SHRI MATA VAISHNO DEVI SPACE RESEARCH GEOTECH. QUALITY CONTROL LAB

AN ISO 9001-2015 NABL CERTIFIED COMPANY. ESTED.1998

NABL ACCREDITED

SMVDSR GEOTECH RESEARCH & QUALITY CONTROL LAB PVT LTD.

MATERIAL TESTING LAB.
SMVDSR QCL
ESTED.1998

Member of:-1-Canada's Society of Petroleum and hydro Energy Geoscientist,
2- American Society for Testing and Material.
3- IPMS INDIA
4- American Society of Geology.

CARRYING OUT GEOTECHNICAL
INVESTIGATION
FOR

THE PROPOSED DESIGN CONSTRUCTION OF 50M SPAN PSC BOX GIRDER SUPERSTRUCTURE PERMANENT BRIDGE ON OPEN FOUNDATION OVER CHITANG KHOLA RIVER AT KM 24.900.

REPORTNO: -SMVDSR/5670703858/5212W/GTR

SUBMITTED TO

CLIENT: - CHIEF ENGINEER BRTF 87 RCC PROJECT SWASTIK.
CONTRACTOR: - M/S SHIVAM CONSTRUCTION ENTERPRISES PATNA.
CONSULTANT: -
M/s SMVDS GEOTECH RESEARCH & QUALITY CONTROL LAB. DEPARTMENT OF DEOLOGY (JAMMU DIVISION)
Life Member of

1. American Society of Testing and material. (ASTM)
2. Canada society of Petroleum Energy Geoscientist.
3. APP IPMS MUMBAI
4. Geological Society of Canada.
5. NABL ACCREDITED.
6. DRDO(SASE)
7. APPROVED BY ANTI CORRUPTION FOUNDATION OF INDIA FOR (THIRD PARTY INSPECTION)
8. APPROVED BY JAL SHAKTI PHE GROUNDWATER DEPARTMENT GOVT OF J&K UT FOR (THIRDPARTY INSPECTION)

An ISO 9001-2008, ISO 27035 NABL CERTIFIED COMPANY

CONTACT: -09419900222, 7006437406E.Mail info@smvdsr.in , smvdsr@gmail.com web. www.smvdsr.in

Checked by:-DR. NIRESHJOAT.
Approvedby:-CHIEFCONSULTANT(SMVDSRDEPTT.OFGEOLOGYANDDESIGNJAMMUDIVISION.
Geotech Scientist:-DRSRSINGH
Qualification: - MS (EE) M.Tech. Ph.D. in Geotech. MS, IPMS.
Class(A)Grade.
License/Regd.No:-54768/G

Specialistin:-Soil,Rock,MaterialLab.testing,underground,andsurface/foundationgeotechnicalengineeringConsultant, Rock and Soil Diamond core drilling/Sampling, Electrical and Structural Design Consultant ,Environmental air pollution ,Survey and DPR Consultants. Hydro power Solar power, Wind energy, Bridge and Highway ,Railway, Tunnels Consultants

DR SR SINGH
GEO-TECHNICAL CONSULTANTSMVD
QUALITY CONTROLL AB
JAMMU

IS STANDARD CODE APPLIED IN THIS GEOTECHNICALINVESTIGATIONREPORT

S.NO	TYPE OFTESTS	ISCODE.
	Drilling through percussion Boring 150mm dia Bore size.	IS:1892-1979PART-3.6.3
	Water absorption	IS:1124-1974
	Compressive strength	IS:1121-1974
	Moisture Content	IS:2720(Part-2)1973
	Specific Gravity	IS:2720(Part-21)
	Triaxial Shear Test	IS:2720(Part-11)1985
	Atterberg Limits	IS:2720(Part-5)1985
	Ground Water Condition	IS:1892-1979
	Collection of DS soil Samples	IS:1892-1979Part-6
	Collection of UD soil samples.	IS:1892-1979-Part6.1
	Standard Penetration tests (DCPT)	IS:2131-1963
	DCPT	IS:4968Part-II1976 re2007
	Geophysical, seismic and Electric Resistivity	IS:1892-1979Part-2.2.2.1Part2.2.3 and IS 1892-1979B-1and B-2.
	PLT (Plate Load Test)	(IS:1888-1982)

CONTEN

INTRODUCTION

The Geotechnical investigation is required for the purpose of designing an efficient and economical foundation of the Bridge structure, the knowledge of general geological characteristics, subsoil profile, its characteristics strength, compressibility and information about ground water table is an essential requirement.

The report presents the analysis of the test results, safe load bearing capacity soil profile and recommendations regarding type of foundation. The observed data of field investigations and laboratory tests are presented in tabular form and the same has been used to access the nature of soil and to evaluate the various soil parameters required for the design of foundations**.**

SCOPEOFWORK

1. SCOPE OFWORK:

As per the initial requirements for finding the characteristics of soil strata, based on extent of site and type of structures, the following scope for soil Investigation programmed is being requested -

A. Mobilization of Equipment and Personnel

B. Field Tests

a. Geophysical, seismic and Electric Resistivity Tests in the boreholes and Sampling / logging of bores @ 1.5m intervals up to15 m depth refusal whichever is earlier.

b. Collection of disturbed & undisturbed soil sample s for Laboratory testing. It needs to be representative to characterize all strata of soil to compare with Geophysical tests.

C. Laboratory Tests

Classification tests (Sieve Analysis, Atterberg Limits etc. as relevant) and Physical Properties tests on representative soil samples collected from boreholes. Identification of presence of deposit apart from normal soil.

D. Consultancy

a. Interpretation of tests results.
b. Recommendations on soil parameters.
c. Recommendation of type of foundations and allowable bearing pressure for the design of foundations.
d. Preparation & submission of a detailed report containing the following –

- Results of Field and laboratory tests
- Soil profile varying with depth at different locations
- Physical and Engineering properties of soils
- Design parameters required for Foundation design as per relevant IS codes
- Recommendations on type of foundations and allowable bearing pressure for the design of foundations.

FIELDINVESTIGATION
Method 1 applied at the test Location

Seismic methods are applied primarily in order to determine quasi-homogeneous zones according to parameters of fragmentation, physical and chemical weathering and deformability of Rock masses and cohesion and cohesionless soil. Applied seismic methods comprise sending impulses underground and registering the resulting refracted arrivals from subsurface interfaces on a number of receivers positioned on or near the surface of both abutments, Times elapsed from sending to receiving seismic waves depend on depths of studied structures and propagation velocities of seismic waves along paths of their propagation from the source to the refractor (or reflector) to the receiver.

This report is presents four tests of preparation of seismic sections as a basis for geotechnical design of foundations. All tests are presentations of an optimum program of exploratory boring supplemented by results of deep seismic refraction studies.

Results of geophysical investigations should be included in the data obtained by geological mapping, which will in correlation with drilling results complete the picture of geological structure of terrain and facilitate categorization of materials and rocks for the purpose of developing the Geotech-engineering and Hydrogeological profile as a base for designers in the project execution stage.

2.0 INTRODUCTION

This is prerequisite to design an efficient and economical foundation of the structures. The work of Geophysical Investigation such as seismic refraction test is entrusted to **M/s Shri Mata Vaishno Devi Space Research Geo Technical Engineering. Quality Control Lab. Jammu Division** to find out general geophysical characteristics, seismic refraction test, subsoil profile, its characteristics strength, compressibility and information about ground water table.

The observed data of field geophysical investigations and laboratory tests are presented and used to access the nature of subsoil strata and determination of seismic velocity waves and ERM (Electrical Resistivity Method) at both sides of the bridges, required for the design of foundations for the structures and thus the report presents the analysis of test results and recommendations regarding types of foundation and safe structure foundations.

The geophysical studies are measurements of physical quantities (resistance, speed of propagation of sound, density, magnetism, conductivity, etc.) aimed at identifying comprehensively the rock mass structure and Lithology characteristics to be used in geotechnical/ Geo physical studies, water investigations, etc. The big advantage of geophysical methods is that instruments are relatively inexpensive, and investigations are much faster and cheaper than conventional investigations - exploratory drilling.

The applied seismic methods comprise sending impulses underground and registering the consequent arrivals, refracted from subsurface interfaces by a number of detectors laid out at or near the surface. Under the influence of an external impulse, particles of matter in the underground move from their original positions toward each other and collide, and thereby transmit mechanical motion underground from one point to another. In other words, under the influence of an impulse, particles of matter in the underground begin to vibrate in the direction of seismic wave propagation, if waves are longitudinal or P-waves, or perpendicularly to this direction, in case of transverse or S-waves, while not changing their positions in the medium through which the elastic waves propagate and transmit mechanical energy from one point to another given in table -1 times elapsed from sending to receiving a seismic wave depend on depths of studied structures and velocities of propagation of seismic.

Waves along paths of their propagation from the source to refractor (or reflector) to receivers
To initiate mechanical force, explosives, hammer, weight drop or other source of impulse/ER are used. Successful application of seismic methods is based on the fact that underground layers have different elastic properties and density that directly depend on their Lithological composition. Analysis of thus changed properties of seismic waves therefore allows determining the tectonic structure of the underground, Lithological composition of underground strata, and in favorable circumstances also directly proposed bridge structures.

The x-t coordinate system, times of first arrivals of waves to individual geophones from the moment the wave was generated. The points in the diagram are connected, in an ideal case as in Figure 2, and represent two directions of which the first intersects the x-axis at the origin and has the equation:

$$t=(1/V1)x$$

While the second line has the equation:

$$t=(1/v)x+Io$$

From these equations we determine the velocities V1 and V2 of upper and lower seismic media, and calculate depth to first seismic discontinuity.

Also, by reading the values from the x-t diagram the depth to the layer can be calculated using the equation:-

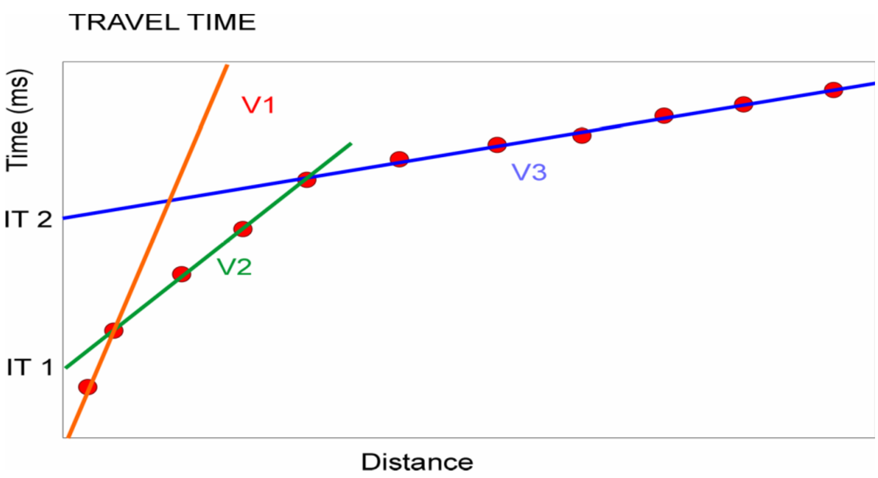
$$z_c = \frac{x_c}{2}\sqrt{\frac{V_2 - V_1}{V_2 + V_1}}$$

3.0 INTERPRETATION OF REFRACTION SEISMIC INVESTIGATIONS

Results of seismic refraction measurements are usually processed on personal computers using the GPR/GRM method according to Palmer (Generalized Reciprocal Method, Palmer, 1981 and 1991). Dromocrones of longitudinal waves are obtained by analyzing first arrivals of elastic waves.

A more detailed Lithological picture is obtained in combination with geological prospecting and drilling. When data are insufficient for the GRM method, it is possible to use the conventional intercept-time method (ITM) with lower accuracy.

The intercept-time method is based on the transformation of travel time of the refracted wave into the time intercept line (Ti line) for seismic boundaries with different velocity Vr. The transformation contains a reduction in travel time with the velocity Vr and refers to detectors. After the transformation, reverse and partially overlapping refraction with same boundaries should coincide with Ti lines. The method is used for determining the boundaries of layers (depth) and wave analysis [4].



SITE

THE PROPOSED CONSTRUCTION 50m Span PSC BOX GIRDER BRIDGE

The Proposed structures are proposed to design and construction of Open foundations. Thus A1 and A2 abutments are involved for seismic refraction geophysical and geological investigation.
Geological Characteristic.
The seismic refraction Geophysical investigations were carried out to predict the nature of stratification at the location of proposed site. General geological features evaluated based on preliminary reconnaissance surveys and secondary data pertaining to the site. The deposits at the test location conform blow NGL the residual / transported stream that come under recent period of geological formation. The sub-Soil stratum at proposed construction location generally comprises of silty sand with varying proportions of fine to coarse sand, gravels and Sandy boulders/rock.

5.0 GROUND WATER TABLE.

The seasonally seepage type ground water Table (GWT) was surveyed through GRE-1 at not founded up to 10 m depth.

5.1 DEVELOPMENT OF SEISMIC MODELS FOR GEOTECHNICAL DESIGN.

In the following, we have tested two sites for measure/surveyed of preparation of seismic sections as a basis for geotechnical design of foundations. Both tests are illustrations of optimum program of exploratory boring supplemented by results of deep seismic refraction studies, which largely satisfies geotechnical needs in conforming to construction design requirements. Besides, we should emphasize their big role, supported by other geophysical methods, in the preparation of prognostic engineering geophysical profiles in the stage of project design as well as remediation solutions during excavation and preparation for construction of foundations of structure.

Seismic geophysical surveys were conducted as part of geophysical investigation works at each abutment location of the bridge. The separated depth profile of the refraction section of the each abutments location contains interpretations of seismic recordings obtained by the inverse Delta-t-V method. Isoclines of longitudinal wave velocities are shown in the range 180-2575 m/s with the increment of 100 m/s. Illustrations are supplemented by Lithological description with the legend taken from the determination of the exploratory of open pit. The type and quality of rock/ soil is determined by this Lithological description, and is additionally spatially defined up to depths of approximately 15 meters by velocities of seismic waves. Fault zones and intervals of highly fractured sandy rock in the base are marked by dashed lines, table

The depth section shows the distribution of P-waves propagation velocities based on which the type and quality of the material in the shallow underground can be estimated, especially in the surface zone and upper weathering zone. Locations where larger fault systems were found and associated zones of wider fracture systems are marked by dots fill graphs lines on the seismic sections. Sandy rocks registered in the ground are occasionally accompanied by occurrences of tectonic breccias, which follow one another along the faults observed on the refraction sections. The geotechnical section made on the basis of geological mapping and seismic investigation data collected from the BH-1 and BH-2 at both Abutments and both sites is compared with the diagram of P-waves velocity pattern of the same site The diagram of velocity dependence on depth points at the conclusion that the subsurface is characterized by a thicker weathering zone, 2-8m meters. In connection with the occurrence of faults zones and developed fracture systems, intervals of fractured sandy rock mass with silty Sandy lyres presented at the left as well as right side of the Nallah In order to define Geomechanical properties of soil required for the construction of the bridge, geophysical investigations were carried out at the project site. Seismic studies were performed using the method of seismic refraction at two profiles in total.

Objective of the Seismic refraction investigation

The objective of these investigations was to determine the most accurate possible spatial distribution of Geomechanically media under the entire design structure and their Geomechanically properties. Data were digitally processed on a computer, and the results are time and depth sections along measurement lines for the total of two profiles. They define boundaries of zones with different Geomechanically properties underground available in this region and find the reasoning of soil stabilization.

The refraction seismic investigations defined zones with different elastic and Geomechanical properties Geomechanical properties, defined on the basis of recorded velocities of seismic (transverse and longitudinal) waves, are clearly indicative of medium- and high-bearing materials.

The obtained data indicate a relatively uniform Geomechanical structure of the terrain,

Geophysical Lithological Test Report table -1

SMVDSR GEOTECH RESEARCH AND QUALITY CONTROL LAB (Test result on the basic of Seismic Method)				
Applied Method as per IS 1892-1979 B-1				
Location:-			GPR Machine Used:-5422	
Project			**Radar Used**	**GPR Delta Forecast 3000.**
Depth(m)	Seismic ME	Velocity unit m/s	Compressibility	Lithology
1		2532		Fractured rock
2		2654		Fractured rock
3		2354		Fractured rock
4		2546		Fractured rock
5		2354		Fractured rock
6		4521		Fractured rock
7		4547		Fractured rock
8		2535		Fractured rock
9		2354		
10		2354		
				Fractured rock

SMVDSR GEOTECH RESEARCH AND QUALITY CONTROL LAB (Test result on the basic of Seismic Method)				
Applied Method as per IS 1892-1979 B-1				
Location: -			GPR Machine Used:-	
Project			**Radar Used**	**GPR Delta Forecast 3000.**
Depth(m)	Seismic ME	Velocity unit m/s	Compressibility	Lithology
1		3254		Fractured rock
2		3254		Fractured rock
3		3214		Fractured rock
4		2354		Fractured rock
5		2325		Fractured rock
6		2351		Fractured rock
7		2325		Fractured rock
8		2354		Fractured rock
9		2321		
10		235		
				Fractured rock

ANALYSISOFFOUNDATIONS:

The allowable bearing capacity of sub-soil strata for Isolated rect. Raft foundation have been computed from Resistivity v/s shear and settlement failure considerations as per IS: 6403-1981 & IS: 8009(Part-I)-1976.The details of foundation analysis a represented in the following paragraphs.

ISOLATED RAFT FOUNDATION

SHEARFAILURECONSIDERATION

The value of net safe bearing capacity of sub-soil strata has been estimated by considering shear failure using interpolation of the following equation for calculating the net ultimate bearing capacity:

$qd=C.N_cS_cxd_cxi_c +q\ x(N_q-1).s_qxd_qxi_q+1/2xrxBxN_rs_rxd_rxi_rxW^{\prime}$

$qd= 2/3\ xC.N^{\prime}_cS_cxd_cxi_c+q\ x(N^{\prime}_q-1).s_qxd_qxi_q+1/2xrxBxN^{\prime}_rs_rxd_rxi_rxW^{\prime}$ Inclination factors: i_r, i_q and i_r

have been takenas1.0.

The factor of safety has been considered as2.5.

The following least soil parameters were selected for calculations:-

$$BS_c=S_q=1+\frac{0.2}{L}$$

$$BS_r=1\ \frac{0.4}{L}$$

(For circular)

Depth Factors have been considered as under:-

$$d_c=1\ +0.2\ \frac{D_f}{B}\sqrt{N\Phi},$$

$$d_q=d_r=1+0.1\ \frac{D_f}{B}\sqrt{N\Phi},$$

$d_q=d_r=1.0, for \Phi<10deg.$

for Φ>10 deg.

EXAMPLE OF SAMPLE CALCULATIONS FOR COMPUTATION OF ALLOWABLE BEARING CAPACITY OF SUB-STRATA FOR RAFT FOUNDATION.

Thefollowingequationforcalculatingnetultimatebearingcapacity(ByInterpolationofgeneraland local shear failure)has been used:-

$qd = C.N_c S_c \times d_c \times i_c + q \times (N_q - 1).s_q \times d_q \times i_q + 1/2 \times r \times B \times N_r s_r \times d_r \times i_r \times W'$,

$q_d = 2/3\, C N'_c s_c d_c i_c + q\,(N'_q - 1) s_q d_q i_q + \frac{1}{2} \gamma B N'_\gamma s_\gamma d_\gamma i_\gamma W'$

Where:

N_c, N_q, N_r, N_c', N_q', N_r' = Bearing capacity factors

S_c, S_q, S_r = Shape factors

d_c, d_q, d_r = Depth factors

i_c, i_q, i_r = Inclination factors

c = Cohesion of soil

q = Overburden pressure

γ = Density of soil

B = Width of footing

W' = Water table correction factor

The parameters considered are:-

Size of foundation =1.2m

Depth of foundation from NGL = 15.0m

Water table correction factor has taken as 1.0

Factor ofs afety =2.5

The soil parameters considered for soil just below foundation are:

c =0.16 Kg/ cm^2

ø =27 °

γ =0.00189Kg/ cm^2

q =3.0 x0.189 =0.567Kg/ cm^2

Ø' =tan–1(2/3 tanø)=18.85°

Forø'=18.85°,

Considering General Shear failure

N_c'=13.945, N_q'=5.834, N_r' =4.760,

For circular footing shape factors: -

$S_c=S_q=1+\frac{0.2\,B}{L}$ =1.2

$S_r=1-\frac{0.4\,B}{L}$ =0.6

Depth factor = dc = 1 + 0.2 (D_f / B) √ $N_Ø$=

1.109[Where√ $N_Ø$=tan (45 +Ø/ 2)=1.627]

$d_q=d_\gamma$= 1.054

Inclination factors=i_c =i_q=i_γ=1.0
Now, using the above equation, the net ultimate bearing capacity: -

q_d=8.008 Kg/cm^2. =80.08 T / m^2

Thus, net safe bearing capacity =80.08/ 2.5 =32.03 T/ m^2

Settlement Failure Consideration:-

Allowable settlement considered=25,40 &50mm

Load intensity assumed (at the foundation depth) = 10.0T/m^2Depth of influence Zone below the foundation depth considered
=1.5 xB=1.5 x900 =1350 cm.

Layer wise following soil parameters were selected for analysis:-

Layer No.	Depth below existing ground level(m)	Layer Thickness (cm)	Effective layer thickness (cm)	Type of strata	SPT'N' Observed	SPT'N' corrected
1	0.0 – 3.00	300	300	Silty sand mixed	-	-
3	300 – 1000	700	700	Boulders gravels	100	100

The sub-soil strata within the zone of influence being coarse grained, the settlement of various layers below the foundation level and up to the zone of influence were computed by using the chart of settlement Vs SPT' N' given on page17 of IS:8009 (part-I)-1976.

As the curve is for maximum 60 SPT 'N' value and6.0mwidth we can consider the same For design purpose

Average corrected SPT 'N; value within the zone of

influence =100ForSPT 'N'=100 and load intensity of

$10 t/m^2$

Settlement = 4.8.0 mm, Applying rigidity factor as

0.8Settlement=4.8 x0.8 =3.84mm

Hence, net allowable bearing pressure for25mm settlement

$$\frac{10 \times 25}{3.84} = 65.10\ t/m^2$$

Net allowable bearing pressure for 40

mm settlement

$$= \frac{10 \times 40}{3.84} = 117.18\ t/m^2$$

Net allowable bearing pressure for 50

mm settlement

$$= \frac{10 \times 50}{3.84} = 130.20\ t/m^2$$

DR SR SINGH
GEO-TECHNICAL CONSULTANT
SMVDSR (JAMMU)

SMAPLE CALCULATION FOR A1

Design of Shallow Foundation in Soil

Estimation of Allowable Safe Bearing Capacity of "Open Foundation"

[As per IS : 6403, IS : 8009 (Part I) and IRC : 78-2014]

Project	**THE PROPOSED DESIGN CONSTRUCTION OF 50M SPAN PSC BOX GIRDER SUPERSTRUCTURE PERMANENT BRIDGE ON OPEN FOUNDATION OVER CHITANG KHOLA RIVER AT KM 24.900.**
Structure	**Bridge**

Proposed Structure No.		Pier / Abutment No.	**1**
Location of Structure (Proposed Design Chainage in "km")	**24-900**	Based on Boreholes	**1**

A) FOUNDATION SOIL PARAMETERS :

Layer No	Description of Foundation Soil Layer	RL of Layer Top (m)	RL of Layer Bottom (m)	Thickness of Layer (m)	Total Unit Weight of Soil (t/m³)	Cohesion, c (t/m²)	Angle of Shearing Resistance, ϕ (deg)
1	Sand/Gravels Mix Boulders Fractured rock	0.000	-3.000	3.00	2.10	0.00	31.1
2	Sand/Gravels Mix Boulders Fractured rock	-3.000	-5.000	2.00	2.11	0.00	31.0

97.92

B) DETAILS OF DIFFERENT LEVELS : 39.16968318

1)	Proposed Finished Road Level	=	-	m	
2)	Affluxed Highest Flood Level (H.F.L.)	=	0.000	m	0
3)	River Bed / Stream Bed / Canal Bed / Ground Level	=	0.000	m	0.000
4)	Ground Water Level (G.W.L)	=	0.000	m	0
5)	Maximum Scour Level below bed level	=	0.000	m	
6)	Founding Level	=	-1.500	m	

C) STRUCTURAL PARAMETERS :

1)	Type of Foundation	=	RECT		
2)	Shape of Open Foundation	=	Rect		
3)	Dia of Well Foundation **(B)**	=	8.00	m	
4)			12.00	m	
5)	Depth of Base of Open Foundation below bed level **(D)**	=	1.50	m	**NOT OK as per IRC : 78**
6)	Depth of the G.W.L. from Channel Bed Level **(D_w)**	=	0.000	m	
7)	Angle of Inclination of Load to the Vertical **(α)**	=	0	deg.	

DR SR SINGH
GEO-TECHNICAL CONSULTANT
SMVDSR (JAMMU)

D) **SHEAR ZONE :**

1)	Depth of Shear Zone below the Foundation Base = **[0.50*B*tan(45 + ϕ / 2)]**	=	7.1	m
2)	Level of the Bottom of Shear Zone	=	-8.6	m

E) **DESIGNED END BEARING SOIL PARAMETERS :**

1)	Cohesion of End Bearing Soil Layer **(c_d)**	=	0.00	t/m^2
2)	Angle of Shearing Resistance of End Bearing Soil Layer **(ϕ_d)**	=	31.1	deg.
3)	Angle of Shearing Resistance of End Bearing Soil Layer **(ϕ_d)**	=	0.54	rad.
4)	Saturated Unit Weight of End Bearing Soil Layer **(γ_{satd})**	=	1.98	t/m^3
5)	Effective Unit Weight of End Bearing Soil Layer **(γ_{subd})**	=	0.98	t/m^3
6)	Effective Overburden Pressure at Base of Open Foundation **(q)**	=	1.65	t/m^2

F) **FAILURE TYPE :** **GENERAL SHEAR**

G) **DESIGN ANGLE OF SHEARING RESISTANCE :**

			For General Shear	For Local Shear	
1)	Angle of Shearing Resistance of End Bearing Soil Layer **(ϕ)**	=	31.10	Not Applicable	deg.
2)	Angle of Shearing Resistance of End Bearing Soil Layer **(ϕ)**	=	0.54	Not Applicable	rad.

H) **BEARING CAPACITY FACTORS :**

			For General Shear	For Local Shear
1)	N_c	=	32.67	Not Applicable
2)	N_q	=	20.63	Not Applicable
3)	N_γ	=	25.99	Not Applicable

I) **SHAPE FACTORS :**

					For General Shear	For Local Shear
1)	s_c	=	**[1+ 0.2*(B/L)]**	=	1.000	1.000
2)	s_q	=	**[1+ 0.2*(B/L)]**	=	1.000	1.000
3)	s_γ	=	**[1 - 0.4*(B/L)]**	=	0.600	0.600

J) **DEPTH FACTORS :**

				For General Shear	For Local Shear
1)	d_c =	**[1+ 0.2 * (D/B) * tan(π/4 + ϕ/2)]**	=	1.066	Not Applicable
2)	d_q =	**[1+ 0.1 * (D/B) * tan(π/4+ ϕ/2)]**	=	1.033	Not Applicable
3)	d_γ =	**[1+ 0.1 * (D/B) * tan(π/4+ ϕ/2)]**	=	1.033	Not Applicable

K) **INCLINATION FACTOR :**

DR SR SINGH
GEO-TECHNICAL CONSULTANT
SMVDSR (JAMMU)

					For General Shear	For Local Shear
1)	i_c	=	$[1 - (\alpha/90)]^2$	=	1.000	1.000
2)	i_q	=	$[1 - (\alpha/90)]^2$	=	1.000	1.000
3)	i_γ	=	$[1 - (\alpha/\phi)]^2$	=	1.000	Not Applicable

L) WATER TABLE FACTOR :

W' = 1.000

LOAD BEARING CAPACITY

A] Equations for Estimation of Net Ultimate Bearing Capacity

1.) General Shear Failure --------

$$Q_{nu} = [\, cN_c s_c d_c i_c + q(N_q - 1) s_q d_q i_q + (1/2) B \gamma N_\gamma s_\gamma d_\gamma i_\gamma W' \,]$$

cNcscdcic	0
q(Nq-1)sqdqiq	33.46644581
1/2ByNysydyiyW'	64.45776214
Qnu =	97.92420795

B] Estimation of Net Ultimate & Net Safe Bearing Capacity

NET ULTIMATE LOAD BEARING CAPACITY **(Q_{nu})** = 97.9 t/m^2

"FACTOR OF SAFETY" AGAINST NET ULTIMATE BEARING CAPACITY **(FOS)** = 2.5 **(As per IS 6403 & IRC 78)**

NET SAFE LOAD BEARING CAPACITY **(Q_{ns})**
[$Q_{ns} = Q_{nu}$ / FOS] = **39.2** **t/m^2**

DR SR SINGH
GEO-TECHNICAL CONSULTANT
SMVDSR (JAMMU)

Design of Shallow Foundation in Soil
Estimation of Allowable Safe Bearing Capacity of "Open Foundation"
[As per IS : 6403, IS : 8009 (Part I) and IRC : 78-2014]

Project	**THE PROPOSED DESIGN CONSTRUCTION OF 50M SPAN PSC BOX GIRDER SUPERSTRUCTURE PERMANENT BRIDGE ON OPEN FOUNDATION OVER CHITANG KHOLA RIVER AT KM 24.900.**
Structure	**BRIDGE**

Proposed Structure No.		Pier / Abutment No.	**2**
Location of Structure (Proposed Design Chainage in "km")	**24.900**	Based on Boreholes	**2**

A) FOUNDATION SOIL PARAMETERS :

Layer No	Description of Foundation Soil Layer	RL of Layer Top (m)	RL of Layer Bottom (m)	Thickness of Layer (m)	Total Unit Weight of Soil (t/m^3)	Cohesion, c (t/m^2)	Angle of Shearing Resistance, ϕ (deg)
1	Sand/Gravels Mix Boulders Fractured rock	0.000	-3.000	3.00	1.98	0.00	31.3
2	Sand/Gravels Mix Boulders Fractured rock	-3.000	-5.000	2.00	2.11	0.00	32.0

94.29

B) DETAILS OF DIFFERENT LEVELS : 37.71428537

1)	Proposed Finished Road Level	=	-	m	
2)	Affluxed Highest Flood Level (H.F.L.)	=	0.000	m	0
3)	River Bed / Stream Bed / Canal Bed / Ground Level	=	0.000	m	0.000
4)	Ground Water Level (G.W.L)	=	0.000	m	0
5)	Maximum Scour Level below bed level	=	0.000	m	
6)	Founding Level	=	-1.500	m	

C) STRUCTURAL PARAMETERS :

1)	Type of Foundation	=	RECT		
2)	Shape of Open Foundation	=	Rect		
3)	Sige of Foundation **(B)**	=	8.00	m	
4)			12.00	m	
5)	Depth of Base of Open Foundation below bed level **(D)**	=	1.50	m	**NOT OK as per IRC : 78**
6)	Depth of the G.W.L. from Channel Bed Level **(D_w)**	=	0.000	m	
7)	Angle of Inclination of Load to the Vertical **(α)**	=	0	deg.	

D) SHEAR ZONE :

DR SR SINGH
GEO-TECHNICAL CONSULTANT
SMVDSR (JAMMU)

1)	Depth of Shear Zone below the Foundation Base = **[0.50*B*tan(45 + ϕ / 2)]**	=	7.1	m
2)	Level of the Bottom of Shear Zone	=	-8.6	m

E) **DESIGNED END BEARING SOIL PARAMETERS :**

1)	Cohesion of End Bearing Soil Layer **(c_d)**	=	0.00	t/m^2
2)	Angle of Shearing Resistance of End Bearing Soil Layer **(ϕ_d)**	=	31.3	deg.
3)	Angle of Shearing Resistance of End Bearing Soil Layer **(ϕ_d)**	=	0.55	rad.
4)	Saturated Unit Weight of End Bearing Soil Layer **(γ_{satd})**	=	1.98	t/m^3
5)	Effective Unit Weight of End Bearing Soil Layer **(γ_{subd})**	=	0.98	t/m^3
6)	Effective Overburden Pressure at Base of Open Foundation **(q)**	=	1.47	t/m^2

F) **FAILURE TYPE :** **GENERAL SHEAR**

G) **DESIGN ANGLE OF SHEARING RESISTANCE :**

			For General Shear	For Local Shear	
1)	Angle of Shearing Resistance of End Bearing Soil Layer **(ϕ)**	=	31.30	Not Applicable	deg.
2)	Angle of Shearing Resistance of End Bearing Soil Layer **(ϕ)**	=	0.55	Not Applicable	rad.

H) **BEARING CAPACITY FACTORS :**

			For General Shear	For Local Shear
1)	N_c	=	32.67	Not Applicable
2)	N_q	=	20.63	Not Applicable
3)	N_γ	=	25.99	Not Applicable

I) **SHAPE FACTORS :**

					For General Shear	For Local Shear
1)	s_c	=	**[1+ 0.2*(B/L)]**	=	1.000	1.000
2)	s_q	=	**[1+ 0.2*(B/L)]**	=	1.000	1.000
3)	s_γ	=	**[1 - 0.4*(B/L)]**	=	0.600	0.600

J) **DEPTH FACTORS :**

				For General Shear	For Local Shear
1)	d_c =	**[1+ 0.2 * (D/B) * tan(π/4 + ϕ/2)]**	=	1.067	Not Applicable
2)	d_q =	**[1+ 0.1 * (D/B) * tan(π/4+ ϕ/2)]**	=	1.033	Not Applicable
3)	d_γ =	**[1+ 0.1 * (D/B) * tan(π/4+ ϕ/2)]**	=	1.033	Not Applicable

K) **INCLINATION FACTOR :**

For General Shear	For Local Shear

DR SR SINGH
GEO-TECHNICAL CONSULTANT
SMVDSR (JAMMU)

1)	i_c	=	$[1 - (\alpha/90)]^2$	=	1.000	1.000
2)	i_q	=	$[1 - (\alpha/90)]^2$	=	1.000	1.000
3)	i_γ	=	$[1 - (\alpha/\phi)]^2$	=	1.000	Not Applicable

L) **WATER TABLE FACTOR :**

W' = 1.000

LOAD BEARING CAPACITY

A] **Equations for Estimation of Net Ultimate Bearing Capacity**

1.) ***General Shear Failure --------***

$$Q_{nu} = [\, cN_c s_c d_c i_c + q(N_q - 1) s_q d_q i_q + (1/2) B\gamma N_\gamma s_\gamma d_\gamma i_\gamma W' \,]$$

cNcscdcic	0
q(Nq-1)sqdqiq	29.81947952
1/2ByNysydyiyW'	64.46623391
Qnu =	94.28571343

B] **Estimation of Net Ultimate & Net Safe Bearing Capacity**

NET ULTIMATE LOAD BEARING CAPACITY **(Q_{nu})** = 94.3 t/m^2

"FACTOR OF SAFETY" AGAINST NET ULTIMATE BEARING CAPACITY
(FOS) = 2.5 **(As per IS 6403 & IRC 78)**

NET SAFE LOAD BEARING CAPACITY **(Q_{ns})**
[$Q_{ns} = Q_{nu}$ / FOS] = **37.7** **t/m^2**

DR SR SINGH
GEO-TECHNICAL CONSULTANT
SMVDSR (JAMMU)

The allowable bearing capacity (column 5) will be taken as lower of the allowable bearing pressure as obtained by shear failure (column 3) and as obtained by settlement consideration (column 4).

BH NO A1

BH1

SIZE OF FOOTING (m)	Depth below proposed foundation level(m)	Allowable bearing Capacity (Shear Failure Criteria) t/sqm	Allowable bearing Pressure (40mm settlement) t/sqm	Net Allowable Bearing Capacity t/sqm
8.00x 12.00	1.5	97.9	**104.17**	39.16
8.00x 12.00	3	110.45		44.18
8.00x 12.00	4.5	123		49.2
8.00x 12.00	6	135.55		54.22
8.00x 12.00	7.5	148.1		59.24
8.00x 12.00	9	160.65		64.26
8.00x 12.00	10.5	173.2		69.28
8.00x 12.00	12	185.75		74.3
8.00x 12.00	13.5	198.3		79.32
8.00x 12.00	15	210.85		84.34
BH-2				
8.00x 12.00	1.5	94.3	**104.17**	37.72
8.00x 12.00	3	106.85		42.74
8.00x 12.00	4.5	119.4		47.76
8.00x 12.00	6	131.95		52.78
8.00x 12.00	7.5	144.5		57.8
8.00x 12.00	9	157.05		62.82
8.00x 12.00	10.5	169.6		67.84
8.00x 12.00	12	182.15		72.86
8.00x 12.00	13.5	194.7		77.88
8.00x 12.00	15	207.25		82.9

Shri Mata Vaishno Devi Space Research Geotech Engineer SMVDSR

DR SR SINGH
GEO-TECHNICAL CONSULTANT
SMVDSR (JAMMU)

COMMENTS AND SUGGESTIONS

a) The deposits of the test location confirm the residual weathered hill deposits which have come under recent period of geological formation. The substrata, generally, consists of sandy gravels, silty clay of low plasticity (CL) with boulders, silty clay mixture, of low plasticity (granular Material). The state of sub strata is noted to be in medium to hard state of compaction.

b) The ground water table (GWT) was not observed for BH1and 2

c) FOS (factor of safety 2.5 and water safety factor 0.5 has been applied for evaluation of the bearing capacity)

d) Minimum depth of footing is 2.5m has been assumed for Isolated Raft Footing.

e) Bearing capacity of explored strata at proposed construction location for various depths have been tabulated both based on shear considerations and also based on settlement criteria. However, safe bearing capacity recommended in our report shall be adopted for structural design. Suggested to the designer adopt the SCB and depth of footing as per structure load.

f) Given type of proposed structure and the materials encountered at shallow depths, use of isolated raft footing is recommended as a safe and viable foundation system.

g) Due care must be taken, not to lay the foundation directly on any loose / un-compacted location. It may be mentioned here that the adoption of a rigid footing shall ensure more uniform settlements and sufficient bridging over any potential loose/compressible soil pocket.

DR SR SINGH
GEO-TECHNICAL CONSULTANT
SMVDSR (JAMMU)

CLOSURE

We appreciate the opportunity given to us to submit this report. This presented report is based on observations and tests on samples collected from the boreholes as decided by the client. In case any difference is noticed in the field subsoil strata and reported subsoil strata during excavation please contact us before proceeding with further construction.

SHRI MATA VAISHNO DEVI SPACERESEARCH GEO TECHNICAL ENGINEERING

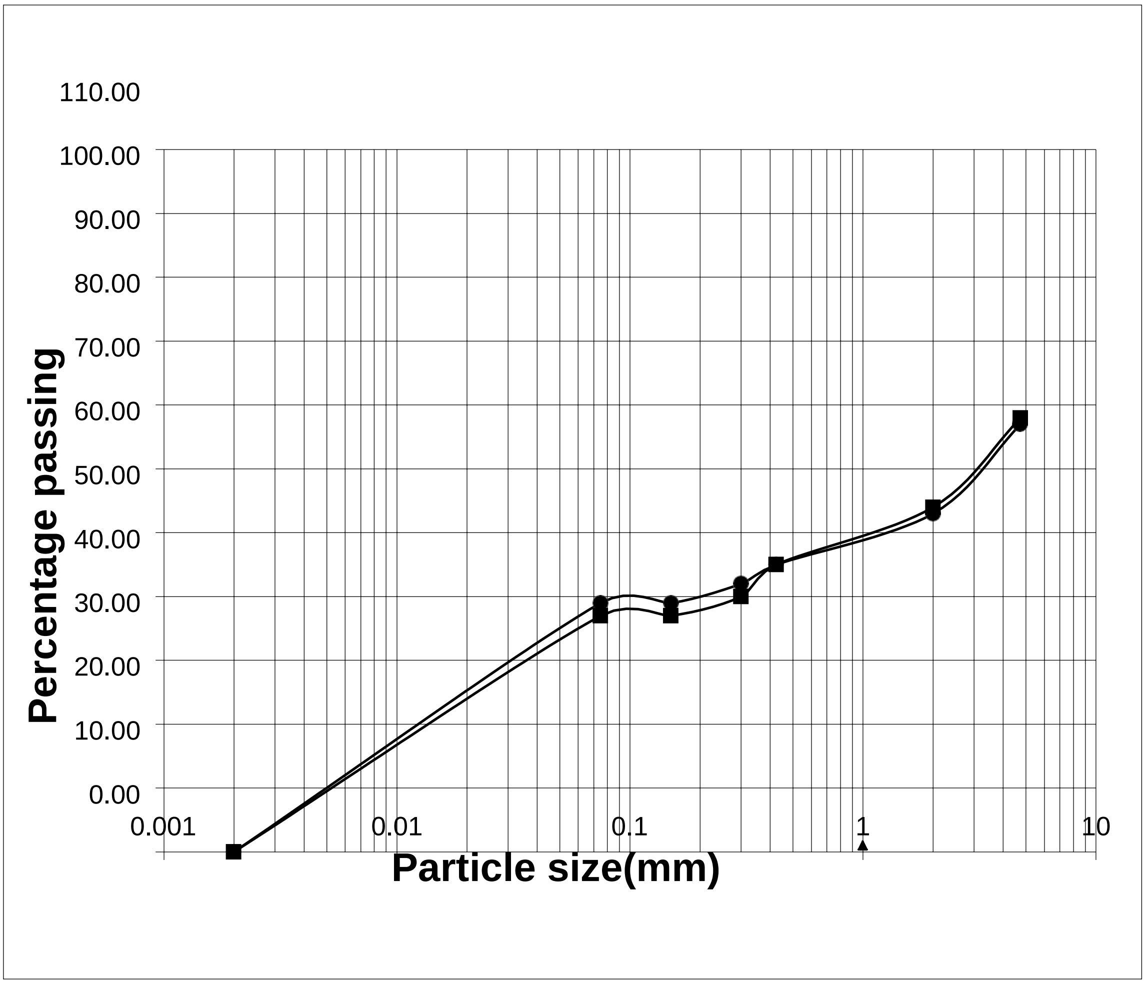
DR SR SINGH
GEO-TECHNICAL CONSULTANT
SMVDSR (JAMMU)

LAB TESTS

DR SR SINGH
GEO-TECHNICAL CONSULTANT
SMVDSR (JAMMU)

GRAINSIZE ANALYSIS

Bore hole No.:1



Symbol	Description of soil	Depth(m)	Gravel (%)	Sand (%)	Silt+Clay (%)
●	Sandy gravels mixed	1.50	33	28.0	39.0
■	Sandy gravels mixed	3.00	32	31.0	37.0

DR SR SINGH
GEO-TECHNICAL CONSULTANT
SMVDSR (JAMMU)

(mtr) : 3.00

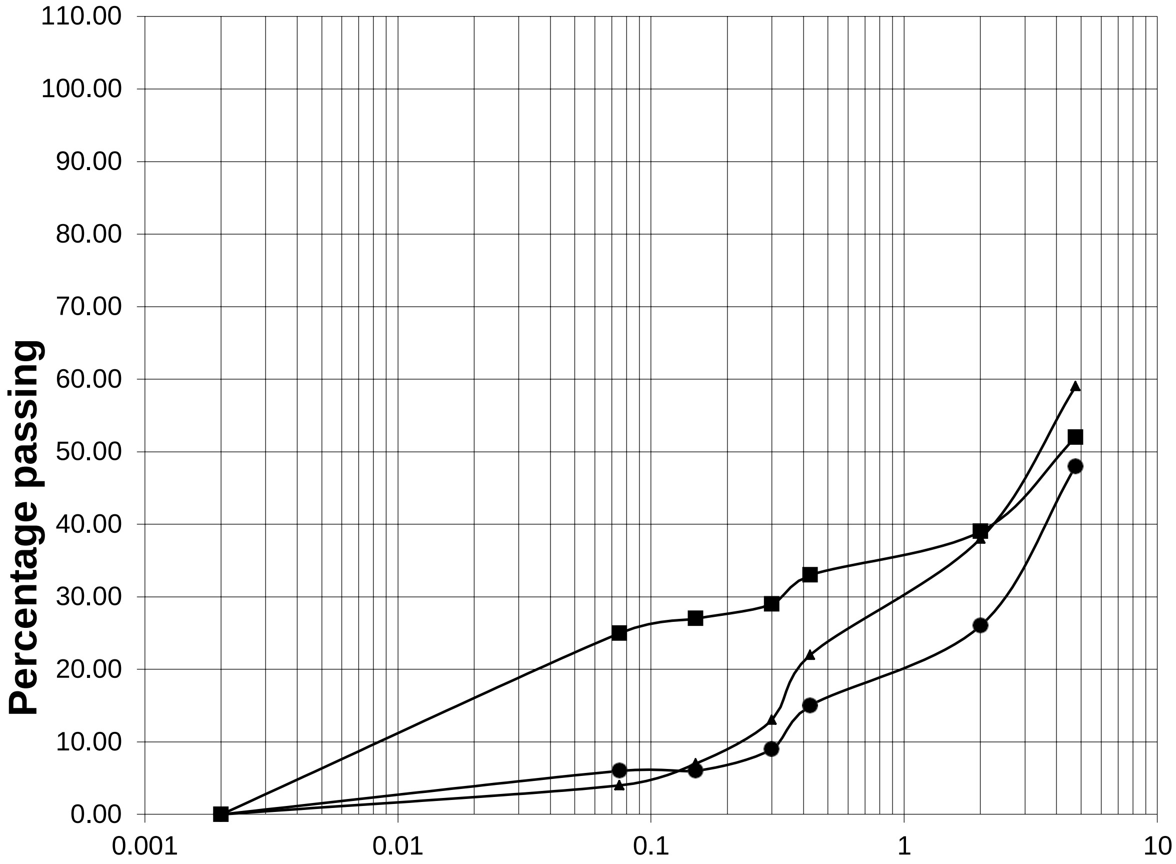
SIEVESIZE	WEIGHT OFSOILRET AINED	%RETAINED	CUMMULATIVE %RETAINED	%FINER
4.75	33.0	33	33.00	67.00
2	14.0	14	47	53.00
0.425	8.0	8	55	45.00
0.3	3.0	3	58	42.00
0.15	3.0	3	61	39.00
0.075	0.0	0	61	39.00
0.002				0

Shri Mata Vaishno Devi Space Research Geotech Engineer SMVDSR

DR SR SINGH
GEO-TECHNICAL CONSULTANT
SMVDSR (JAMMU)

GRAINSIZE ANALYSIS

Borehole No.: BH1



Symbol	Description of soil	Depth(m)	Gravel (%)	Sand (%)	Silt + Clay(%)
●	Silty Soil mixed with sand	1.5.00	52	42.0	6.0
■	Silty Soil mixed with sand	3.00	48	27.0	25.0
▲					

DR SR SINGH
GEO-TECHNICAL CONSULTANT
SMVDSR (JAMMU)

Bore hole No.:BH2

Depth (mtr) : 1.5

SIEVESIZE	WEIGHT OFSOILRETAINED	%RETAINED	CUMMULATIVE %RETAINED	%FINER
4.75	52.0	52	52.00	48.00
2	22.0	22	74	26.00
0.425	11.0	11	85	15.00
0.3	6.0	6	91	9.00
0.15	3.0	3	94	6.00
0.075	0.0	0	94	6.00
0.002				0

Depth(mtr) : 3.00

SIEVESIZE	WEIGHT OFSOILRETAINED	%RETAINED	CUMMULATIVE %RETAINED	%FINER
4.75	48.0	48	48.00	52.00
2	13.0	13	61	39.00
0.425	6.0	6	67	33.00
0.3	4.0	4	71	29.00
0.15	2.0	2	73	27.00
0.075	2.0	2	75	25.00
0.002				0

Shri Mata Vaishno Devi Space Research Geotech Engineer SMVDSR