1.00 Meter	Optimum Moisture Content, % :	13.40



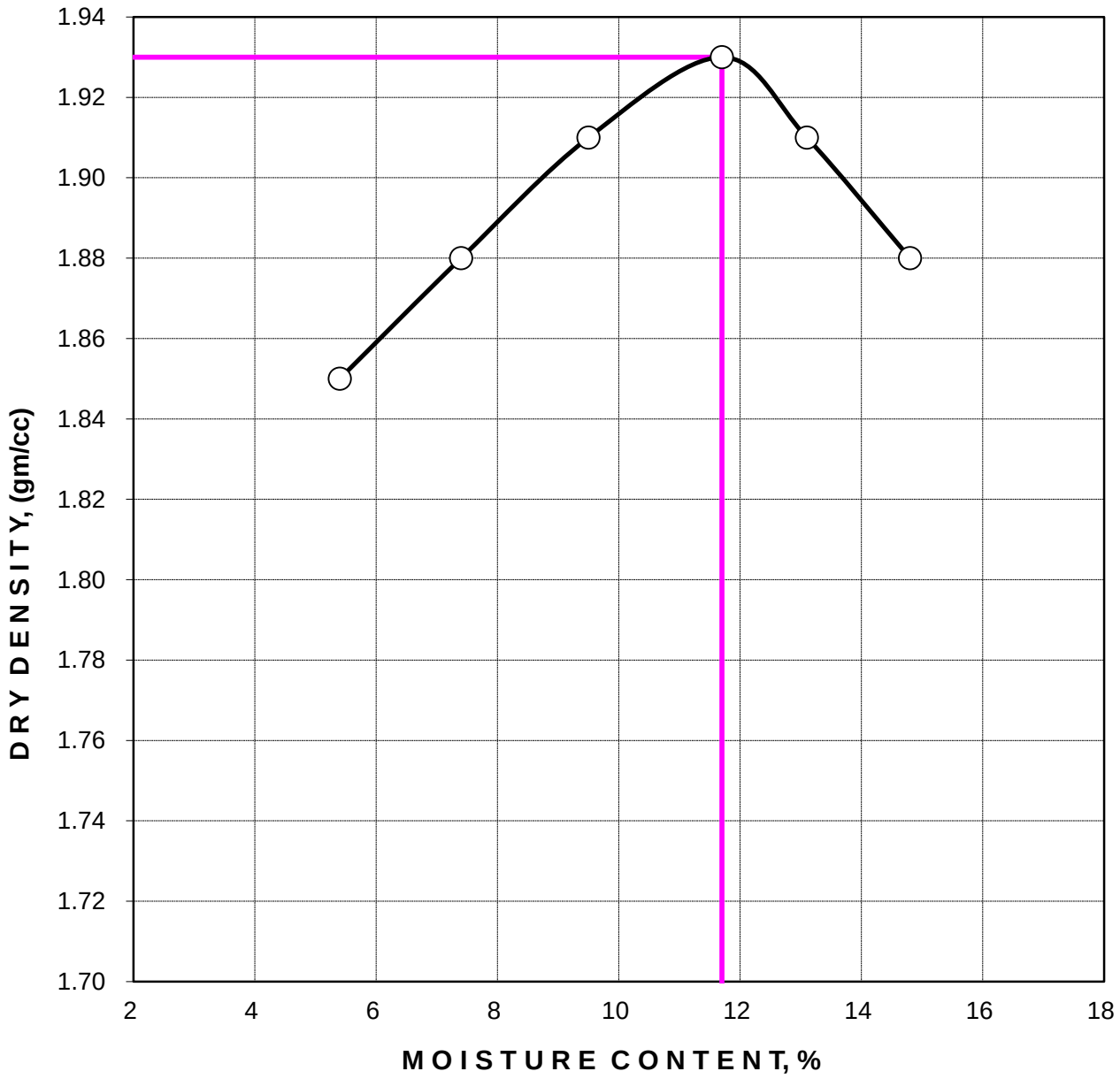
PROCTOR COMPACTION TEST

SAMPLE DETAILS		TEST RESULTS	
Location	14.950 Km	Maximum Dry Density, gm/cc :	1.90
Sample Depth	1.00 Meter	Optimum Moisture Content, % :	12.80



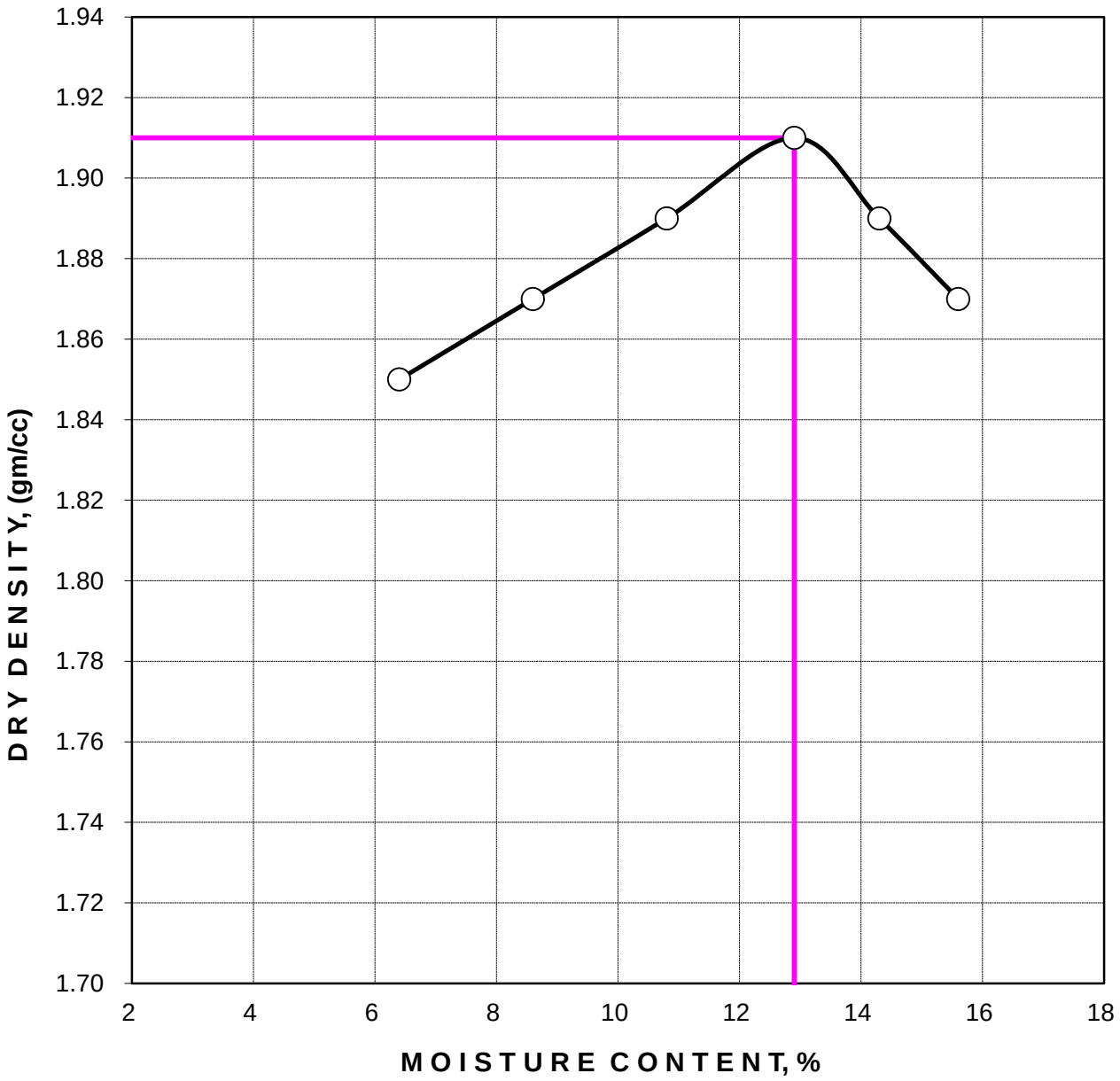
PROCTOR COMPACTION TEST

SAMPLE DETAILS		TEST RESULTS	
Location	97.00 Km	Maximum Dry Density, gm/cc :	1.93
Sample Depth	1.00 Meter	Optimum Moisture Content, % :	11.70



PROCTOR COMPACTION TEST

SAMPLE DETAILS		TEST RESULTS	
Location	98.150 Km	Maximum Dry Density, gm/cc :	1.91
Sample Depth	1.00 Meter	Optimum Moisture Content, % :	12.90



KUNIKA GEOTECHNICAL SERVICES PVT LTD

CALIFORNIA BEARING RATIO

Project : Sikkim

Location : 0.00 Km

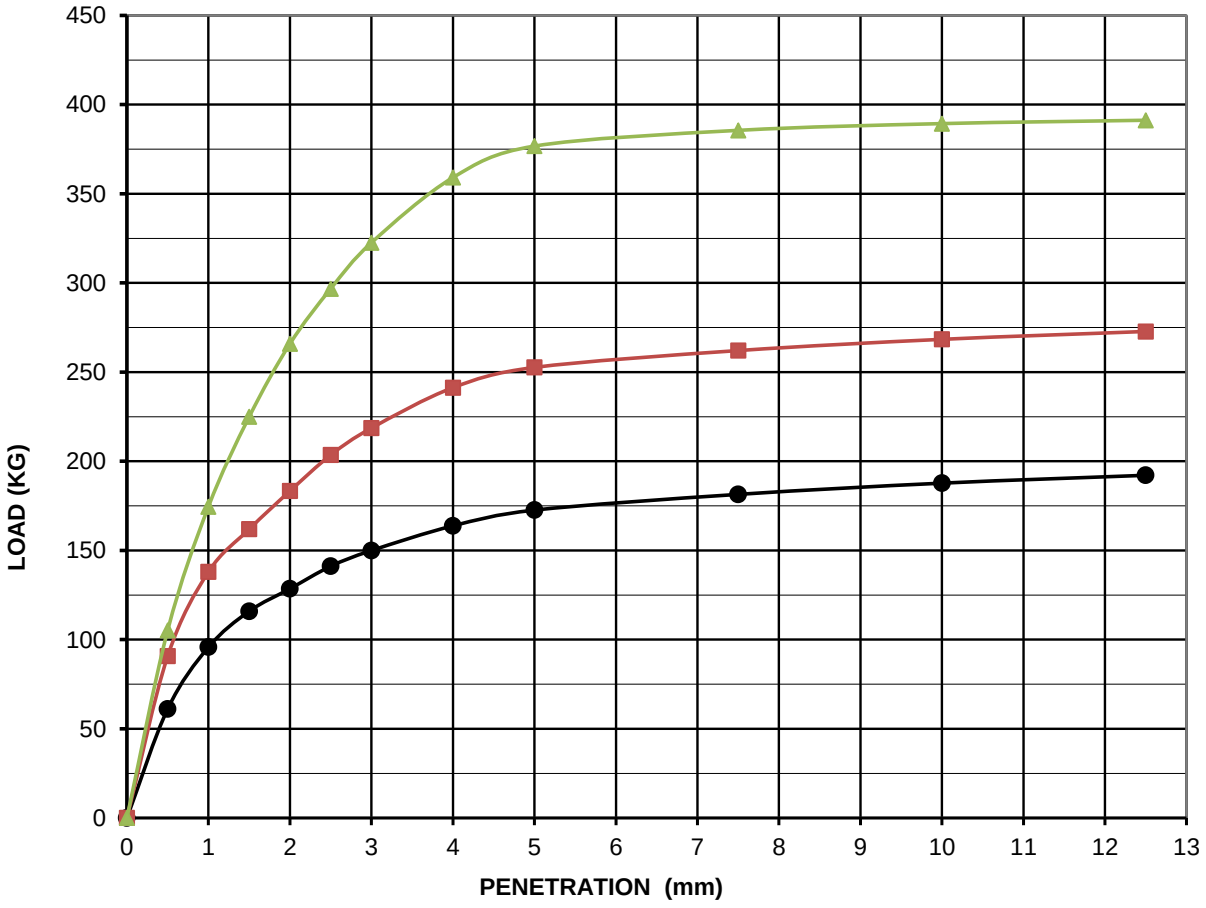
Sample Depth (m) : 1.00 m

Surcharge Weight Used : 5

Proving Ring Factor : 0.63

Un-soaking :

	I - energy level				II - energy level			III - energy level		
Penetra-tion (mm)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	Standar d Load (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)
0	0	0			0	0		0	0	
0.50	97	61.1			144	90.7		167	105.21	
1.00	152	95.8			219	138.0		277	174.51	
1.50	184	115.9			257	161.9		357	224.91	
2.00	204	128.5			291	183.3		422	265.86	
2.50	224	141.1	1370	10.3	323	203.5	14.9	471	296.73	21.7
3.00	238	149.9			347	218.6		512	322.56	
4.00	260	163.8			383	241.3		570	359.1	
5.00	**274**	172.6	2055	8.4	**401**	252.6	12.3	**598**	376.74	18.3
7.50	288	181.4			416	262.1		612	385.56	
10.00	298	187.7			426	268.4		618	389.34	
12.50	305	192.2			433	272.8		621	391.23	



I - energy level

II - energy level

III - energy level

CBR Value for I - energy level = 8.4

CBR Value for II - energy level = 12.3

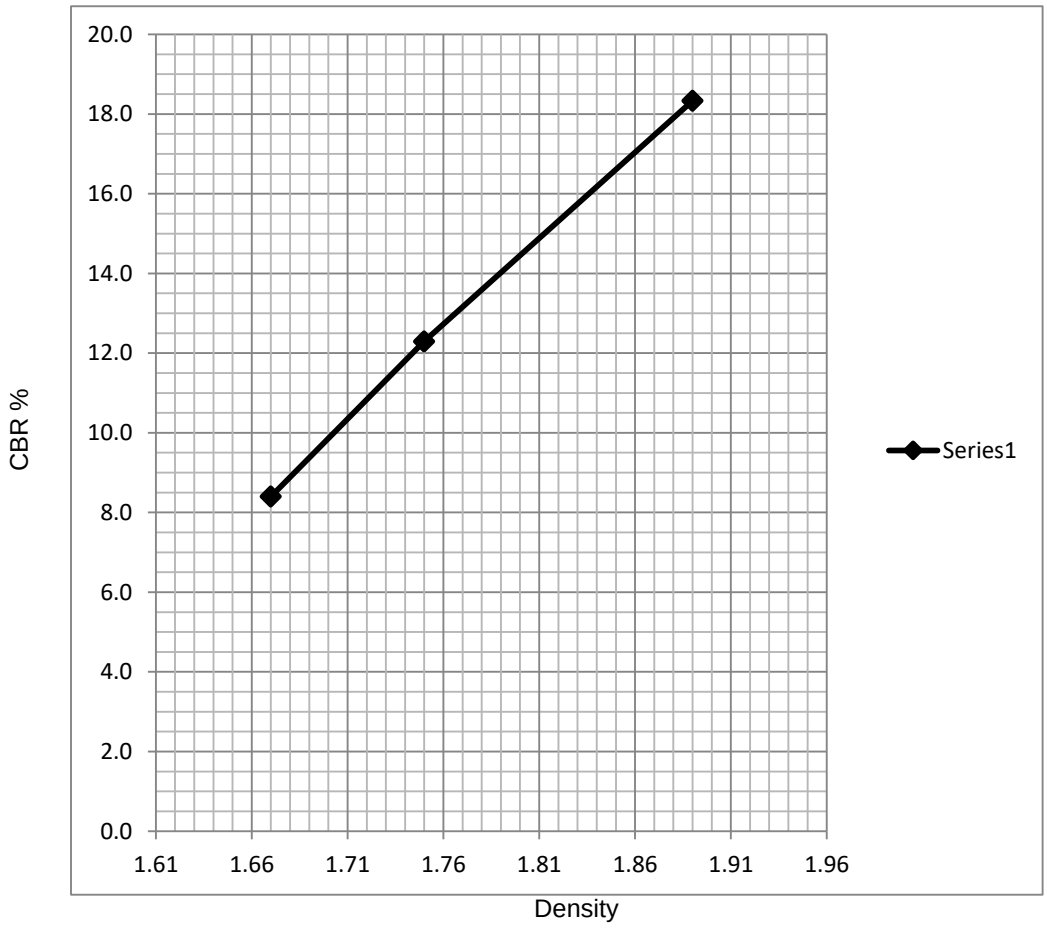
CBR Value for III - energy level = 18.3

KUNIKA GEOTECHNICAL SERVICES PVT LTD

Location : 0.00 Km

CBR Value for I - energy level =	**8.4**	No. of Blows =	**10**
CBR Value for II - energy level =	**12.3**	No. of Blows =	**25**
CBR Value for III - energy level =	**18.3**	No. of Blows =	**55**

Density Value for I - energy level =	**1.67**
Density Value for II - energy level =	**1.75**
Density Value for III - energy level =	**1.89**



KUNIKA GEOTECHNICAL SERVICES PVT LTD

CALIFORNIA BEARING RATIO

Project : Sikkim

Location : 5.00 Km

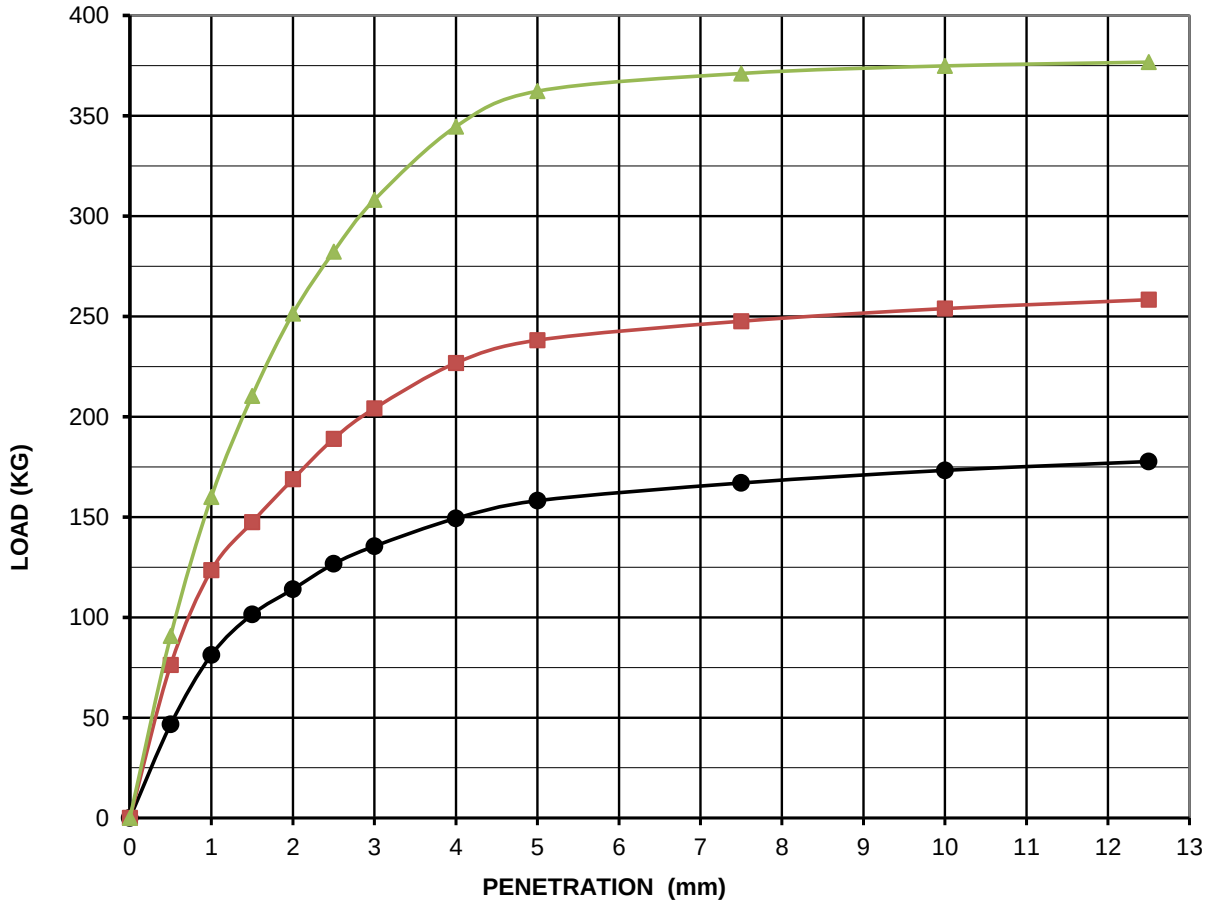
Sample Depth (m) : 1.00 m

Surcharge Weight Used : 5

Proving Ring Factor : 0.63

Un-soaking :

	I - energy level				II - energy level			III - energy level		
Penetra-tion (mm)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	Standar d Load (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)
0	0	0			0	0		0	0	
0.50	74	46.6			121	76.2		144	90.72	
1.00	129	81.3			196	123.5		254	160.02	
1.50	161	101.4			234	147.4		334	210.42	
2.00	181	114.0			268	168.8		399	251.37	
2.50	201	126.6	1370	9.2	300	189.0	13.8	448	282.24	20.6
3.00	215	135.5			324	204.1		489	308.07	
4.00	237	149.3			360	226.8		547	344.61	
5.00	**251**	158.1	2055	7.7	**378**	238.1	11.6	**575**	362.25	17.6
7.50	265	167.0			393	247.6		589	371.07	
10.00	275	173.3			403	253.9		595	374.85	
12.50	282	177.7			410	258.3		598	376.74	



I - energy level

II - energy level

III - energy level

CBR Value for I - energy level = 7.7

CBR Value for II - energy level = 11.6

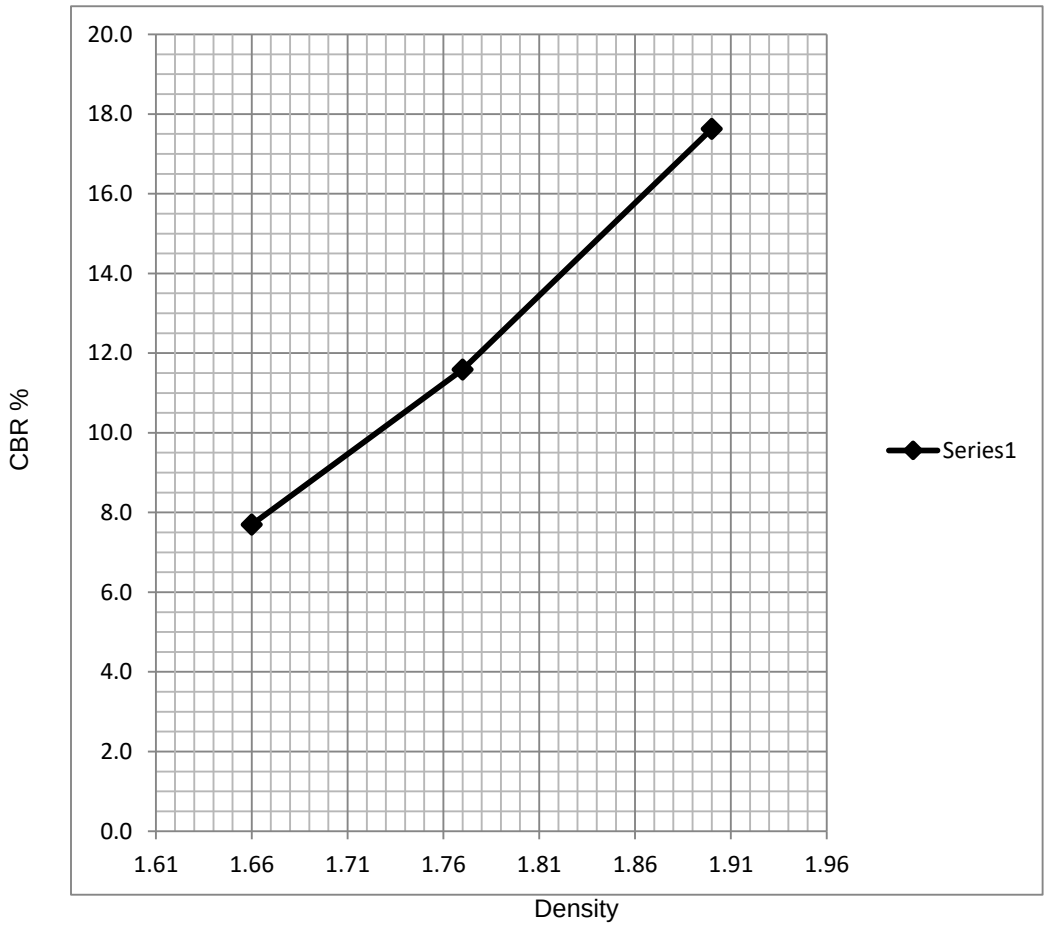
CBR Value for III - energy level = 17.6

KUNIKA GEOTECHNICAL SERVICES PVT LTD

Location : 5.00 Km

CBR Value for I - energy level =	**7.7**	No. of Blows =	**10**
CBR Value for II - energy level =	**11.6**	No. of Blows =	**25**
CBR Value for III - energy level =	**17.6**	No. of Blows =	**55**

Density Value for I - energy level =	**1.66**
Density Value for II - energy level =	**1.77**
Density Value for III - energy level =	**1.90**



KUNIKA GEOTECHNICAL SERVICES PVT LTD

CALIFORNIA BEARING RATIO

Project : Sikkim

Location : 6.30 Km

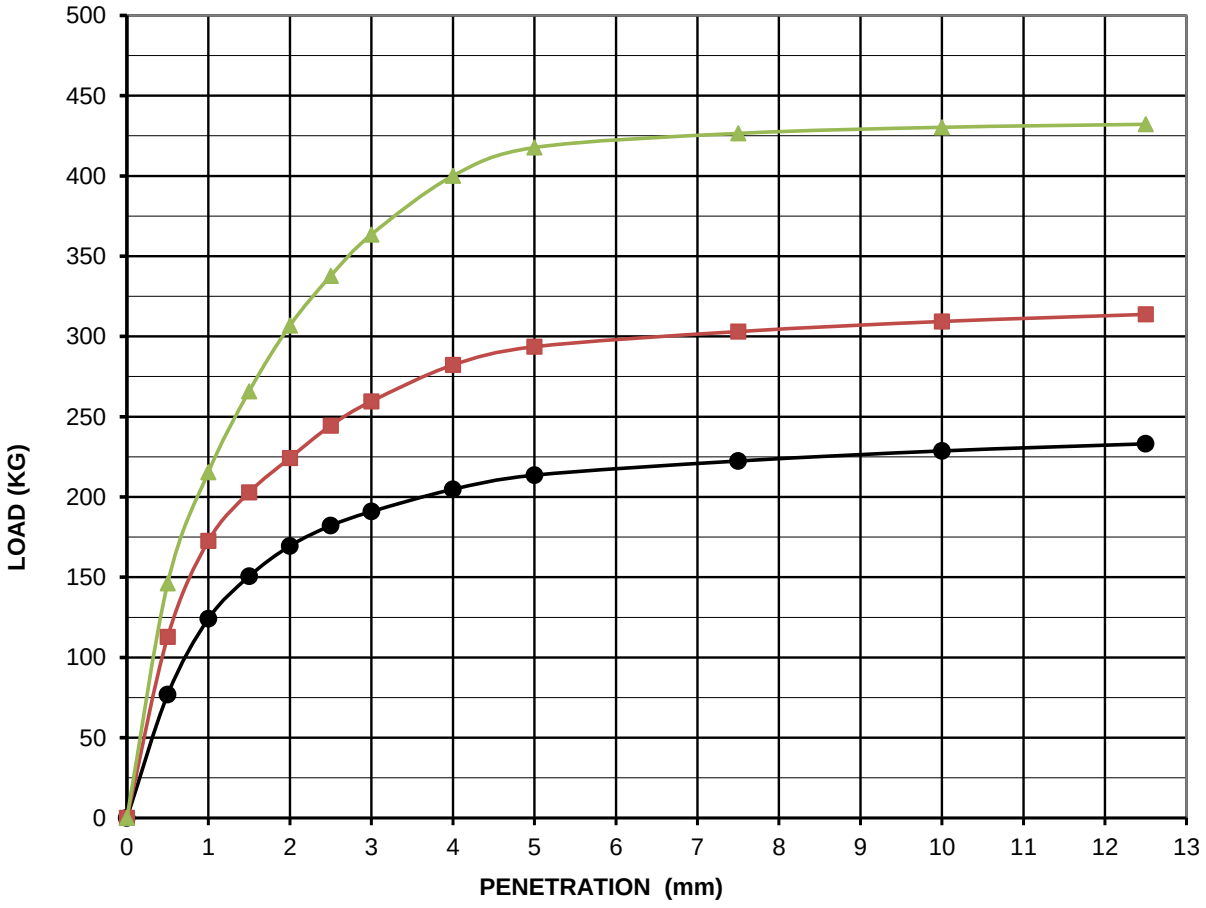
Sample Depth (m) : 1.00 m

Surcharge Weight Used : 5

Proving Ring Factor : 0.63

Un-soaked :

	I - energy level				II - energy level			III - energy level		
Penetra-tion (mm)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	Standar d Load (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)
0	0	0			0	0		0	0	
0.50	122	76.9			179	112.8		232	146.16	
1.00	197	124.1			274	172.6		342	215.46	
1.50	239	150.6			322	202.9		422	265.86	
2.00	269	169.5			356	224.3		487	306.81	
2.50	289	182.1	1370	13.3	388	244.4	17.8	536	337.68	24.6
3.00	303	190.9			412	259.6		577	363.51	
4.00	325	204.8			448	282.2		635	400.05	
5.00	**339**	213.6	2055	10.4	**466**	293.6	14.3	**663**	417.69	20.3
7.50	353	222.4			481	303.0		677	426.51	
10.00	363	228.7			491	309.3		683	430.29	
12.50	370	233.1			498	313.7		686	432.18	



I - energy level

II - energy level

III - energy level

CBR Value for I - energy level = 10.4

CBR Value for II - energy level = 14.3

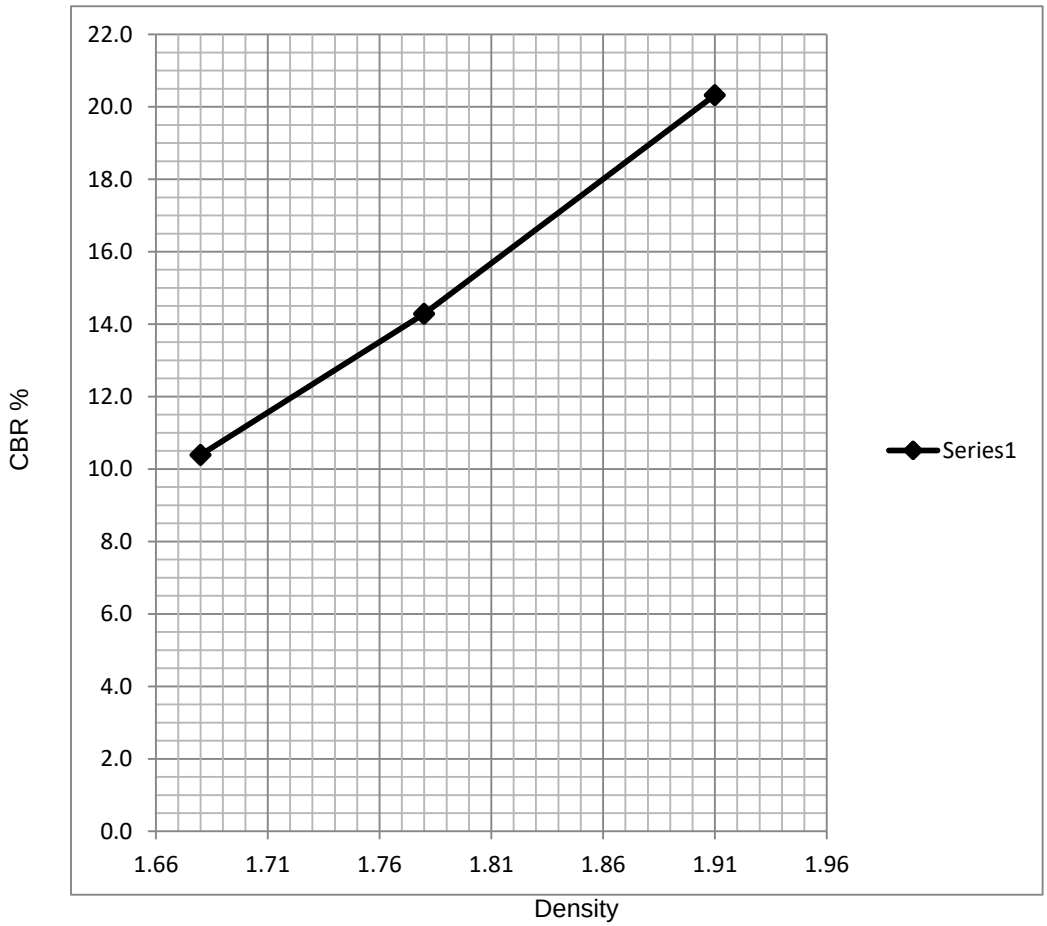
CBR Value for III - energy level = 20.3

KUNIKA GEOTECHNICAL SERVICES PVT LTD

Location : 6.30 Km

CBR Value for I - energy level =	**10.4**	No. of Blows =	**10**
CBR Value for II - energy level =	**14.3**	No. of Blows =	**25**
CBR Value for III - energy level =	**20.3**	No. of Blows =	**55**

Density Value for I - energy level =	**1.68**
Density Value for II - energy level =	**1.78**
Density Value for III - energy level =	**1.91**



KUNIKA GEOTECHNICAL SERVICES PVT LTD

CALIFORNIA BEARING RATIO

Project : Sikkim

Location : 10.00 Km

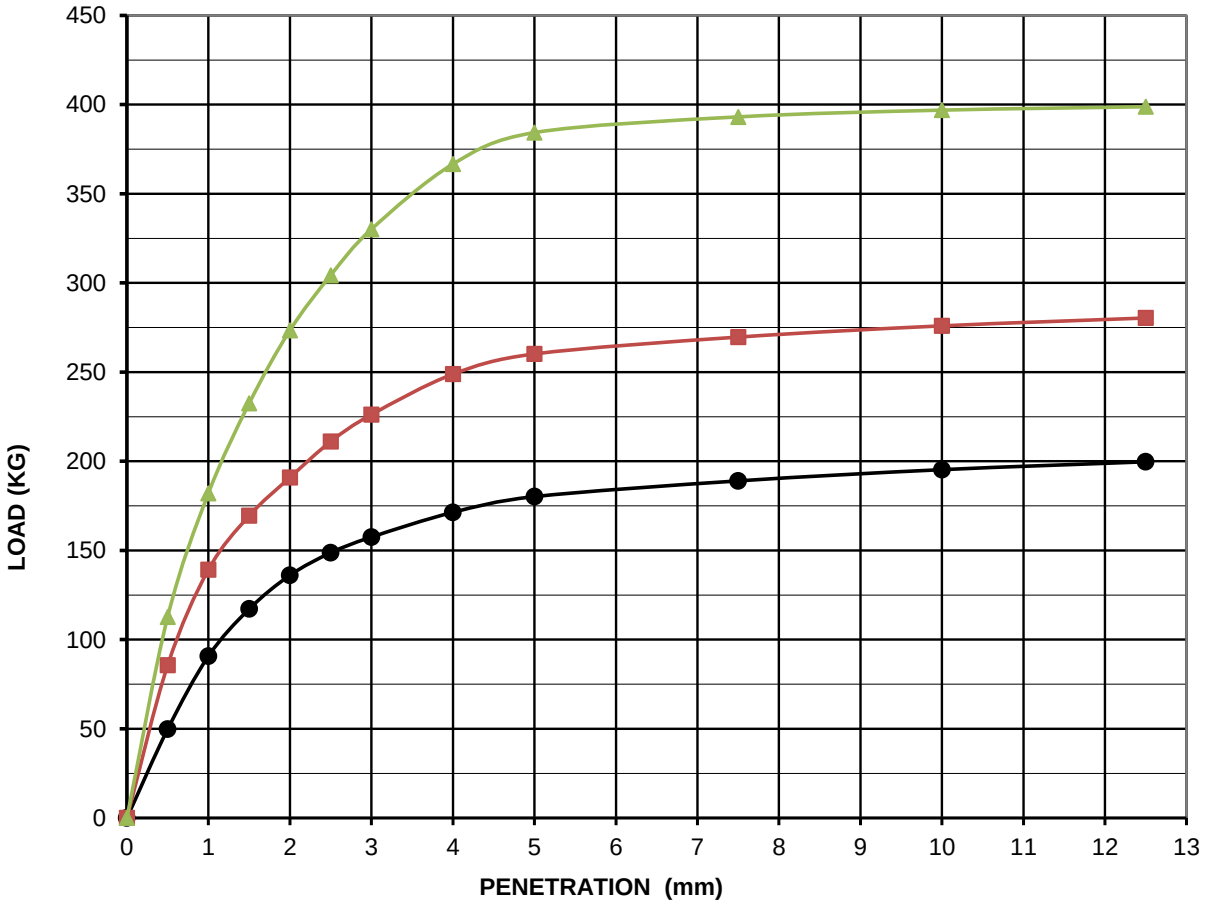
Sample Depth (m) : 1.00 m

Surcharge Weight Used : 5

Proving Ring Factor : 0.63

Un-soaking :

	I - energy level				II - energy level			III - energy level		
Penetra-tion (mm)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	Standar d Load (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)
0	0	0			0	0		0	0	
0.50	79	49.8			136	85.7		179	112.77	
1.00	144	90.7			221	139.2		289	182.07	
1.50	186	117.2			269	169.5		369	232.47	
2.00	216	136.1			303	190.9		434	273.42	
2.50	236	148.7	1370	10.9	335	211.1	15.4	483	304.29	22.2
3.00	250	157.5			359	226.2		524	330.12	
4.00	272	171.4			395	248.9		582	366.66	
5.00	**286**	180.2	2055	8.8	**413**	260.2	12.7	**610**	384.3	18.7
7.50	300	189.0			428	269.6		624	393.12	
10.00	310	195.3			438	275.9		630	396.9	
12.50	317	199.7			445	280.4		633	398.79	



I - energy level

II - energy level

III - energy level

CBR Value for I - energy level = 8.8

CBR Value for II - energy level = 12.7

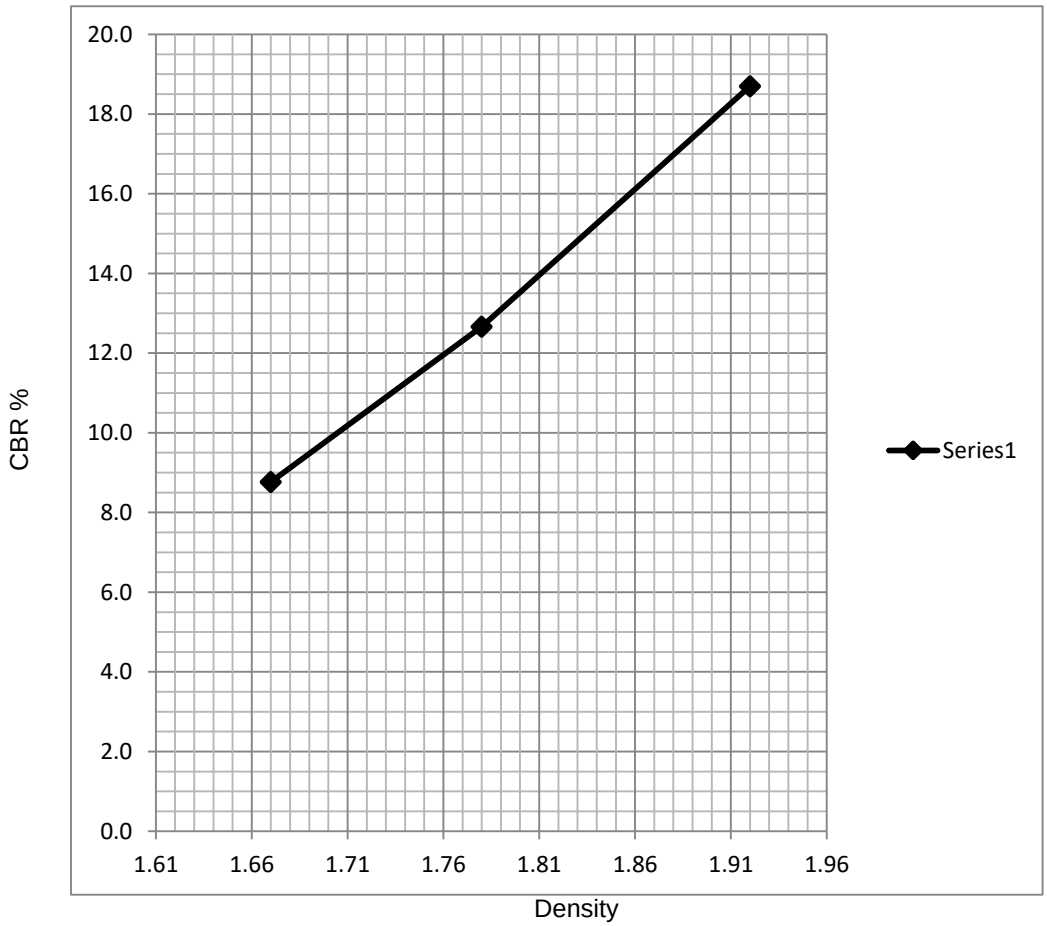
CBR Value for III - energy level = 18.7

KUNIKA GEOTECHNICAL SERVICES PVT LTD

Location : 10.00 Km

CBR Value for I - energy level =	**8.8**	No. of Blows =	**10**
CBR Value for II - energy level =	**12.7**	No. of Blows =	**25**
CBR Value for III - energy level =	**18.7**	No. of Blows =	**55**

Density Value for I - energy level =	**1.67**
Density Value for II - energy level =	**1.78**
Density Value for III - energy level =	**1.92**



KUNIKA GEOTECHNICAL SERVICES PVT LTD

CALIFORNIA BEARING RATIO

Project : Sikkim

Location : 14.95 Km

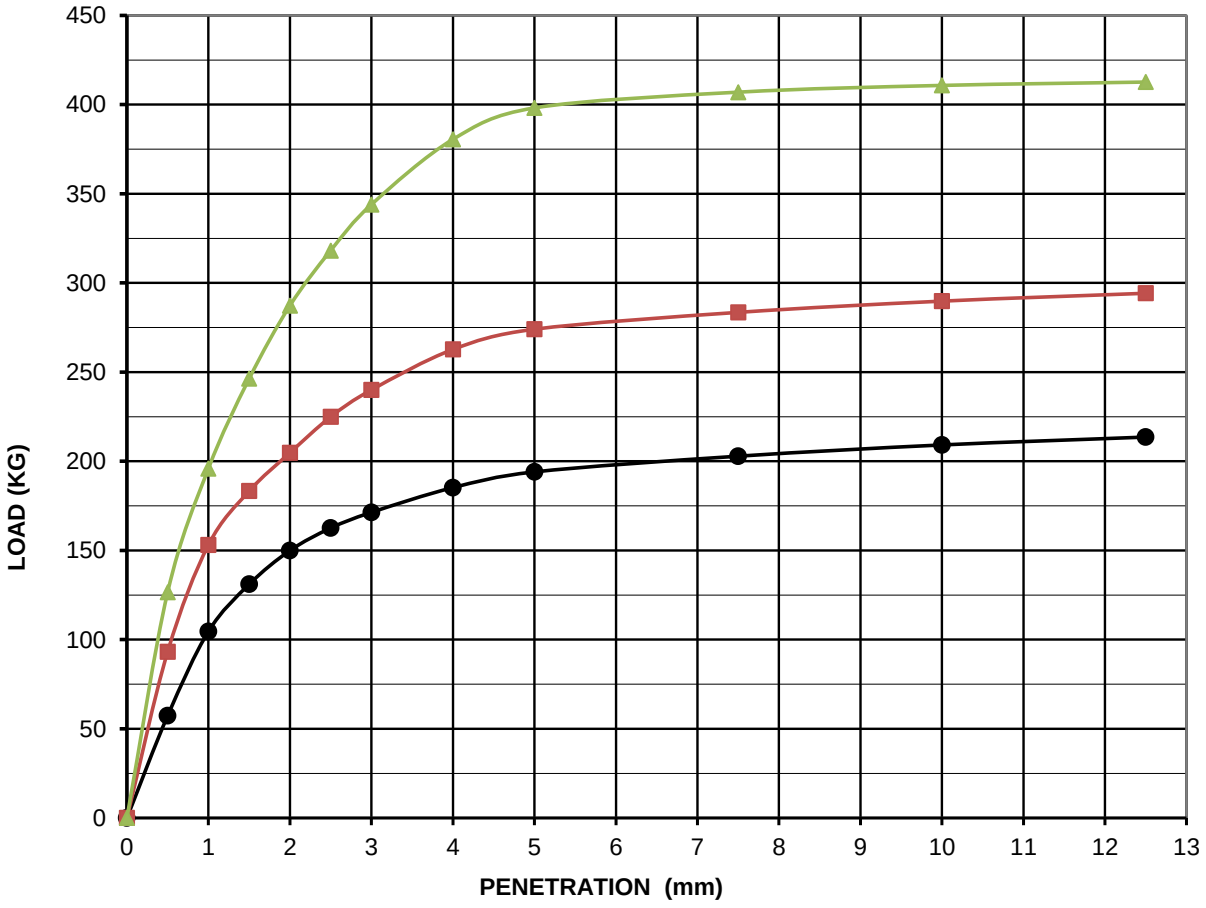
Sample Depth (m) : 1.00 m

Surcharge Weight Used : 5

Proving Ring Factor : 0.63

Un-soaked :

	I - energy level				II - energy level			III - energy level		
Penetra-tion (mm)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	Standar d Load (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)
0	0	0			0	0		0	0	
0.50	91	57.3			148	93.2		201	126.63	
1.00	166	104.6			243	153.1		311	195.93	
1.50	208	131.0			291	183.3		391	246.33	
2.00	238	149.9			325	204.8		456	287.28	
2.50	258	162.5	1370	11.9	357	224.9	16.4	505	318.15	23.2
3.00	272	171.4			381	240.0		546	343.98	
4.00	294	185.2			417	262.7		604	380.52	
5.00	**308**	194.0	2055	9.4	**435**	274.1	13.3	**632**	398.16	19.4
7.50	322	202.9			450	283.5		646	406.98	
10.00	332	209.2			460	289.8		652	410.76	
12.50	339	213.6			467	294.2		655	412.65	



I - energy level

II - energy level

III - energy level

CBR Value for I - energy level = 9.4

CBR Value for II - energy level = 13.3

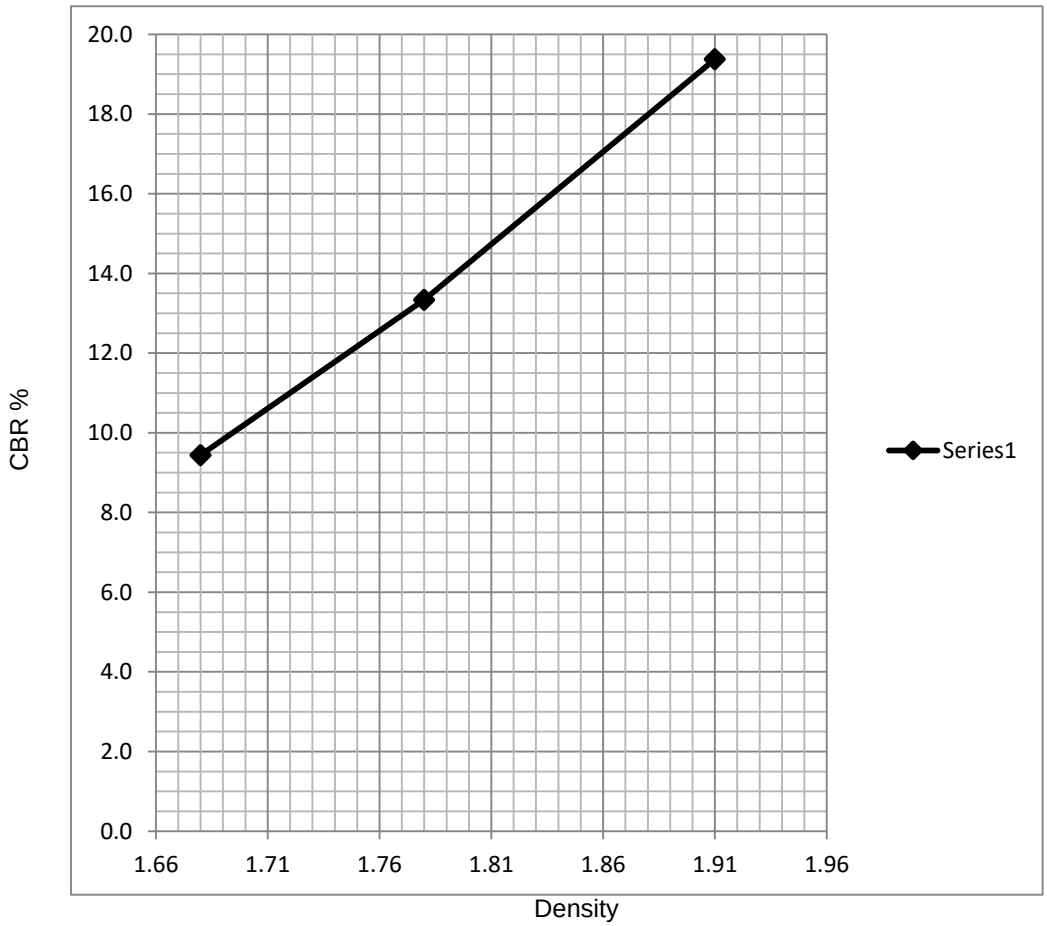
CBR Value for III - energy level = 19.4

KUNIKA GEOTECHNICAL SERVICES PVT LTD

Location : 14.95 Km

CBR Value for I - energy level =	**9.4**	No. of Blows =	**10**
CBR Value for II - energy level =	**13.3**	No. of Blows =	**25**
CBR Value for III - energy level =	**19.4**	No. of Blows =	**55**

Density Value for I - energy level =	**1.68**
Density Value for II - energy level =	**1.78**
Density Value for III - energy level =	**1.91**



KUNIKA GEOTECHNICAL SERVICES PVT LTD

CALIFORNIA BEARING RATIO

Project : Sikkim

Location : 97.00 Km

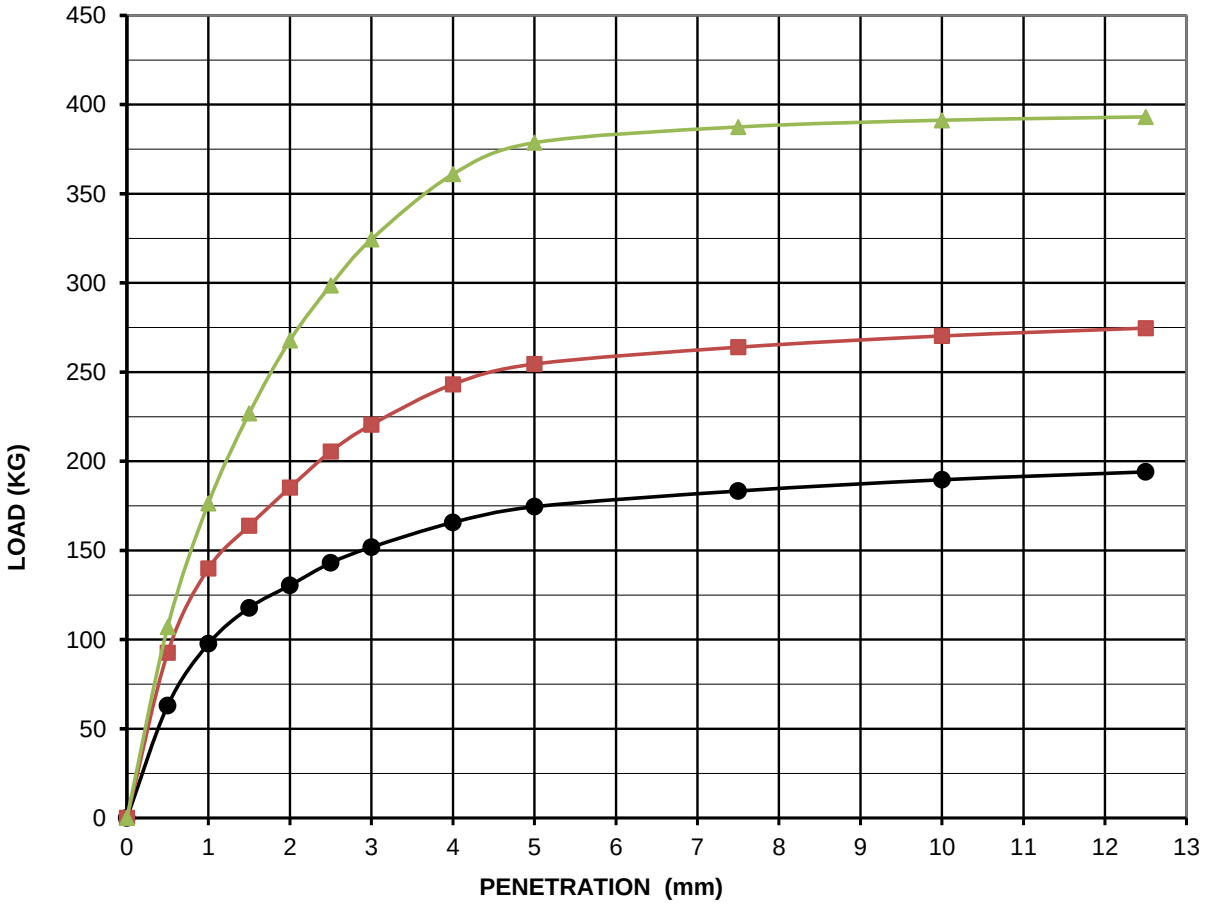
Sample Depth (m) : 1.00 m

Surcharge Weight Used : 5

Proving Ring Factor : 0.63

Un-soaking :

	I - energy level				II - energy level			III - energy level		
Penetra-tion (mm)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	Standar d Load (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)
0	0	0			0	0		0	0	
0.50	100	63.0			147	92.6		170	107.1	
1.00	155	97.7			222	139.9		280	176.4	
1.50	187	117.8			260	163.8		360	226.8	
2.00	207	130.4			294	185.2		425	267.75	
2.50	227	143.0	1370	10.4	326	205.4	15.0	474	298.62	21.8
3.00	241	151.8			350	220.5		515	324.45	
4.00	263	165.7			386	243.2		573	360.99	
5.00	**277**	174.5	2055	8.5	**404**	254.5	12.4	**601**	378.63	18.4
7.50	291	183.3			419	264.0		615	387.45	
10.00	301	189.6			429	270.3		621	391.23	
12.50	308	194.0			436	274.7		624	393.12	



I - energy level

II - energy level

III - energy level

CBR Value for I - energy level = 8.5

CBR Value for II - energy level = 12.4

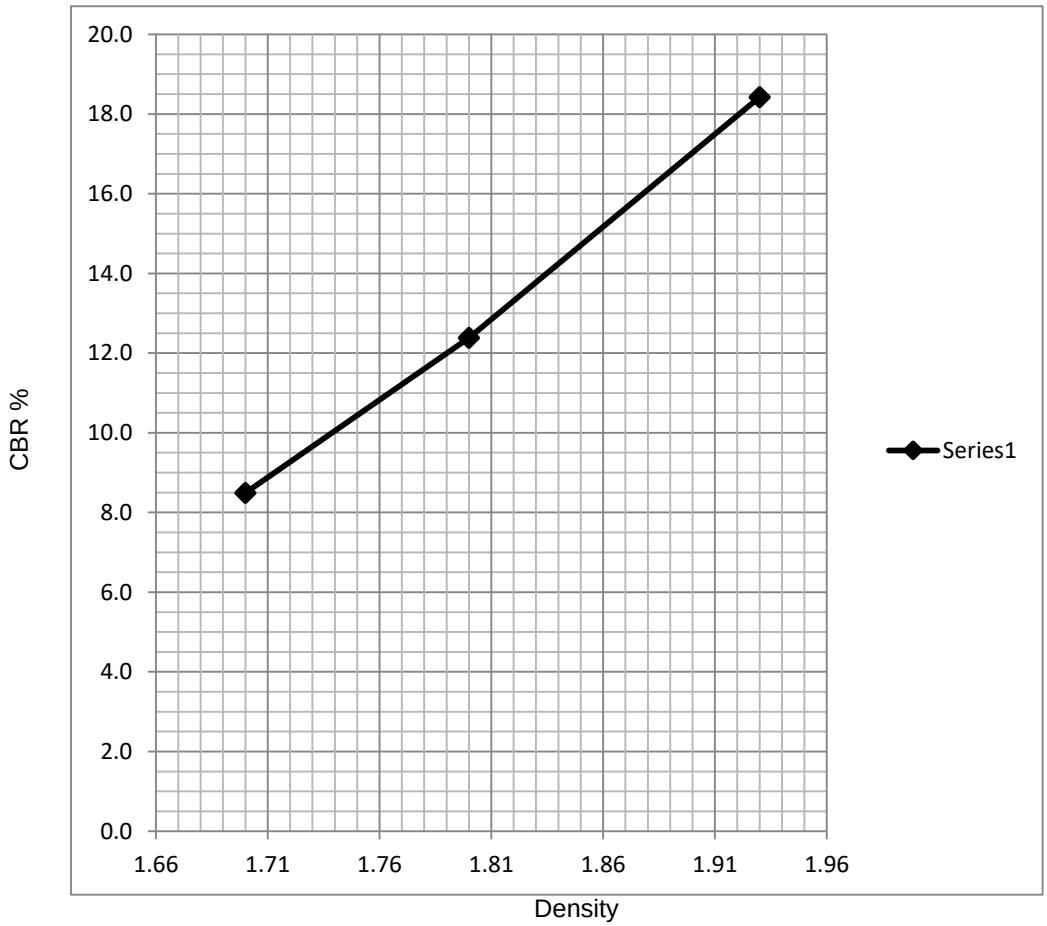
CBR Value for III - energy level = 18.4

KUNIKA GEOTECHNICAL SERVICES PVT LTD

Location : 97.00 Km

CBR Value for I - energy level =	**8.5**	No. of Blows =	**10**
CBR Value for II - energy level =	**12.4**	No. of Blows =	**25**
CBR Value for III - energy level =	**18.4**	No. of Blows =	**55**

Density Value for I - energy level =	**1.70**
Density Value for II - energy level =	**1.80**
Density Value for III - energy level =	**1.93**



KUNIKA GEOTECHNICAL SERVICES PVT LTD

CALIFORNIA BEARING RATIO

Project : Sikkim

Location : 98.150 Km

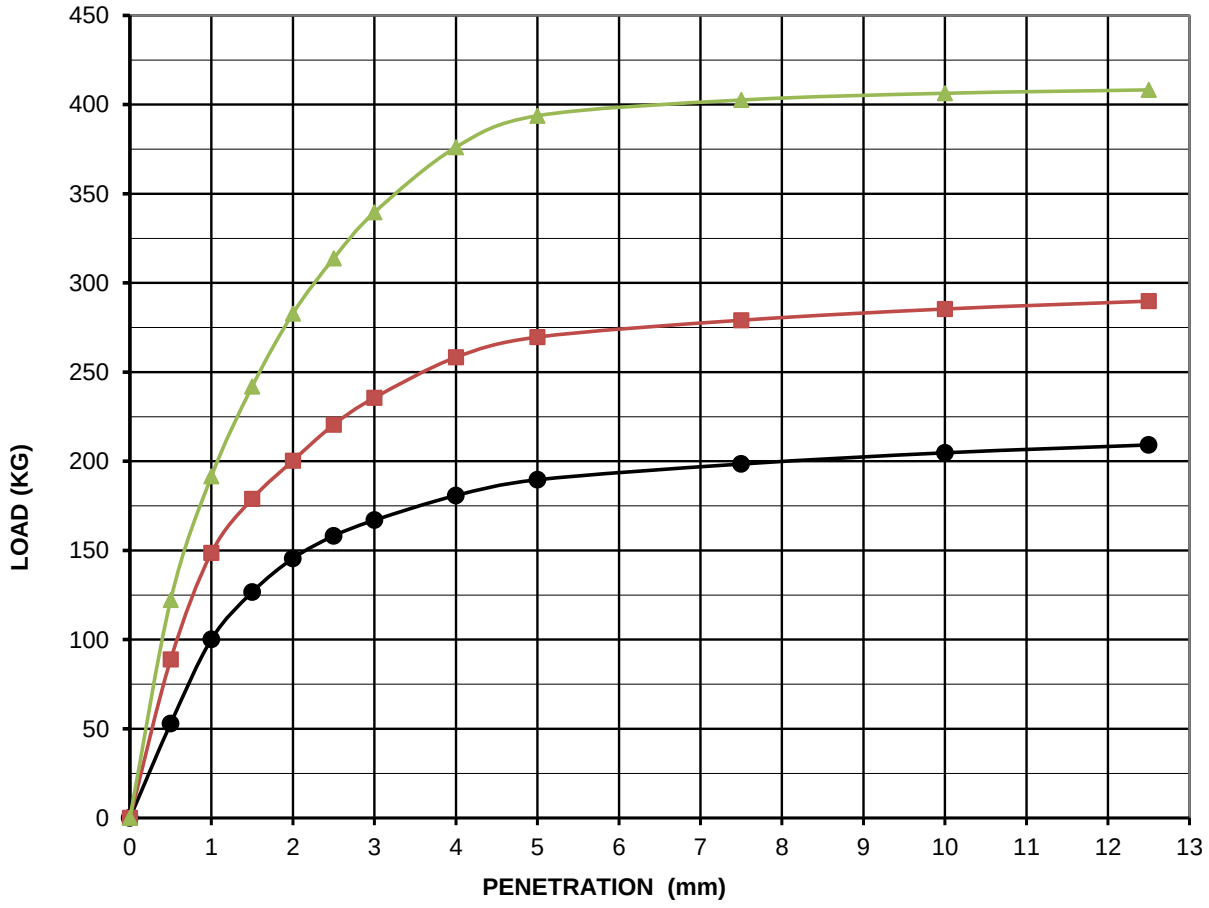
Sample Depth (m) : 1.00 m

Surcharge Weight Used : 5

Proving Ring Factor : 0.63

Un-soaked :

	I - energy level				II - energy level			III - energy level		
Penetra-tion (mm)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	Standar d Load (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)
0	0	0			0	0		0	0	
0.50	84	52.9			141	88.8		194	122.22	
1.00	159	100.2			236	148.7		304	191.52	
1.50	201	126.6			284	178.9		384	241.92	
2.00	231	145.5			318	200.3		449	282.87	
2.50	251	158.1	1370	11.5	350	220.5	16.1	498	313.74	22.9
3.00	265	167.0			374	235.6		539	339.57	
4.00	287	180.8			410	258.3		597	376.11	
5.00	**301**	189.6	2055	9.2	**428**	269.6	13.1	**625**	393.75	19.2
7.50	315	198.5			443	279.1		639	402.57	
10.00	325	204.8			453	285.4		645	406.35	
12.50	332	209.2			460	289.8		648	408.24	



I - energy level

II - energy level

III - energy level

CBR Value for I - energy level = 9.2

CBR Value for II - energy level = 13.1

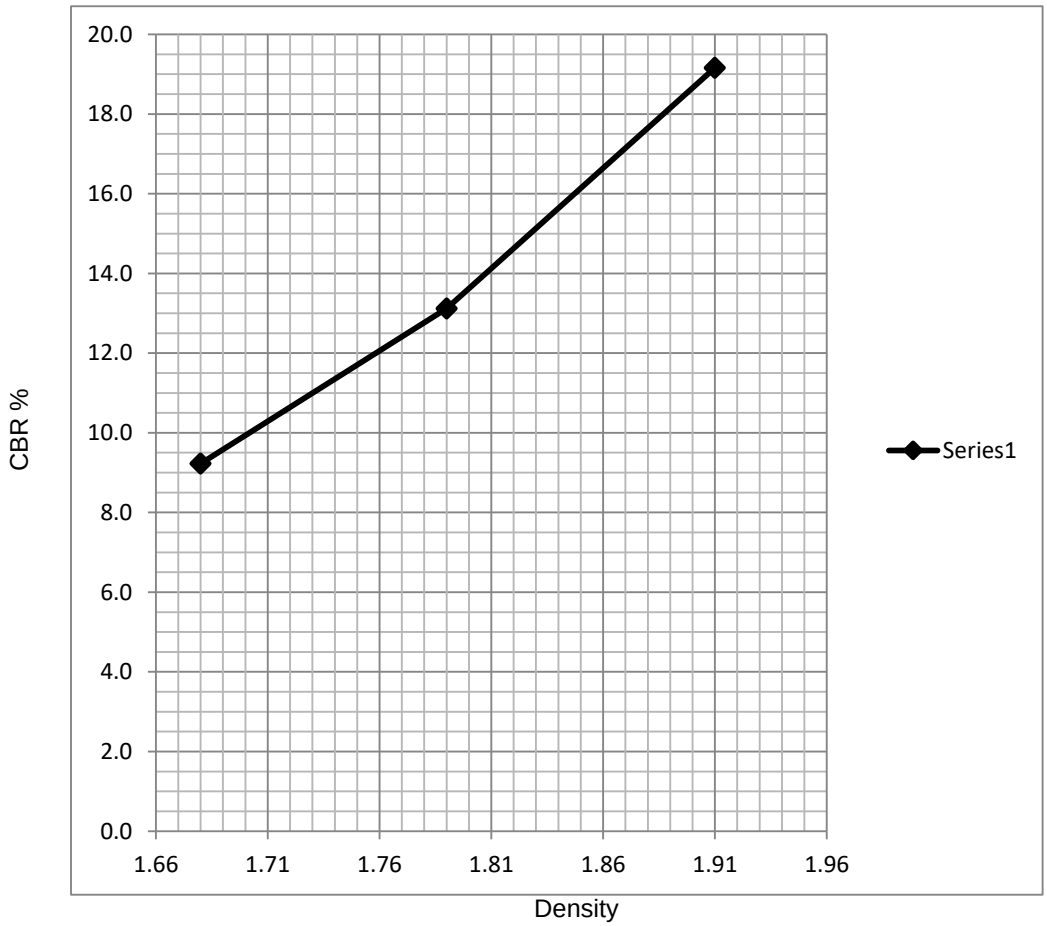
CBR Value for III - energy level = 19.2

KUNIKA GEOTECHNICAL SERVICES PVT LTD

Location : 98.150 Km

CBR Value for I - energy level =	**9.2**	No. of Blows =	**10**
CBR Value for II - energy level =	**13.1**	No. of Blows =	**25**
CBR Value for III - energy level =	**19.2**	No. of Blows =	**55**

Density Value for I - energy level =	**1.68**
Density Value for II - energy level =	**1.79**
Density Value for III - energy level =	**1.91**



KUNIKA GEOTECHNICAL SERVICES PVT LTD

CALIFORNIA BEARING RATIO

Project : Sikkim

Location : 0.00 Km

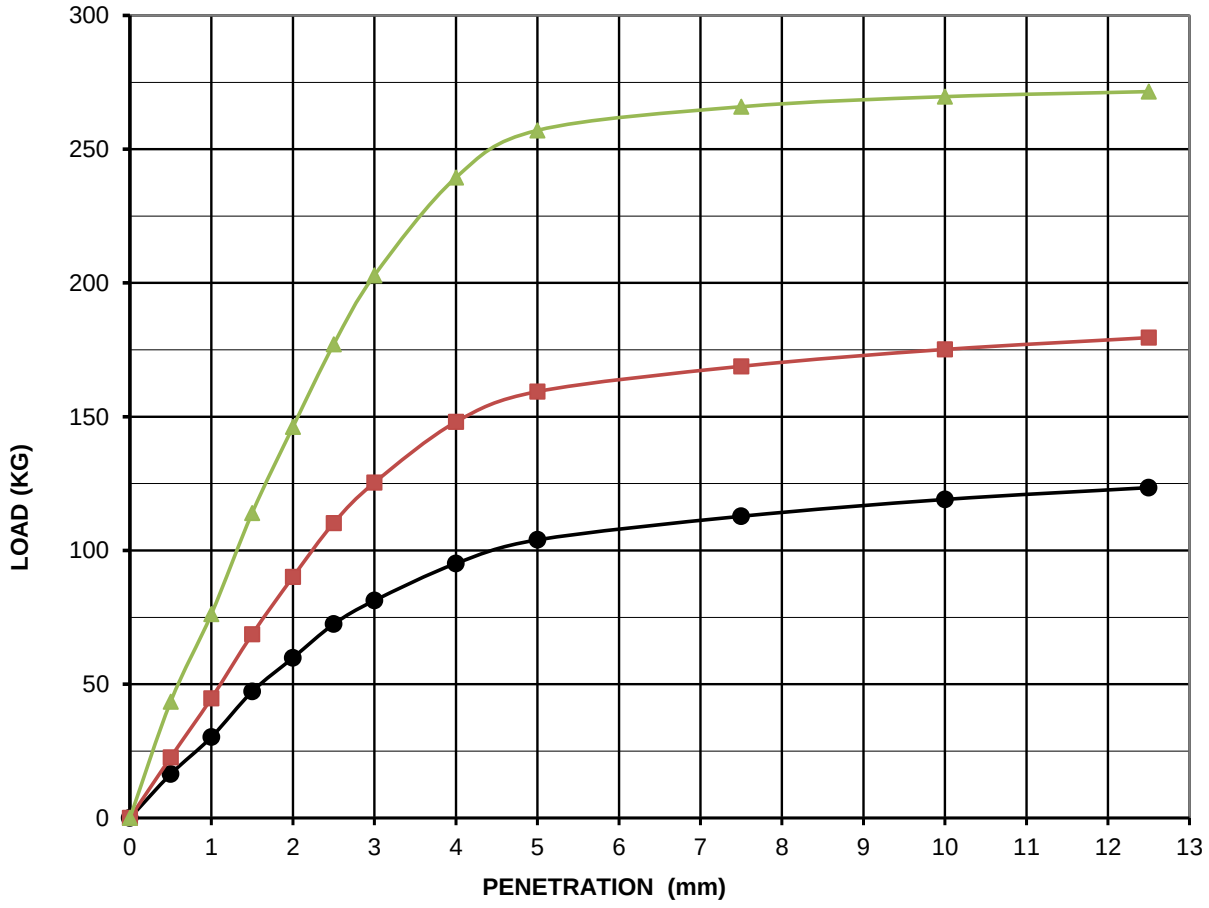
Sample Depth (m) : 1.00 m

Surcharge Weight Used : 5

Proving Ring Factor : 0.63

Soaking Time : 96 Over

	I - energy level				II - energy level			III - energy level		
Penetra-tion (mm)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	Standar d Load (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)
0	0	0			0	0		0	0	
0.50	26	16.4			36	22.7		69	43.47	
1.00	48	30.2			71	44.7		121	76.23	
1.50	75	47.3			109	68.7		181	114.03	
2.00	95	59.9			143	90.1		232	146.16	
2.50	115	72.5	1370	5.3	175	110.3	8.05	281	177.03	12.92
3.00	129	81.3			199	125.4		322	202.86	
4.00	151	95.1			235	148.1		380	239.4	
5.00	165	104.0	2055	5.1	253	159.4	7.76	408	257.04	12.51
7.50	179	112.8			268	168.8		422	265.86	
10.00	189	119.1			278	175.1		428	269.64	
12.50	196	123.5			285	179.6		431	271.53	



I - energy level

II - energy level

III - energy level

CBR Value for I - energy level = 5.1

CBR Value for II - energy level = 7.8

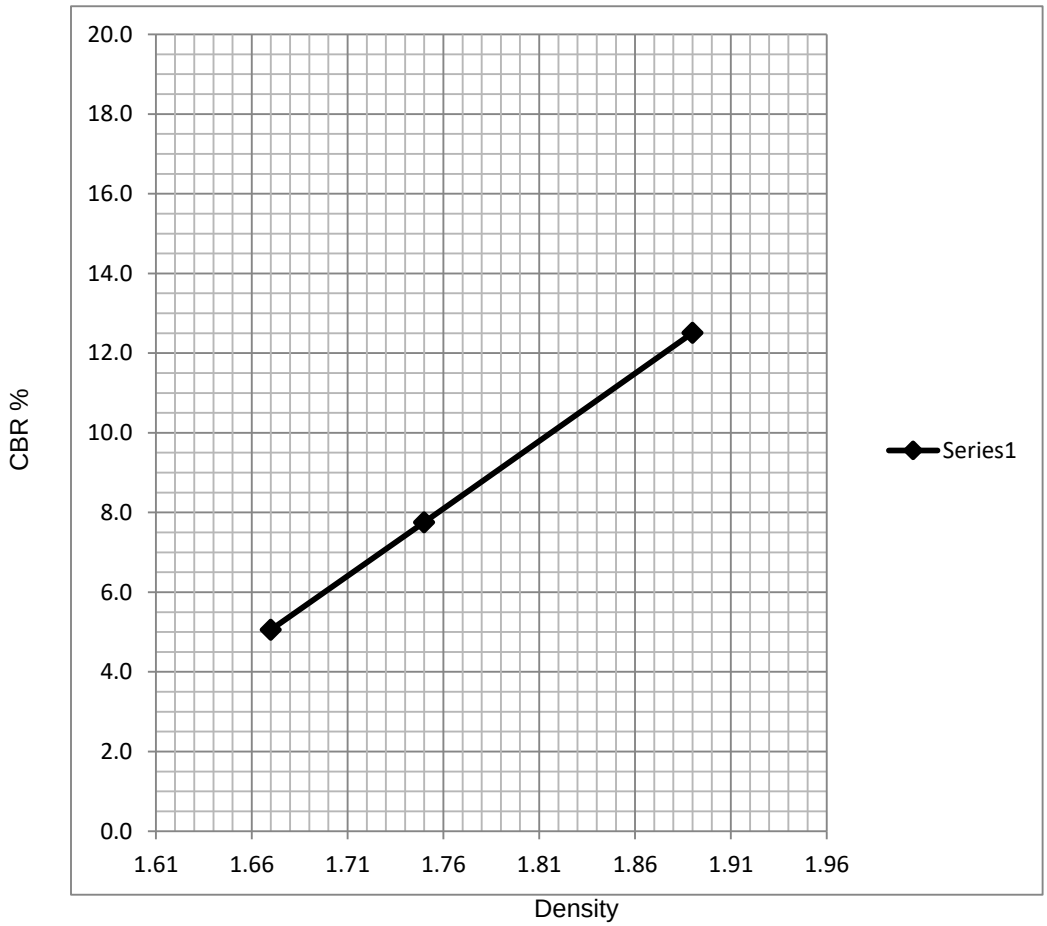
CBR Value for III - energy level = 12.5

KUNIKA GEOTECHNICAL SERVICES PVT LTD

Location : 0.00 Km

CBR Value for I - energy level =	**5.1**	No. of Blows =	**10**
CBR Value for II - energy level =	**7.8**	No. of Blows =	**25**
CBR Value for III - energy level =	**12.5**	No. of Blows =	**55**

Density Value for I - energy level =	**1.67**
Density Value for II - energy level =	**1.75**
Density Value for III - energy level =	**1.89**



KUNIKA GEOTECHNICAL SERVICES PVT LTD

CALIFORNIA BEARING RATIO

Project : Sikkim

Location : 5.00 Km

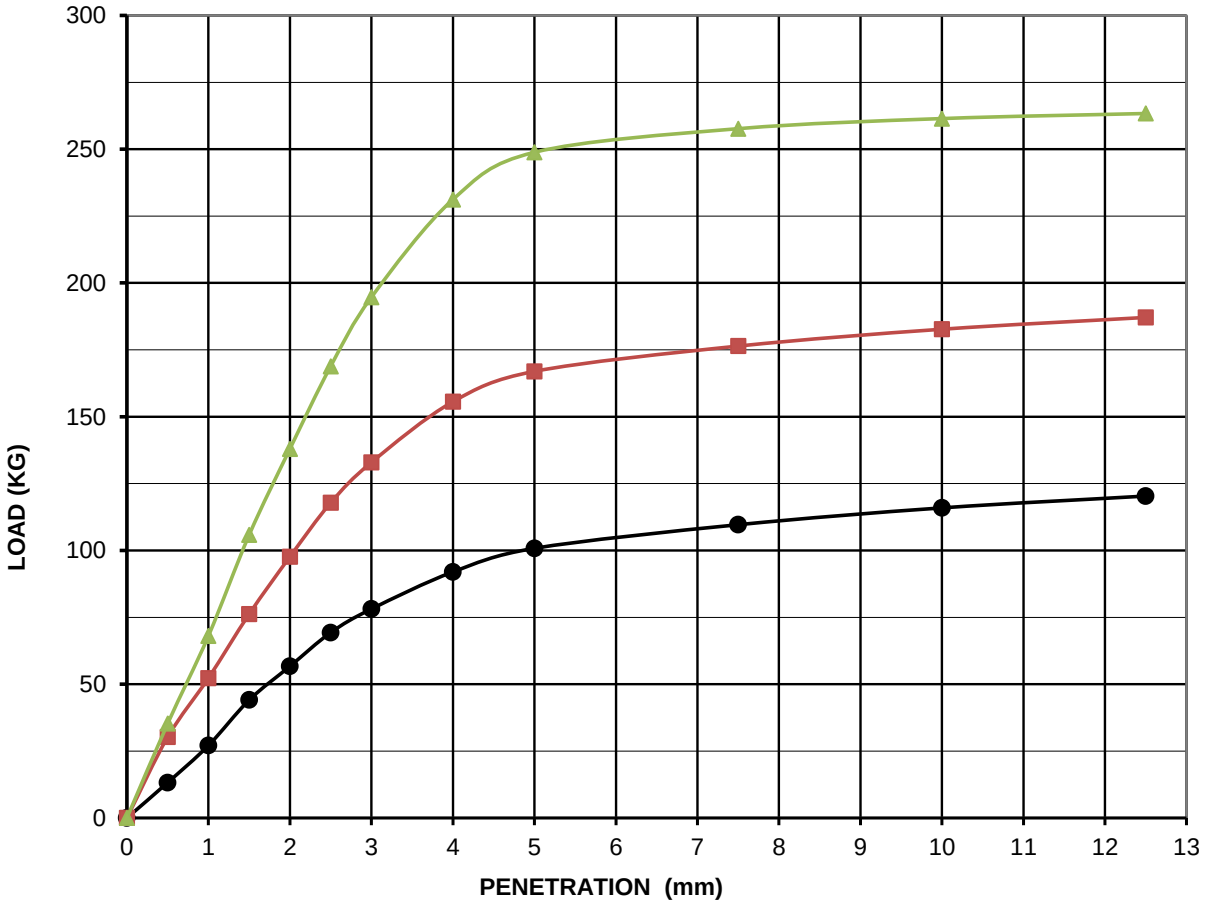
Sample Depth (m) : 1.00 m

Surcharge Weight Used : 5

Proving Ring Factor : 0.63

Soaking Time : 96 Over

	I - energy level				II - energy level			III - energy level		
Penetra-tion (mm)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	Standar d Load (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)
0	0	0			0	0		0	0	
0.50	21	13.2			48	30.2		56	35.28	
1.00	43	27.1			83	52.3		108	68.04	
1.50	70	44.1			121	76.2		168	105.84	
2.00	90	56.7			155	97.7		219	137.97	
2.50	110	69.3	1370	5.1	187	117.8	8.6	268	168.84	12.3
3.00	124	78.1			211	132.9		309	194.67	
4.00	146	92.0			247	155.6		367	231.21	
5.00	**160**	100.8	2055	4.9	**265**	167.0	8.1	**395**	248.85	12.1
7.50	174	109.6			280	176.4		409	257.67	
10.00	184	115.9			290	182.7		415	261.45	
12.50	191	120.3			297	187.1		418	263.34	



I - energy level

II - energy level

III - energy level

CBR Value for I - energy level = 4.9

CBR Value for II - energy level = 8.1

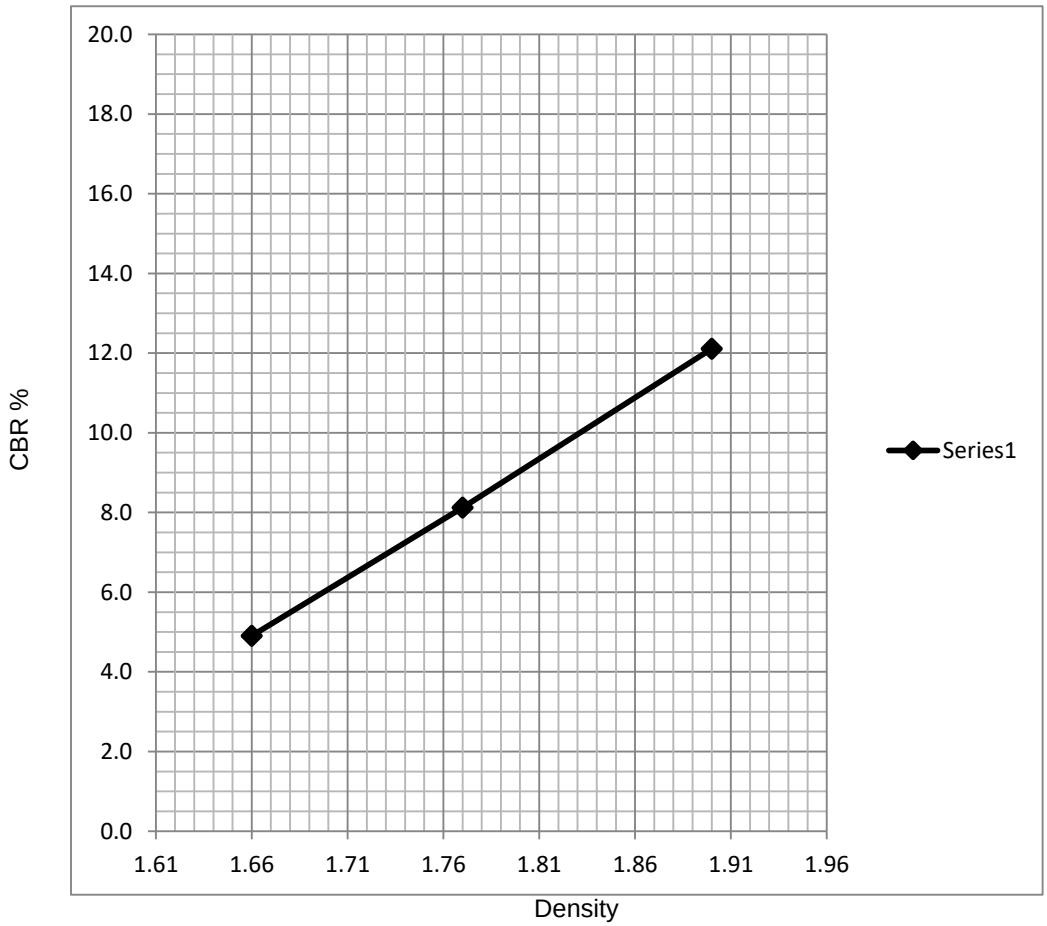
CBR Value for III - energy level = 12.1

KUNIKA GEOTECHNICAL SERVICES PVT LTD

Location : 5.00 Km

CBR Value for I - energy level =	**4.9**	No. of Blows =	**10**
CBR Value for II - energy level =	**8.1**	No. of Blows =	**25**
CBR Value for III - energy level =	**12.1**	No. of Blows =	**55**

Density Value for I - energy level =	**1.66**
Density Value for II - energy level =	**1.77**
Density Value for III - energy level =	**1.90**



KUNIKA GEOTECHNICAL SERVICES PVT LTD

CALIFORNIA BEARING RATIO

Project : Sikkim

Location : 6.30 Km

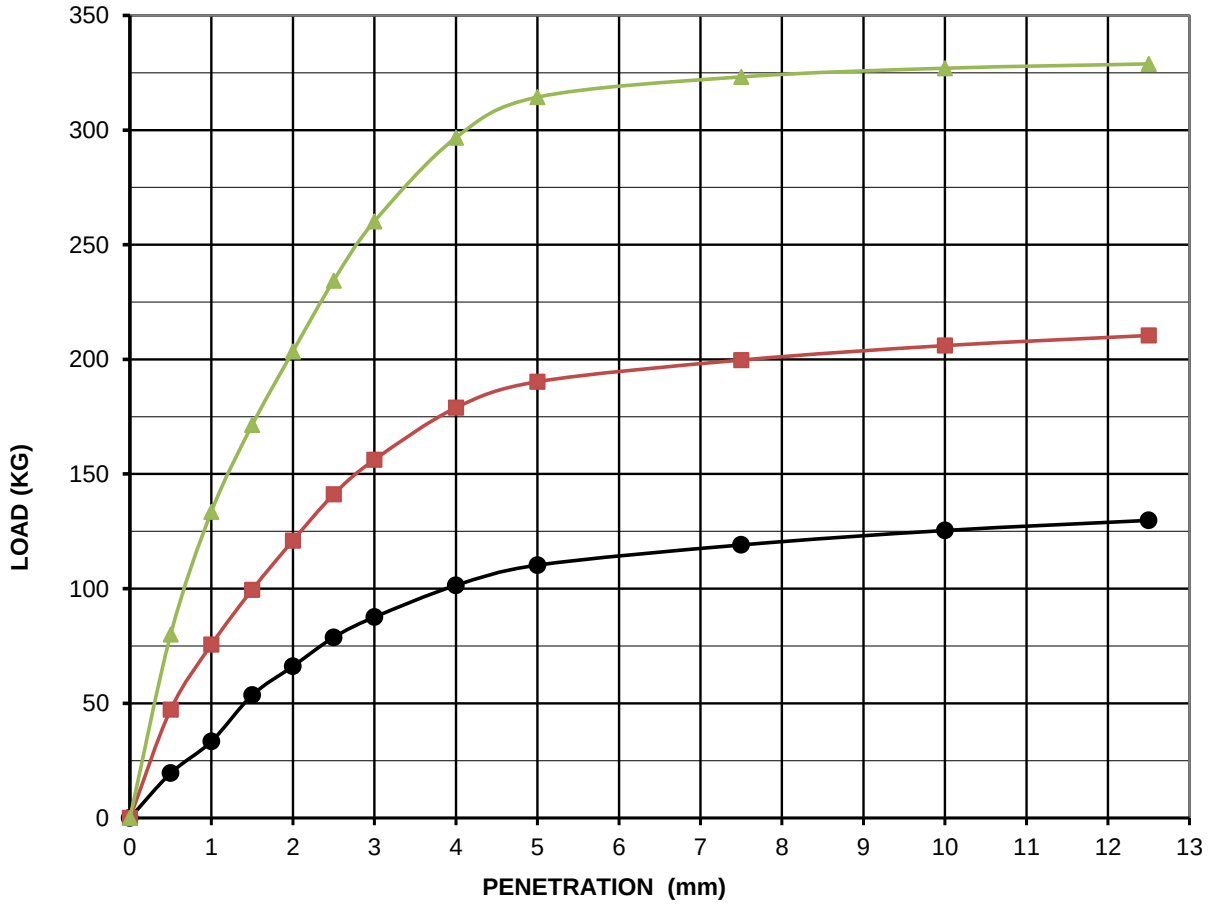
Sample Depth (m) : 1.00 m

Surcharge Weight Used : 5

Proving Ring Factor : 0.63

Soaking Time : 96 Over

	I - energy level				II - energy level			III - energy level		
Penetra-tion (mm)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	Standar d Load (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)
0	0	0			0	0		0	0	
0.50	31	19.5			75	47.3		127	80.01	
1.00	53	33.4			120	75.6		212	133.56	
1.50	85	53.6			158	99.5		272	171.36	
2.00	105	66.2			192	121.0		323	203.49	
2.50	125	78.8	1370	5.7	224	141.1	10.3	372	234.36	17.1
3.00	139	87.6			248	156.2		413	260.19	
4.00	161	101.4			284	178.9		471	296.73	
5.00	**175**	110.3	2055	5.4	**302**	190.3	9.3	**499**	314.37	15.3
7.50	189	119.1			317	199.7		513	323.19	
10.00	199	125.4			327	206.0		519	326.97	
12.50	206	129.8			334	210.4		522	328.86	



I - energy level

II - energy level

III - energy level

CBR Value for I - energy level = 5.4

CBR Value for II - energy level = 9.3

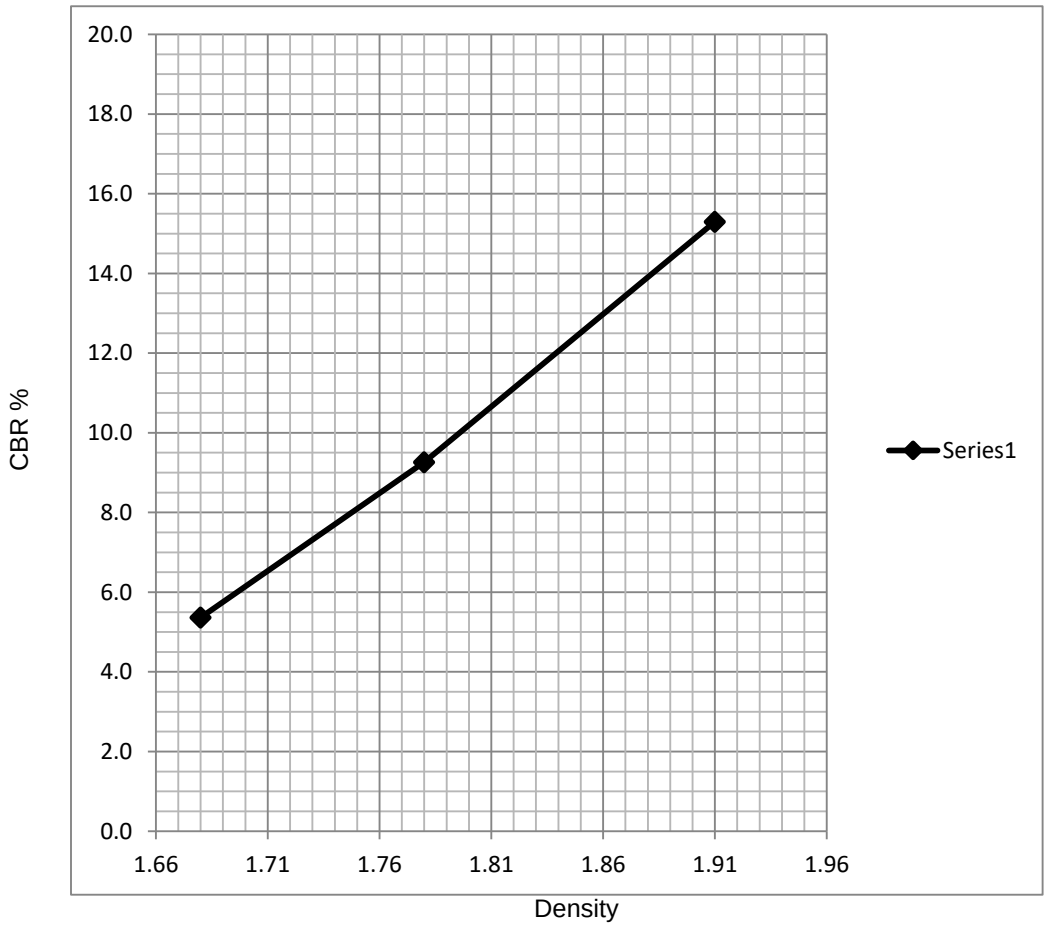
CBR Value for III - energy level = 15.3

KUNIKA GEOTECHNICAL SERVICES PVT LTD

Location : 6.30 Km

CBR Value for I - energy level =	**5.4**	No. of Blows =	**10**
CBR Value for II - energy level =	**9.3**	No. of Blows =	**25**
CBR Value for III - energy level =	**15.3**	No. of Blows =	**55**

Density Value for I - energy level =	**1.68**
Density Value for II - energy level =	**1.78**
Density Value for III - energy level =	**1.91**



KUNIKA GEOTECHNICAL SERVICES PVT LTD

CALIFORNIA BEARING RATIO

Project : Sikkim

Location : 10.00 Km

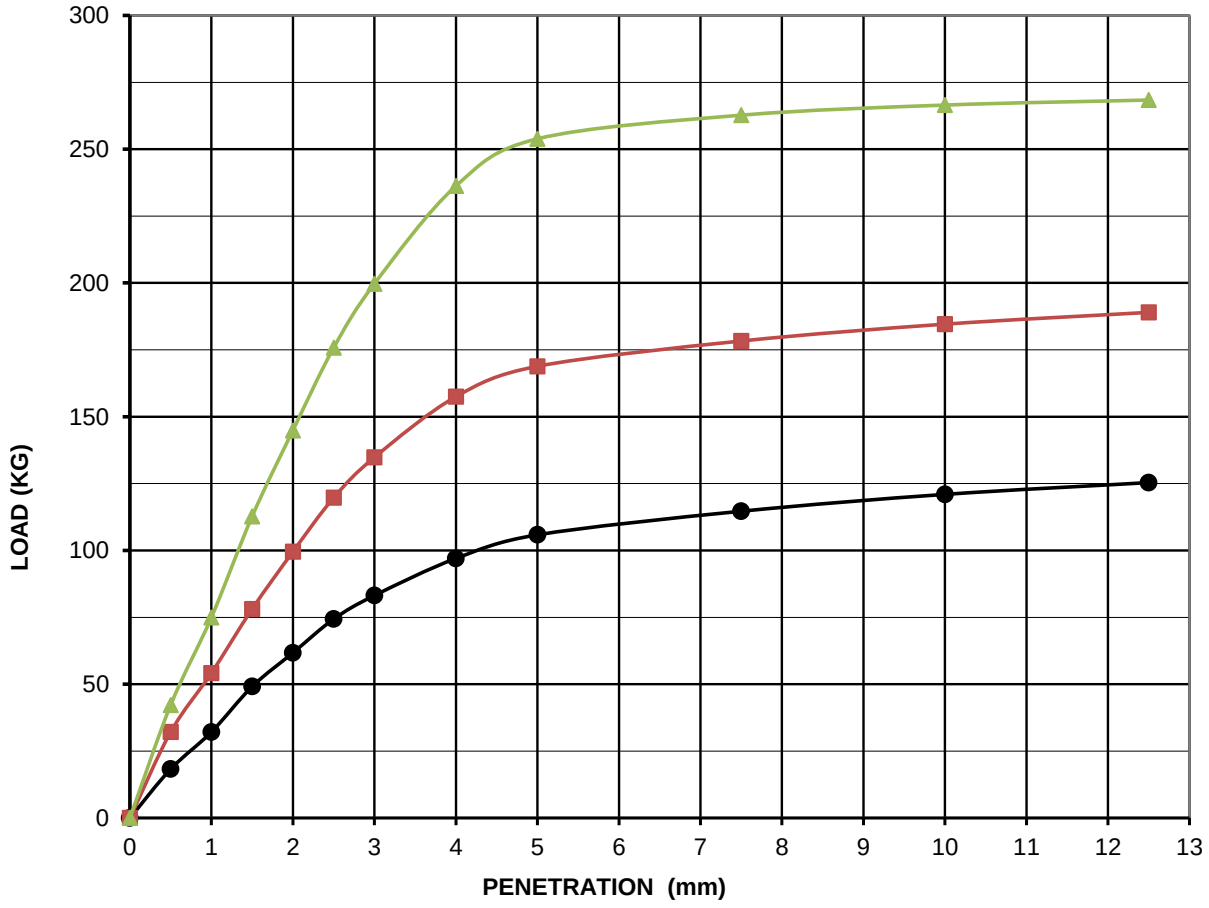
Sample Depth (m) : 1.00 m

Surcharge Weight Used : 5

Proving Ring Factor : 0.63

Soaking Time : 96 Over

	I - energy level				II - energy level			III - energy level		
Penetra-tion (mm)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	Standar d Load (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)
0	0	0			0	0		0	0	
0.50	29	18.3			51	32.1		67	42.21	
1.00	51	32.1			86	54.2		119	74.97	
1.50	78	49.1			124	78.1		179	112.77	
2.00	98	61.7			158	99.5		230	144.9	
2.50	118	74.3	1370	5.4	190	119.7	8.7	279	175.77	12.8
3.00	132	83.2			214	134.8		317	199.71	
4.00	154	97.0			250	157.5		375	236.25	
5.00	**168**	105.8	2055	5.2	**268**	168.8	8.2	**403**	253.89	12.4
7.50	182	114.7			283	178.3		417	262.71	
10.00	192	121.0			293	184.6		423	266.49	
12.50	199	125.4			300	189.0		426	268.38	



I - energy level

II - energy level

III - energy level

CBR Value for I - energy level = 5.2

CBR Value for II - energy level = 8.2

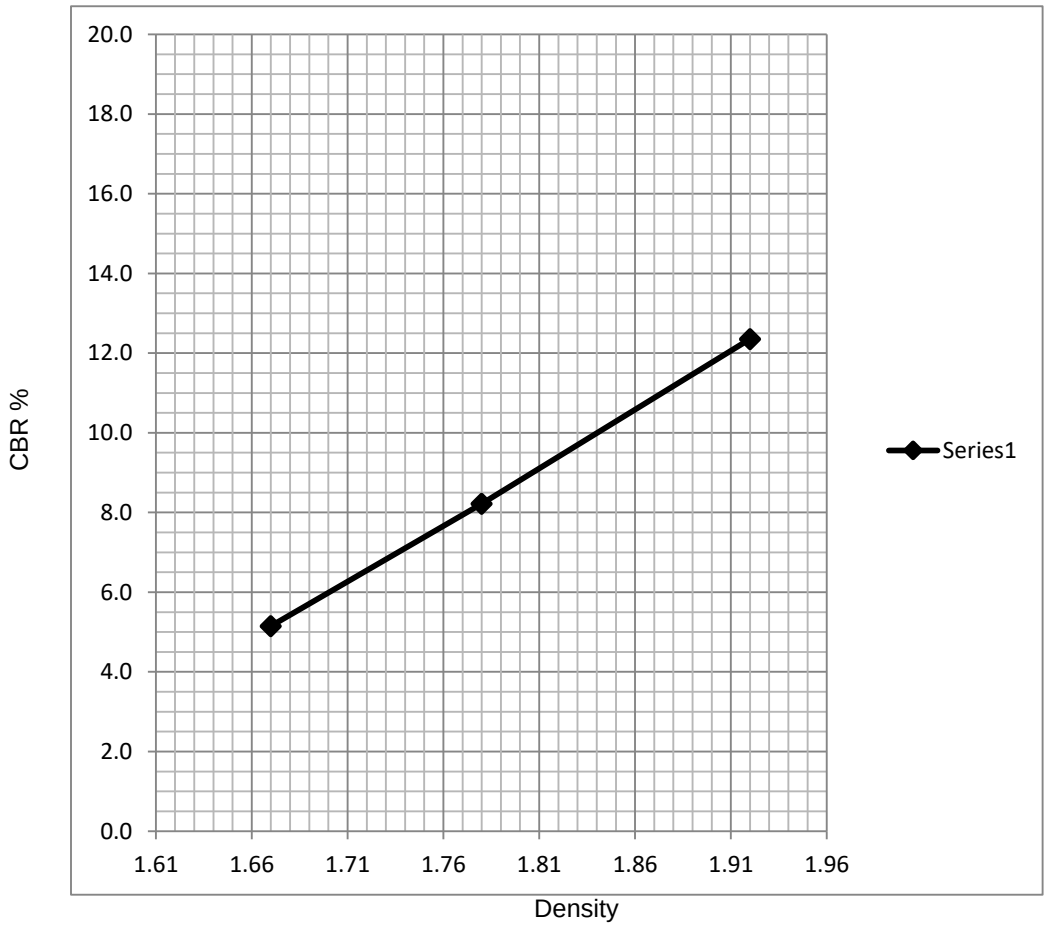
CBR Value for III - energy level = 12.4

KUNIKA GEOTECHNICAL SERVICES PVT LTD

Location : 10.00 Km

CBR Value for I - energy level =	**5.2**	No. of Blows =	**10**
CBR Value for II - energy level =	**8.2**	No. of Blows =	**25**
CBR Value for III - energy level =	**12.4**	No. of Blows =	**55**

Density Value for I - energy level =	**1.67**
Density Value for II - energy level =	**1.78**
Density Value for III - energy level =	**1.92**



KUNIKA GEOTECHNICAL SERVICES PVT LTD

CALIFORNIA BEARING RATIO

Project : Sikkim

Location : 14.95 Km

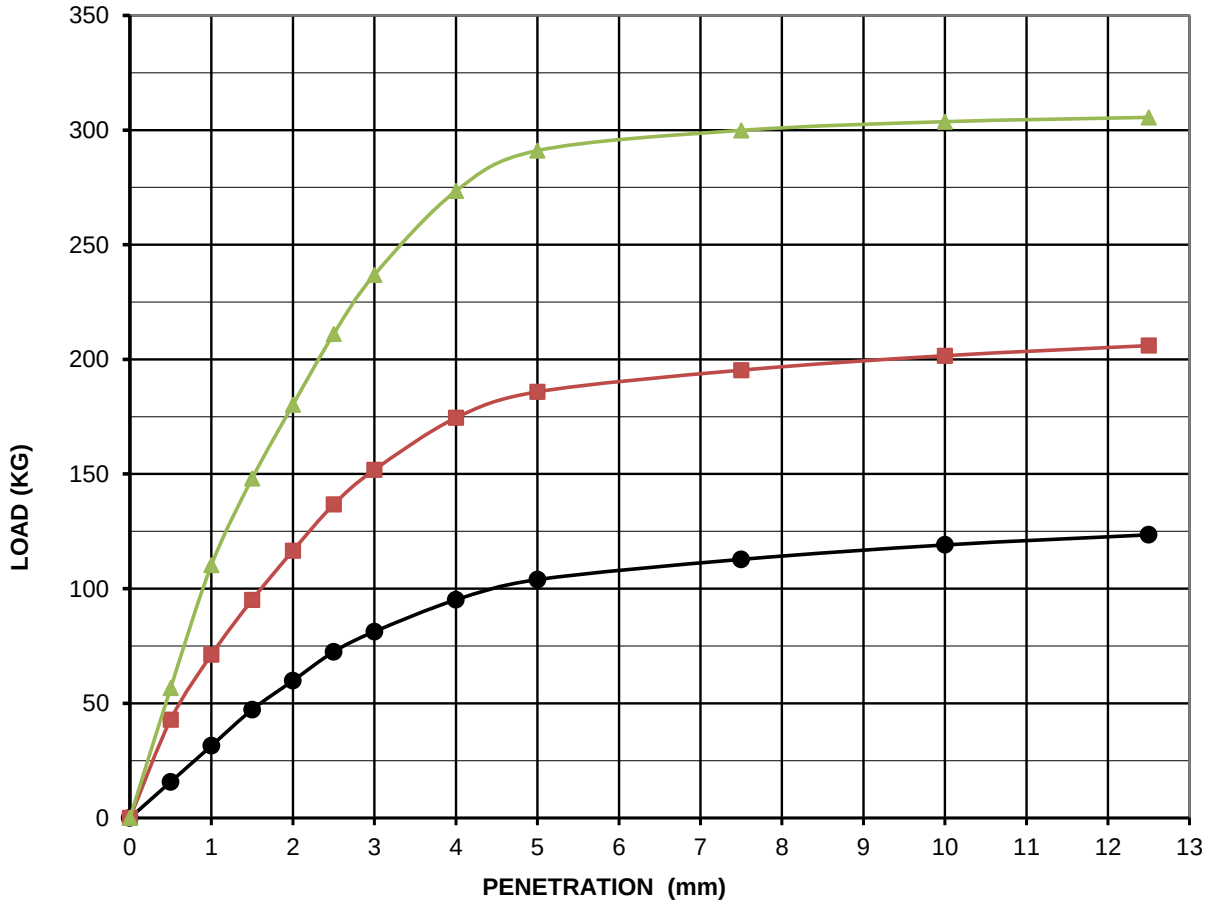
Sample Depth (m) : 1.00 m

Surcharge Weight Used : 5

Proving Ring Factor : 0.63

Soaking Time : 96 Over

	I - energy level				II - energy level			III - energy level		
Penetra-tion (mm)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	Standar d Load (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)
0	0	0			0	0		0	0	
0.50	25	15.8			68	42.8		90	56.7	
1.00	50	31.5			113	71.2		175	110.25	
1.50	75	47.3			151	95.1		235	148.05	
2.00	95	59.9			185	116.6		286	180.18	
2.50	115	72.5	1370	5.3	217	136.7	10.0	335	211.05	15.4
3.00	129	81.3			241	151.8		376	236.88	
4.00	151	95.1			277	174.5		434	273.42	
5.00	**165**	104.0	2055	5.1	**295**	185.9	9.0	**462**	291.06	14.2
7.50	179	112.8			310	195.3		476	299.88	
10.00	189	119.1			320	201.6		482	303.66	
12.50	196	123.5			327	206.0		485	305.55	



I - energy level

II - energy level

III - energy level

CBR Value for I - energy level = 5.1

CBR Value for II - energy level = 9.0

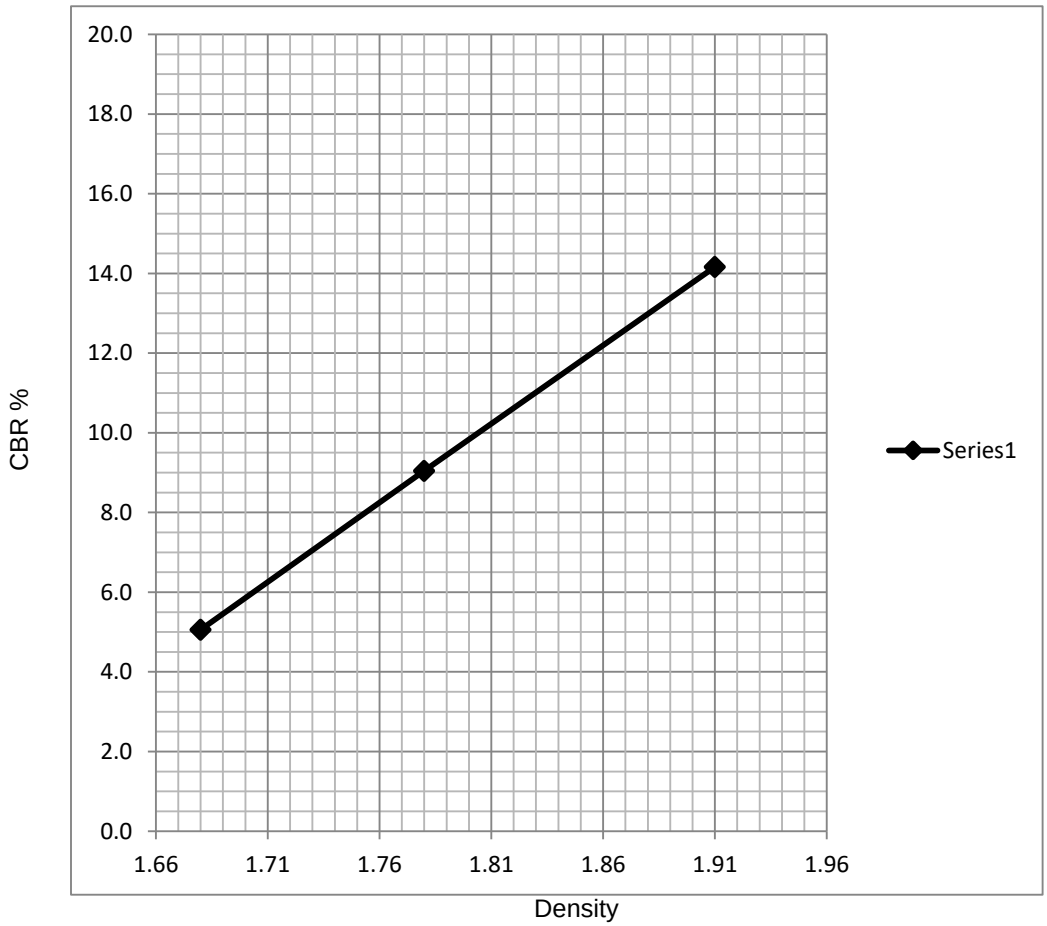
CBR Value for III - energy level = 14.2

KUNIKA GEOTECHNICAL SERVICES PVT LTD

Location : 14.95 Km

CBR Value for I - energy level =	**5.1**	No. of Blows =	**10**
CBR Value for II - energy level =	**9.0**	No. of Blows =	**25**
CBR Value for III - energy level =	**14.2**	No. of Blows =	**55**

Density Value for I - energy level =	**1.68**
Density Value for II - energy level =	**1.78**
Density Value for III - energy level =	**1.91**



KUNIKA GEOTECHNICAL SERVICES PVT LTD

CALIFORNIA BEARING RATIO

Project : Sikkim

Location : 97.00 Km

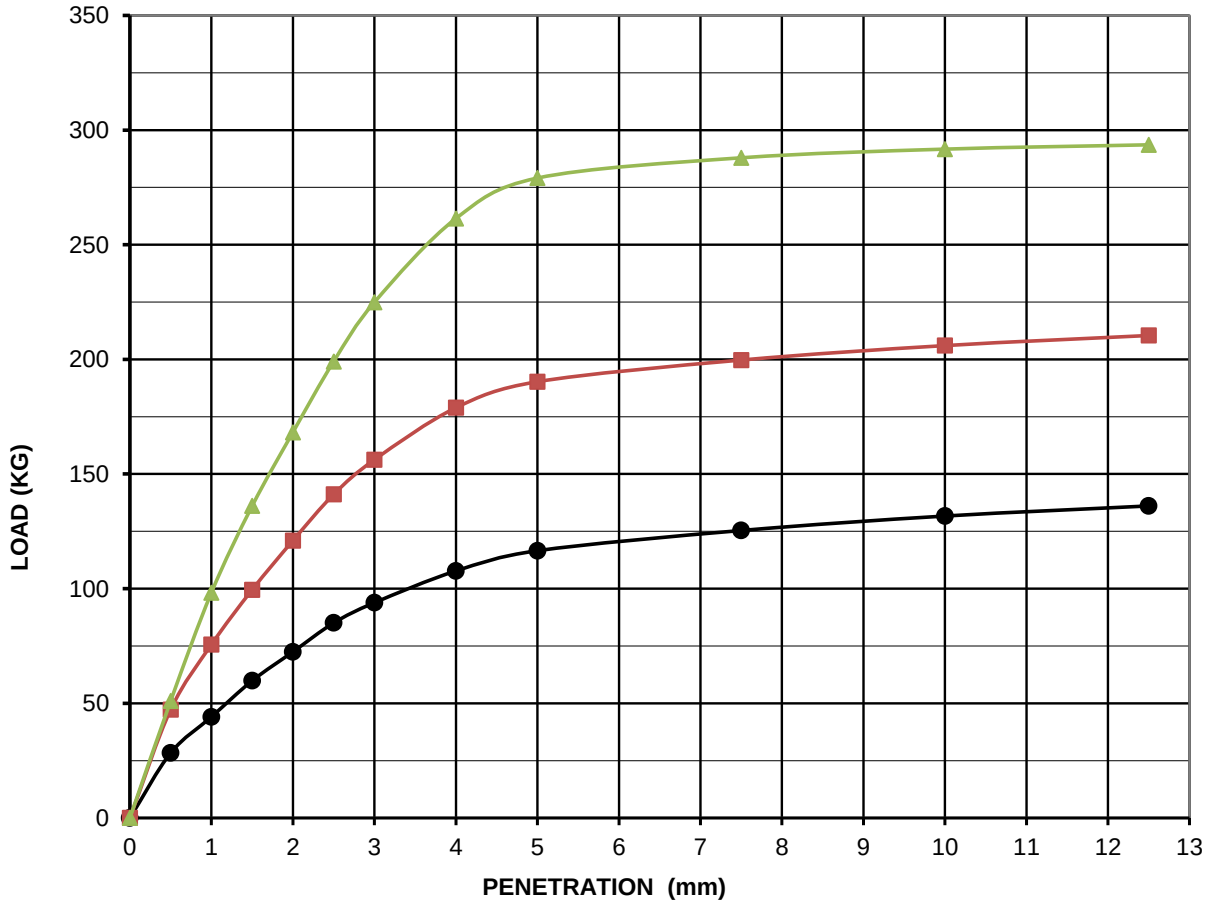
Sample Depth (m) : 1.00 m

Surcharge Weight Used : 5

Proving Ring Factor : 0.63

Soaking Time : 96 Over

	I - energy level				II - energy level			III - energy level		
Penetra-tion (mm)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	Standar d Load (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)
0	0	0			0	0		0	0	
0.50	45	28.4			75	47.3		81	51.03	
1.00	70	44.1			120	75.6		156	98.28	
1.50	95	59.9			158	99.5		216	136.08	
2.00	115	72.5			192	121.0		267	168.21	
2.50	135	85.1	1370	6.2	224	141.1	10.3	316	199.08	14.5
3.00	149	93.9			248	156.2		357	224.91	
4.00	171	107.7			284	178.9		415	261.45	
5.00	**185**	116.6	2055	5.7	**302**	190.3	9.3	**443**	279.09	13.6
7.50	199	125.4			317	199.7		457	287.91	
10.00	209	131.7			327	206.0		463	291.69	
12.50	216	136.1			334	210.4		466	293.58	



I - energy level

II - energy level

III - energy level

CBR Value for I - energy level = 5.7

CBR Value for II - energy level = 9.3

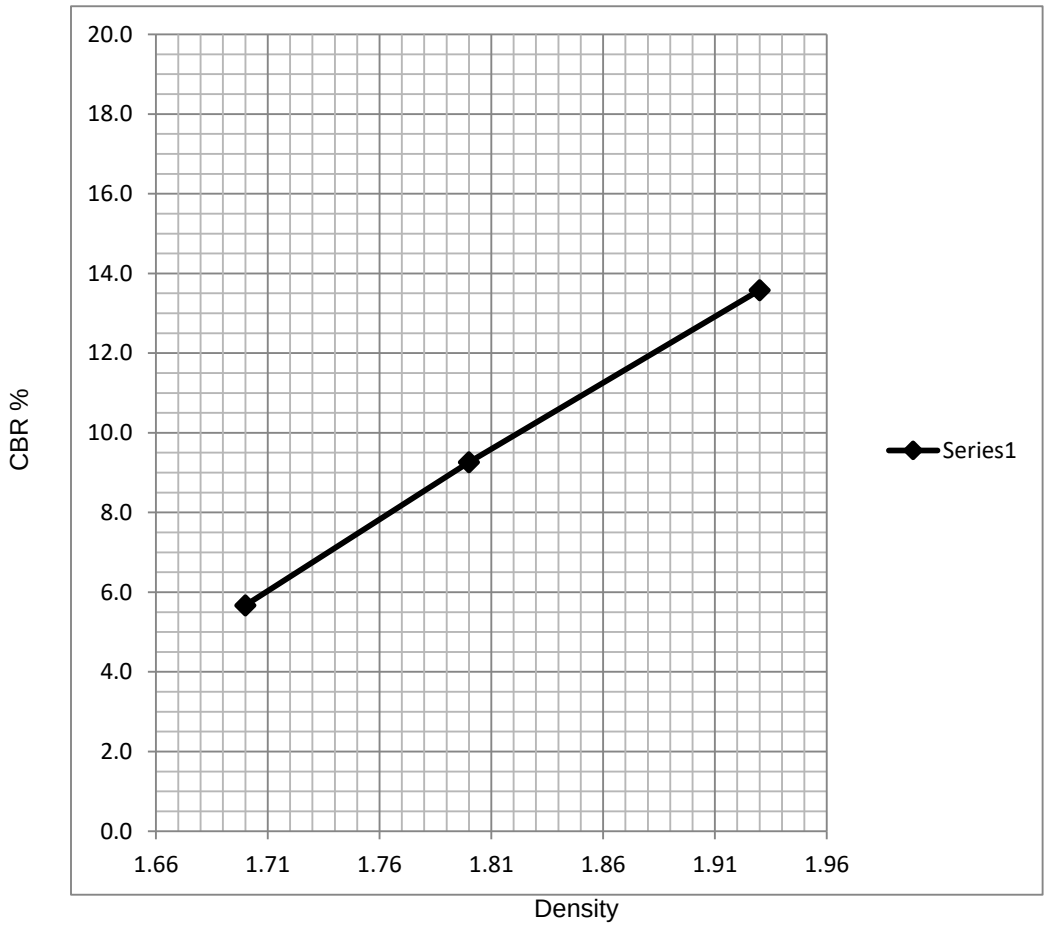
CBR Value for III - energy level = 13.6

KUNIKA GEOTECHNICAL SERVICES PVT LTD

Location : 97.00 Km

CBR Value for I - energy level =	**5.7**	No. of Blows =	**10**
CBR Value for II - energy level =	**9.3**	No. of Blows =	**25**
CBR Value for III - energy level =	**13.6**	No. of Blows =	**55**

Density Value for I - energy level =	**1.70**
Density Value for II - energy level =	**1.80**
Density Value for III - energy level =	**1.93**



KUNIKA GEOTECHNICAL SERVICES PVT LTD

CALIFORNIA BEARING RATIO

Project : Sikkim

Location : 98.150 Km

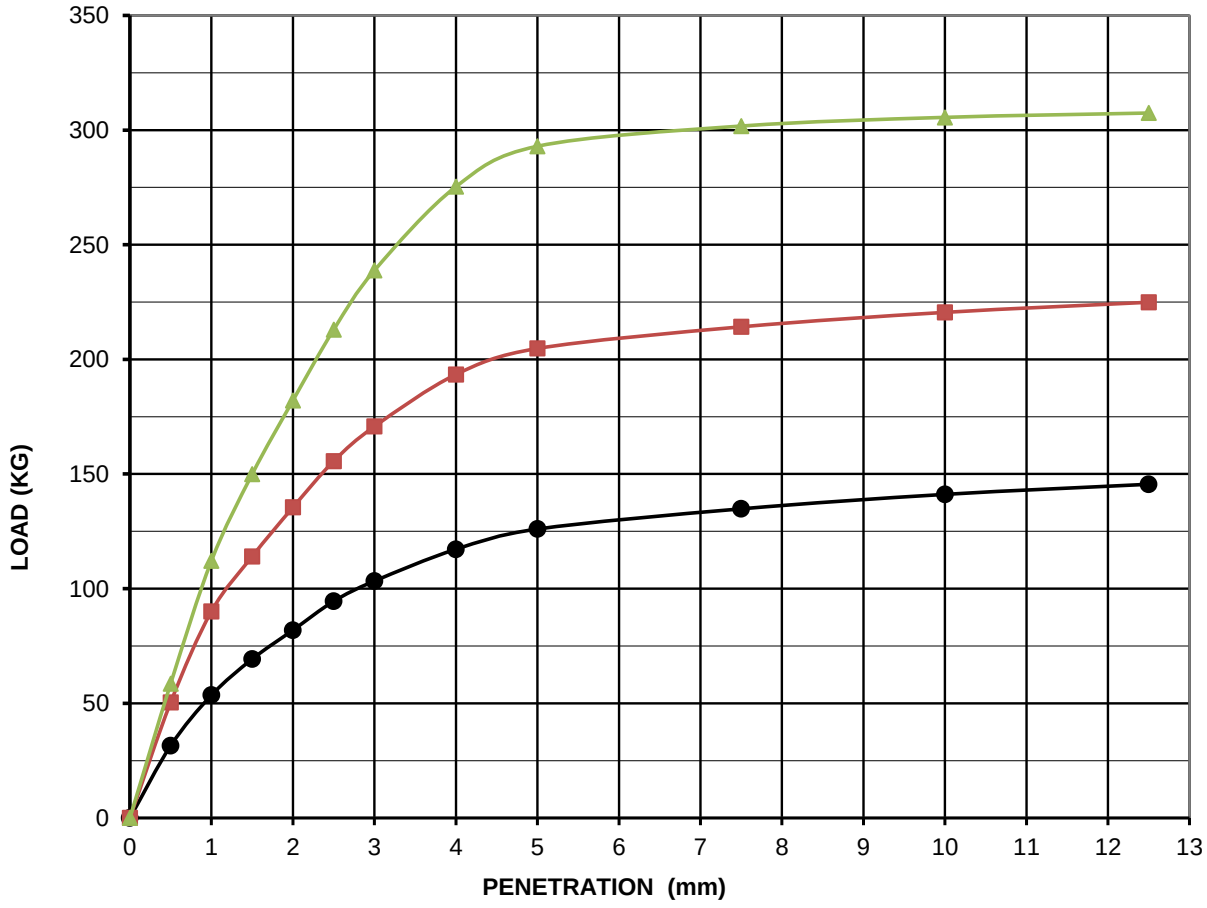
Sample Depth (m) : 1.00 m

Surcharge Weight Used : 5

Proving Ring Factor : 0.63

Soaking Time : 96 Over

	I - energy level				II - energy level			III - energy level		
Penetra-tion (mm)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	Standar d Load (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)	Proving Ring Dail Gauge Reading (Div)	Load on Plunger (kg)	CBR (%)
0	0	0			0	0		0	0	
0.50	50	31.5			80	50.4		93	58.59	
1.00	85	53.6			143	90.1		178	112.14	
1.50	110	69.3			181	114.0		238	149.94	
2.00	130	81.9			215	135.5		289	182.07	
2.50	150	94.5	1370	6.9	247	155.6	11.4	338	212.94	15.5
3.00	164	103.3			271	170.7		379	238.77	
4.00	186	117.2			307	193.4		437	275.31	
5.00	**200**	126.0	2055	6.1	**325**	204.8	10.0	**465**	292.95	14.3
7.50	214	134.8			340	214.2		479	301.77	
10.00	224	141.1			350	220.5		485	305.55	
12.50	231	145.5			357	224.9		488	307.44	



I - energy level

II - energy level

III - energy level

CBR Value for I - energy level = 6.1

CBR Value for II - energy level = 10.0

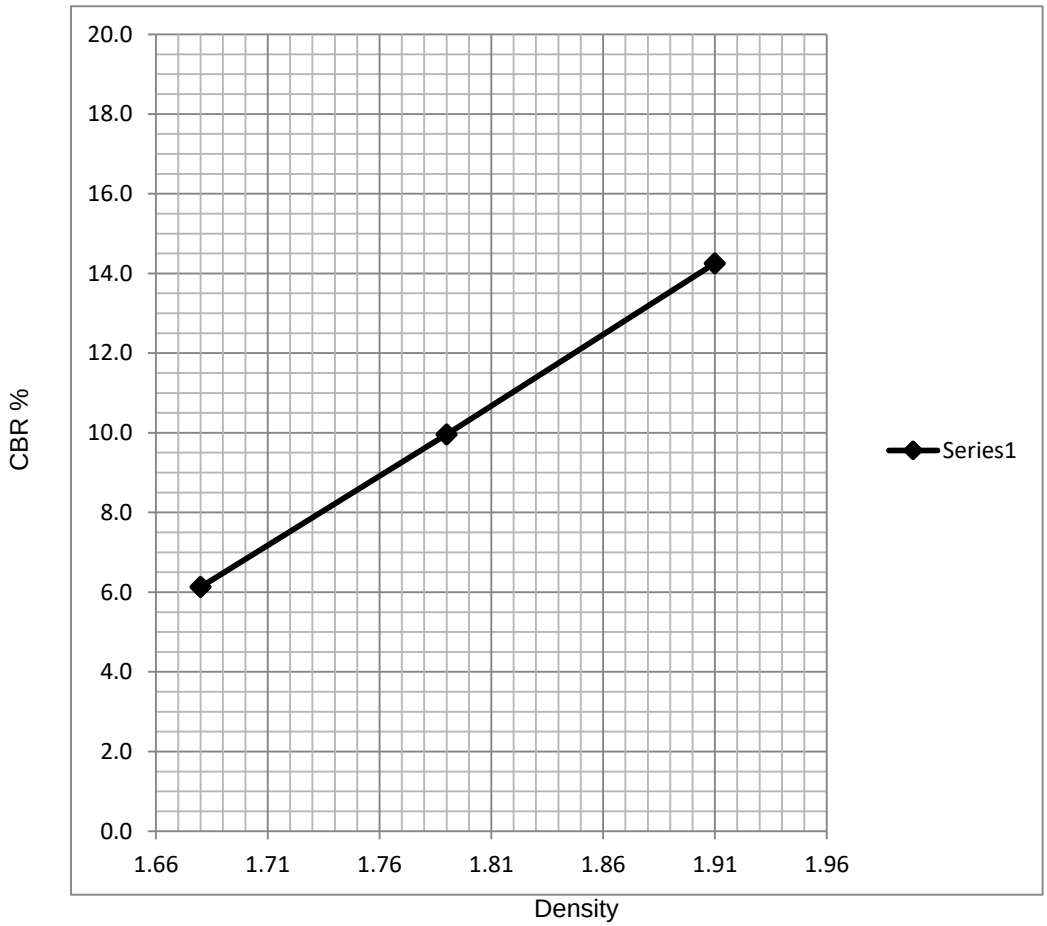
CBR Value for III - energy level = 14.3

KUNIKA GEOTECHNICAL SERVICES PVT LTD

Location : 98.150 Km

CBR Value for I - energy level =	**6.1**	No. of Blows =	**10**
CBR Value for II - energy level =	**10.0**	No. of Blows =	**25**
CBR Value for III - energy level =	**14.3**	No. of Blows =	**55**

Density Value for I - energy level =	**1.68**
Density Value for II - energy level =	**1.79**
Density Value for III - energy level =	**1.91**



Date : 19/09/2024 **Report No.- 10281**

GEOTECHNICAL INVESTIGATION REPORT

FOR

CONSULTANCY SERVICES FOR PREPARATION OF DPR AND PROVIDING SERVICES FOR PRE-CONSTRUCTION ACTIVITIES IN RESPECT OF "WIDENING AND UP-GRADATION OF EXISTING CARRIAGEWAY INTO 2L+PS CONFIGURATION FROM LAVAMORE (KM 61.10) TO START OF PEDONG BYPASS (KM 79.700) AND FROM RESHI(KM 96.254) .TO RHENOCK (KM 101.554) ALONG NH-717A & FROM RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300) ALONG NH-717B IN THE STATES OF SIKKIM AND WB".

RESHI TO RONGLI, SIKKAM.

CLIENT:

NATIONAL HIGHWAY & INFRASTRUCTURE DEVELOPMENT CORP. LTD.

SUBMITTED TO:

M/S DSD INFRATECH MANAGEMENT PVT. LTD

511, TOWER B, ITHUM, PLOT-A40, SECTOR-62, NOIDA, UTTAR PRADESH.

PREPARED AND SUBMITTED BY:

KUNIKA GEOTECHNICAL SERVICES PVT LTD

(AN IS0 9001-2015 CERTIFIED COMPANY)

B – 141, FIRST FLOOR, SECTOR - 69, NOIDA, UTTAR PRADESH

kgsindia@yahoo.com kgsindia2@gmail.com Ph. No. 08750787882, 7011416334

REPORT ON
GEOTECHNICAL INVESTIGATION
FOR
RESHI TO RONGLI, SIKKAM.

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REPORT ON
GEOTECHNICAL INVESTIGATION
FOR
RESHI TO RONGLI, SIKKAM.

1.0 INTRODUCTION:

1.1 The client, **NHIDCL**, has undertaken a project of "Consultancy Services For Preparation Of DPR And Providing Services For Pre-Construction Activities in Respect of "Widening And Up-Gradation Of Existing Carriageway into 2L+PS Configuration From Lavamore (Km 61.10) To Start Of Pedong Bypass (Km 79.700) And From Reshi(Km 96.254) .To Rhenock (Km 101.554) Along NH-717A & From Rhenock (Km 0.00) To Rongli Bazaar (Km 15.300) Along NH-717B in the States Of Sikkim and WB".

1.2 **National Highway & Infrastructure Development Corp. Ltd.**, have entrusted the work to **M/s Xplorer Consultancy Services Pvt. Ltd. in joint venture DSD Infratech Management Pvt. Ltd.**

1.3 **M/s DSD Infratech Management Pvt. Ltd.** have entrusted the work of sub soil investigation at structure locations to **M/s Kunika Geotechnical Services Pvt Ltd, (KGSPL),** B – 141, First Floor, Sector - 69, Noida, Uttar Pradesh.

1.4 KGSPL carried out the field - work during August, 2024. Field identification tests and some in situ strength tests as well as laboratory tests on soil & Rock samples were carried out.

1.5 All the field work and laboratory tests were conducted as per the IS specifications and instructions of client. This report is based on the data collected during the field work and laboratory testing on collected soil samples.

2.0 DETAILS OF SITE :

2.1 The details of the site & test location for the proposed project are shown in the figure. The proposed Project site is between **Reshi to Rongli, Sikkam.**

3.0 SCOPE OF WORK:

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

3.1 Mobilizing necessary plant, equipment and personnel to the project site, setting up the equipment, shifting of the equipment from one test location to another location, carrying out the field investigations on land and demobilization on completion of work.

3.2.2 Making NX Size diameter bore holes at various locations in all types of soil or rock stratum using suitable approved method of boring at the specified locations to be given at site by the Engineer-in-Charge up to desired depths

3.2.3 Conducting standard penetration tests in the bore holes at 1.50 m interval in depth & at every change of strata, whichever is earlier as per specifications / instructions of Engineer-in-Charge.

3.2.4 Collecting undisturbed soil samples from bore holes at 3.00 m interval in depth or at every change of strata, whichever is earlier as per specifications.

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

3.2.6 Collecting Rock core samples from the borehole at regular intervals.

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

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

1. **Soil Samples**
   - (a) Sieve Analysis.
   - (b) Hydrometer Analysis
   - (c) Specific Gravity
   - (d) Moisture Content
   - (e) Dry Density
   - (f) Atterberg Limits
   - (g) Direct Shear Test
   - (h) Triaxial Shear Test
   - (i) Consolidation Test

2. **Rock Samples**
   (a) Density Tests
   (b) Water Absorption and Porosity
   (c) Determination of Specific Gravity
   (d) Unconfined Compression Test
   (e) Carry out Point Load Index.

3.4 Preparation and submission of report in three copies.

4.0 FIELD INVESTIGATIONS:

4.1 Necessary plant, equipment and personnel for conducting the requisite field work were mobilized to the site. These were shifted from one test location to another location during execution of the field work and demobilized on satisfactory completion of the entire field work.

4.2 Fourteen bore holes carried out were first marked on the ground surface as per the layout given to us by the Engineer-in-Charge.

4.3 All bore holes were bored at this site as per IS: 1892-1979. Casing as required was used to retain the bore holes.

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

4.3.3 When rebound or refusal was resulted during SPT attempt, the drilling bit was changed to TC (tungsten carbide) or diamond and core recovery, RQD (rock quality designation) both were measured.

4.3.4 Undisturbed soil samples were collected from the bore hole at every 3.00 m interval

in depth & at change of strata as per sampling specifications, in thin walled sampling tubes of 100 mm dia and 450 mm length fitted to an adopter with ball and socket arrangement. These sampling tubes after retrieval from the bore holes were properly waxed and sealed at both ends. These were carefully labeled and transported to the laboratory for testing. Undisturbed soil samples wherever slipped during lifting, were duly marked in the field bore logs as well as in the soil profile.

4.3.5 Rock cores were also collected from the boreholes at suitable depths/intervals to supplement the boring records. These samples were collected in core boxes of suitable sizes. These samples were properly sealed, labeled, recorded & carefully transported to the laboratory for testing.

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

4.3.7 The depth of ground water table was checked / measured in the bore hole during the boring activity.

4.3.8 **Summary of Borehole:**

Sr. No.	Chainage (Km)	No. of Bore Hole	Easting	Northing	Depth of Borehole , (m)	Depth of Water table , (m)
Viaduct - 3						
1	7+560	A1	662904.537	3008567.517	15.0	Not Met
2	7+585	P1	662912.034	3008591.746	15.0	Not Met
3	7+615	P2	662930.199	3008614.187	15.0	Not Met
4	7+645	P3	662958.355	3008625.758	15.0	Not Met
5	7+670	A2	662983.075	3008625.233	15.0	Not Met
TUNNEL						
6	11+200	1	665368.471	3010018.846	25.0	Not Met
7	11+750	2	665890.161	3010147.076	25.0	Not Met

Sr. No.	Chainage (Km)	No. of Bore Hole	Easting	Northing	Depth of Borehole , (m)	Depth of Water table , (m)
STEEL COMPOSIT MNB - 4						
8	13+690	A1	667544.833	3009655.405	15.0	Not Met
9	13+740	A2	667590.536	3009635.825	15.0	Not Met

5.0 LABORATORY INVESTIGATIONS:

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

5.1 GRAIN SIZE ANALYSIS

For this purpose an oven dry pulverized soil sample is sieved through the set of sieves 20mm, 10mm, 4.75mm, 2.0mm, 1.0mm, 600micron, 300micron, 150micron and 75micron. The amounts of soil retained on each sieve are noted down. The % retained, cumulative % retained and % passing are computed by these retained weights. If the % passing 75 micron sieve is appreciable, Hydrometer method is used to find the % fraction of particle sizes from 75micron to 2micron.

5.2 LIQUID LIMIT

For liquid limit, Casagrande apparatus is used. For this test air dry soil sample passing 425micron is taken and mixed with distilled water to give a stiff and homogeneous paste and is left for sufficient time for maturing in an air tight container. A portion of the above paste is kept in the cup of Casagrande apparatus, a groove is cut with groove cutting tool and blows are imparted by turning the handle at the rate of 2 revolutions per second. The numbers of blows are counted till the continuous contact of the bottom of the groove occurs. Few quantity of soil from the close portion of the groove after the contact occurs, are taken and its water content is determined by oven drying method.

The liquid limit (w_L) is computed by the equation.

$w_L = w_N(n/25)e$

Where w_N =water content (% corresponding to n blows)

e=0.092 for soils with w_L <50

=0.12 for soils with w_L >50

5.3 PLASTIC LIMIT

For this test sample is prepared in the same way as for liquid limit test. A ball is formed of sub sample weighting about 5 gm. This ball is rolled between the fingers of one hand and the glass plate with pressure sufficient to reduce the mass into a thread of about 3mm in 5 to 10 complete forward and back movements. When a diameter of 3mm is reached, soil is again remolded into a ball. The process of rolling and remolding is repeated until the thread a start just crumbing at a diameter of 3mm.The crumbled thread is immediately transferred to an air tight container for determination of its moisture content by oven drying method.

This water content is termed as plastic limit. (w_p)

5.4 PLASTICITY INDEX

The plasticity index Ip is given by
$I_p = w_L - w_p$

5.5 WATER CONTENT

For this test the soil sample of known quantity (w_m) is taken in a container.

The container with this soil sample is placed in an oven for drying at 105-110ºc for 16-24 hours. After drying the dry sample is again weighed to determine the dry weight of sample (w_d)

The moisture content is computed by the following equation:

$w_N = (w_m - w_d)/ w_d$

5.6 DRY DENSITY & BULK DENSITY

For determination of bulk density, a sample of known volume 'V' is extracted from the undisturbed sample. Its bulk weight 'W' and moisture content 'w_N' is determined

by oven drying method.

The bulk density is determined by following equation

γ_b = W/V and dry density $\gamma_d = \gamma_b /(1+ w_N)$

5.7 SPECIFIC GRAVITY

The specific gravity of soil sample is determined by density bottle method. For this test 5-10g (w_2) sample of oven dry, cool soil is taken in 50ml capacity density bottle and its weight is noted down. The soil is covered with distilled water and left for sufficient period for suitable soaking. The entrapped air is removed by vacuum. The soil in bottle is filled full with water and its weight is noted down as w_3. The mass of empty bottle (w_1) and bottle with full distilled water also noted (w_4).

The specific gravity is found by the following equation.

$G=w_2-w_1/[(w_2-w_1)-(w_3-w_4)]$

5.8 DIRECT SHEAR TEST

For this test shear box test apparatus is used. The prepared specimen from remolded/undisturbed sample is placed carefully in the box. The plain grid is kept on top of the specimen with its serrations at right angles to the direction of shear. The upper porous stone is placed on the grid and loading pad on the stone. The box with specimen is gently placed in the container (water jacket). The specimen is submerged with water. The container is mounted with the shear box and the specimen inside, on the shearing machine. The upper part of the box is so adjusted that it touches the proving ring. The jack is brought forward to bear up against the box container. The proving ring dial gauge is set to read zero.

The steel ball is placed in the recess of the loading pad. The loading yoke is set in contact with the steel ball on the loading pad. Vertical displacement dial gauge to read zero in contact with the top of the yoke. The normal load is applied and any change in thickness of specimen is recorded. Shear displacement dial gauge is also set to read zero.

The locking screw is now removed and two parts of the shear box are separated by advancing the spacing screws. The specimen is sheared at constant rate of strain. The readings of the proving ring dial gauge are noted down every 15 seconds for the first one minute and then every 30 seconds thereafter. The reading of change in the thickness dial gauge and shear displacement dial gauge are also recorded at the same

time interval. The test is continued until the specimen fails. The specimen is assumed to fail when the proving ring dial gauge starts receding or at shear displacement of approximately 15% of the length takes place.

The soil is removed from the box and test is repeated on the identical specimen under increased normal load. For consolidated undrained test the specimen is prepared and set in the apparatus as above and after submergence, the specimen is allowed to consolidate fully under normal loads. The specimen is then sheared as in undrained test. At the end of the test, the specimen is removed and its final water content is determined. The test is repeated on other identical specimen in similar way under increasing normal loads. For drained test, after completion of consolidation under a particular normal load, specimen is sheared at a slow rate to allow the pore water pressure inside the specimen may be drained out ie completely dissipated. Final water content of failed specimen is determined. The test is repeated on other identical specimen after consolidation under increasing normal loads.

6.0 TYPE AND DEPTH OF FOUNDATIONS:

Based upon the results of field investigations, laboratory test results & considering the structure going to construct, the following type of foundations have been analyzed herein below : -

- **OPEN SHALLOW FOUNDATIONS ON SOIL STRATA**:

The allowable bearing capacity of sub-soil strata for Open foundation has been computed from shear and settlement failure considerations.

Allowable Bearing Capacity (As per IS:6403)

The net intensity of loading which the foundation will carry without undergoing settlement in excess of the permissible value for the structure under consideration but not exceeding net safe bearing capacity.

Net Safe Bearing Capacity from Shear consideration

For Clayey Soil ($\phi = 0$)

The values are computed from unconfined compressive strength UCS, using the following equation;

$q_d = C\ N_c\ S_c\ d_c$ - Refer IS:6403, Clause 5.3

Where

q_d = Net Ultimate bearing capacity

A factor of safety of 2.5 is used.

Considering $\phi = 0$, $N_c = 5.14$

Thus the equation is simplified as

$q_{(Net\ safe)} = 1 / 2.5 \times C \times 5.14\ S_c\ d_c$

= 2.056 C Sc dc

For C - ϕ Soils

Refer IS: 6403 – 1981, Clause 5.1

General Shear Failure

q_d = C N_c Sc dc + γ D (N_q – 1) S_q d_q + 0.5 γ B Nγ Sγ dγ W ’

Local Shear Failure

$q_{d'}$ = 2/3C N'_c Sc dc + γ D (N'_q – 1) S_q d_q + 0.5 γ B Nγ’ Sγ dγ W ’

Where

qd and qd’ are net ultimate bearing capacity for general and local shear failure

Net safe bearing capacity = 1 / 2.5 x Net ultimate bearing capacity

Bearing capacity factor shall be determined for ϕ for general shear failure and ϕ’ = $\tan^{-1}(0.67 \tan\phi)$ for local shear failure.

Shape and depth factors shall be determined as per IS: 6403-1981.

For cohesion less soil with e_o value less than 0.55, values are computed for General shear failure, for e_o values between 0. 55 to 0.75 the values are computed by linear interpolation between local and general shear failure, and for eo value greater than 0.75 the values are computed for local shear failure.

For footing resting on multilayer deposit, Bowls recommends that the ultimate bearing capacity of footing be determined using average values of cohesion, C_{av} and angle of shearing resistance, ϕ_{av}. The average values are computed over a depth H below the base of footing,

Where

H = 0.5 B tan (45 + ϕ/2)

Safe Bearing pressure from settlement Consideration.

For normal consolidated clay

Sf = Sc + Si
Sc = λ Soed
Si = $pB(1-\mu^2)$ I /E; will be negligible
μ = poison’s ratio,
Soed = $\Sigma(h_I C_c /(1 + e_0)) \log_{10} ((\Delta p' + p_0') / p_0'))$

(Reference: clause 9.2.2.2 IS 8009 (Part I))

Where;

h_I = thickness of soil layer (m)
C_c = Compression index
e_0 = Initial void ratio
p_0' = effective overburden pressure (t/sqm)
Δp' = net increase in pressure at centre of cohesive soil layer

For pre compressed clays

S_1 = Sc (for fully saturated clays)
Sc = λ Soed; λ is taken from table – 1, IS: 8009 (Part – 1), 0.7
Soed = $\Sigma m_v h_I \Delta p$

(Reference: clause 9.2.2.3 IS 8009 (Part I))

Where;

h_I = thickness of soil layer (m)
m_v = Coefficient of volume compression
Δp = net increase in pressure at center of cohesive soil layer

If clays are lightly over consolidated, then the above method may be adopted but if the clay is heavily over consolidated, it may not be necessary to compute the settlement.

If the soil deposits consist of several regular soil layers in the influence zone, the settlement of each layer below the foundation shall be computed and summed to obtain the total settlement.

The settlement contribution by non cohesive / partially cohesive soil layer shall be estimated by the methods in clause 9.1, IS: 8009 (Part I); De Beer Marten method shall be used.

De Beer and Martens' Procedure

S_2 = $(2.303 / C_i) \log_{10} ((\Delta p + p_0') / p_0')) hi$
h_I = thickness of soil layer (m)
C_i = a constant of compressibility = $3/2 (C_{kd} / p_0')$
C_{kd} = average static cone resistance
p_0' = effective overburden pressure (t/sqm)
Δp = net increase in pressure at centre of non cohesive/ partially cohesive soil layer

Total settlement = $S_1 + S_2$

For purely non-cohesive soils

Settlement shall be determined for unit pressure for a specified width of footing based on Corrected SPT values between the level of base of footing and the depth equal to 1.5 to 2.0 times the width of footing. Corrections shall be applied as applicable. Refer; IS: 8009 (Part-1).

- **<u>OPEN SHALLOW FOUNDATIONS ON ROCK STRATA</u>**:

Estimation of Bearing Capacity by Various Methods

(1) For Sound Rock (As per IS: 12070 – 1987)

Where the rock is sound the strength of the foundation rock is generally much in excess of the design requirements, provided the walls of the discontinuities are closed and they are favorably oriented with respect to the applied forces. The investigations should, therefore, be concentrated on:

i) The identification and mapping of all discontinuities in the rock mass within the zone of influence of the foundation including the determination of the aperture (opening) of discontinuities;
ii) An evaluation of the mechanical properties of these discontinuities, frictional resistance, compressibility and strength of infilling material ; and
iii) The identification and evaluation of the strength of the rock material according to relevant Indian Standard.

In case of rock mass with favorable characteristics that is, rock surface is parallel to the base of the foundation, the load has no tangential component, the rock mass has no open discontinuities). The safe bearing pressure should be estimated from the equation:

$q_s = q_c \times N_j$

Where

q_s = Safe bearing pressure (gross),

q_c = Average uniaxial compressive strength of rock cores,

N_j = Empirical coefficient depending on the spacing of discontinuities

Spacing of Discontinuities, cm	N_j
300	0.40
100-300	0.25
30-100	0.10

Note - Equation includes a factor of safety of 3

(2) **For Non-Homogeneous And unsound Rocks** (As per IRS – Bridge Sub-structure & Foundation Code)

A factor of safety of 6 to 8 on unconfined compression strength should normally be adequate to cover such rock deficiencies in fixing the allowable bearing pressure.

In the case of badly disintegrated rocks or very soft varieties of rock where the core recovery during boring is found to be less than 35% and test cylinders are not available, the allowable bearing pressure may be assessed by adopting methods prescribed for soil.

(3) PRESUMTIVE VALUES

For preliminary design these presumptive values may be taken based on the assessment of experienced engineering geologist taking in consideration the various characteristics of rock mass.

Normally as per IRC: 78, allowable bearing pressure exceeding 2MPa (200T/m2) shall not be adopted.

As per IS: 12070, Net safe bearing pressures for massive crystalline bedrock may be taken as high as 1000 T/m2 for preliminary design and as low as 30 T/m2 for soft shale.

Based on our assessment of the rock condition, a suitable value of net allowable bearing pressure has been selected.

(4) ANALYSIS OF SAFE BEARING PRESSURE FROM THE RMR SYSTEM:

Analysis has been carried out using the RMR also known as Geo-mechanics classification by considering various parameters such as uniaxial compressive strength, RQD, spacing and condition of discontinuities and ground water condition. The correlation between the RMR value and allowable pressure has been given in Table-3, IS: 12070. This will ensure settlement of raft foundation up to 6.0m to be less than 12mm.

TABLE - 3 (IS: 12070) NET SAFE BEARING PRESSURE BASED ON RMR

Classification No.	I	II	III	IV	V
Description of rock	Very good	Good	Fair	Poor	Very poor
RMR	100 - 81	80 - 61	60 - 41	40 - 21	20 - 0
qns (T/m2)	600 - 448	440 - 288	280 - 141	135 - 48	45 - 30

The RMR for use in Table 3 should be the average within a depth below foundation level equal to the width of foundation, provided the RMR is fairly uniform within the depth. If the upper part of the rock, within a depth of about one fourth of the width of foundation, is of lower quality the value of this part should be used or the inferior rock should be removed. Since these values are based on limiting the settlement, they should not be increased if the foundation is embedded into the rock.

CORRECTIONS TO BE APPLIED

For getting the allowable bearing pressure the safe bearing pressure obtained from 7.2.3 shall be multiplied with the correction factors according to the geological condition as per IS: 12070 Clause 9.2

For submerged conditions - correction factor of 0.50 to 0.75 depending upon the aperture of joints.

For orientation of joints - correction factor of 0.50 to 1.00 depending upon the orientation of joints

➢ Pile foundation: Pile Capacity Calculations as per IRC -78 2014

Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance. The ultimate load carrying capacity will be calculated from one of the two approaches given below: Where cores of the rock can be taken and unconfined compressive strength directly established using standard method of testing, the approach described in method 1 will be used. In situations where strata is highly fragmented, where RQD is nil or (CR+RQD)/2 is less than 30 percent, or where strata is not classified as a granular or clayey soil, or when the crushing strength is less than 10 MPa, the approach described in method 2 will be used. Also, for weak rock like chalk, mud stone, clay stone, shale and other

intermediate rocks, method 2 is applicable.

Method-1

$$Q_a = (K_{Sp} \times q_c \times d_f \times A_b)/F_1 + (C_{us} \times A_s)/F_2$$

Where,

Q_a = Allowable capacity of Pile

q_c = Average Unconfined compressive strength of rock for twice the least lateral dimensions of pile MPa

d_f = Depth factor = 1+0.4 (Length of socket/Diameter of socket)

A_b = Cross-sectional area of base of pile

C_{us} = Ultimate shear strength along socket length=0.225 Sqrt (qc) or Restricted to 3.0 MPa

A_s = Surface area of socket in m^2 (πDL)

L = Length of socket into rock-top 300mm rock surface neglected, m

F1 = Factor of safety for end bearing resistance (FOS=6)

F2 = Factor of safety for side socket resistance (FOS=3)

K_{sp} = An empirical co-efficient whose value ranges from 0.3 to 1.2 as per the table below for the rocks where core recovery is reported,

(CR+RQD)/2	K_{sp}
30%	0.3
100%	1.2

Method-2

This method is applicable when cores and/or core testing result are not available, or when geo- material is highly fragmented. The shear strength of geo-material is obtained from its correlation with extrapolated SPT values for 300 mm of penetration as given in table below:

Shear Strength/Consistency	Moderately Weak	Weak	Very Weak
Approx. N Value	300-200	200-100	100-60
Shear Strength/Cohesion in MPa	3.3-1.9	1.9-0.7	0.7-0.4

$Q_a = (C_{ub} \times N_c \times A_b)/F_1 + (C_{us} \times A_s)/F_2$

Where

C_{ub} - Average shear strength below base of pile, for the depth equal to twice the diameter/least lateral dimension of pile, based on average 'N' value of this region.

C_{us} - Ultimate shear strength along socket length, to be obtained from table, based on average 'N' value of socket portion. This shall be restricted to shear capacity of concrete of the pile, to be taken as 3.0 MPa for M 35 concrete in confined condition, which for other strengths of concrete can be modified by a factor Sqrt (fck/35) Intermediate values cub and cus can be interpolated linearly.

L = Length of socket.

N = 9

Q_a = Allowable capacity of pile

F_1 = Factor of safety for end bearing resistance (FOS=6)

F_2 = Factor of safety for side socket resistance (FOS=3)

Note: The allowable end bearing component after dividing by factor of safety shall be restricted to 5 MPa.

Moment Carrying Capacity:

$$L_s = \frac{2H}{\sigma_1 D} + \sqrt{\frac{4H^2}{\sigma_1{}^2 D^2} + \frac{6M}{\sigma_1 D}}$$

where

Ls = Socket length

H = Horizontal force at top of the socket

M - Moment at the top of the socket

D = Diameter of the pile.

σ_1 = Permissible compressive strength in rock which is leaser of 30 kg/sq cm or 0.33qc

Pile Capacity: As per IRC 78 (Part-2) - 2020

Characteristic Pile resistance (capacity) of the pile Q_{uc} is determine by calculating the end bearing and skin reaction along the pile surface based on soil parameters. The

calculation of characteristic pile resistance or ultimate pile resistance (Q_{uc}) is calculated as per IRC 78-2014. The characteristic capacity thus arrived shall be further divided by respective partial factor for ground resistance GR as per Table 5 of IRC 78 (Part-2) – 2020 for soil & Table 9 of IRC 78 (Part-2) – 2020 for rock strata as below:

$$Q_{Rd} = Q_{ubc}/\gamma_b + Q_{ufc}/\gamma_s$$

Where

Q_{ubc} = Characteristic base resistance
Q_{ufc} = Characteristic shaft resistance
Q_{Rd} = Reduced capacity of pile based on partial factor for ground resistance.

The Ultimate design resistance or capacity of pile,
$Q_{ud} = Q_{rd}/M$

Where M = Model Factor

Recommended Foundations

Based upon the results of field investigations, laboratory test results & considering the structure going to construct, the following type of foundations have been analyzed herein below : -

1) Cast in-situ Pile Foundation

Type of foundation (s)	Diameter of Pile,(m)	Rock socketing(m)
Pile Foundation	1.20m	3D

7.0 FINDING OF GEOTECHNICAL INVESTIGATION:

The study of bore logs/results of laboratory and other field tests as above from ground level reveal that:-

8.0 RECOMMENDATIONS

Type of Foundation: Bored Cast in situ RCC Pile

Depending on the field and laboratory observations of subsoil strata, test results and the

type of structures proposed at site, the most feasible soil-foundation system is recommended as normal bored cast in situ R.C.C. piles foundations of 1.0m & 1.2m diameter at different depths with cut-off level of 1.80m depth below existing Ground level.

The safe load capacity of piles as per **Working Stress Method** are as follows:

Chainage, Km	Bore Hole No.	Dia. of piles, (m)	Cut-off level below EGL(m)	Length of piles below cut-off level (m)	Length of Socketing, (m)	Pile Capacity, (T)	
						In compression	In lateral
Viaduct - 3							
7+560	A1	1.2	1.8	13.2	3.6	365.0	50
7+585	P1	1.2	1.8	13.2	3.6	362.0	50
7+615	P2	1.2	1.8	13.2	3.6	354.0	50
7+645	P3	1.2	1.8	13.2	3.6	353.0	50
7+670	A2	1.2	1.8	13.2	3.6	354.0	50
STEEL COMPOSIT MNB - 4							
13+690	A1	1.2	1.8	13.2	3.6	358.0	50
13+740	A2	1.2	1.8	13.2	3.6	362.0	50

Type of Foundation: Open Foundation

The net safe bearing capacity/ Allowable Pressure Intensity for **open foundation** are given in following table.

Chainage (Km)	Depth of foundation below existing ground surface (m)	Size of Foundation (m)	Net Safe Bearing Capacity/ Allowable Pressure Intensity (T/m^2)
			Recommended
Viaduct - 3			
7+560, A1	3.0	8.0 x 8.0	19.7
	4.0	8.0 x 8.0	23.7
7+585, P1	3.0	8.0 x 8.0	20.0
	4.0	8.0 x 8.0	24.0
7+615, P2	3.0	8.0 x 8.0	20.5
	4.0	8.0 x 8.0	24.6
7+645, P3	3.0	8.0 x 8.0	19.7
	4.0	8.0 x 8.0	23.6
7+670, A2	3.0	8.0 x 8.0	20.7
	4.0	8.0 x 8.0	24.8
STEEL COMPOSIT MNB - 4			
13+690, A1	3.0	10.0 x 10.0	33.8
	4.0	10.0 x 10.0	39.8
13+740, A2	3.0	10.0 x 10.0	33.4
	4.0	10.0 x 10.0	39.3

9.0 CLOSURE

We appreciate the opportunity to submit this Geotechnical Investigation Report. The above recommendations have been made on the basis of in situ tests and laboratory tests conducted on the samples collected from the boreholes bored at the locations given by the client. If during excavation, any unusual or abnormal features are noticed, these may be brought to the attention of geotechnical consultant before proceeding with construction work for further suggestions.

For KUNIKA GEOTECHNICAL SERVICES PVT LTD

SAMIR PANDEY
(DIRECTOR)

KUNIKA GEOTECHNICAL SERVICES PVT LTD

CHAINAGE (Km). - 7.560, A1 | **DATE STARTED : 03.08.2024** | **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. | **DATE COMPLETED : 04.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 15.00 m | **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS													
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	WS	NIL	NIL	NIL	1.65	--	--	--	--	--	--	--	--	--	--	0.0	27.8
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50	Completely Weathered Rock.	--	Core	6.0	4.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	5.0	3.33	NIL	--	--	--	--	--	--	--	--	--	--	--	0.0	29.0
	6.00	7.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	7.0	4.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50		--	Core	10.0	6.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	10.50	12.00	1.50		--	Core	31.0	20.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50	Fracture Sandstone.	--	Core	38.0	25.33	NIL	2.504	2.48	0.95	1.05	2.69	7.81	2.75	60.50	--	--	--	--	--
	13.50	15.00	1.50		--	Core	42.0	28.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--

KUNIKA GEOTECHNICAL SERVICES PVT LTD

CHAINAGE (Km). - 7.585, P1 **DATE STARTED : 04.08.2024** **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. **DATE COMPLETED : 05.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 15.00 m **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	WS	NIL	NIL	NIL	1.64	--	--	--	--	--	--	--	--	--	--	0.0	28.0
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50	Completely Weathered Rock.	--	Core	4.0	2.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	6.0	4.00	NIL	--	--	--	--	--	--	--	--	--	--	--	0.0	29.2
	6.00	7.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	7.0	4.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50		--	Core	8.0	5.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	10.50	12.00	1.50		--	Core	34.0	22.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50	Fracture Sandstone.	--	Core	41.0	27.33	NIL	2.512	2.49	0.90	1.10	2.70	7.78	2.70	59.40	--	--	--	--	--
	13.50	15.00	1.50		--	Core	39.0	26.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--

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CHAINAGE (Km). - 7.615, P2 **DATE STARTED : 05.08.2024** **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. **DATE COMPLETED : 06.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 15.00 m **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	Core	5.0	5.00	NIL	1.65	--	--	--	--	--	--	--	--	--	--	0.0	28.2
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50	Completely Weathered Rock.	--	Core	6.0	4.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	4.0	2.67	NIL	--	--	--	--	--	--	--	--	--	--	--	0.0	29.6
	6.00	7.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	9.0	6.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	10.50	12.00	1.50		--	Core	29.0	19.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50	Fracture Sandstone.	--	Core	38.0	25.33	NIL	2.521	2.50	0.85	1.12	2.71	7.75	2.60	57.20	--	--	--	--	--
	13.50	15.00	1.50		--	Core	45.0	30.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--

KUNIKA GEOTECHNICAL SERVICES PVT LTD

CHAINAGE (Km). - 7.645, P3 | **DATE STARTED : 06.08.2024** | **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. | **DATE COMPLETED : 07.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 15.00 m | **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	Core	3.0	3.00	NIL	1.63	--	--	--	--	--	--	--	--	--	--	0.0	27.9
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50	Completely Weathered Rock.	--	Core	5.0	3.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	7.0	4.67	NIL	--	--	--	--	--	--	--	--	--	--	--	0.0	29.6
	6.00	7.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	10.0	6.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	10.50	12.00	1.50		--	Core	32.0	21.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50	Fracture Sandstone.	--	Core	35.0	23.33	NIL	2.494	2.47	0.96	1.10	2.72	9.19	2.58	56.76	--	--	--	--	--
	13.50	15.00	1.50		--	Core	37.0	24.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--

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CHAINAGE (Km). - 7.670, A2 | **DATE STARTED : 07.08.2024** | **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. | **DATE COMPLETED : 08.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 15.00 m | **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	WS	NIL	NIL	NIL	1.65	--	--	--	--	--	--	--	--	--	--	0.0	28.3
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50	Completely Weathered Rock.	--	Core	7.0	4.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	9.0	6.00	NIL	--	--	--	--	--	--	--	--	--	--	--	0.0	29.6
	6.00	7.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	6.0	4.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	10.50	12.00	1.50		--	Core	35.0	23.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50	Fracture Sandstone.	--	Core	41.0	27.33	NIL	2.501	2.48	0.85	0.98	2.71	8.49	2.60	57.20	--	--	--	--	--
	13.50	15.00	1.50		--	Core	46.0	30.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--

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CHAINAGE (Km). - 11.200, Tunnel Start. **DATE STARTED : 20.08.2024** **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. **DATE COMPLETED : 22.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 25.00 m **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00	Completely Weathered Rock.	Refusal	WS	NIL	NIL	NIL	1.72	--	--	--	--	--	--	--	--	--	--	0.0	31.6
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	9.0	6.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	6.00	7.50	1.50		--	Core	12.0	8.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	16.0	10.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50	Fracture Sandstone.	--	Core	18.0	12.00	NIL	2.514	2.49	0.95	1.15	2.69	7.43	3.30	72.60	--	--	--	--	--
	10.50	12.00	1.50		--	Core	23.0	15.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50		--	Core	33.0	22.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	13.50	15.00	1.50		--	Core	48.0	32.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	15.00	16.50	1.50		--	Core	57.0	38.00	8.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	16.50	18.00	1.50	Hard Sandstone.	--	Core	64.0	42.67	10.0	2.546	2.53	0.65	0.95	2.72	6.99	11.40	250.80	--	--	--	--	--
	18.00	19.50	1.50			Core	78.0	52.00	14.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	19.50	21.00	1.50		--	Core	86.0	57.33	18.6	--	--	--	--	--	--	--	--	--	--	--	--	--
	21.00	22.50	1.50	Fine-Grained Quartzite Rock	--	Core	80.0	53.33	20.6	2.561	2.55	0.45	0.75	2.73	6.59	12.60	277.20	--	--	--	--	--
	22.50	24.00	1.50			Core	85.0	56.67	26.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	24.00	25.00	1.00		--	Core	82.0	82.00	42.0	--	--	--	--	--	--	--	--	--	--	--	--	--

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CHAINAGE (Km). - 11.750, Tunnel End. **DATE STARTED : 15.08.2024** **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. **DATE COMPLETED : 18.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 25.00 m **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50	Completely Weathered Rock.	--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	WS	NIL	NIL	NIL	1.73	--	--	--	--	--	--	--	--	--	--	0.0	32.0
	1.50	3.00	1.50		--	Core	8.0	5.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50		--	Core	12.0	8.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	10.0	6.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	6.00	7.50	1.50	Fracture Sandstone.	--	Core	18.0	12.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	24.0	16.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50		--	Core	31.0	20.67	NIL	2.524	2.51	0.55	0.95	2.71	7.38	3.50	77.00	--	--	--	--	--
	10.50	12.00	1.50		--	Core	48.0	32.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50	Hard Sandstone.	--	Core	42.0	28.00	8.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	13.50	15.00	1.50		--	Core	58.0	38.67	12.6	--	--	--	--	--	--	--	--	--	--	--	--	--
	15.00	16.50	1.50		--	Core	69.0	46.00	14.6	2.539	2.52	0.76	0.92	2.72	7.35	10.30	226.60	--	--	--	--	--
	16.50	18.00	1.50		--	Core	65.0	43.33	22.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	18.00	19.50	1.50	Fine-Grained Quartzite Rock		Core	76.0	50.67	30.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	19.50	21.00	1.50		--	Core	70.0	46.67	27.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	21.00	22.50	1.50		--	Core	80.0	53.33	34.0	2.539	2.52	0.76	0.92	2.72	7.35	11.70	257.40	--	--	--	--	--
	22.50	24.00	1.50			Core	75.0	50.00	36.0	--	--	--	--	--	--	--	--	--	--	--	--	--
	24.00	25.00	1.00		--	Core	82.0	82.00	58.0	--	--	--	--	--	--	--	--	--	--	--	--	--

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CHAINAGE (Km). - 13.690, A1 | **DATE STARTED : 08.08.2024** | **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. | **DATE COMPLETED : 09.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 15.00 m | **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50	Completely Weathered Rock.	--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	WS	NIL	NIL	NIL	1.72	--	--	--	--	--	--	--	--	--	--	0.0	31.9
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50		--	Core	4.0	2.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	5.0	3.33	NIL	--	--	--	--	--	--	--	--	--	--	--	0.0	33.1
	6.00	7.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	7.0	4.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50	Fracture Sandstone.	--	Core	31.0	20.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	10.50	12.00	1.50		--	Core	38.0	25.33	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50		--	Core	42.0	28.00	NIL	2.512	2.49	0.90	1.10	2.70	7.78	2.62	57.64	--	--	--	--	--
	13.50	15.00	1.50		--	Core	39.0	26.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--

KUNIKA GEOTECHNICAL SERVICES PVT LTD

ISO 9001:2015

CHAINAGE (Km). - 13.740, A2 | **DATE STARTED : 09.08.2024** | **Annexure A**

LOCATION : Reshi to Rongli, Sikkam. | **DATE COMPLETED : 10.08.2024**

REDUCED LEVEL OF B/HOLE : 100.00 (m) TERMINATION DEPTH (m) 15.00 m | **Water Table (m) - Not Met**

FIELD TEST RESULTS										LABORATORY TEST RESULTS														
Rock profile	Depth (m)		Total Run (m)	Rock Description	SPT Test Results (N)	Type of Samples	Core Recovery in (Cm)	% Core Recovery	RQD in (%)	Wet density (gm/cc)	Dry density (gm/cc)	Natural Moisture Cont. (%)	Water Absorption,%	Specific Gravity	Porosity (%)	Point load st. Index, t/m^2	UCS t/m2	GRAIN SIZE ANALYSIS			SHEAR STRENGTH	
																		GRAVEL (%)	SAND (%)	SILT (%)	DST*	
	From	To																			C, (t/sqm.)	ϕ^0
	0.00	0.50	0.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	0.50	1.50	1.00		Refusal	Core	3.0	3.00	NIL	1.73	--	--	--	--	--	--	--	--	--	--	0.0	31.7
	1.50	3.00	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	3.00	4.50	1.50	Completely Weathered Rock.	--	Core	6.0	4.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	4.50	6.00	1.50		--	Core	4.0	2.67	NIL	--	--	--	--	--	--	--	--	--	--	--	0.0	32.8
	6.00	7.50	1.50		--	WS	NIL	NIL	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	7.50	9.00	1.50		--	Core	10.0	6.67	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	9.00	10.50	1.50		--	Core	27.0	18.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	10.50	12.00	1.50		--	Core	36.0	24.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--
	12.00	13.50	1.50	Fracture Sandstone.	--	Core	39.0	26.00	NIL	2.519	2.50	0.75	0.97	2.71	7.75	2.70	59.40	--	--	--	--	--
	13.50	15.00	1.50		--	Core	42.0	28.00	NIL	--	--	--	--	--	--	--	--	--	--	--	--	--

BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS 6403-1981

LOCATION : Reshi to Rongli, Sikkam.

CHAINAGE (Km). - 7.560, A1

The bearing capacity equation is as follows :

$$q_{net\ safe} = (1/FS)\{cNc\zeta_c d_c i_c + q(N_q-1)\zeta_q d_q i_q + 0.5B\gamma N_\gamma \zeta_\gamma d_\gamma i_\gamma R_w\}$$

where:

$q_{net\ safe}$ =	safe net bearing capacity	c =	cohesion intercept
q =	overburden pressure	B =	Foundation width
γ =	Bulk density of soil below founding level		
R_w =	Water table correction factor		
N_c, N_q, N_γ =	bearing capacity factors, which are a function of ϕ		
d_c, d_q, d_γ =	Depth factors		
$\zeta_c, \zeta_q, \zeta_\gamma$ =	Shape factors		
i_c, i_q, i_γ =	inclination factors		

Soil parameters :

c = 0.00 T/m^2 ϕ = 27.8 degrees GENERAL SHEAR FAILURE

c' = 0.00 T/m^2 ϕ'= 19.4 degrees LOCAL SHEAR FAILURE

General Shear Failure : N_c = 25.42 N_q = 14.40 N_γ = 16.24

Local Shear Failure : N_c' = 14.25 N_q' = 6.01 N_γ' = 4.93

Inclination of Foundation to vertical : 0 degrees

Inclination Factors $i_c = i_q$ = 1.00 i_γ = 1.00

Factor of safety = 2.5 as per IS 1904-1986

Design Water Table depth = Not Met

R_w factor: Constant value(**V**) for worst condition or calculate(**C**) based on WT Depth ? : C

Depth factor to be considered ? N

Bulk Density Profile

Depth, m From	Depth, m To	γ T/m^3
0.0	10.0	1.65

FAILURE CRITERIA : **Local** **SHEAR FAILURE**

Foundation Dimensions B, m	Foundation Dimensions L, m	FOUN-DATION SHAPE	Depth,m	R_w	Shape Factors ζ_c	Shape Factors ζ_q	Shape Factors ζ_γ	Depth factors (GSF) d_c	Depth factors (GSF) d_q	Depth factors (GSF) d_γ	Depth factors (LSF) d_c'	Depth factors (LSF) $d_{q'}$	Depth factors (LSF) d_γ'	$q_{net\ safe}$, T/m^2 GSF	$q_{net\ safe}$, T/m^2 LSF	Safe Net Bearing Capacity T/m^2
8.0	**8.0**	*Rectangle*	**3.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		19.7	**19.7**
8.0	**8.0**	*Rectangle*	**4.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		23.7	**23.7**

BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS 6403-1981

LOCATION : Reshi to Rongli, Sikkam.

CHAINAGE (Km). - 7.585, P1

The bearing capacity equation is as follows :

$$q_{net\ safe} = (1/FS)\{cNc\zeta_c d_c i_c + q(N_q-1)\zeta_q d_q i_q + 0.5B\gamma N_\gamma \zeta_\gamma d_\gamma i_\gamma R_w\}$$

where:

$q_{net\ safe}$ =	safe net bearing capacity	c =	cohesion intercept
q =	overburden pressure	B =	Foundation width
γ =	Bulk density of soil below founding level		
R_w =	Water table correction factor		
N_c, N_q, N_γ =	bearing capacity factors, which are a function of ϕ		
d_c, d_q, d_γ =	Depth factors		
$\zeta_c, \zeta_q, \zeta_\gamma$ =	Shape factors		
i_c, i_q, i_γ =	inclination factors		

Soil parameters :

c = 0.00 T/m^2 ϕ = 28.0 degrees GENERAL SHEAR FAILURE

c' = 0.00 T/m^2 ϕ'= 19.5 degrees LOCAL SHEAR FAILURE

General Shear Failure : N_c = 25.80 N_q = 14.72 N_γ = 16.72

Local Shear Failure : N_c' = 14.39 N_q' = 6.10 N_γ' = 5.03

Inclination of Foundation to vertical : 0 degrees

Inclination Factors $i_c = i_q$ = 1.00 i_γ = 1.00

Factor of safety = 2.5 as per IS 1904-1986

Design Water Table depth = Not Met

R_w factor: Constant value(**V**) for worst condition or calculate(**C**) based on WT Depth ? : C

Depth factor to be considered ? N

Bulk Density Profile

Depth, m From	Depth, m To	γ T/m^3
0.0	10.0	1.64

FAILURE CRITERIA : **Local** **SHEAR FAILURE**

Foundation Dimensions B, m	Foundation Dimensions L, m	FOUN-DATION SHAPE	Depth,m	R_w	Shape Factors ζ_c	Shape Factors ζ_q	Shape Factors ζ_γ	Depth factors (GSF) d_c	Depth factors (GSF) d_q	Depth factors (GSF) d_γ	Depth factors (LSF) d_c'	Depth factors (LSF) $d_{q'}$	Depth factors (LSF) d_γ'	$q_{net\ safe}$, T/m^2 GSF	$q_{net\ safe}$, T/m^2 LSF	Safe Net Bearing Capacity T/m^2
8.0	**8.0**	*Rectangle*	**3.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		20.0	**20.0**
8.0	**8.0**	*Rectangle*	**4.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		24.0	**24.0**

BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS 6403-1981

LOCATION : Reshi to Rongli, Sikkam.

CHAINAGE (Km). - 7.615, P2

The bearing capacity equation is as follows :

$$q_{net\ safe} = (1/FS)\{cNc\zeta_c d_c i_c + q(N_q-1)\zeta_q d_q i_q + 0.5B\gamma N_\gamma \zeta_\gamma d_\gamma i_\gamma R_w\}$$

where:

$q_{net\ safe}$ =	safe net bearing capacity	c =	cohesion intercept
q =	overburden pressure	B =	Foundation width
γ =	Bulk density of soil below founding level		
R_w =	Water table correction factor		
N_c, N_q, N_γ =	bearing capacity factors, which are a function of ϕ		
d_c, d_q, d_γ =	Depth factors		
$\zeta_c, \zeta_q, \zeta_\gamma$ =	Shape factors		
i_c, i_q, i_γ =	inclination factors		

Soil parameters :

c = 0.00 T/m^2 ϕ = 28.2 degrees GENERAL SHEAR FAILURE

c' = 0.00 T/m^2 ϕ'= 19.7 degrees LOCAL SHEAR FAILURE

General Shear Failure : N_c = 26.20 N_q = 15.05 N_γ = 17.21

Local Shear Failure : N_c' = 14.53 N_q' = 6.19 N_γ' = 5.14

Inclination of Foundation to vertical : 0 degrees

Inclination Factors $i_c = i_q$ = 1.00 i_γ = 1.00

Factor of safety = 2.5 as per IS 1904-1986

Design Water Table depth = Not Met

R_w factor: Constant value(**V**) for worst condition or calculate(**C**) based on WT Depth ? : C

Depth factor to be considered ? N

Bulk Density Profile

Depth, m		γ
From	To	T/m^3
0.0	10.0	1.65

FAILURE CRITERIA : **Local** **SHEAR FAILURE**

Foundation Dimensions		FOUN-DATION SHAPE	Depth,m	R_w	Shape Factors			Depth factors (GSF)			Depth factors (LSF)			$q_{net\ safe}$, T/m^2		Safe Net Bearing Capacity T/m^2
B, m	L, m				ζ_c	ζ_q	ζ_γ	d_c	d_q	d_γ	d_c'	$d_{q'}$	d_γ'	GSF	LSF	
8.0	**8.0**	*Rectangle*	**3.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		20.5	**20.5**
8.0	**8.0**	*Rectangle*	**4.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		24.6	**24.6**

BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS 6403-1981

LOCATION : Reshi to Rongli, Sikkam.

CHAINAGE (Km). - 7.645, P3

The bearing capacity equation is as follows :

$$q_{net\ safe} = (1/FS)\{cNc\zeta_c d_c i_c + q(N_q-1)\zeta_q d_q i_q + 0.5B\gamma N_\gamma \zeta_\gamma d_\gamma i_\gamma R_w\}$$

where:

$q_{net\ safe}$ =	safe net bearing capacity	c =	cohesion intercept
q =	overburden pressure	B =	Foundation width
γ =	Bulk density of soil below founding level		
R_w =	Water table correction factor		
N_c, N_q, N_γ =	bearing capacity factors, which are a function of ϕ		
d_c, d_q, d_γ =	Depth factors		
$\zeta_c, \zeta_q, \zeta_\gamma$ =	Shape factors		
i_c, i_q, i_γ =	inclination factors		

Soil parameters :

c = 0.00 T/m^2 ϕ = 27.9 degrees GENERAL SHEAR FAILURE

c' = 0.00 T/m^2 ϕ'= 19.4 degrees LOCAL SHEAR FAILURE

General Shear Failure : N_c = 25.61 N_q = 14.56 N_γ = 16.48

Local Shear Failure : N_c' = 14.32 N_q' = 6.06 N_γ' = 4.98

Inclination of Foundation to vertical : 0 degrees

Inclination Factors $i_c = i_q$ = 1.00 i_γ = 1.00

Factor of safety = 2.5 as per IS 1904-1986

Design Water Table depth = Not Met

R_w factor: Constant value(**V**) for worst condition or calculate(**C**) based on WT Depth ? : C

Depth factor to be considered ? N

Bulk Density Profile

Depth, m From	Depth, m To	γ T/m^3
0.0	10.0	1.63

FAILURE CRITERIA : **Local** **SHEAR FAILURE**

Foundation Dimensions B, m	Foundation Dimensions L, m	FOUN-DATION SHAPE	Depth,m	R_w	Shape Factors ζ_c	Shape Factors ζ_q	Shape Factors ζ_γ	Depth factors (GSF) d_c	Depth factors (GSF) d_q	Depth factors (GSF) d_γ	Depth factors (LSF) d_c'	Depth factors (LSF) $d_{q'}$	Depth factors (LSF) d_γ'	$q_{net\ safe}$, T/m^2 GSF	$q_{net\ safe}$, T/m^2 LSF	Safe Net Bearing Capacity T/m^2
8.0	**8.0**	*Rectangle*	**3.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		19.7	**19.7**
8.0	**8.0**	*Rectangle*	**4.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		23.6	**23.6**

BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS 6403-1981

LOCATION : Reshi to Rongli, Sikkam.

CHAINAGE (Km). - 7.670, A2

The bearing capacity equation is as follows :

$$q_{net\ safe} = (1/FS)\{cNc\zeta_c d_c i_c + q(N_q-1)\zeta_q d_q i_q + 0.5B\gamma N_\gamma \zeta_\gamma d_\gamma i_\gamma R_w\}$$

where:

$q_{net\ safe}$ =	safe net bearing capacity	c =	cohesion intercept
q =	overburden pressure	B =	Foundation width
γ =	Bulk density of soil below founding level		
R_w =	Water table correction factor		
N_c, N_q, N_γ =	bearing capacity factors, which are a function of ϕ		
d_c, d_q, d_γ =	Depth factors		
$\zeta_c, \zeta_q, \zeta_\gamma$ =	Shape factors		
i_c, i_q, i_γ =	inclination factors		

Soil parameters :

c = 0.00 T/m^2 ϕ = 28.3 degrees GENERAL SHEAR FAILURE

c' = 0.00 T/m^2 ϕ'= 19.7 degrees LOCAL SHEAR FAILURE

General Shear Failure : N_c = 26.40 N_q = 15.21 N_γ = 17.46

Local Shear Failure : N_c' = 14.60 N_q' = 6.24 N_γ' = 5.20

Inclination of Foundation to vertical : 0 degrees

Inclination Factors $i_c = i_q$ = 1.00 i_γ = 1.00

Factor of safety = 2.5 as per IS 1904-1986

Design Water Table depth = Not Met

R_w factor: Constant value(**V**) for worst condition or calculate(**C**) based on WT Depth ? : C

Depth factor to be considered ? N

Bulk Density Profile

Depth, m From	Depth, m To	γ T/m^3
0.0	10.0	1.65

FAILURE CRITERIA : **Local** **SHEAR FAILURE**

Foundation Dimensions B, m	Foundation Dimensions L, m	FOUN-DATION SHAPE	Depth,m	R_w	Shape Factors ζ_c	Shape Factors ζ_q	Shape Factors ζ_γ	Depth factors (GSF) d_c	Depth factors (GSF) d_q	Depth factors (GSF) d_γ	Depth factors (LSF) d_c'	Depth factors (LSF) $d_{q'}$	Depth factors (LSF) d_γ'	$q_{net\ safe}$, T/m^2 GSF	$q_{net\ safe}$, T/m^2 LSF	Safe Net Bearing Capacity T/m^2
8.0	**8.0**	*Rectangle*	**3.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		20.7	**20.7**
8.0	**8.0**	*Rectangle*	**4.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		24.8	**24.8**

BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS 6403-1981

LOCATION : Reshi to Rongli, Sikkam.

CHAINAGE (Km). - 13.690, A1

The bearing capacity equation is as follows :

$$q_{net\ safe} = (1/FS)\{cNc\zeta_c d_c i_c + q(N_q-1)\zeta_q d_q i_q + 0.5B\gamma N_\gamma \zeta_\gamma d_\gamma i_\gamma R_w\}$$

where:

$q_{net\ safe}$ =	safe net bearing capacity	c =	cohesion intercept
q =	overburden pressure	B =	Foundation width
γ =	Bulk density of soil below founding level		
R_w =	Water table correction factor		
N_c, N_q, N_γ =	bearing capacity factors, which are a function of ϕ		
d_c, d_q, d_γ =	Depth factors		
$\zeta_c, \zeta_q, \zeta_\gamma$ =	Shape factors		
i_c, i_q, i_γ =	inclination factors		

Soil parameters :

c = 0.00 T/m^2 ϕ = 31.9 degrees GENERAL SHEAR FAILURE

c' = 0.00 T/m^2 ϕ'= 22.5 degrees LOCAL SHEAR FAILURE

General Shear Failure : N_c = 35.19 N_q = 22.91 N_γ = 29.76

Local Shear Failure : N_c' = 17.50 N_q' = 8.26 N_γ' = 7.69

Inclination of Foundation to vertical : 0 degrees

Inclination Factors $i_c = i_q$ = 1.00 i_γ = 1.00

Factor of safety = 2.5 as per IS 1904-1986

Design Water Table depth = Not Met

R_w factor: Constant value(**V**) for worst condition or calculate(**C**) based on WT Depth ? : C

Depth factor to be considered ? N

Bulk Density Profile

Depth, m From	Depth, m To	γ T/m^3
0.0	10.0	1.72

FAILURE CRITERIA : **Local** **SHEAR FAILURE**

Foundation Dimensions B, m	Foundation Dimensions L, m	FOUN-DATION SHAPE	Depth,m	R_w	Shape Factors ζ_c	Shape Factors ζ_q	Shape Factors ζ_γ	Depth factors (GSF) d_c	Depth factors (GSF) d_q	Depth factors (GSF) d_γ	Depth factors (LSF) d_c'	Depth factors (LSF) $d_{q'}$	Depth factors (LSF) d_γ'	$q_{net\ safe}$, T/m^2 GSF	$q_{net\ safe}$, T/m^2 LSF	Safe Net Bearing Capacity T/m^2
10.0	**10.0**	*Rectangle*	**3.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		33.8	**33.8**
10.0	**10.0**	*Rectangle*	**4.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		39.8	**39.8**

BEARING CAPACITY ANALYSIS FOR SHALLOW FOUNDATIONS

Analysis as per IS 6403-1981

LOCATION : Reshi to Rongli, Sikkam.

CHAINAGE (Km). - 13.740, A2

The bearing capacity equation is as follows :

$$q_{net\ safe} = (1/FS)\{cNc\zeta_c d_c i_c + q(N_q-1)\zeta_q d_q i_q + 0.5B\gamma N_\gamma \zeta_\gamma d_\gamma i_\gamma R_w\}$$

where:

$q_{net\ safe}$ =	safe net bearing capacity	c =	cohesion intercept
q =	overburden pressure	B =	Foundation width
γ =	Bulk density of soil below founding level		
R_w =	Water table correction factor		
N_c, N_q, N_γ =	bearing capacity factors, which are a function of ϕ		
d_c, d_q, d_γ =	Depth factors		
$\zeta_c, \zeta_q, \zeta_\gamma$ =	Shape factors		
i_c, i_q, i_γ =	inclination factors		

Soil parameters :

c = 0.00 T/m^2 ϕ = 31.7 degrees GENERAL SHEAR FAILURE

c' = 0.00 T/m^2 ϕ'= 22.4 degrees LOCAL SHEAR FAILURE

General Shear Failure : N_c = 34.61 N_q = 22.38 N_γ = 28.88

Local Shear Failure : N_c' = 17.31 N_q' = 8.13 N_γ' = 7.52

Inclination of Foundation to vertical : 0 degrees

Inclination Factors $i_c = i_q$ = 1.00 i_γ = 1.00

Factor of safety = 2.5 as per IS 1904-1986

Design Water Table depth = Not Met

R_w factor: Constant value(**V**) for worst condition or calculate(**C**) based on WT Depth ? : C

Depth factor to be considered ? N

Bulk Density Profile

Depth, m From	Depth, m To	γ T/m^3
0.0	10.0	1.73

FAILURE CRITERIA : **Local** **SHEAR FAILURE**

Foundation Dimensions B, m	Foundation Dimensions L, m	FOUN-DATION SHAPE	Depth,m	R_w	Shape Factors ζ_c	Shape Factors ζ_q	Shape Factors ζ_γ	Depth factors (GSF) d_c	Depth factors (GSF) d_q	Depth factors (GSF) d_γ	Depth factors (LSF) d_c'	Depth factors (LSF) $d_{q'}$	Depth factors (LSF) d_γ'	$q_{net\ safe}$, T/m^2 GSF	$q_{net\ safe}$, T/m^2 LSF	Safe Net Bearing Capacity T/m^2
10.0	**10.0**	*Rectangle*	**3.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		33.4	**33.4**
10.0	**10.0**	*Rectangle*	**4.0**	1.00	1.20	1.20	0.60				1.00	1.00	1.00		39.3	**39.3**

Pile Capacity Calculation in Rock (As per Method 1, Appendix-5 of IRC:78-2014) :

CH - 7.560, A1

Bed Level =	100.00	m
Cut Off Level =	98.20	m
Top Level of Rock =	88.60	m
Pile Tip Level =	85.00	m
Length of Pile below Cut Off =	13.20	m
Length of Pile Socket =	3.60	m
Diameter of Pile =	1.2	m
Grade of Concrete for Pile =	35.0	
Core Recovery, CR =	24	%
Rock Quality Designation, RQD =	0	%

Refer Clause 709.3.1 of IRC:78-2014 & Appendix-5, 9.1 (Method 1)

Q_u = $R_e + R_{af}$ = $K_{sp} * q_c * d_f * A_b + C_{us} * A_s$

Q_{allow} = $(R_e/3) + (R_{af}/6)$

Q_u =	Ultimate Capacity of Pile
Q_{allow} =	Allowable Capacity of Pile
R_e =	Ultimate End Bearing
R_{af} =	Ultimate Side Socket Shear
K_{sp} =	An empirical coefficient
q_c =	Average UCS of rock
d_f =	Depth factor
A_b =	Cross Sectional area of pile
C_{us} =	Ultimate Shear Strength along socket length of pile
A_s =	Surface area of socket

(CR+RQD)/2 =	12	%	
K_{sp} =	0.1		
q_c =	60.5	t/m^2	
d_f =	1.2		
A_b =	1.131	m^2	
C_{us} =	1.75	Mpa	
A_s =	12.441	m^2	(Neglecting top 300mm of top rock)
Factor of Safety for End Bearing =	3		
Factor of Safety for Socket resistance =	6		
Allowable End Bearing Stress =	2.42	t/m^2	
Allowable End Bearing Capacity =	2.7	t	
Allowable Socket resistance =	362.9	t	
Q_{allow} =	365.6	t	

Pile Capacity Calculation in Rock (As per Method 1, Appendix-5 of IRC:78-2014) :

CH - 7.585, P1

Bed Level =	100.00	m
Cut Off Level =	98.20	m
Top Level of Rock =	88.60	m
Pile Tip Level =	85.00	m
Length of Pile below Cut Off =	13.20	m
Length of Pile Socket =	3.60	m
Diameter of Pile =	1.2	m
Grade of Concrete for Pile =	35.0	
Core Recovery, CR =	25	%
Rock Quality Designation, RQD =	0	%

Refer Clause 709.3.1 of IRC:78-2014 & Appendix-5, 9.1 (Method 1)

Q_u = $R_e + R_{af}$ = $K_{sp} * q_c * d_f * A_b + C_{us} * A_s$

Q_{allow} = $(R_e/3) + (R_{af}/6)$

Q_u =	Ultimate Capacity of Pile
Q_{allow} =	Allowable Capacity of Pile
R_e =	Ultimate End Bearing
R_{af} =	Ultimate Side Socket Shear
K_{sp} =	An empirical coefficient
q_c =	Average UCS of rock
d_f =	Depth factor
A_b =	Cross Sectional area of pile
C_{us} =	Ultimate Shear Strength along socket length of pile
A_s =	Surface area of socket

(CR+RQD)/2 =	12.5	%	
K_{sp} =	0.1		
q_c =	59.4	t/m^2	
d_f =	1.2		
A_b =	1.131	m^2	
C_{us} =	1.73	Mpa	
A_s =	12.441	m^2	(Neglecting top 300mm of top rock)
Factor of Safety for End Bearing =	3		
Factor of Safety for Socket resistance =	6		
Allowable End Bearing Stress =	2.376	t/m^2	
Allowable End Bearing Capacity =	2.7	t	
Allowable Socket resistance =	359.6	t	
Q_{allow} =	362.2	t	

Pile Capacity Calculation in Rock (As per Method 1, Appendix-5 of IRC:78-2014) :

CH - 7.615, P2

Bed Level =	100.00	m
Cut Off Level =	98.20	m
Top Level of Rock =	88.60	m
Pile Tip Level =	85.00	m
Length of Pile below Cut Off =	13.20	m
Length of Pile Socket =	3.60	m
Diameter of Pile =	1.2	m
Grade of Concrete for Pile =	35.0	
Core Recovery, CR =	24	%
Rock Quality Designation, RQD =	0	%

Refer Clause 709.3.1 of IRC:78-2014 & Appendix-5, 9.1 (Method 1)

$Q_u = R_e + R_{af} = K_{sp} * q_c * d_f * A_b + C_{us} * A_s$

$Q_{allow} = (R_e/3) + (R_{af}/6)$

Q_u =	Ultimate Capacity of Pile
Q_{allow} =	Allowable Capacity of Pile
R_e =	Ultimate End Bearing
R_{af} =	Ultimate Side Socket Shear
K_{sp} =	An empirical coefficient
q_c =	Average UCS of rock
d_f =	Depth factor
A_b =	Cross Sectional area of pile
C_{us} =	Ultimate Shear Strength along socket length of pile
A_s =	Surface area of socket

(CR+RQD)/2 =	12	%	
K_{sp} =	0.1		
q_c =	57	t/m^2	
d_f =	1.2		
A_b =	1.131	m^2	
C_{us} =	1.70	Mpa	
A_s =	12.441	m^2	(Neglecting top 300mm of top rock)
Factor of Safety for End Bearing =	3		
Factor of Safety for Socket resistance =	6		
Allowable End Bearing Stress =	2.28	t/m^2	
Allowable End Bearing Capacity =	2.6	t	
Allowable Socket resistance =	352.2	t	
Q_{allow} =	354.8	t	

Pile Capacity Calculation in Rock (As per Method 1, Appendix-5 of IRC:78-2014) :

CH - 7.645, P3

Bed Level =	100.00	m
Cut Off Level =	98.20	m
Top Level of Rock =	88.60	m
Pile Tip Level =	85.00	m
Length of Pile below Cut Off =	13.20	m
Length of Pile Socket =	3.60	m
Diameter of Pile =	1.2	m
Grade of Concrete for Pile =	35.0	
Core Recovery, CR =	23	%
Rock Quality Designation, RQD =	0	%

Refer Clause 709.3.1 of IRC:78-2014 & Appendix-5, 9.1 (Method 1)

$Q_u = R_e + R_{af} = K_{sp} * q_c * d_f * A_b + C_{us} * A_s$

$Q_{allow} = (R_e/3) + (R_{af}/6)$

Q_u =	Ultimate Capacity of Pile
Q_{allow} =	Allowable Capacity of Pile
R_e =	Ultimate End Bearing
R_{af} =	Ultimate Side Socket Shear
K_{sp} =	An empirical coefficient
q_c =	Average UCS of rock
d_f =	Depth factor
A_b =	Cross Sectional area of pile
C_{us} =	Ultimate Shear Strength along socket length of pile
A_s =	Surface area of socket

(CR+RQD)/2 =	11.5	%	
K_{sp} =	0.1		
q_c =	56.5	t/m^2	
d_f =	1.2		
A_b =	1.131	m^2	
C_{us} =	1.69	Mpa	
A_s =	12.441	m^2	(Neglecting top 300mm of top rock)
Factor of Safety for End Bearing =	3		
Factor of Safety for Socket resistance =	6		
Allowable End Bearing Stress =	2.26	t/m^2	
Allowable End Bearing Capacity =	2.6	t	
Allowable Socket resistance =	350.7	t	
Q_{allow} =	353.2	t	

Pile Capacity Calculation in Rock (As per Method 1, Appendix-5 of IRC:78-2014) :

CH - 7.670, A2

Bed Level =	100.00	m
Cut Off Level =	98.20	m
Top Level of Rock =	88.60	m
Pile Tip Level =	85.00	m
Length of Pile below Cut Off =	13.20	m
Length of Pile Socket =	3.60	m
Diameter of Pile =	1.2	m
Grade of Concrete for Pile =	35.0	
Core Recovery, CR =	27	%
Rock Quality Designation, RQD =	0	%

Refer Clause 709.3.1 of IRC:78-2014 & Appendix-5, 9.1 (Method 1)

Q_u = $R_e + R_{af}$ = $K_{sp} * q_c * d_f * A_b + C_{us} * A_s$

Q_{allow} = $(R_e/3) + (R_{af}/6)$

Q_u =	Ultimate Capacity of Pile
Q_{allow} =	Allowable Capacity of Pile
R_e =	Ultimate End Bearing
R_{af} =	Ultimate Side Socket Shear
K_{sp} =	An empirical coefficient
q_c =	Average UCS of rock
d_f =	Depth factor
A_b =	Cross Sectional area of pile
C_{us} =	Ultimate Shear Strength along socket length of pile
A_s =	Surface area of socket

(CR+RQD)/2 =	13.5	%	
K_{sp} =	0.1		
q_c =	57	t/m^2	
d_f =	1.2		
A_b =	1.131	m^2	
C_{us} =	1.70	Mpa	
A_s =	12.441	m^2	(Neglecting top 300mm of top rock)
Factor of Safety for End Bearing =	3		
Factor of Safety for Socket resistance =	6		
Allowable End Bearing Stress =	2.28	t/m^2	
Allowable End Bearing Capacity =	2.6	t	
Allowable Socket resistance =	352.2	t	
Q_{allow} =	354.8	t	

Pile Capacity Calculation in Rock (As per Method 1, Appendix-5 of IRC:78-2014) :

CH - 13.690, A1

Bed Level =	100.00	m
Cut Off Level =	98.20	m
Top Level of Rock =	88.60	m
Pile Tip Level =	85.00	m
Length of Pile below Cut Off =	13.20	m
Length of Pile Socket =	3.60	m
Diameter of Pile =	1.2	m
Grade of Concrete for Pile =	35.0	
Core Recovery, CR =	22	%
Rock Quality Designation, RQD =	0	%

Refer Clause 709.3.1 of IRC:78-2014 & Appendix-5, 9.1 (Method 1)

$Q_u = R_e + R_{af} = K_{sp} * q_c * d_f * A_b + C_{us} * A_s$

$Q_{allow} = (R_e/3) + (R_{af}/6)$

Q_u =	Ultimate Capacity of Pile
Q_{allow} =	Allowable Capacity of Pile
R_e =	Ultimate End Bearing
R_{af} =	Ultimate Side Socket Shear
K_{sp} =	An empirical coefficient
q_c =	Average UCS of rock
d_f =	Depth factor
A_b =	Cross Sectional area of pile
C_{us} =	Ultimate Shear Strength along socket length of pile
A_s =	Surface area of socket

(CR+RQD)/2 =	11	%	
K_{sp} =	0.1		
q_c =	58.3	t/m^2	
d_f =	1.2		
A_b =	1.131	m^2	
C_{us} =	1.72	Mpa	
A_s =	12.441	m^2	(Neglecting top 300mm of top rock)
Factor of Safety for End Bearing =	3		
Factor of Safety for Socket resistance =	6		
Allowable End Bearing Stress =	2.332	t/m^2	
Allowable End Bearing Capacity =	2.6	t	
Allowable Socket resistance =	356.2	t	
Q_{allow} =	358.9	t	

Pile Capacity Calculation in Rock (As per Method 1, Appendix-5 of IRC:78-2014) :

CH - 13.740, A2

Bed Level =	100.00	m
Cut Off Level =	98.20	m
Top Level of Rock =	88.60	m
Pile Tip Level =	85.00	m
Length of Pile below Cut Off =	13.20	m
Length of Pile Socket =	3.60	m
Diameter of Pile =	1.2	m
Grade of Concrete for Pile =	35.0	
Core Recovery, CR =	22.6	%
Rock Quality Designation, RQD =	0	%

Refer Clause 709.3.1 of IRC:78-2014 & Appendix-5, 9.1 (Method 1)

$Q_u = R_e + R_{af} = K_{sp} * q_c * d_f * A_b + C_{us} * A_s$

$Q_{allow} = (R_e/3) + (R_{af}/6)$

Q_u =	Ultimate Capacity of Pile
Q_{allow} =	Allowable Capacity of Pile
R_e =	Ultimate End Bearing
R_{af} =	Ultimate Side Socket Shear
K_{sp} =	An empirical coefficient
q_c =	Average UCS of rock
d_f =	Depth factor
A_b =	Cross Sectional area of pile
C_{us} =	Ultimate Shear Strength along socket length of pile
A_s =	Surface area of socket

(CR+RQD)/2 =	11.3	%	
K_{sp} =	0.1		
q_c =	59.4	t/m^2	
d_f =	1.2		
A_b =	1.131	m^2	
C_{us} =	1.73	Mpa	
A_s =	12.441	m^2	(Neglecting top 300mm of top rock)
Factor of Safety for End Bearing =	3		
Factor of Safety for Socket resistance =	6		
Allowable End Bearing Stress =	2.376	t/m^2	
Allowable End Bearing Capacity =	2.7	t	
Allowable Socket resistance =	359.6	t	
Q_{allow} =	362.2	t	

CH NO 7 + 560

CH NO 7 + 585

CH NO 7 + 615

CH NO 13 + 690

CH NO 11 + 200

CH NO 11 + 750

CH NO 13 +740

CH NO 7 + 645

CH NO 7 + 670

Hydraulic Calculation for Box Culvert

Culverts : Hydarulic Calculation

Calculation of Discharge with Emperical Formula and Rational Formula for pick run off from catchment area

(Ref : SP:13-2004, Page-7)

1 Discharge by Dicken's Formula

	Q1	=	**$CM^{3/4}$**
Where,	Q1	=	The peak run-off in m^3/sec
	M	=	The Catchment area in sq.km
	C	=	11-14 Where the annual rainfall is 60 to 120 cm
		=	14-19 where the annual rainfall is more than 120 cm
		=	22 in Western ghats

2 Discharge by Ryve's Formula

	Q2	=	**$CM^{2/3}$**
Where,	Q1	=	The peak run-off in m^3/sec
	M	=	The Catchment area in sq.km
	C	=	6.8 for area within 25 km of the coast
		=	8.5 for area between 25 km to 160 km of the coast
		=	10.0 for limited areas near the hills

3 Discharge by Ingli's Formula

	Q3	=	$\frac{125M}{\sqrt{(M+10)}}$
Where,	Q3	=	The peak run-off in m^3/sec
	M	=	The Catchment area in sq.km

4 Discharge by Rational Formula

	Q4	=	**$0.028\ PAI_c$**
Where,	Q4	=	Max run-off in m^3/sec
	A	=	Area of catchment in Hactares
	I_c	=	Critical intensity of rainfall in cm per hour
	P	=	Co-efficient of run-off for the catchment characteristics
		=	0.5
	F	=	Total Precipiation in cm per hour
			(5 cm of rain in 20 minutes) = 15 cm per hour
	t	=	1 hour
	I_o	=	F/2(1+1/T), (One Hour Rainfall)
	t_c	=	Concentration time in Hours = $(0.87 \times L^3/H)^{0.385}$
	I_c	=	$I_0\ (2/(t_c+1))$
	L	=	The distance from critical point to the structure in km
	H	=	The fall in level from the critical point to the structure in m
	T	=	1 hour
Design Discharge		=	**Max. of (Q1 , Q2 , Q3, Q4)**
			(Limited to 1.5 times of second highest Discharge)

Hydarulic Design

Discharge Capacity through the Drain (Flowing full) is given by

	Q	=	**K x A x $\sqrt{2}$ x g x h** Where, $K = 1/\sqrt{(1 + K_e + K_f)}$
		=	A x 4.43 x $\sqrt{(\ h/(1 + K_e + K_f)}$
Where,	Q	=	Discharge carriying capacity in m^3/s
	A	=	Area of Pipe & Area of Box in Sqm
	h	=	Operating/Driving head in m (Assumed 0.25 m)
	K_e	=	0.1000 for pipe/0.050 for rectangular culvert
	K_f	=	$0.00394 \times L / R^{1.20}$ for Pipe
		=	$0.00394 \times L / R^{1.25}$ for Rectangular Drain

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 0+085

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment		156 m
Width of Catchment		111 m
Catchment Area of the Culvert		0.017 sq.km
Distance from critical point to the structure		0.1558 km
The fall in level from the critical point to the structure		0.08 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.017 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**0.907 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.017 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**0.668 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.017 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**0.684 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		1.7308	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.1558	km
	H	=	The fall in level from the critical point to the structure		0.08	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.296	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	115.30	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**2.7937**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	0.907	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.668	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	0.684	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	2.794	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**2.794**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			1.360	cum/sec
	Area required to flow the Design Discharge			0.460	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.115	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**2.794**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 0+275

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	3.000

Discharge Capacity through the pipe (Flowing full) is given by

$$Q = K \times A \times \sqrt{2 \times g \times h}$$

Where, $K = 1/\sqrt{(1 + K_e + K_f)}$

$$Q = A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$$

Where	A	= Area of Box Culvert in Sqm = D*L	9	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.000	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0118	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9705	
	Q_{dc}	**= Discharge Capacity**	**67.016**	**cum/sec**

B) Design Discharge

Length of Catchment			150	m
Width of Catchment			119	m
Catchment Area of the Culvert			0.018	sq.km
Distance from critical point to the structure			0.1497	km
The fall in level from the critical point to the structure			0.07	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.018	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**0.924**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.018	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**0.680**	**cum/sec**

3) By Ingli's Formula

$$Q3 = \frac{125M}{\sqrt{(M+10)}}$$

Where,	M	= The Catchment area in sq.km	0.018	sq.km
	Q3	**= The peak run-off in m^3/sec**	**0.702**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		1.7763	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.1497	km
	H	=	The fall in level from the critical point to the structure		0.07	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.287	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	116.10	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**2.8872**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	0.924	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.680	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	0.702	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	2.887	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**2.887**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			1.387	cum/sec
	Area required to flow the Design Discharge			0.388	Sqm
	Area of BOX when flow with full depth			9.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.043	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**67.016 cum/sec**	**>**	**2.887**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 0+470

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	3.000

Discharge Capacity through the pipe (Flowing full) is given by

$$Q = K \times A \times \sqrt{2 \times g \times h}$$

Where, $K = 1/\sqrt{(1 + K_e + K_f)}$

$$Q = A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$$

Where	A	= Area of Box Culvert in Sqm = D*L	9	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.000	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0118	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9705	
	Q_{dc}	**= Discharge Capacity**	**67.016**	**cum/sec**

B) Design Discharge

Length of Catchment			103	m
Width of Catchment			93	m
Catchment Area of the Culvert			0.010	sq.km
Distance from critical point to the structure			0.103	km
The fall in level from the critical point to the structure			0.05	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

$$Q1 = CM^{3/4}$$

Where, M	=	The Catchment area in sq.km	0.010	sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19	
Q1	**=**	**The peak run-off in cum/sec**	**0.581**	**cum/sec**

2) By Ryve's Formula

$$Q2 = CM^{2/3}$$

Where, M	=	The Catchment area in sq.km	0.010	sq.km
C	=	6.8 for area within 25 km of the coast	10.0	
	=	8.5 for area between 25 km to 160 km of the coast		
	=	10.0 for limited areas near the hill		
Q2	**=**	**The peak run-off in m^3/sec**	**0.450**	**cum/sec**

3) By Ingli's Formula

$$Q3 = \frac{125M}{\sqrt{(M+10)}}$$

Where, M	=	The Catchment area in sq.km	0.010	sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**0.378**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		0.9557	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.103	km
	H	=	The fall in level from the critical point to the structure		0.05	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.215	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	122.96	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**1.6453**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	0.581	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.450	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	0.378	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	1.645	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**1.645**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			0.871	cum/sec
	Area required to flow the Design Discharge			0.221	Sqm
	Area of BOX when flow with full depth			9.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.025	
B)	**Capacity of Proposed Box Culvert**				

Discharge Capacity	**Q_{dc}**	**67.016 cum/sec**	**>**	**1.645**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 0+550

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

	Length of Catchment		92	m
	Width of Catchment		83	m
	Catchment Area of the Culvert		0.008	sq.km
	Distance from critical point to the structure		0.0918	km
	The fall in level from the critical point to the structure		0.05	m
	(Note: Country Slope has been considered as 1 in 1000)			

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.008	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**0.490**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.008	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**0.386**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.008	sq.km
	Q3	**= The peak run-off in m^3/sec**	**0.301**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		0.7611	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.0918	km
	H	=	The fall in level from the critical point to the structure		0.05	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.197	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	124.84	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**1.3301**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	0.490	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.386	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	0.301	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	1.330	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**1.330**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			0.734	cum/sec
	Area required to flow the Design Discharge			0.219	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.055	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**1.330**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 0+820

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		208	m
Width of Catchment		134	m
Catchment Area of the Culvert		0.028	sq.km
Distance from critical point to the structure		0.2082	km
The fall in level from the critical point to the structure		0.10	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.028	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**1.296**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.028	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**0.918**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.028	sq.km
	Q3	**= The peak run-off in m^3/sec**	**1.100**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		2.7871	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.2082	km
	H	=	The fall in level from the critical point to the structure		0.10	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.370	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	109.07	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**4.2559**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	1.296	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.918	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	1.100	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	4.256	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**4.256**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			1.944	cum/sec
	Area required to flow the Design Discharge			0.700	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.175	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**4.256 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 1+051

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	3.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	9	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.000	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0118	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9705	
	Q_{dc}	**= Discharge Capacity**	**67.016**	**cum/sec**

B) Design Discharge

	Length of Catchment		218	m
	Width of Catchment		132	m
	Catchment Area of the Culvert		0.029	sq.km
	Distance from critical point to the structure		0.2182	km
	The fall in level from the critical point to the structure		0.11	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.029	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**1.326**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.029	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**0.937**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.029	sq.km
	Q3	**= The peak run-off in m^3/sec**	**1.134**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		2.8723	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.2182	km
	H	=	The fall in level from the critical point to the structure		0.11	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.383	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	108.01	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**4.3432**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	1.326	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.937	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	1.134	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	4.343	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**4.343**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			1.988	cum/sec
	Area required to flow the Design Discharge			0.583	Sqm
	Area of BOX when flow with full depth			9.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.065	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**67.016 cum/sec**	**>**	**4.343**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 1+340

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		362	m
Width of Catchment		270	m
Catchment Area of the Culvert		0.098	sq.km
Distance from critical point to the structure		0.3617	km
The fall in level from the critical point to the structure		0.18	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.098	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**3.317**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.098	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**2.118**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.098	sq.km
	Q3	**= The peak run-off in m^3/sec**	**3.839**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		9.7589	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.3617	km
	H	=	The fall in level from the critical point to the structure		0.18	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.566	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	95.43	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**13.038**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	3.317	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	2.118	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	3.839	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	13.038	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**13.038**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			4.976	cum/sec
	Area required to flow the Design Discharge			2.146	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.536	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**13.038 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Name of Road : CONSULTANCY SERVICES FOR PREPARATION OF DPR AND PROVIDING SERVICES FOR PRE-CONSTRUCTION ACTIVITIES IN RESPECT OF "WIDENING AND UP-GRADATION OF EXISTING CARRIAGEWAY INTO 2L+PS CONFIGURATION FROM LAVAMORE (KM 61.10) TO START OF PEDONG BYPASS (KM 79.700) AND FROM RESHI(KM 96.254) .TO RHENOCK (KM 101.554) ALONG NH-717A & FROM RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300) ALONG NH-717B IN THE STATES OF SIKKIM AND WB".

Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 1+552

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	3.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	9	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.000	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0118	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9705	
	Q_{dc}	**= Discharge Capacity**	**67.016**	**cum/sec**

B) Design Discharge

Length of Catchment	387	m	
Width of Catchment	169	m	
Catchment Area of the Culvert	0.065	sq.km	
Distance from critical point to the structure	0.3868	km	
The fall in level from the critical point to the structure	0.19	m	

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.065	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**2.451**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.065	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**1.618**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.065	sq.km
	Q3	**= The peak run-off in m^3/sec**	**2.568**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		6.5186	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.3868	km
	H	=	The fall in level from the critical point to the structure		0.19	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.596	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	93.63	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**8.5445**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	2.451	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.618	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	2.568	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	8.545	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**8.545**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			3.677	cum/sec
	Area required to flow the Design Discharge			1.147	Sqm
	Area of BOX when flow with full depth			9.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.127	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**67.016 cum/sec**	**>**	**8.545**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 1+932

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	3.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	9	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.000	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0118	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9705	
	Q_{dc}	**= Discharge Capacity**	**67.016**	**cum/sec**

B) Design Discharge

Length of Catchment	275	m	
Width of Catchment	157	m	
Catchment Area of the Culvert	0.043	sq.km	
Distance from critical point to the structure	0.2751	km	
The fall in level from the critical point to the structure	0.14	m	

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.043	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**1.798**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.043	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**1.228**	**cum/sec**

3) By Ingli's Formula

$$Q3 = \frac{125M}{\sqrt{(M+10)}}$$

Where,	M	= The Catchment area in sq.km	0.043	sq.km
	Q3	**= The peak run-off in m^3/sec**	**1.701**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		4.3122	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.2751	km
	H	=	The fall in level from the critical point to the structure		0.14	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.458	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	102.46	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**6.1856**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	1.798	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.228	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	1.701	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	6.186	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**6.186**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			2.697	cum/sec
	Area required to flow the Design Discharge			0.831	Sqm
	Area of BOX when flow with full depth			9.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.092	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**67.016 cum/sec**	**>**	**6.186 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 2+173

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment			206 m
Width of Catchment			131 m
Catchment Area of the Culvert			0.027 sq.km
Distance from critical point to the structure			0.2061 km
The fall in level from the critical point to the structure			0.10 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.027 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**1.263 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.027 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**0.897 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.027 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**1.063 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		2.6922	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.2061	km
	H	=	The fall in level from the critical point to the structure		0.10	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.367	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	109.30	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**4.1197**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	1.263	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.897	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	1.063	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	4.120	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**4.120**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			1.894	cum/sec
	Area required to flow the Design Discharge			0.678	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.169	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**4.120**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Name of Road : CONSULTANCY SERVICES FOR PREPARATION OF DPR AND PROVIDING SERVICES FOR PRE-CONSTRUCTION ACTIVITIES IN RESPECT OF "WIDENING AND UP-GRADATION OF EXISTING CARRIAGEWAY INTO 2L+PS CONFIGURATION FROM LAVAMORE (KM 61.10) TO START OF PEDONG BYPASS (KM 79.700) AND FROM RESHI(KM 96.254) .TO RHENOCK (KM 101.554) ALONG NH-717A & FROM RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300) ALONG NH-717B IN THE STATES OF SIKKIM AND WB".

Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 2+280

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	3.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	9	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.000	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0118	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9705	
	Q_{dc}	**= Discharge Capacity**	**67.016**	**cum/sec**

B) Design Discharge

Length of Catchment	199	m	
Width of Catchment	167	m	
Catchment Area of the Culvert	0.033	sq.km	
Distance from critical point to the structure	0.1986	km	
The fall in level from the critical point to the structure	0.10	m	

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.033	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**1.474**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.033	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**1.029**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.033	sq.km
	Q3	**= The peak run-off in m^3/sec**	**1.305**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		3.3075	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.1986	km
	H	=	The fall in level from the critical point to the structure		0.10	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.357	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	110.14	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**5.0999**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	1.474	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.029	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	1.305	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	5.100	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**5.100**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			2.210	cum/sec
	Area required to flow the Design Discharge			0.685	Sqm
	Area of BOX when flow with full depth			9.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.076	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**67.016 cum/sec**	**5.100**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 2+535

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	3.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		9 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		1.000 m
h	= Opening/Driving Head		3.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$		0.0118
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9705
Q_{dc}	**= Discharge Capacity**		**67.016 cum/sec**

B) Design Discharge

Length of Catchment		185 m
Width of Catchment		110 m
Catchment Area of the Culvert		0.020 sq.km
Distance from critical point to the structure		0.185 km
The fall in level from the critical point to the structure		0.09 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.020 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**1.022 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.020 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**0.743 cum/sec**

3) By Ingli's Formula

$$Q3 = \frac{125M}{\sqrt{(M+10)}}$$

Where, M	=	The Catchment area in sq.km	0.020 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**0.801 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		2.0293	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.185	km
	H	=	The fall in level from the critical point to the structure		0.09	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.338	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	111.70	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**3.1734**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	1.022	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.743	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	0.801	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	3.173	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**3.173**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			1.532	cum/sec
	Area required to flow the Design Discharge			0.426	Sqm
	Area of BOX when flow with full depth			9.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.047	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**67.016 cum/sec**	**>**	**3.173**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 2+840

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		272	m
Width of Catchment		116	m
Catchment Area of the Culvert		0.031	sq.km
Distance from critical point to the structure		0.2716	km
The fall in level from the critical point to the structure		0.14	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.031	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**1.417**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.031	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**0.994**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.031	sq.km
	Q3	**= The peak run-off in m^3/sec**	**1.239**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		3.1398	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.2716	km
	H	=	The fall in level from the critical point to the structure		0.14	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.454	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	102.78	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**4.5177**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	1.417	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.994	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	1.239	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	4.518	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**4.518**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			2.126	cum/sec
	Area required to flow the Design Discharge			0.744	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.186	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**4.518**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 3+046

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		243	m
Width of Catchment		179	m
Catchment Area of the Culvert		0.043	sq.km
Distance from critical point to the structure		0.2433	km
The fall in level from the critical point to the structure		0.12	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.043	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**1.809**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.043	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**1.235**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.043	sq.km
	Q3	**= The peak run-off in m^3/sec**	**1.715**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		4.3489	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.2433	km
	H	=	The fall in level from the critical point to the structure		0.12	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.417	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	105.45	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**6.4204**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	1.809	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.235	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	1.715	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	6.420	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**6.420**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			2.714	cum/sec
	Area required to flow the Design Discharge			1.057	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.264	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**6.420**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 3+146

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment			194 m
Width of Catchment			161 m
Catchment Area of the Culvert			0.031 sq.km
Distance from critical point to the structure			0.1942 km
The fall in level from the critical point to the structure			0.10 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.031 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**1.413 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.031 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**0.992 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.031 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**1.235 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		3.1285	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.1942	km
	H	=	The fall in level from the critical point to the structure		0.10	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.350	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	110.63	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**4.8457**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	1.413	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.992	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	1.235	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	4.846	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**4.846**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			2.120	cum/sec
	Area required to flow the Design Discharge			0.797	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.199	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**4.846**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 3+410

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment			143 m
Width of Catchment			113 m
Catchment Area of the Culvert			0.016 sq.km
Distance from critical point to the structure			0.1426 km
The fall in level from the critical point to the structure			0.07 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.016 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**0.856 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.016 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**0.635 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.016 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**0.633 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		1.6038	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.1426	km
	H	=	The fall in level from the critical point to the structure		0.07	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.276	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	117.07	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**2.6286**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	0.856	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.635	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	0.633	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	2.629	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**2.629**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			1.284	cum/sec
	Area required to flow the Design Discharge			0.433	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.108	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**2.629** **cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 3+495

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		123	m
Width of Catchment		106	m
Catchment Area of the Culvert		0.013	sq.km
Distance from critical point to the structure		0.1229	km
The fall in level from the critical point to the structure		0.06	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.013	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**0.732**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.013	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**0.553**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.013	sq.km
	Q3	**= The peak run-off in m^3/sec**	**0.514**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		1.3022	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.1229	km
	H	=	The fall in level from the critical point to the structure		0.06	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.246	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	119.87	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**2.1853**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	0.732	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.553	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	0.514	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	2.185	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**2.185**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			1.099	cum/sec
	Area required to flow the Design Discharge			0.360	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.090	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**2.185 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 3+616

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L	4	Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
h	= Opening/Driving Head	2.000	m
K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment	142	m
Width of Catchment	94	m
Catchment Area of the Culvert	0.013	sq.km
Distance from critical point to the structure	0.1417	km
The fall in level from the critical point to the structure	0.07	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.013	sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19	
Q1	**=**	**The peak run-off in cum/sec**	**0.742**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.013	sq.km
C	=	6.8 for area within 25 km of the coast	10.0	
	=	8.5 for area between 25 km to 160 km of the coast		
	=	10.0 for limited areas near the hill		
Q2	**=**	**The peak run-off in m^3/sec**	**0.559**	**cum/sec**

3) By Ingli's Formula

$$Q3 = \frac{125M}{\sqrt{(M+10)}}$$

Where, M	=	The Catchment area in sq.km	0.013	sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**0.524**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		1.3254	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.1417	km
	H	=	The fall in level from the critical point to the structure		0.07	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.275	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	117.19	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**2.1745**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	0.742	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.559	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	0.524	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	2.175	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**2.175**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			1.113	cum/sec
	Area required to flow the Design Discharge			0.358	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.089	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**2.175**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 3+765

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment			232 m
Width of Catchment			158 m
Catchment Area of the Culvert			0.037 sq.km
Distance from critical point to the structure			0.2316 km
The fall in level from the critical point to the structure			0.12 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.037 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**1.590 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.037 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**1.101 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.037 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**1.444 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		3.6602	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.2316	km
	H	=	The fall in level from the critical point to the structure		0.12	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.401	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	106.62	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**5.4635**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	1.590	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.101	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	1.444	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	5.464	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**5.464**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			2.385	cum/sec
	Area required to flow the Design Discharge			0.899	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.225	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**5.464**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 3+870

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L	4	Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
h	= Opening/Driving Head	2.000	m
K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment	195	m
Width of Catchment	86	m
Catchment Area of the Culvert	0.017	sq.km
Distance from critical point to the structure	0.1949	km
The fall in level from the critical point to the structure	0.10	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	= The Catchment area in sq.km	0.017	sq.km
C	= 14-19 where the annual rainfall is more than 120 cm	19	
Q1	**= The peak run-off in cum/sec**	**0.888**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	= The Catchment area in sq.km	0.017	sq.km
C	= 6.8 for area within 25 km of the coast	10.0	
	= 8.5 for area between 25 km to 160 km of the coast		
	= 10.0 for limited areas near the hill		
Q2	**= The peak run-off in m^3/sec**	**0.656**	**cum/sec**

3) By Ingli's Formula

$$Q3 = \frac{125M}{\sqrt{(M+10)}}$$

Where, M	= The Catchment area in sq.km	0.017	sq.km
Q3	**= The peak run-off in m^3/sec**	**0.665**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		1.6839	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.1949	km
	H	=	The fall in level from the critical point to the structure		0.10	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.351	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	110.55	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**2.6062**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	0.888	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.656	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	0.665	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	2.606	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**2.606**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			1.332	cum/sec
	Area required to flow the Design Discharge			0.429	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.107	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**2.606**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 4+083

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		332	m
Width of Catchment		160	m
Catchment Area of the Culvert		0.053	sq.km
Distance from critical point to the structure		0.3325	km
The fall in level from the critical point to the structure		0.17	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.053	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**2.106**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.053	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**1.414**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.053	sq.km
	Q3	**= The peak run-off in m^3/sec**	**2.100**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		5.326	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.3325	km
	H	=	The fall in level from the critical point to the structure		0.17	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.530	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	97.64	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**7.2805**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	2.106	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.414	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	2.100	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	7.281	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**7.281**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			3.160	cum/sec
	Area required to flow the Design Discharge			1.198	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.300	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**7.281**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 4+410

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		253	m
Width of Catchment		163	m
Catchment Area of the Culvert		0.041	sq.km
Distance from critical point to the structure		0.2528	km
The fall in level from the critical point to the structure		0.13	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.041	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**1.735**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.041	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**1.190**	**cum/sec**

3) By Ingli's Formula

$$Q3 = \frac{125M}{\sqrt{(M+10)}}$$

Where,	M	= The Catchment area in sq.km	0.041	sq.km
	Q3	**= The peak run-off in m^3/sec**	**1.623**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		4.1135	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.2528	km
	H	=	The fall in level from the critical point to the structure		0.13	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.429	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	104.53	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**6.0198**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	1.735	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.190	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	1.623	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	6.020	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**6.020**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			2.603	cum/sec
	Area required to flow the Design Discharge			0.991	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.248	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**6.020**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 4+570

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment			266 m
Width of Catchment			212 m
Catchment Area of the Culvert			0.056 sq.km
Distance from critical point to the structure			0.266 km
The fall in level from the critical point to the structure			0.13 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.056 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**2.196 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.056 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**1.467 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.056 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**2.219 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		5.6291	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.266	km
	H	=	The fall in level from the critical point to the structure		0.13	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.446	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	103.29	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**8.1399**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	2.196	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.467	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	2.219	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	8.140	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**8.140**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			3.294	cum/sec
	Area required to flow the Design Discharge			1.340	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.335	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**8.140**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 4+725

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		208	m
Width of Catchment		85	m
Catchment Area of the Culvert		0.018	sq.km
Distance from critical point to the structure		0.2079	km
The fall in level from the critical point to the structure		0.10	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.018	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**0.918**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.018	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**0.676**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.018	sq.km
	Q3	**= The peak run-off in m^3/sec**	**0.695**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		1.7608	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.2079	km
	H	=	The fall in level from the critical point to the structure		0.10	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.369	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	109.11	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**2.6897**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	0.918	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.676	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	0.695	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	2.690	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**2.690**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			1.378	cum/sec
	Area required to flow the Design Discharge			0.443	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.111	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**2.690**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 4+920

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		155	m
Width of Catchment		125	m
Catchment Area of the Culvert		0.019	sq.km
Distance from critical point to the structure		0.1549	km
The fall in level from the critical point to the structure		0.08	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.019	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**0.989**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.019	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**0.722**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.019	sq.km
	Q3	**= The peak run-off in m^3/sec**	**0.768**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		1.9438	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.1549	km
	H	=	The fall in level from the critical point to the structure		0.08	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.294	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	115.42	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**3.1408**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	0.989	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.722	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	0.768	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	3.141	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**3.141**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			1.484	cum/sec
	Area required to flow the Design Discharge			0.517	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.129	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**3.141**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 5+235

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment			230 m
Width of Catchment			115 m
Catchment Area of the Culvert			0.026 sq.km
Distance from critical point to the structure			0.2303 km
The fall in level from the critical point to the structure			0.12 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.026 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**1.247 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.026 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**0.887 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.026 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**1.045 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		2.6473	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.2303	km
	H	=	The fall in level from the critical point to the structure		0.12	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.400	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	106.75	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**3.9563**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	1.247	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.887	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	1.045	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	3.956	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**3.956**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			1.870	cum/sec
	Area required to flow the Design Discharge			0.651	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.163	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**3.956 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 5+485

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

	Length of Catchment		204	m
	Width of Catchment		115	m
	Catchment Area of the Culvert		0.023	sq.km
	Distance from critical point to the structure		0.2036	km
	The fall in level from the critical point to the structure		0.10	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.023	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**1.137**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.023	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**0.818**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.023	sq.km
	Q3	**= The peak run-off in m^3/sec**	**0.925**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		2.3418	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.2036	km
	H	=	The fall in level from the critical point to the structure		0.10	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.363	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	109.58	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**3.5926**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	1.137	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.818	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	0.925	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	3.593	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**3.593**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			1.706	cum/sec
	Area required to flow the Design Discharge			0.591	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.148	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**3.593**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 5+625

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		234	m
Width of Catchment		128	m
Catchment Area of the Culvert		0.030	sq.km
Distance from critical point to the structure		0.2342	km
The fall in level from the critical point to the structure		0.12	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.030	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**1.370**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.030	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**0.965**	**cum/sec**

3) By Ingli's Formula

$$Q3 = \frac{125M}{\sqrt{(M+10)}}$$

Where,	M	= The Catchment area in sq.km	0.030	sq.km
	Q3	**= The peak run-off in m^3/sec**	**1.185**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		3.0017	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.2342	km
	H	=	The fall in level from the critical point to the structure		0.12	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.405	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	106.35	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**4.4691**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	1.370	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	0.965	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	1.185	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	4.469	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**4.469**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			2.055	cum/sec
	Area required to flow the Design Discharge			0.736	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.184	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**4.469**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 5+902

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment			558 m
Width of Catchment			217 m
Catchment Area of the Culvert			0.121 sq.km
Distance from critical point to the structure			0.5578 km
The fall in level from the critical point to the structure			0.28 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.121 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**3.897 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.121 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**2.444 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.121 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**4.753 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		12.096	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.5578	km
	H	=	The fall in level from the critical point to the structure		0.28	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.790	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	83.48	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**14.138**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	3.897	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	2.444	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	4.753	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	14.138	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**14.138**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			5.846	cum/sec
	Area required to flow the Design Discharge			2.327	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.582	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**14.138 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 6+115

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment		439 m
Width of Catchment		202 m
Catchment Area of the Culvert		0.088 sq.km
Distance from critical point to the structure		0.4386 km
The fall in level from the critical point to the structure		0.22 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.088 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**3.081 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.088 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**1.983 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.088 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**3.481 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		8.8444	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.4386	km
	H	=	The fall in level from the critical point to the structure		0.22	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.656	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	90.21	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**11.17**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	3.081	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.983	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	3.481	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	11.170	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**11.170**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			4.622	cum/sec
	Area required to flow the Design Discharge			1.838	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.460	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**11.170 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 6+285

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment		306 m
Width of Catchment		195 m
Catchment Area of the Culvert		0.060 sq.km
Distance from critical point to the structure		0.3063 km
The fall in level from the critical point to the structure		0.15 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.060 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**2.295 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.060 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**1.526 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.060 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**2.353 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		5.9699	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.3063	km
	H	=	The fall in level from the critical point to the structure		0.15	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.498	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	99.75	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**8.3372**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	2.295	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.526	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	2.353	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	8.337	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**8.337**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			3.442	cum/sec
	Area required to flow the Design Discharge			1.372	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.343	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**8.337**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 6+494

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment		424 m
Width of Catchment		110 m
Catchment Area of the Culvert		0.047 sq.km
Distance from critical point to the structure		0.4241 km
The fall in level from the critical point to the structure		0.21 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.047 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**1.905 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.047 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**1.293 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.047 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**1.836 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		4.6563	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.4241	km
	H	=	The fall in level from the critical point to the structure		0.21	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.639	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	91.13	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**5.9409**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	1.905	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.293	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	1.836	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	5.941	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**5.941**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			2.857	cum/sec
	Area required to flow the Design Discharge			0.978	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.244	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**5.941**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 6+755

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment			301 m
Width of Catchment			220 m
Catchment Area of the Culvert			0.066 sq.km
Distance from critical point to the structure			0.3014 km
The fall in level from the critical point to the structure			0.15 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.066 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**2.487 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.066 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**1.639 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.066 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**2.618 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		6.6451	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.3014	km
	H	=	The fall in level from the critical point to the structure		0.15	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.492	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	100.17	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**9.3186**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	2.487	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.639	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	2.618	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	9.319	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**9.319**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			3.730	cum/sec
	Area required to flow the Design Discharge			1.534	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.383	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**9.319**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 7+205

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment		534 m
Width of Catchment		283 m
Catchment Area of the Culvert		0.151 sq.km
Distance from critical point to the structure		0.5343 km
The fall in level from the critical point to the structure		0.27 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.151 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**4.608 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.151 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**2.837 cum/sec**

3) By Ingli's Formula

$$Q3 = \frac{125M}{\sqrt{(M+10)}}$$

Where, M	=	The Catchment area in sq.km	0.151 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**5.933 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		15.123	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.5343	km
	H	=	The fall in level from the critical point to the structure		0.27	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.764	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	84.70	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**17.932**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	4.608	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	2.837	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	5.933	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	17.932	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**17.932**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			6.911	cum/sec
	Area required to flow the Design Discharge			2.951	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.738	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**17.932 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 7+532

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment			640 m
Width of Catchment			212 m
Catchment Area of the Culvert			0.136 sq.km
Distance from critical point to the structure			0.6399 km
The fall in level from the critical point to the structure			0.32 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.136 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**4.251 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.136 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**2.641 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.136 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**5.333 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		13.583	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.6399	km
	H	=	The fall in level from the critical point to the structure		0.32	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.878	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	79.57	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**15.13**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	4.251	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	2.641	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	5.333	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	15.130	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**15.130**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			6.377	cum/sec
	Area required to flow the Design Discharge			2.490	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.623	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**15.130 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 7+905

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		307	m
Width of Catchment		187	m
Catchment Area of the Culvert		0.057	sq.km
Distance from critical point to the structure		0.3069	km
The fall in level from the critical point to the structure		0.15	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.057	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**2.227**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.057	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**1.486**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.057	sq.km
	Q3	**= The peak run-off in m^3/sec**	**2.261**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		5.7359	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.3069	km
	H	=	The fall in level from the critical point to the structure		0.15	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.498	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	99.71	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**8.0066**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	2.227	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.486	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	2.261	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	8.007	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**8.007**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			3.340	cum/sec
	Area required to flow the Design Discharge			1.318	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.329	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**8.007**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 8+178

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		471	m
Width of Catchment		189	m
Catchment Area of the Culvert		0.089	sq.km
Distance from critical point to the structure		0.4712	km
The fall in level from the critical point to the structure		0.24	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.089	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**3.100**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.089	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**1.994**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.089	sq.km
	Q3	**= The peak run-off in m^3/sec**	**3.508**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		8.9139	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.4712	km
	H	=	The fall in level from the critical point to the structure		0.24	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.693	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	88.23	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**11.01**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	3.100	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.994	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	3.508	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	11.010	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**11.010**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			4.649	cum/sec
	Area required to flow the Design Discharge			1.812	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.453	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**11.010 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 8+450

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	3.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L	9	Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.000	m
h	= Opening/Driving Head	3.000	m
K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$	0.0118	
K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9705	
Q_{dc}	**= Discharge Capacity**	**67.016**	**cum/sec**

B) Design Discharge

Length of Catchment	340	m
Width of Catchment	155	m
Catchment Area of the Culvert	0.053	sq.km
Distance from critical point to the structure	0.3402	km
The fall in level from the critical point to the structure	0.17	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	= The Catchment area in sq.km	0.053	sq.km
C	= 14-19 where the annual rainfall is more than 120 cm	19	
Q1	**= The peak run-off in cum/sec**	**2.096**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	= The Catchment area in sq.km	0.053	sq.km
C	= 6.8 for area within 25 km of the coast	10.0	
	= 8.5 for area between 25 km to 160 km of the coast		
	= 10.0 for limited areas near the hill		
Q2	**= The peak run-off in m^3/sec**	**1.408**	**cum/sec**

3) By Ingli's Formula

$$Q3 = \frac{125M}{\sqrt{(M+10)}}$$

Where, M	= The Catchment area in sq.km	0.053	sq.km
Q3	**= The peak run-off in m^3/sec**	**2.086**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		5.2901	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.3402	km
	H	=	The fall in level from the critical point to the structure		0.17	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.540	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	97.04	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**7.1867**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	2.096	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.408	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	2.086	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	7.187	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**7.187**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			3.144	cum/sec
	Area required to flow the Design Discharge			0.965	Sqm
	Area of BOX when flow with full depth			9.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.107	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**67.016 cum/sec**	**>**	**7.187 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 8+725

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	5.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	15	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.364	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0134	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9697	
	Q_{dc}	**= Discharge Capacity**	**111.61**	**cum/sec**

B) Design Discharge

Length of Catchment		1607	m
Width of Catchment		583	m
Catchment Area of the Culvert		0.936	sq.km
Distance from critical point to the structure		1.607	km
The fall in level from the critical point to the structure		0.80	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.936	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**18.085**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.936	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**9.570**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.936	sq.km
	Q3	**= The peak run-off in m^3/sec**	**35.390**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		93.629	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		1.607	km
	H	=	The fall in level from the critical point to the structure		0.80	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		1.783	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	53.68	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**70.358**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	18.085	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	9.570	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	35.390	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	70.358	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**70.358**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			27.127	cum/sec
	Area required to flow the Design Discharge			9.456	Sqm
	Area of BOX when flow with full depth			15.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.630	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**111.6 cum/sec**	**>**	**70.358 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 8+880

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	5.000

Discharge Capacity through the pipe (Flowing full) is given by

$$\mathbf{Q = K \times A \times \sqrt{2 \times g \times h}}$$

Where, $K = 1/\sqrt{(1 + K_e + K_f)}$

$$Q = A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$$

Where	A	= Area of Box Culvert in Sqm = D*L	15	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.364	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0134	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9697	
	Q_{dc}	**= Discharge Capacity**	**111.61**	**cum/sec**

B) Design Discharge

Length of Catchment			1555	m
Width of Catchment			553	m
Catchment Area of the Culvert			0.861	sq.km
Distance from critical point to the structure			1.555	km
The fall in level from the critical point to the structure			0.78	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

$Q1 = CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.861	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**16.978**	**cum/sec**

2) By Ryve's Formula

$Q2 = CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.861	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**9.048**	**cum/sec**

3) By Ingli's Formula

$$\mathbf{Q3 = \frac{125M}{\sqrt{(M+10)}}}$$

Where,	M	= The Catchment area in sq.km	0.861	sq.km
	Q3	**= The peak run-off in m^3/sec**	**32.646**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		86.069	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		1.555	km
	H	=	The fall in level from the critical point to the structure		0.78	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		1.739	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	54.55	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**65.731**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	16.978	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	9.048	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	32.646	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	65.731	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**65.731**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			25.467	cum/sec
	Area required to flow the Design Discharge			8.834	Sqm
	Area of BOX when flow with full depth			15.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.589	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**111.61 cum/sec**	**>**	**65.731 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 9+155

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	3.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	9	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.000	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0118	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9705	
	Q_{dc}	**= Discharge Capacity**	**67.016**	**cum/sec**

B) Design Discharge

Length of Catchment	1498	m	
Width of Catchment	339	m	
Catchment Area of the Culvert	0.508	sq.km	
Distance from critical point to the structure	1.498	km	
The fall in level from the critical point to the structure	0.75	m	

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.508	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**11.433**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.508	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**6.365**	**cum/sec**

3) By Ingli's Formula

$$Q3 = \frac{125M}{\sqrt{(M+10)}}$$

Where,	M	= The Catchment area in sq.km	0.508	sq.km
	Q3	**= The peak run-off in m^3/sec**	**19.589**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		50.799	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		1.498	km
	H	=	The fall in level from the critical point to the structure		0.75	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		1.689	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	55.55	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**39.506**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	11.433	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	6.365	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	19.589	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	39.506	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**39.506**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			17.149	cum/sec
	Area required to flow the Design Discharge			5.306	Sqm
	Area of BOX when flow with full depth			9.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.590	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**67.016 cum/sec**	**>**	**39.506 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 9+285

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	3.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	9	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.000	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0118	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9705	
	Q_{dc}	**= Discharge Capacity**	**67.016**	**cum/sec**

B) Design Discharge

Length of Catchment	1475	m	
Width of Catchment	354	m	
Catchment Area of the Culvert	0.522	sq.km	
Distance from critical point to the structure	1.475	km	
The fall in level from the critical point to the structure	0.74	m	

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.522	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**11.672**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.522	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**6.484**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.522	sq.km
	Q3	**= The peak run-off in m^3/sec**	**20.124**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		52.222	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		1.475	km
	H	=	The fall in level from the critical point to the structure		0.74	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		1.669	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	55.97	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**40.917**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	11.672	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	6.484	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	20.124	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	40.917	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**40.917**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			17.508	cum/sec
	Area required to flow the Design Discharge			5.495	Sqm
	Area of BOX when flow with full depth			9.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.611	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**67.016 cum/sec**	**>**	**40.917 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 9+534

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	3.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	9	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.000	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0118	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9705	
	Q_{dc}	**= Discharge Capacity**	**67.016**	**cum/sec**

B) Design Discharge

Length of Catchment	1290	m	
Width of Catchment	291	m	
Catchment Area of the Culvert	0.375	sq.km	
Distance from critical point to the structure	1.29	km	
The fall in level from the critical point to the structure	0.65	m	

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.375	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**9.109**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.375	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**5.201**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.375	sq.km
	Q3	**= The peak run-off in m^3/sec**	**14.562**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		37.525	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		1.29	km
	H	=	The fall in level from the critical point to the structure		0.65	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		1.506	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	59.62	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**31.322**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	9.109	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	5.201	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	14.562	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	31.322	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**31.322**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			13.664	cum/sec
	Area required to flow the Design Discharge			4.206	Sqm
	Area of BOX when flow with full depth			9.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.467	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**67.016 cum/sec**	**>**	**31.322 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 9+713

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	3.000

Discharge Capacity through the pipe (Flowing full) is given by

$$\mathbf{Q = K \times A \times \sqrt{2 \times g \times h}}$$

Where, $K = 1/\sqrt{(1 + K_e + K_f)}$

$$Q = A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$$

Where	A	= Area of Box Culvert in Sqm = D*L	9	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.000	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0118	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9705	
	Q_{dc}	**= Discharge Capacity**	**67.016**	**cum/sec**

B) Design Discharge

Length of Catchment	1186	m	
Width of Catchment	256	m	
Catchment Area of the Culvert	0.303	sq.km	
Distance from critical point to the structure	1.186	km	
The fall in level from the critical point to the structure	0.59	m	

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

$Q1 = CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.303	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**7.763**	**cum/sec**

2) By Ryve's Formula

$Q2 = CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.303	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**4.511**	**cum/sec**

3) By Ingli's Formula

$$\mathbf{Q3 = \frac{125M}{\sqrt{(M+10)}}}$$

Where,	M	= The Catchment area in sq.km	0.303	sq.km
	Q3	**= The peak run-off in m^3/sec**	**11.806**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		30.317	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		1.186	km
	H	=	The fall in level from the critical point to the structure		0.59	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		1.411	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	61.96	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**26.296**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	7.763	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	4.511	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	11.806	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	26.296	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**26.296**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			11.644	cum/sec
	Area required to flow the Design Discharge			3.531	Sqm
	Area of BOX when flow with full depth			9.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.392	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**67.016 cum/sec**	**>**	**26.296 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 9+822

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	3.000

Discharge Capacity through the pipe (Flowing full) is given by

$$Q = K \times A \times \sqrt{2 \times g \times h}$$

Where, $K = 1/\sqrt{(1 + K_e + K_f)}$

$$Q = A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$$

Where	A	= Area of Box Culvert in Sqm = D*L	9	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.000	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0118	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9705	
	Q_{dc}	**= Discharge Capacity**	**67.016**	**cum/sec**

B) Design Discharge

Length of Catchment	933	m	
Width of Catchment	397	m	
Catchment Area of the Culvert	0.371	sq.km	
Distance from critical point to the structure	0.9329	km	
The fall in level from the critical point to the structure	0.47	m	

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.371	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**9.024**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.371	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**5.158**	**cum/sec**

3) By Ingli's Formula

$$Q3 = \frac{125M}{\sqrt{(M+10)}}$$

Where,	M	= The Catchment area in sq.km	0.371	sq.km
	Q3	**= The peak run-off in m^3/sec**	**14.384**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		37.058	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.9329	km
	H	=	The fall in level from the critical point to the structure		0.47	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		1.173	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	68.74	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**35.666**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	9.024	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	5.158	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	14.384	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	35.666	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**35.666**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			13.537	cum/sec
	Area required to flow the Design Discharge			4.790	Sqm
	Area of BOX when flow with full depth			9.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.532	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**67.016 cum/sec**	**>**	**35.666 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 10+285

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		729	m
Width of Catchment		272	m
Catchment Area of the Culvert		0.198	sq.km
Distance from critical point to the structure		0.7292	km
The fall in level from the critical point to the structure		0.36	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.198	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**5.645**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.198	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**3.398**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.198	sq.km
	Q3	**= The peak run-off in m^3/sec**	**7.761**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		19.827	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.7292	km
	H	=	The fall in level from the critical point to the structure		0.36	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.970	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	75.82	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**21.045**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	5.645	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	3.398	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	7.761	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	21.045	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**21.045**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			8.468	cum/sec
	Area required to flow the Design Discharge			3.464	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.866	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**21.045 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 10+527

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment			1019 m
Width of Catchment			163 m
Catchment Area of the Culvert			0.166 sq.km
Distance from critical point to the structure			1.019 km
The fall in level from the critical point to the structure			0.51 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.166 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**4.943 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.166 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**3.020 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.166 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**6.512 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		16.61	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		1.019	km
	H	=	The fall in level from the critical point to the structure		0.51	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		1.256	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	66.23	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**15.401**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	4.943	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	3.020	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	6.512	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	15.401	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**15.401**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			7.415	cum/sec
	Area required to flow the Design Discharge			2.535	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.634	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**15.401 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 10+720

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		396	m
Width of Catchment		205	m
Catchment Area of the Culvert		0.081	sq.km
Distance from critical point to the structure		0.3958	km
The fall in level from the critical point to the structure		0.20	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.081	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**2.889**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.081	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**1.873**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.081	sq.km
	Q3	**= The peak run-off in m^3/sec**	**3.195**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		8.1162	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.3958	km
	H	=	The fall in level from the critical point to the structure		0.20	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.606	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	93.01	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**10.569**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	2.889	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.873	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	3.195	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	10.569	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**10.569**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			4.334	cum/sec
	Area required to flow the Design Discharge			1.739	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.435	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**10.569 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 10+870

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		544	m
Width of Catchment		203	m
Catchment Area of the Culvert		0.110	sq.km
Distance from critical point to the structure		0.5439	km
The fall in level from the critical point to the structure		0.27	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.110	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**3.637**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.110	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**2.298**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.110	sq.km
	Q3	**= The peak run-off in m^3/sec**	**4.336**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		11.031	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.5439	km
	H	=	The fall in level from the critical point to the structure		0.27	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.774	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	84.20	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**13.002**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	3.637	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	2.298	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	4.336	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	13.002	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**13.002**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			5.455	cum/sec
	Area required to flow the Design Discharge			2.140	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.535	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**13.002 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 11+100

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment			573	m
Width of Catchment			164	m
Catchment Area of the Culvert			0.094	sq.km
Distance from critical point to the structure			0.5729	km
The fall in level from the critical point to the structure			0.29	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.094	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**3.218**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.094	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**2.061**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.094	sq.km
	Q3	**= The peak run-off in m^3/sec**	**3.686**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		9.3693	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.5729	km
	H	=	The fall in level from the critical point to the structure		0.29	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.806	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	82.73	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**10.851**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	3.218	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	2.061	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	3.686	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	10.851	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**10.851**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			4.826	cum/sec
	Area required to flow the Design Discharge			1.786	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.446	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**10.851 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 11+810

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		468	m
Width of Catchment		141	m
Catchment Area of the Culvert		0.066	sq.km
Distance from critical point to the structure		0.4677	km
The fall in level from the critical point to the structure		0.23	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.066	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**2.471**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.066	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**1.630**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.066	sq.km
	Q3	**= The peak run-off in m^3/sec**	**2.596**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		6.5883	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.4677	km
	H	=	The fall in level from the critical point to the structure		0.23	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.689	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	88.43	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**8.1566**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	2.471	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.630	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	2.596	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	8.157	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**8.157**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			3.706	cum/sec
	Area required to flow the Design Discharge			1.342	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.336	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**8.157**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 12+005

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		386	m
Width of Catchment		218	m
Catchment Area of the Culvert		0.084	sq.km
Distance from critical point to the structure		0.3863	km
The fall in level from the critical point to the structure		0.19	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.084	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**2.966**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.084	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**1.917**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.084	sq.km
	Q3	**= The peak run-off in m^3/sec**	**3.309**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		8.4062	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.3863	km
	H	=	The fall in level from the critical point to the structure		0.19	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.595	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	93.67	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**11.023**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	2.966	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.917	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	3.309	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	11.023	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**11.023**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			4.449	cum/sec
	Area required to flow the Design Discharge			1.814	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.454	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**11.023 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 12+158

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		487	m
Width of Catchment		255	m
Catchment Area of the Culvert		0.124	sq.km
Distance from critical point to the structure		0.4871	km
The fall in level from the critical point to the structure		0.24	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.124	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**3.971**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.124	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**2.485**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.124	sq.km
	Q3	**= The peak run-off in m^3/sec**	**4.873**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		12.404	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.4871	km
	H	=	The fall in level from the critical point to the structure		0.24	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.711	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	87.30	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**15.16**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	3.971	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	2.485	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	4.873	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	15.160	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**15.160**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			5.957	cum/sec
	Area required to flow the Design Discharge			2.495	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.624	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**15.160 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 12+318

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		575	m
Width of Catchment		203	m
Catchment Area of the Culvert		0.117	sq.km
Distance from critical point to the structure		0.5751	km
The fall in level from the critical point to the structure		0.29	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.117	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**3.790**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.117	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**2.384**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.117	sq.km
	Q3	**= The peak run-off in m^3/sec**	**4.580**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		11.655	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.5751	km
	H	=	The fall in level from the critical point to the structure		0.29	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.808	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	82.62	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**13.481**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	3.790	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	2.384	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	4.580	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	13.481	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**13.481**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			5.685	cum/sec
	Area required to flow the Design Discharge			2.219	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.555	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**13.481 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 12+435

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	4.000
Width of Box Culvert Culvert (m)	L	=	6.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	24	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.714	m
	h	= Opening/Driving Head	4.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0121	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9703	
	Q_{dc}	**= Discharge Capacity**	**206.33**	**cum/sec**

B) Design Discharge

Length of Catchment		1021	m
Width of Catchment		579	m
Catchment Area of the Culvert		0.592	sq.km
Distance from critical point to the structure		1.021	km
The fall in level from the critical point to the structure		0.51	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.592	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**12.817**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.592	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**7.046**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.592	sq.km
	Q3	**= The peak run-off in m^3/sec**	**22.723**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		59.162	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		1.021	km
	H	=	The fall in level from the critical point to the structure		0.51	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		1.258	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	66.17	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**54.811**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	12.817	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	7.046	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	22.723	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	54.811	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**54.811**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			19.226	cum/sec
	Area required to flow the Design Discharge			6.375	Sqm
	Area of BOX when flow with full depth			24.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.266	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**206.33 cum/sec** >	**54.811**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 12+600

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment			470 m
Width of Catchment			193 m
Catchment Area of the Culvert			0.090 sq.km
Distance from critical point to the structure			0.4697 km
The fall in level from the critical point to the structure			0.23 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.090 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**3.134 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.090 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**2.014 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.090 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**3.560 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		9.0472	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.4697	km
	H	=	The fall in level from the critical point to the structure		0.23	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.692	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	88.31	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**11.186**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	3.134	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	2.014	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	3.560	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	11.186	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**11.186**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			4.701	cum/sec
	Area required to flow the Design Discharge			1.841	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.460	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**11.186 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 12+685

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment			596 m
Width of Catchment			216 m
Catchment Area of the Culvert			0.129 sq.km
Distance from critical point to the structure			0.5961 km
The fall in level from the critical point to the structure			0.30 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.129 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**4.079 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.129 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**2.545 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.129 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**5.049 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		12.855	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.5961	km
	H	=	The fall in level from the critical point to the structure		0.30	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.831	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	81.59	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**14.685**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	4.079	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	2.545	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	5.049	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	14.685	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**14.685**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			6.119	cum/sec
	Area required to flow the Design Discharge			2.417	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.604	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**14.685 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 12+788

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment			492 m
Width of Catchment			120 m
Catchment Area of the Culvert			0.059 sq.km
Distance from critical point to the structure			0.4919 km
The fall in level from the critical point to the structure			0.25 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.059 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**2.280 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.059 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**1.518 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.059 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**2.333 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		5.9203	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.4919	km
	H	=	The fall in level from the critical point to the structure		0.25	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.717	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	87.03	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**7.2131**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	2.280	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.518	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	2.333	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	7.213	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**7.213**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			3.421	cum/sec
	Area required to flow the Design Discharge			1.187	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.297	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**7.213**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 12+883

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		416	m
Width of Catchment		147	m
Catchment Area of the Culvert		0.061	sq.km
Distance from critical point to the structure		0.416	km
The fall in level from the critical point to the structure		0.21	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.061	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**2.333**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.061	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**1.548**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.061	sq.km
	Q3	**= The peak run-off in m^3/sec**	**2.404**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		6.1014	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.416	km
	H	=	The fall in level from the critical point to the structure		0.21	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.630	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	91.66	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**7.8297**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	2.333	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.548	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	2.404	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	7.830	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**7.830**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			3.499	cum/sec
	Area required to flow the Design Discharge			1.289	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.322	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**7.830**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 13+030

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	3.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	9	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.000	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$	0.0118	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9705	
	Q_{dc}	**= Discharge Capacity**	**67.016**	**cum/sec**

B) Design Discharge

	Length of Catchment		420	m
	Width of Catchment		273	m
	Catchment Area of the Culvert		0.115	sq.km
	Distance from critical point to the structure		0.4203	km
	The fall in level from the critical point to the structure		0.21	m
	(Note: Country Slope has been considered as 1 in 1000)			

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.115	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**3.750**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.115	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**2.362**	**cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where,	M	= The Catchment area in sq.km	0.115	sq.km
	Q3	**= The peak run-off in m^3/sec**	**4.517**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		11.492	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.4203	km
	H	=	The fall in level from the critical point to the structure		0.21	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.635	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	91.38	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**14.701**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	3.750	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	2.362	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	4.517	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	14.701	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**14.701**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			5.625	cum/sec
	Area required to flow the Design Discharge			1.974	Sqm
	Area of BOX when flow with full depth			9.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.219	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**67.016 cum/sec**	**>**	**14.701 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 13+267

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment		332	m
Width of Catchment		174	m
Catchment Area of the Culvert		0.058	sq.km
Distance from critical point to the structure		0.3323	km
The fall in level from the critical point to the structure		0.17	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.058	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**2.239**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.058	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**1.493**	**cum/sec**

3) By Ingli's Formula

$$Q3 = \frac{125M}{\sqrt{(M+10)}}$$

Where,	M	= The Catchment area in sq.km	0.058	sq.km
	Q3	**= The peak run-off in m^3/sec**	**2.277**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		5.778	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.3323	km
	H	=	The fall in level from the critical point to the structure		0.17	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.530	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	97.66	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**7.8996**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	2.239	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.493	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	2.277	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	7.900	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**7.900**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			3.359	cum/sec
	Area required to flow the Design Discharge			1.300	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.325	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**7.900 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 13+518

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	3.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	9	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.000	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0118	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9705	
	Q_{dc}	**= Discharge Capacity**	**67.016**	**cum/sec**

B) Design Discharge

Length of Catchment	889	m	
Width of Catchment	430	m	
Catchment Area of the Culvert	0.382	sq.km	
Distance from critical point to the structure	0.8887	km	
The fall in level from the critical point to the structure	0.44	m	

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.382	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**9.232**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.382	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**5.263**	**cum/sec**

3) By Ingli's Formula

$$Q3 = \frac{125M}{\sqrt{(M+10)}}$$

Where,	M	= The Catchment area in sq.km	0.382	sq.km
	Q3	**= The peak run-off in m^3/sec**	**14.819**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		38.199	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.8887	km
	H	=	The fall in level from the critical point to the structure		0.44	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		1.130	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	70.13	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**37.507**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	9.232	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	5.263	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	14.819	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	37.507	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**37.507**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			13.848	cum/sec
	Area required to flow the Design Discharge			5.037	Sqm
	Area of BOX when flow with full depth			9.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.560	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**67.016 cum/sec**	**>**	**37.507 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 13+928

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	3.000
Width of Box Culvert Culvert (m)	L	=	4.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	12	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	1.200	m
	h	= Opening/Driving Head	3.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = 0.00394 x L / $R^{1.25}$	0.0125	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9701	
	Q_{dc}	**= Discharge Capacity**	**89.325**	**cum/sec**

B) Design Discharge

Length of Catchment		945	m
Width of Catchment		460	m
Catchment Area of the Culvert		0.435	sq.km
Distance from critical point to the structure		0.9447	km
The fall in level from the critical point to the structure		0.47	m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.435	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**10.169**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.435	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**5.735**	**cum/sec**

3) By Ingli's Formula

$$Q3 = \frac{125M}{\sqrt{(M+10)}}$$

Where,	M	= The Catchment area in sq.km	0.435	sq.km
	Q3	**= The peak run-off in m^3/sec**	**16.814**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		43.452	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.9447	km
	H	=	The fall in level from the critical point to the structure		0.47	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		1.185	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	68.39	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**41.601**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	10.169	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	5.735	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	16.814	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	41.601	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**41.601**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			15.253	cum/sec
	Area required to flow the Design Discharge			5.589	Sqm
	Area of BOX when flow with full depth			12.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.466	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**89.325 cum/sec**	**>**	**41.601 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 14+180

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where A	= Area of Box Culvert in Sqm = D*L		4 Sqm
R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter		0.667 m
h	= Opening/Driving Head		2.000 m
K_e	= Entry Loss due to friction in box	U/S to D/S	0.050
K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$		0.0131
K	= $1/\sqrt{(1 + K_e + K_f)}$		0.9699
Q_{dc}	**= Discharge Capacity**		**24.305 cum/sec**

B) Design Discharge

Length of Catchment		326 m
Width of Catchment		234 m
Catchment Area of the Culvert		0.076 sq.km
Distance from critical point to the structure		0.3261 km
The fall in level from the critical point to the structure		0.16 m

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where, M	=	The Catchment area in sq.km	0.076 sq.km
C	=	14-19 where the annual rainfall is more than 120 cm	19
Q1	**=**	**The peak run-off in cum/sec**	**2.756 cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where, M	=	The Catchment area in sq.km	0.076 sq.km
C	=	6.8 for area within 25 km of the coast	10.0
	=	8.5 for area between 25 km to 160 km of the coast	
	=	10.0 for limited areas near the hill	
Q2	**=**	**The peak run-off in m^3/sec**	**1.796 cum/sec**

3) By Ingli's Formula

Q3 = $\frac{125M}{\sqrt{(M+10)}}$

Where, M	=	The Catchment area in sq.km	0.076 sq.km
Q3	**=**	**The peak run-off in m^3/sec**	**3.001 cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		7.6208	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.3261	km
	H	=	The fall in level from the critical point to the structure		0.16	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.522	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	98.14	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**10.471**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	2.756	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.796	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	3.001	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	10.471	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**10.471**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			4.134	cum/sec
	Area required to flow the Design Discharge			1.723	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.431	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**10.471 cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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Length : 15.30Km. (RHENOCK (KM 0.00) TO RONGLI BAZAAR (KM 15.300))

Hydraulic Design Sample Calculation for Box Culvert at Ch. 14+294

A) Capacity of Proposed Box Culvert

Height of Box Culvert	D	=	2.000
Width of Box Culvert Culvert (m)	L	=	2.000

Discharge Capacity through the pipe (Flowing full) is given by

Q = K x A x √2 x g x h

Where, K = $1/\sqrt{(1 + K_e + K_f)}$

Q = $A * 4.43 * \sqrt{(h/(1 + K_e + K_f)}$

Where	A	= Area of Box Culvert in Sqm = D*L	4	Sqm
	R	= Hydraulic Mean Radius = Water Section Area/Wetted Perimeter	0.667	m
	h	= Opening/Driving Head	2.000	m
	K_e	= Entry Loss due to friction in box U/S to D/S	0.050	
	K_f	= Head loss due to friction in pipe = $0.00394 \times L / R^{1.25}$	0.0131	
	K	= $1/\sqrt{(1 + K_e + K_f)}$	0.9699	
	Q_{dc}	**= Discharge Capacity**	**24.305**	**cum/sec**

B) Design Discharge

Length of Catchment	309	m	
Width of Catchment	184	m	
Catchment Area of the Culvert	0.057	sq.km	
Distance from critical point to the structure	0.3086	km	
The fall in level from the critical point to the structure	0.15	m	

(Note: Country Slope has been considered as 1 in 1000)

1) By Dicken's Formula

Q1 = $CM^{3/4}$

Where,	M	= The Catchment area in sq.km	0.057	sq.km
	C	= 14-19 where the annual rainfall is more than 120 cm	19	
	Q1	**= The peak run-off in cum/sec**	**2.206**	**cum/sec**

2) By Ryve's Formula

Q2 = $CM^{2/3}$

Where,	M	= The Catchment area in sq.km	0.057	sq.km
	C	= 6.8 for area within 25 km of the coast	10.0	
		= 8.5 for area between 25 km to 160 km of the coast		
		= 10.0 for limited areas near the hill		
	Q2	**= The peak run-off in m^3/sec**	**1.474**	**cum/sec**

3) By Ingli's Formula

$$\mathbf{Q3} = \frac{\mathbf{125M}}{\sqrt{\mathbf{(M+10)}}}$$

Where,	M	= The Catchment area in sq.km	0.057	sq.km
	Q3	**= The peak run-off in m^3/sec**	**2.233**	**cum/sec**

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	4)	**By Rational Formula**				
	Q4	**=**	**$0.028*P*A*I_c$**			
Where,	A	=	Area of catchment in Hectares		5.6655	ha
	F	=	Rain fall in cm dropped by severest strom in T hours		74.7	cm
	T	=	Time Period in hours		1	hour
	I_o	=	(F/2)*(1+1/T)		74.7	cm/hour
	L	=	Distance from critical point to the structure		0.3086	km
	H	=	The fall in level from the critical point to the structure		0.15	m
	t_c	=	$(0.87 \times L^3 / H)^{0.385}$		0.501	hour
	I_c	=	Critical Intensity of rainfall in cm per hour =	$I_0 (2/(t_c+1))$	99.56	cm/hour
	P	=	Co-efficient of run-off for the catchment characteristics		0.50	
	Q4	**=**	**Max run-off in m^3/sec**		**7.8972**	**cum/sec**

Result :

A)	**Design Discharge**				
1)	By Dicken's Formula	Q1	The peak run-off in m^3/sec	2.206	cum/sec
2)	By Ryve's Formula	Q2	The peak run-off in m^3/sec	1.474	cum/sec
3)	By Ingli's Formula	Q3	The peak run-off in m^3/sec	2.233	cum/sec
4)	By Rational Formula	Q4	Max run-off in m^3/sec	7.897	cum/sec
	Design Discharge = Maximum (Q1, Q2, Q3 & Q4)			**7.897**	**cum/sec**
	(Limited to 1.5 times of second highest Discharge)			3.310	cum/sec
	Area required to flow the Design Discharge			1.300	Sqm
	Area of BOX when flow with full depth			4.000	Sqm
	Number of Box Required to accomodate the Design Discharge			0.325	
B)	**Capacity of Proposed Box Culvert**				
	Discharge Capacity	**Q_{dc}**	**24.305 cum/sec**	**>**	**7.897**	**cum/sec**

Discharge Capacity of proposed culvert is greater than the design discharge.

So, Proposed Culvert is Safe

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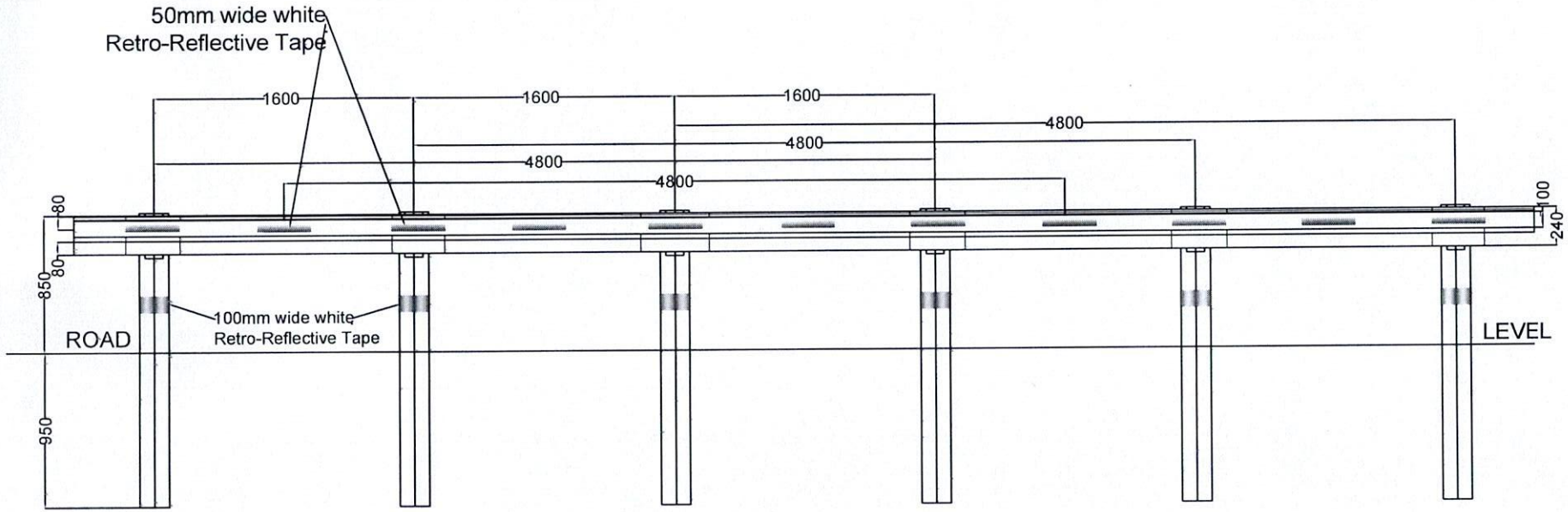
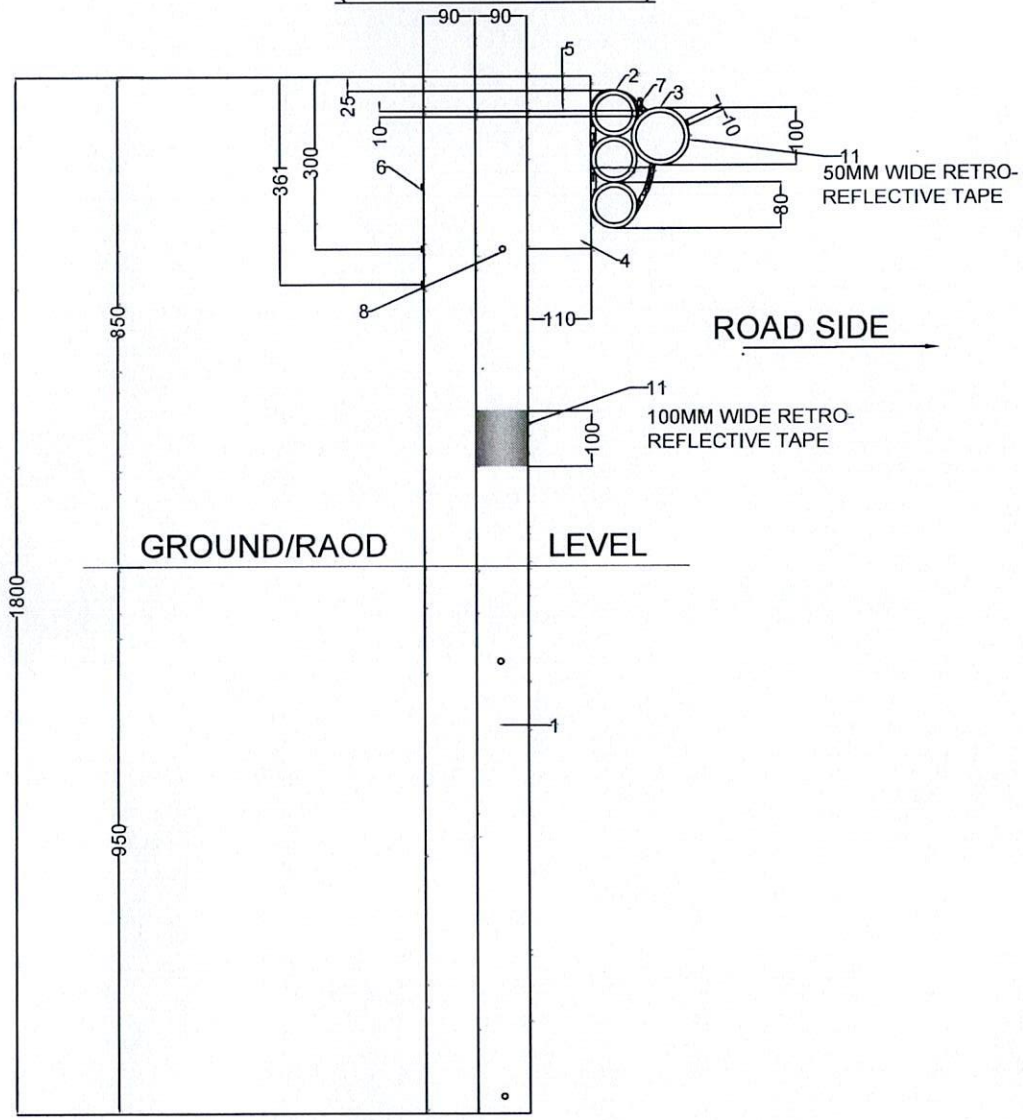
TYPICAL DRAWING OF BAHU-BALLI BAMBOO CRASH BARRIER (KOOCH KAVACH)



FRONT VIEW FROM ROAD SIDE

		NAME	DATE
BAHU-BALLI BAMBOO CRASH BARRIER	DRWN		
	CHKD		
	STRD		
	APPD		
SCALE 1:1		DRAWING NO.:	
		SHEET 1 OF 2	

TYPICAL DRAWING OF BAHU-BALLI BAMBOO CRASH BARRIER (KOOCH KAVACH)



SIDE VIEW

SECTIONAL LABEL	DESCRIPTION	DIA	LENGTH
1	POST ELEMENTS	90 MM	1800 MM
2	BEAM ELEMENTS	80 MM	4800 MM
3	FRONT CUSHIONING ELEMENT	100 MM	1422 MM
4	SPACER	110 MM	300 MM
5	BEAM- POST CONNECTOR	M10	360 MM
6	BEAM- SPACER- POST CONNECTOR	M10	280 MM
7	WIRE ROPE	8 MM	52000 MM
8	POST BOLTS	M10	190 MM
9	BEAM BOLTS	M10	250 MM
10	WASHER	10 MM	1.5 MM
11	WHITE RETRO-RFLECTIVE TAPE	-	50MM WIDE & 200 MM LONG ON FRONT BEAM AND 100 MM WIDE & 285 MM LONG ON CIRCUMFERENCE OF FRONT POSTS

BAHU-BALLI BAMBOO CRASH BARRIER

	NAME	DATE
DRWN		
CHKD		
STRD		
APPD		

SCALE 1:1

DRAWING NO.:

SHEET 2 OF 2