डेडीकेटेड फ्रेट कोरीडोर

DESIGN AND CONSTRUCTION OF CIVIL, STRUCTURES AND TRACK WORKS FOR SINGLE LINE RAILWAY INVOLVING FORMATION IN EMBANKMENTS/CUTTINGS, BALLAST ON FORMATION, TRACK WORKS, BRIDGES, STRUCTURES, BUILDINGS, YARDS, INTEGRATION WITH IR EXISTING RAILWAY SYSTEM AND TESTING & COMMISSIONING ON DESIGN-BUILD LUMP SUM BASIS FOR SAHNEWAL - PILKHANI SECTION OF EASTERN DEDICATED FREIGHT CORRIDOR

Contract Package: 301

ICB No. HQ/EN/EC/D-B/SAHNEWAL - PILKHANI

PART - 4 - REFERENCE DOCUMENT

GEO TECH DATA - VOLUME - 3

SAHNEWAL TO PILKHANI

From Km. 360.200 to Km. 187.500

GEO TECH DATA

From Km. 316.000 to Km. 360.000

VOL 4/7

EMPLOYER

DEDICATED FREIGHT CORRIDOR CORPORATION OF INDIA LIMITED

(A GOVERNMENT OF INDIA ENTERPRISES)

MINISTRY OF RAILWAYS

COUNTRY : INDIA

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1	Introduction				2888-2901
Bridges Location					
2	170391	359/23-25	386	200	2902-2909
3	163211	352/21-23	383	197	2910-2919
4	162100	351/15-17	382	196	2920-2936
5	161267	350/19-21	380	194	2937-2946
6	160100	349/15-17	379	193	2947-2955
7	159390	348/25-27	377	191	2956-2968
8	156400	345/4-6	376A	190	2969-2980
9	151600	341/3-5	374	187	2981-2991
10	150823	340/7-9	372	185	2992-3000
11	148704	338/3-5	371	184	3001-3009
12	147247	336/20-22	370	183	3010-3018
13	146391	335/23-35	369-A	182	3019-3029
14	145145	334/16-18	369-A1	181	3030-3041
15	144042	333/15-17	369	180	3042-3052
16	143065	332/15-17	368	179	3053-3061
17	142637	332/1-3	367	178	3062-3072
18	138640	328/1-3	366-A	177	3073-3081
19	136620	326/1-3	365 A	175	3082-3090
20	136345	325/25-27	365	174	3091-3101
21	134319	323/23-25	364	173	3102-3113
22	132402	321/27-29	363	172	3114-3124
23	131393	320/25-27	362	171	3125-3139
24	128393	317/28-30	361		3140-3152
25	164575	353/35 - 354/4	385	199	3153-3195
26	130459	319/25-27	361A	170	3196-3218
27		316/22-24	359		3219-3238
Alignment					
28		358/1			3239-3247
29		357/1			3248-3256
30		356/1			3257-3265
31		355/0-1			3266-3274
32		347/1			3275-3283
33		347/25-27			3284-3292
34		346/1			3293-3301
35		344/1			3302-3310
36		343/1			3311-3319
37		342/1			3320-3328
38		339/1			3339-3337
39		337/1			3338-3346
40		331			3347-3355
41		330			3356-3364
42		329			3365-3375
43		327			3376-3386
44		324			3387-3400
45		322			3401-3411
46		318/26-28			3412-3422

DEDICATED FREIGHT CORRIDOR CORPORATION OF INDIA LTD.

(LUDHIANA TO AMBALA)

PART - I

RAILWAY KM. 360.00-316.00

SAHNEWAL (LUDHIANA) TO SIRHIND SECTION

DETAIL FOR DEPTH OF BOREHOLES			
	Minor Bridge :	276.00	m
	Major Bridge :	270.00	m
	Alignment :	228.00	m
	Total Depth :	774.00	m

CONTENTS

MINOR BRIDGES

MAJOR BRIDGES							
S.No	Chapter No.	Bridge No.	Location	Bore hole No.	Depth of Borehole (m)	Date	Page No.
24	25	385	353/35 354/4	A1	30.00	27.05.2009-28.05.2009	257 - 286
				P1	30.00	26.05.2009-27.05.2009	
				P4	30.00	29.05.2009-30.05.2009	
				A2	30.00	28.05.2009-29.05.2009	
25	26	361A	319/25-27	A1	30.00	06.06.2009-07.06.2009	287 - 309
				A2	30.00	07.06.2009	
26	27	359	316/22-24	A1	30.00	08.06.2009	310 - 329
				P2	30.00	08.06.2009-09.06.2009	
				A2	30.00	08.06.2009-09.06.2009	
Total Depth of Major Bridge(m)					270.00		

Alignment						
S.No	Chapter No.	Location	Bore hole No.	Depth of Borehole (m)	Date	Page No.
27	28	358/1	1	12.00	24.05.2009	330 - 338
28	29	357/1	1	12.00	24.05.2009	337 - 347
29	30	356/1	1	12.00	25.05.2009	348 - 356
30	31	355/0-1	1	12.00	25.05.2009	357 - 365
31	32	347/1	1	12.00	30.05.2009	366 - 374
32	33	347/25-27	1	12.00	30.05.2009	375 - 383
33	34	346/1	1	12.00	31.05.2009	384 - 392
34	35	344/1	1	12.00	31.05.2009	393 - 401
35	36	343/1	1	12.00	31.05.2009	402 - 410
36	37	342/1	1	12.00	01.06.2009	411 - 419
37	38	339/1	1	12.00	01.06.2009	420 - 429
38	39	337/1	1	12.00	02.06.2009	430 - 437
39	40	331	1	12.00	04.06.2009	438 - 446
40	41	330	1	12.00	04.06.2009	447 - 455
41	42	329	1	12.00	04.06.2009	456 - 466
42	43	327	1	12.00	05.09.2009	467 - 477
43	44	324	1	12.00	05.06.2009	478 - 491
44	45	322	1	12.00	06.06.2009	492 - 502
45	46	318/26-28	1	12.00	08.06.2009	503 - 513
			Total Depth of Alignment(m)	228.00		
			Grand Total	774.00		

CHAPTER-01

GENERAL INTRODUCTION
GEO-TECHNICAL INVESTIGATION REPORT

GEO-TECHNICAL INVESTIGATION REPORT

CHAPTER – 1

1.1 *INTRODUCTION*

The main function of a foundation is to distribute or transmit all the loads coming over it to the soil or ground upon which it rests.

The knowledge of the characteristics of underlying strata is therefore very essential for safe & economical design of foundations. The performance of supporting stratum depends upon the physical properties of subsoil, type & shape of footing & structure, water table depth etc.

It is therefore necessary to have sufficient information about the arrangement & behavior of the underlying materials and their physical properties, for adopting and designing the structural foundation. Soil exploration through field investigation and relevant laboratory testing of the substrata are essential to arrive at required parameter for designing of foundations.

1.2 *CLIENTAGE*

The work of Geo-technical investigation for Preparation of Detailed Project report for construction of Dedicated Freight Corridor from Kesri (Ambala) at Rly. Km 248.000 to Sahnewal (Ludhiana) at Rly. Km 360.000 in the State of Punjab was awarded to Consulting Engineers Group Ltd., Jaipur (Rajasthan) by DFCCIL, Ludhiana.

1.3 *LOCATION AND CHARACTERISTICS OF THE SITE*

Geo-technical investigation was carried out at the sites and locations approved by DFCCIL.

This covers from Sahnewal (Ludhiana) at Rly. Km 360.000 to Kesri (Ambala) at Rly. Km 248.000 in the State of Punjab.

1.4 *SCOPE OF WORK*

Field investigation at the site were planned to determine the required strength characteristics of the underlying soil/rock strata to design the foundation of the structure proposed to be constructed at various locations. The data obtained from these investigations have been analysed to arrive at the required parameters, for safe design of the foundation of structures.

In order to achieve the stated objectives, the stipulated scope of work, allotted to the consultants involved carrying out the following operations.

(i) Transportation of the personnel, plant and equipment to the site of work and with drawing the same on completion of work.

(ii) Drilling bore holes at the specified locations as approved by project co-ordination consultant and DFCCIL.

(iii) Conducting Standard Penetration Test in boreholes as per Indian Standard Specifications (IS-2131).

(iv) Collecting disturbed/undisturbed soil samples from the bore holes, sealing, numbering and preserving them as per the requirement.

(v) Carrying out following tests on the Soil specimen in order to establish their engineering characteristics.

- Sieve analysis
- Hydrometer analysis
- Natural moisture content
- Bulk density
- Specific gravity
- Atterberg limits
- Shear strength test
- Free Swell Index

(vi) Chemical analysis of soil and water samples.

(vii) Preparation of detailed investigation report

1.5 *FIELD INVESTIGATIONS*

The subsurface investigation of soil or rock strata in the field involves three basic operations: -

- Drilling
- Sampling
- Conducting field tests, followed by laboratory from the field tests on soil/rock samples retrieved from the field.

1.6 *INVESTIGATIONS OF SOILS STRATA*

1.6.1 *Drilling Bore Holes*

In soils, boreholes of diameter 100mm to 150mm were drilled with the help of a posthole auger. Power winch was used to drill the boreholes. The auger was pressed into the soil and twisted. Extension rods were connected to auger to increase the reach of auger inside the borehole, upto the required depth. Any loose soil was carefully removed from the bottom of the borehole so that the penetration test may be performed on undisturbed strata. Water table was recorded in each borehole

1.6.2 Sampling

The soil that was removed during drilling of boreholes was continuously examined for changes in the soil stratification at regular intervals and at levels where is change in soil type samples were collected for further testing in the laboratory. Disturbed soil samples were collected during drilling operation & from SPT tube. Undisturbed soil samples were collected at required depth in thin wall samples tubes according to IS 2132-1986.

The sampling tube was pushed into soil by continuous and rapid motion. The tube was then turned at least for two revolutions to shear the sample off at the bottom. Sampling tubes were waxed and sealed at both ends and carefully labeled and transported to laboratory for testing.

1.6.3 Standard Penetration Test

The standard penetration was conducted in boreholes (in soil) following the standard procedure as per IS 2131-1981which specifies the procedure for conducting SPT for soils. The test was carried out using the standard split spoon sampler to measure the number of blows 'N'.

Standard split spoon sampler was attached to a 'A' rod. It was driven into the soil to a distance of 45 cm using a standard hammer of 63.5 kg falling freely from a height of 75 cm to the required depth. While driving, the number of blows required to penetrate every 15 cm are recorded. The total number of blows required for the last 30 cm is taken as 'N' value at that particular depth of the borehole. This value is then used for calculating the allowable bearing pressure of the soil.

1.6.4 *Laboratory Tests for Soil*

Undisturbed soil samples were tested in the laboratory for determination of the following characteristics and properties.

- Shear strength
- Dry Density
- Bulk Density
- Natural Moisture Content

Other tests, which were conducted, are: -

- Sieve Analysis
- Hydrometer Analysis
- Atterberg Limit
- Specific Gravity test

The entire tests were conducted in accordance with the procedures prescribed in IS: 2720.

1.6.5 *Allowable Bearing Pressure*

Considering the proposed structure and taking into account the 'N' values, an allowable settlement of 25 mm has been adopted for evaluating the net allowable bearing capacity, based on the settlement criterion (IS 8009 Pt.1).

The method given by ***Peck, Hanson and Thorn burn*** procedure is also adopted. The average N values within the effective zone of pressure bulb up to 1.0 to1.5 times the width of foundation (B) have been considered for calculation.

While computing the average 'N' values (as per IRS "code of practice for the design of sub-structures and foundations of Bridges" IS; 6403-1981), then any individual value more than 50% greater than the average shall be neglected but the N values for loose seams shall be included.

Net safe bearing capacity as per Peck, et, al.:

$$q_{set} = 0.044\ Nn\ C_w\ S$$

Where

q_{set} = Net allowable Bearing Capacity for a given allowable settlement(t/m^2)

N_n = Corrected N values after correction for over burden etc

C_w = Correction Factor

S = Permissible Settlement in mm.i.e 25mm

$$C_w = \frac{0.5 + 0.5\ (D_w)}{(D_f + B)}$$

Where,

D_w = Depth of water table below the ground surface

D_f = Depth of foundation

B = Width of foundation

Soils containing both coarse grained (gravels & sands) and fine grained (clays), c and φ are used to determine the soil strength. In case of predominantly fine grained soils, c and φ are determined by the Triaxial Compression test as per IS: 2720 pt XII. For predominantly coarse grained, c and φ are determined by Direct Shear test as per IS; 2720 pt XIII. These c and φ values were used for determining the SBC of soil as per shear failure criteria.

Assumptions and formula used in calculation as per IS:6403-1981 are given below -

The ultimate net bearing capacity in case of general shear failure is given by

$$q_d = c\,N_c\,s_c\,d_c\,i_c + q\,(N_q-1)\,s_q\,d_q\,i_q + (1/2)\,B\,\gamma\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma\,W'$$

The ultimate net bearing capacity in case of local shear failure is given by

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

Where,

$d_c = 1 + 0.2\,(D_f/B)*SQRT(N_\phi)$

$d_q = d_\gamma = 1$ for $\phi < 10^\circ$

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)*SQRT(N_\phi)$ for $\phi > 10^\circ$

$N_\phi = \tan^2(\pi/4 + \phi/2)$

ϕ' for local shear failure $= \tan^{-1}(0.67\tan\phi)$

Average shear strength parameters have been used for calculating safe bearing capacity from shear failure criterion as per IS: 6403-1981 (Annexure – B).

Lower of the two values obtained from settlement and shear criteria is used in arriving at net allowable bearing capacity of the soil.

1.7 *PILE LOAD CARRYING CAPACITY*

1.7.1 Normal Bored Cast in- situ Pile Foundations:

The safe Load carrying capacities of piles have been worked out on the basis of IRC-78 as per provision/assumptions provided therein. For calculating designed Capacity of pile recommendation of IRS "code of practice for the design of sub-structures and foundations of Bridges", IS: 2911 are followed. The minimum factor of safety on ultimate axial capacity should be as per clause 709.3.2 of IRC 78: 2000.The final design/construction of foundations, the safe /allowable load carrying capacity of these piles should be taken by conducting actual initial load tests on these piles casted in the respective area.

Further the piles should have necessary structural strength to transmit/sustain the design load.

APPENDIX - A

GEOTECHNICAL SUBSUFACE PROFILE AND FOUNDATIONDETAILS AT A GLANCE
PART - I
(KM. 360.00 TO KM. 316.00)

APPENDIX – A : GEOTECHNICAL SUBSURFACE PROFILE AND FOUNDATION DETAILS AT A GLANCE

PART - I (KM. 360.00 TO KM 316.00)

Minor Bridges

S.No.	Bridge No.	Chainage	Proposed Bridge Detail		No. of Bore-hole	Bore-hole Identification	BH Level (m)	Depth of Bore-hole Actual	Ground Water Table Position (m.)	Sub Soil Strata Profile	Recommended Net SBC (t/m2)	Pile Load Carrying Capacity (t)		Expected Depth of Foundation	Type of expected Foundation
			Span Length	Type of Super Structure								1.0m Dia	1.20 m Dia		
1	386	359/23-25	1 x 3 x 2	Box	1	1	-	12.00	Below 18.00	0.00-1.50m. - Sandy Silt 1.50-12.00m - Silty Sand Below 12.00m. - Silty Sand with Gravels	1.50m - 13.00 3.00m – 17.00 4.50m – 18.00 6.00m – 19.00			Below 3.00m from EGL	Open
2	383	352/21-23	1 x 1.2 x 1.2	Box	1	1	257.201	12.00	11.30	0.00-1.50m. - Clayey Silt with Sand 1.50-3.00m - Clayey Silt with Sand & Gravels 3.00-6.00m - Sandy Silt 6.00-9.00m - Silty Sand 9.00-12.00m - Silty Sand with Gravels Below 12.00m. - Silty Sand	1.50m - 13.00 3.00m – 15.00 4.50m – 17.00 6.00m – 19.00			Below 3.00m from EGL	Open
3	382	351/15-17	EXISTING BRIDGE NOT VISIBLE	NO PROPOSAL	1	1	257.96	12.00	11.80	0.00-1.50m. - Sandy Silt with Clay 1.50-4.50m - Sandy Silt 4.50-12.00m - Silty Sand	1.50m - 12.00 3.00m – 14.00 4.50m – 16.00 6.00m – 18.00			Below 3.00m from EGL	Open
4	380	350/19-21	1 x 1.2 x 1.2	Box	1	1	257.043	12.00	9.75	0.00-3.00m. - Clayey Silt 3.00-3.80m - Sandy Silt 3.80-12.00m - Silty Sand	1.50m - 11.00 3.00m – 15.00 4.50m – 17.00 6.00m – 19.00			Below 3.00m from EGL	Open
5	379	349/15-17	EXISTING BRIDGE NOT VISIBLE	NO PROPOSAL	1	1	257.816	12.00	Below 13.00	0.00-1.00m. - Clayey Silt with Sand 1.00-9.00m - Sandy Silt 9.00-12.00m - Clayey Silt	1.50m - 8.50 3.00m – 16.00 4.50m – 17.00 6.00m – 18.00			Below 3.00m from EGL	Open
6	377	348/25-27	1 x 1.2 x 1.2	Box	1	1	258.575	12.00	Below 13.00	0.00-1.50m. - Clayey Silt with Sand 1.50-4.60m - Clayey Silt with Sand & Gravels 4.60-12.00m - Silty Sand	1.50m - 13.00 3.00m – 18.00 4.50m – 20.00 6.00m – 22.00			Below 3.00m from EGL	Open
7	376 A	345/4-6	EXISTING BRIDGE NOT VISIBLE	NO PROPOSAL	1	1	262.562	12.00	Below 16.00	0.00-2.50m. - Clayey Silt with Sand 2.50-3.00m - Sandy Silt 3.00-12.00m - Silty Sand	1.50m - 12.00 3.00m – 14.50 4.50m – 17.00 6.00m – 19.00			Below 3.00m from EGL	Open
8	374	341/3-5	EXISTING BRIDGE NOT VISIBLE	NO PROPOSAL	1	1	262.190	12.00	Below 16.00	0.00-1.50m. - Sandy Silt with Clay 1.50-3.60m - Sandy Silt 3.60-12.00m - Silty Sand	1.50m - 11.00 3.00m – 12.50 4.50m – 18.00 6.00m – 20.50			Below 3.00m from EGL	Open
9	372	340/7-9	1 x 3.05	Slab	1	1	258.862	12.00	Below 18.00	0.00-1.50m. - Sandy Silt with Clay 1.50-12.00m - Silty Sand	1.50m - 12.50 3.00m – 17.00 4.50m – 19.00 6.00m – 20.50			Below 3.00m from EGL	Open

10	371	338/3-5	1 x 3.05	Slab	1	1	260.302	12.00	Below 17.00	0.00-1.50m. - Sandy Silt 1.50-12.00m - Silty Sand	1.50m - 12.00 3.00m – 20.00 4.50m – 23.00 6.00m – 25.00			Below 3.00m from EGL	Open
11	370	336/20-22	1 x 3.05	Slab	1	1	262.054	12.00	02.10	0.00-1.50m. - Sandy Silt 1.50-3.00m - Silty Sand 3.00-6.00m - Silty Sand with Gravels 6.00-12.00m - Silty Sand	1.50m - 7.50 3.00m – 16.00 4.50m – 19.00 6.00m – 21.00			Below 3.00m from EGL	Open
12	369 A	335/23-25	1 x 6.10	Slab	1	1	262.366	12.00	Below 18.00	0.00-1.50m. - Sandy Silt with Clay 1.50-3.00m - Sandy Silt with Clay & Gravels 3.00-9.00m - Silty Sand 9.00-12.00m - Silty Sand with Gravels Below 12.00m - Silty Sand	1.50m - 10.00 3.00m – 27.00 4.50m – 28.00 6.00m – 30.00			Below 3.00m from EGL	Open
13	369 AI	334/16-18	1x1.2x1.2	Box	1	1	262.910	12.00	Below 19.00	0.00-3.00m. - Clayey Silt with Sand 3.00-9.00m - Silty Sand 9.00-12.00m - Silty Sand with Gravels Below 12.00m - Silty Sand	1.50m - 8.50 3.00m – 20.00 4.50m – 23.00 6.00m – 25.50			Below 3.00m from EGL	Open
14	369	333/15-17	EXISTING BRIDGE NOT VISIBLE	NO PROPOSAL	1	1	262.853	12.00	Below 20.00	0.00-2.10m. - Clayey Silt with Sand 2.10-6.00m - Sandy Silt 6.00-12.00m - Silty Sand Below 12.00m - Silty Sand with Gravels	1.50m - 7.50 3.00m – 16.00 4.50m – 18.00 6.00m – 21.00			Below 3.00m from EGL	Open
15	368	332/15-17	1 x 1.2 x 1.2	Box	1	1	263.654	12.00	Below 20.00	0.00-1.50m. - Filled up Strata 1.50-6.00m - Gravelly Silt with Sand 6.00-12.00m - Silty Sand	1.50m - 20.00 3.00m – 23.00 4.50m – 26.00 6.00m – 28.00			Below 3.00m from EGL	Open
16	367	332/1-3	1 x 1.2 x 1.2	Box	1	1	263.690	12.00	Below 18.00	0.00-3.00m. - Sandy Silt with Clay 3.00-12.00m - Silty Sand	1.50m - 6.00 3.00m – 12.00 4.50m – 14.00 6.00m – 16.00			Below 4.50m from EGL	Open
17	366 A	328/1-3	EXISTING BRIDGE NOT VISIBLE	NO PROPOSAL	1	1	263.454	12.00	Below 20.00	0.00-1.50m. - Sandy Silt with Clay 1.50-3.00m - Silty Sand 3.00-4.50m - Silty Sand with Gravels 4.50-6.00m - Silty Sand 6.00-7.50m - Sandy Silt 7.50-12.00m - Sand	1.50m - 11.00 3.00m – 16.00 4.50m – 18.00 6.00m – 21.00			Below 3.00m from EGL	Open
18	365 A	326/1-3	EXISTING BRIDGE NOT VISIBLE	-	1	1	263.877	12.00	Below 18.00	0.00-1.50m. - Sandy Silt with Clay 1.50-4.50m - Silty Sand with Gravels 4.50-12.00m - Silty Sand	1.50m - 9.00 3.00m – 10.50 4.50m – 12.00 6.00m – 13.50			Below 3.00m from EGL	Open
19	365	325/25-27	EXISTING BRIDGE NOT VISIBLE	NO PROPOSAL	1	1	263.826	12.00	Below 18.00	0.00-3.00m. - Sandy Silt with Clay 3.00-12.00m - Silty Sand Bellow 12.00m - Sand	1.50m - 10.00 3.00m – 11.00 4.50m – 13.00 6.00m – 15.00			Below 3.00m from EGL	Open
20	364	323/23-25	1 x 3.66	Slab	1	1	264.076	12.00	Below 20.00	0.00-3.00m. - Clayey Silt 3.00-4.50m - Clayey Silt with Gravels 4.50-10.50m - Clayey Silt 10.50-12.00m - Sand	1.50m - 8.00 3.00m – 12.50 4.50m – 17.50 6.00m – 19.00			Below 4.50m from EGL	Open
21	363	321/27-29	1 x 1.2 x 1.2	Box	1	1	264.156	12.00	Below 20.00	0.00-1.50m. - Silty Sand with Clay 1.50-6.00m - Silty Sand 6.00-7.50m - Silty Sand with Gravels 7.50-10.50m - Silty Sand 10.50-12.00m - Sand	1.50m - 12.00 3.00m – 15.50 4.50m – 18.00 6.00m – 20.00			Below 3.00m from EGL	Open

22	362	320/25-27	2 x 3.05	Slab	1	1	263.438	12.00	Below 20.00	0.00-0.50m. - Sandy Silt with Clay 0.50-3.00m - Sandy Silt with Clay & Gravels 3.00-4.50m - Silty Sand 4.50-7.50m - Clayey Silt 7.50-12.00m - Silty Sand	1.50m - 8.00 3.00m – 14.50 4.50m – 18.00 6.00m – 19.00			Below 3.00m from EGL	Open
23	361	317/28-30			1	1	264.243	12.00	Below 20.00	0.00-1.50m. - Sandy Silt with Clay 1.50-3.00m - Clayey Silt with Gravels 3.00-4.50m - Clayey Silt 4.50-7.50m - Silty Sand 7.50-10.50m - Silty Sand with Gravels 10.50-12.00m - Silty Sand	1.50m - 12.00 3.00m – 15.00 4.50m – 36.00 6.00m – 36.00			Below 3.00m from EGL	Open
					23			**276.00**							

Major Bridges

24	385	353/35 354/4	3 x 24.4	Steel Girder	1	A1	257.530	30.00	4.30	0.00-4.60m. - Clayey Silt 4.60-12.00m - Silty Sand 12.00-15.00m - Clayey Silt 15.00-30.00m - Silty Sand	1.50m - 14.00 3.00m – 18.00 4.50m – 21.00 6.00m – 22.00	18.00m - 160.00 21.00m - 230.00 24.00m - 300.00	18.00m - 210.00 21.00m - 240.00 24.00m - 270.00	-	Pile
					1	P1	257.578	30.00	5.15	0.00-1.50m. - Filled up strata 1.50-3.00m - Sandy Silt with Gravels 3.00-6.80m - Sandy Silt 6.80-9.00m - Silty Sand 9.00-12.00m - Silty Sand with Gravels 12.00-15.00m - Clayey Silt with sand and Gravels 15.00-30.00m - Silty Sand	-	18.00m - 170.00 21.00m - 230.00 24.00m - 280.00	18.00m - 220.00 21.00m - 300.00 24.00m - 360.00	-	Pile
					1	P4	256.190	30.00	3.45	0.00-3.00m. - Clayey Silt 3.00-6.00m - Sandy Silt with Gravels 6.00-30.00m - Silty Sand	-	18.00m - 160.00 21.00m - 200.00 24.00m - 250.00	18.00m - 210.00 21.00m - 260.00 24.00m - 320.00	-	Pile
					1	A2	255.58	30.00	3.15	0.00-3.00m. - Clayey Silt with Gravels 3.00-6.00m - Sandy Silt with Gravels 6.00-9.00m - Silty Sand 9.00-12.00m - Silty Sand with Gravels 12.00-30.00m - Silty Sand	1.50m - 11.50 3.00m – 20.00 4.50m – 20.50 6.00m – 21.00	18.00m - 210.00 21.00m - 270.00 24.00m - 330.00	18.00m - 280.00 21.00m - 340.00 24.00m - 420.00	-	Pile
25	361A	319/25-27	1 x 45.7	Through Type Steel Truss	1	A1	263.403	30.00	13.80	0.00-1.50m. - Silty Sand 1.50-3.00m - Silty Sand with Gravels 3.00-4.50m - Clayey Silt 4.50-6.00m - Sandy Silt 6.00-30.00m - Silty Sand	1.50m - 9.00 3.00m –11.00 4.50m – 27.00 6.00m – 28.00	18.00m - 220.00 21.00m - 280.00 24.00m - 350.00	18.00m - 280.00 21.00m - 360.00 24.00m - 440.00	-	Pile
					1	A2	263.643	30.00	14.00	0.00-0.50m. - Silty Sand 0.50-3.00m - Clayey Silt with Gravels 3.00-10.50m - Silty Sand 10.50-12.00m - Sandy Silt 12.00-13.50m - Clayey Silt 13.50-30.00m - Silty Sand	1.50m - 10.00 3.00m –16.00 4.50m – 18.00 6.00m – 19.00	18.00m - 165.00 21.00m - 230.00 24.00m - 290.00	18.00m - 220.00 21.00m - 300.00 24.00m - 370.00	-	Pile
26	359	316/22-24	1 x 18.3	PSC GIRDER	1	A1	263.353	30.00	13.50	0.00-3.00m. - Sandy Silt 3.00-30.00m - Silty Snad	1.50m - 8.00 3.00m –10.00 4.50m – 11.00 6.00m – 12.00	18.00m -180.00 21.00m - 230.00 24.00m - 280.00	18.00m -230.00 21.00m - 290.00 24.00m - 360.00	-	Pile
					1	P2	262.891	30.00	13.50	0.00-1.50m. - Sandy Silt 1.50-3.00m - Sandy Silt with Gravels 3.00-30.00m - Silty Sand	-	18.00m - 160.00 21.00m - 210.00 24.00m - 260.00	18.00m - 210.00 21.00m - 270.00 24.00m - 330.00	-	Pile
					1	A2	262.766	30.00	13.50	0.00-1.50m. - Sandy Silt with Clay 1.50-3.00m - Silty Sand with Clay 3.00-30.00m - Silty Sand	1.50m - 16.00 3.00m –20.00 4.50m – 20.50 6.00m – 21.00	18.00m - 210.00 21.00m - 260.00 24.00m - 330.00	18.00m - 270.00 21.00m - 340.00 24.00m - 420.00	-	Pile
					9			**270.00**							

Alignment															
27		358/1			1	1	256.013	12.00	Below 16.00	0.00-3.00m. - Sandy Silt 3.00-12.00m - Silty Sand	1.50m - 13.00 3.00m – 18.00 4.50m – 18.50 6.00m – 19.50			Below 3.00m from EGL	Open
28		357/1			1	1	254.983	12.00	Below 17.00	0.00-1.50m. - Sandy Silt 1.50-9.00m - Silty Sand 9.00-12.00m - Silty Sand with Gravels Below 12.00m - Silty Sand	1.50m - 13.00 3.00m – 19.00 4.50m – 20.00 6.00m – 20.50			Below 2.00m from EGL	Open
29		356/1			1	1	255.322	12.00	Below 16.00	0.00-1.50m. - Sandy Silt 1.50-9.00m - Silty Sand 9.00-12.00m - Silty Sand with Gravels Below 12.00m - Silty Sand	1.50m - 9.00 3.00m – 15.00 4.50m – 16.00 6.00m – 20.00			Below 3.00m from EGL	Open
30		355/0-1			1	1	255.751	12.00	Below 17.00	0.00-3.00m. - Sandy Silt 3.00-4.50m - Sandy Silt with Gravels 4.50-12.00m - Silty Sand Below 12.00m. - Silty Sand with Clay	1.50m - 20.00 3.00m – 26.00 4.50m – 26.50 6.00m – 27.00			Below 2.00m from EGL	Open
31		347/1			1	1	257.916	12.00	Below 14.00	0.00-12.0m - Silty Sand Below 12.00m - Silty Sand	1.50m - 9.00 3.00m – 16.00 4.50m – 17.00 6.00m – 18.00			Below 3.00m from EGL	Open
32		347/25-27			1	1	259.574	12.00	Below 14.00	0.00-6.00m. - Sandy Silt 6.00-9.00m - Sandy Silt with Gravels 9.00-12.00m - Silty Sand	1.50m - 9.50 3.00m – 17.00 4.50m – 18.00 6.00m – 20.00			Below 3.00m from EGL	Open
33		346/1			1	1	261.885	12.00	Below 16.00	0.00-12.00m. - Silty Sand	1.50m - 9.00 3.00m – 16.00 4.50m – 17.50 6.00m – 19.00			Below 3.00m from EGL	Open
34		344/1			1	1	262.602	12.00	Below 30.00	0.00-12.00m - Silty Sand Below 12.00m - Sandy Silt with Clay	1.50m - 13.00 3.00m – 17.50 4.50m – 27.00 6.00m – 33.00			Below 2.00m from EGL	Open
35		343/1			1	1	260.094	12.00	Below 30.00	0.00-1.50m. - Sandy Silt with Clay 1.50-3.00m - Sandy Silt with Clay & Gravels 3.00-6.00m - Silty Sand with Gravels 6.00-12.00m - Sandy Silt with Gravels	1.50m - 12.50 3.00m – 17.00 4.50m – 18.50 6.00m –20.00			Below 2.00m from EGL	Open
36		342/1			1	1	260.329	12.00	Below 18.00	0.00-1.50m. - Sandy Silt 1.50-2.00m - Sandy Silt with Clay 2.00-12.00m - Silty Sand	1.50m - 12.00 3.00m – 17.50 4.50m – 23.00 6.00m – 24.00			Below 2.00m from EGL	Open
37		339/1			1	1	260.453	12.00	Below 18.00	0.00-1.50m. - Sandy Silt 1.50-12.00m - Silty Sand	1.50m - 12.50 3.00m – 20.00 4.50m – 22.00 6.00m – 23.00			Below 2.00m from EGL	Open
38		337/1			1	1	261.344	12.00	Below 15.00	0.00-0.90m. - Sandy Silt 0.90-1.50m - Silty Sand 1.50-3.00m - Silty Sand with Clay 3.00-12.00m - Silty Sand	1.50m - 12.50 3.00m – 21.00 4.50m – 25.00 6.00m – 26.00			Below 2.00m from EGL	Open

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39		331			1	1	263.48	12.00	Below 18.00	0.00-1.50m. - Sandy Silt with Clay 1.50-5.00m - Silty Sand 5.00-6.00m - Silty Sand with Gravels 6.00-12.00m - Silty Sand	1.50m - 12.00 3.00m -19.00 4.50m – 21.00 6.00m – 23.00			Below 2.00m from EGL	Open
40		330			1	1	264.882	12.00	Below 20.00	0.00-1.50m. - Sandy Silt 1.50-5.00m - Silty Sand 5.00-6.00m - Silty Sand with Gravels 6.00-12.00m - Silty Sand	1.50m - 12.50 3.00m – 18.00 4.50m – 22.00 6.00m – 24.00			Below 2.00m from EGL	Open
41		329			1	1	263.224	12.00	Below 20.00	0.00-1.50m. - Sandy Silt 1.50-7.50m - Silty Sand 7.50-12.00m - Fine Sand	1.50m - 11.00 3.00m – 19.00 4.50m – 21.00 6.00m – 22.00			Below 2.00m from EGL	Open
42		327			1	1	265.223	12.00	Below 20.00	0.00-1.50m. - Sandy Silt with Clay 1.50-3.00m - Sandy Silt with Clay & Gravels 3.00-4.50m - Silty Sand 4.50-6.00m - Silty Sand with Gravels 6.00-7.50m - Silty Sand 7.50-10.50m - Silty Sand with Gravels 10.50-12.00m - Silty Sand	1.50m - 11.00 3.00m – 17.00 4.50m – 19.00 6.00m – 21.00			Below 3.00m from EGL	Open
43		324			1	1	265.973	12.00	Below 20.00	0.00-6.00m. - Sandy Silt with Clay 6.00-7.50m -Silty Sand 7.50-12.00m - Fine Sand	1.50m - 11.00 3.00m – 18.00 4.50m – 20.00 6.00m – 24.00			Below 2.00m from EGL	Open
44		322			1	1	265.574	12.00	Below 20.00	0.00-1.50m. - Sandy Silt 1.50-4.50m - Silty Sand 4.50-6.00m - Silty Sand with Gravels 6.00-12.00m - Silty Sand	1.50m - 13.50 3.00m – 23.00 4.50m – 26.00 6.00m – 28.00			Below 2.00m from EGL	Open
45		318/26-28			1	1	265.804	12.00	Below 20.00	0.00-1.50m. - Silty Sand 1.50-3.00m - Silty Sand with Gravels 3.00-3.50m - Sandy Silt 3.50-6.00m - Silty Sand 6.00-7.50m - Silty Sand with Gravels 7.50-12.00m - Silty Sand	1.50m - 13.00 3.00m – 18.00 4.50m – 19.00 6.00m – 20.00			Below 2.00m from EGL	Open
		TOTAL			**19**			**228.00**							
		GRAND TOTAL			**51**			**774.00**							

'MINOR BRIDGES'

CHAPTER – 02

"Minor Bridge No. 386",

Location – Existing Km. - 359/23-25

2.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 1x3x2

2.2 BOREHOLE DESCRIPTIONS:

(a) Location of Structure, Boreholes with RL of existing GL shown in **FIGURE-1**.

(b) Subsurface Characteristic of Soil/Rock shown in *ANNEXURE-I.*

(c) Borelogs and sub soil profile shown in *ANNEXURE-II.*

(d) Calculations of Safe Bearing Capacities in *ANNEXURE-III.*

(e) Calculations of Probable Settlement in *ANNEXURE-IV.*

(f) Depth of water Table ≥18.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.50	Sandy Silt	Loose
	1.50 to 12.00	Silty Sand	Medium Dense
	Below 12.00	Silty Sand with Gravels	Medium Dense

2.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.60	0.002	0.0021	NIL	0.0011	0.029
	9.00	8.80	0.007	0.0011	NIL	0.0010	0.019

2.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	NIL
	9.00	NIL

2.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	13.00
	3.00	17.00
	4.50	18.00
	6.00	19.00

2.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

2.7 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 3.00 m from EGL

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Note- The above recommendations are based on the field and laboratory tests conducted on the soil, and our experience in this regard. If the actual subsoil conditions during excavation for the foundation differ from the observations reported here, the design experts/consultants should be referred for suggestion, further investigations. However, the Depth and Type of foundation is to be decided by the structure designer depending upon the type of loading/structure and site conditions.

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 386 AT CHAINAGE 359/24-26

Project :	Chainage 359/24-26 Bridge No. 386			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				24.05.2009 to 24.05.2009	1	1 (LHS)	below 18.00 m.	12.00mtr	

Depth from GL (m)	Observed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel										
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.					c kg/cm^2	ϕ degree
0.00	-	-	-	Sandy Silt	2.00	50.33	40.36	2.65	4.66	0.00	0.00	22	NP	NIL	-	-	-	-	-	-
1.50	11	1.43	15.73	Silty Sand	2.23	10.48	85.52	1.71	0.06	0.00	0.00	24	NP	NIL	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	2.11	19.98	76.52	1.39	0.00	0.00	0.00	22	NP	NIL	1.84	2.46	1.80	2.66	0.00	27.00
6.00	16	0.97	15.52	Silty Sand	1.65	13.52	84.01	0.32	0.50	0.00	0.00	26	NP	NIL	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand	0.00	5.80	91.09	2.45	0.66	0.00	0.00	28	NP	NIL	1.70	13.41	1.50	2.66	0.00	27.00
12.00	27	0.75	20.25	Silty Sand with Gravels	0.00	10.08	81.13	2.17	1.13	3.23	2.26	26	NP	NIL	-	-	-	-	-	-

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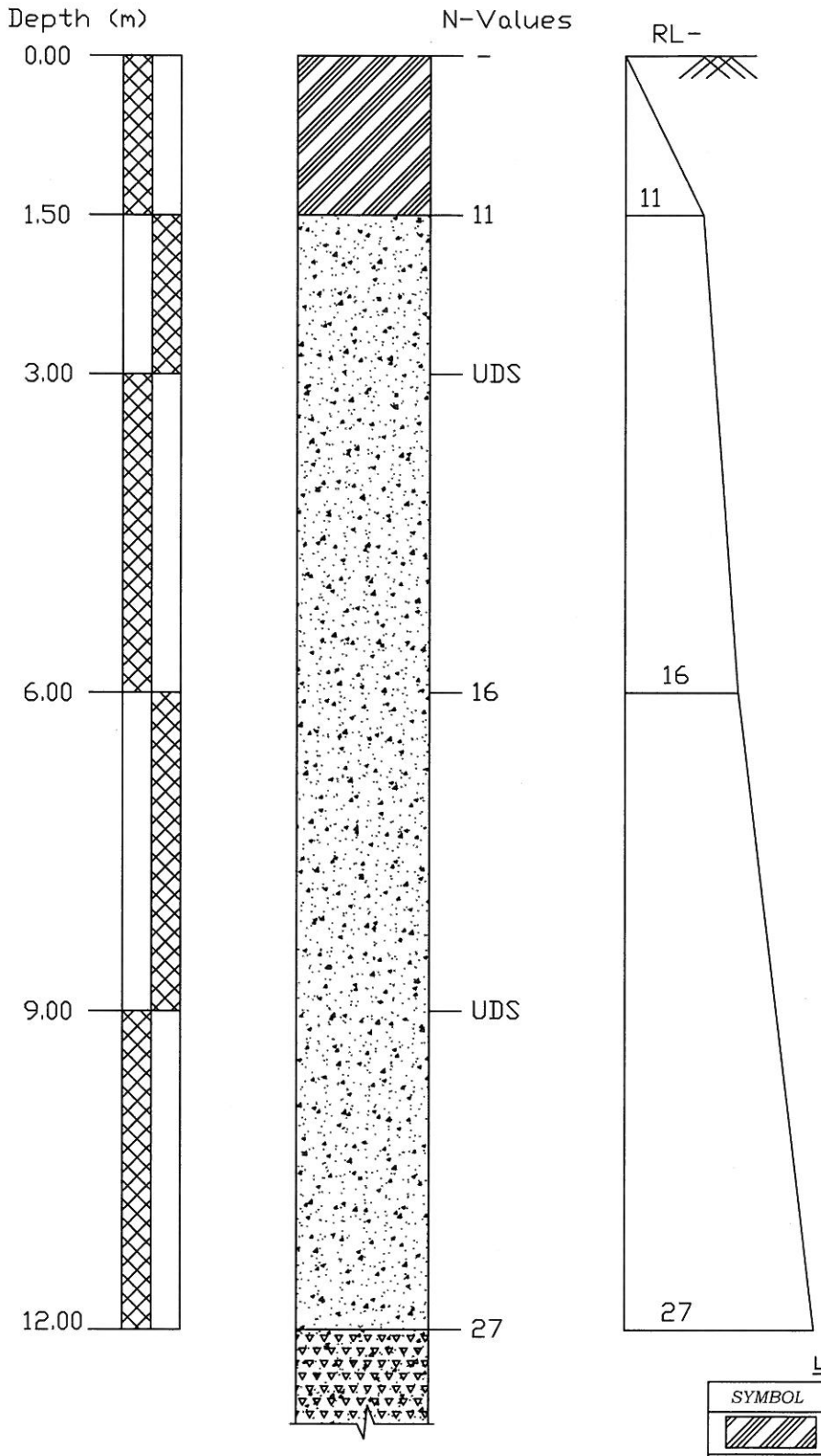
BORELOG OF BH–1(LHS) AT EXISTING KM–359/23–25 FOR MINOR BRIDGE NO.–386,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT
	SILTY SAND
	SILTY SAND WITH GRAVELS

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ANNEXURE- III

Calculation of SBC for shallow foundations as per IS : 6403 - 1981

INPUT DATA

Minor Bridge No 359/24-26 BH-1

Type of footing

1	Continuous Strip		
2	Rectangular	***Rectangular***	**2**
3	Square		
4	Circular		

Angle of internal friction (ϕ °)	27.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.47
Direction of load with vertical ($^{\circ}$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.70
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)	Length (m)
1	1.50	3.00	8.00
2	3.00	3.00	8.00
3	4.50	3.00	8.00
4	6.00	3.00	8.00

SHEAR FAILURE CRITERIA

Assumptions and formula used in calculation as per IS:6403-1981 are given below -

The ultimate net bearing capacity in case of general shear failure is given by

$$q_d = c\, N_c\, s_c\, d_c\, i_c + q\,(N_q\text{-}1)\, s_q\, d_q\, i_q + (1/2)\, B\, \gamma\, N_\gamma\, s_\gamma\, d_\gamma\, i_\gamma\, W'$$

The ultimate net bearing capacity in case of local shear failure is given by

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

Where,

$d_c = 1 + 0.2\,(D_f/B)*SQRT(N_\phi)$

$d_q = d_\gamma = 1$ for $\phi < 10^{\circ}$

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)*SQRT(N_\phi)$ for $\phi > 10^{\circ}$

$N_\phi = \tan^2(\pi/4 + \phi/2)$

ϕ' for local shear failure = $\tan^{-1}(0.67 \tan\phi)$

OUTPUT

The computer aided results for shear failure criteria are tabulated below. The results are interpolated values of bearing capacity obtained from general and local shear failure criteria.

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ANNEXURE- III

Bearing capacity factors :

ϕ	27.00
N_c	24.49
N_q	13.76
N_γ	15.49

ϕ'	18.85
N'_c	13.94
N'_q	5.83
N'_γ	4.76

Shape factors :

S.no.	Width(m)	Length (m)	S_c	S_q	S_γ
1	3.00	8.00	1.08	1.08	0.85
2	3.00	8.00	1.08	1.08	0.85
3	3.00	8.00	1.08	1.08	0.85
4	3.00	8.00	1.08	1.08	0.85

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.16	1.08	1.08
2	3.00	3.00	1.33	1.16	1.16
3	4.50	3.00	1.49	1.24	1.24
4	6.00	3.00	1.65	1.33	1.33

Inclination factors :

$i_c = (1-\alpha / 90)^2$	$i_q = (1-\alpha / 90)^2$	$i_\gamma = (1-\alpha / \phi)^2$
1.00	1.00	1.00

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	1.50	3.00	0.00	0.50
2	3.00	3.00	-0.50	0.50
3	4.50	3.00	-1.00	0.50
4	6.00	3.00	-1.50	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	18.66	6.64	18.66
2	3.00	3.00	8.00	33.62	12.27	33.62
3	4.50	3.00	8.00	35.98	13.14	35.98
4	6.00	3.00	8.00	38.34	14.00	38.34

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Minor BridgeNo. 386
Chainage	359/24-26
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	13.00
Average N value	15.00
Settlement for 10 t/m2 (mm)	20.00
Total Settlement (mm)	26.00
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	18.9

Footing Depth (m)	3.00
SBC (t/m2)	17.00
Average N value	15.88
Settlement for 10 t/m2 (mm)	20.00
Total Settlement (mm)	34.00
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	22.6

Footing Depth (m)	4.50
SBC (t/m2)	18.00
Average N value	16.46
Settlement for 10 t/m2 (mm)	19.00
Total Settlement (mm)	34.20
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	20.2

Footing Depth (m)	6.00
SBC (t/m2)	19.00
Average N value	17.32
Settlement for 10 t/m2 (mm)	18.00
Total Settlement (mm)	34.20
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	18.6

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CHAPTER – 03

"Minor Bridge No. 383",

Location – Existing Km. - 352/21-23

2910

3.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 1x1.2x1.2

3.2 BOREHOLE DESCRIPTIONS:

(a) Location of Structure, Boreholes with RL of existing GL shown in **FIGURE-1**.

(b) Subsurface Characteristic of Soil/Rock shown in *ANNEXURE-I.*

(c) Borelogs and sub soil profile shown in *ANNEXURE-II.*

(d) Calculation of Safe Bearing Capacities in *ANNEXURE-III.*

(e) Calculation of Probable Settlement in *ANNEXURE-IV.*

(f) Depth of water Table 11.30m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.50	Clayey Silt with Sand	Loose
	1.50 to 3.00	Clayey Silt with Sand & Gravels	Medium Dense
	3.00 to 6.00	Sandy Silt	Medium Dense
	6.00 to 9.00	Silty Sand	Medium Dense
	9.00 to 12.00	Silty Sand with Gravels	Medium Dense
	Below 12.00	Silty Sand	Dense

3.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.70	0.002	0.0014	NIL	0.0009	0.024

3.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	NIL
	9.00	NIL

3.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BORE HOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (µS/cm)
Test Result	7.3	115	101	190	900	0.1	3.0	1105	710
Permissible limit as per IS 456/	Not less then 6.0	2000 for CC and 500 for	400	200	3000	5 ml of 0.02 normal	25 ml of 0.02 normal H_2SO_4	-	-

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Morth		RCC				NaoH			

3.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m^2)
BH-1	1.50	13.00
	3.00	15.00
	4.50	17.00
	6.00	19.00

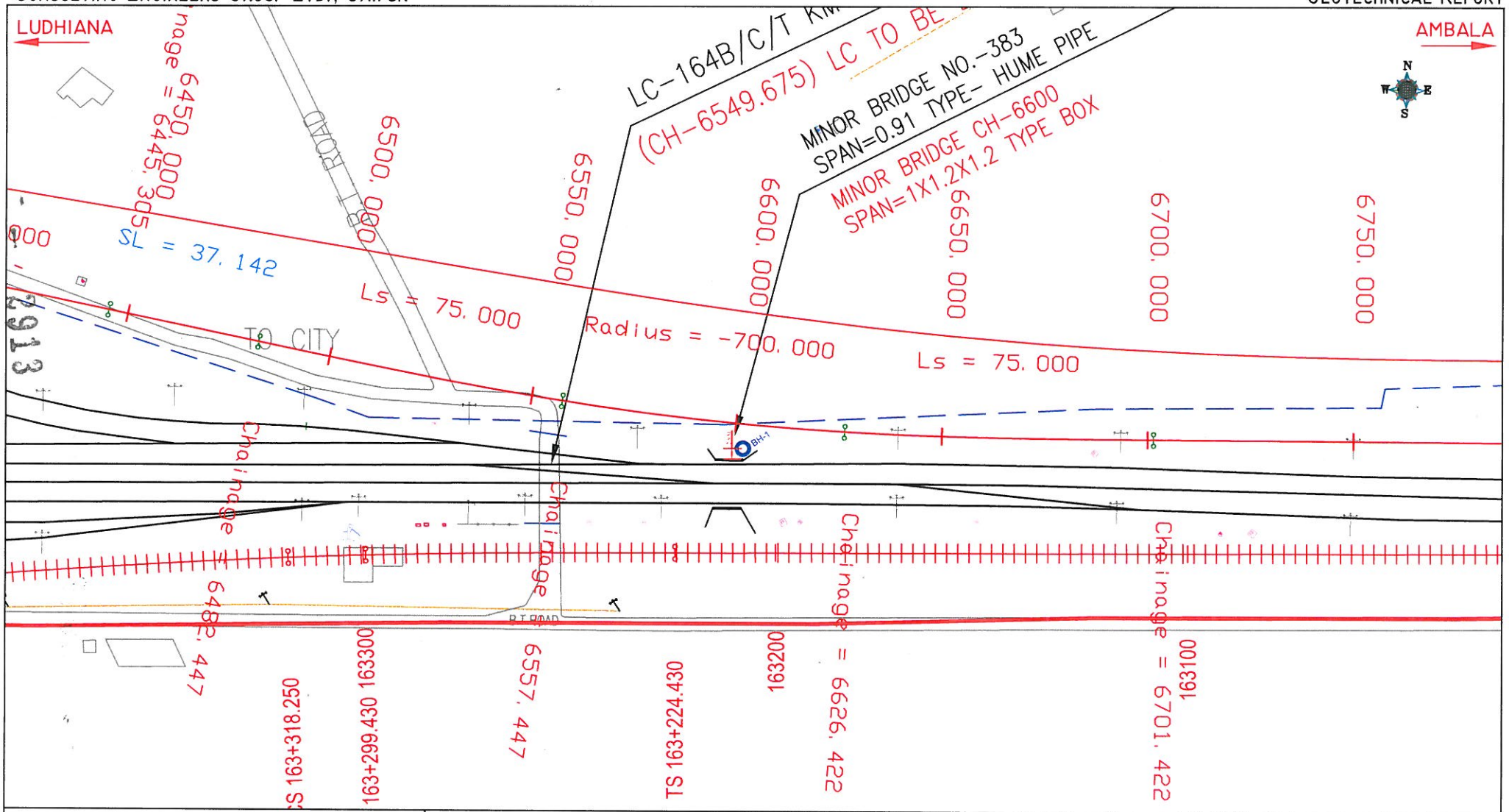
3.7 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.
- Chemical contents of Water are within the safe limits for construction purpose.

3.8 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 3.00m from EGL

Note- The above recommendations are based on the field and laboratory tests conducted on the soil, and our experience in this regard. If the actual subsoil conditions during excavation for the foundation differ from the observations reported here, the design experts/consultants should be referred for suggestion, further investigations. However, the Depth and Type of foundation is to be decided by the structure designer depending upon the type of loading/structure and site conditions.



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 352/21-23	RL OF BH-I = 257.201	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel. +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 383 AT CHAINAGE 352/21-23

Project :	Chainage 352/21-23 Bridge No. 383			Date of Testing	Location at		B.H. No.		Depth of Water Table		Termination Depth			Surface Elevation					
				26.05.2009 to 26.05.2009	1		1 (LHS)		below 11.00 m.		12.00mtr			257.201					
Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc		kg/cm^2	degree
0.00	-	-	-	Clayey Silt with Sand	13.35	72.46	6.65	3.22	1.21	3.11	0.00	33	23	10	-	-	-	-	-	-
1.50	13	1.44	18.72	Clayey Silt with Sand & Gravels	15.34	56.27	7.30	1.99	2.55	12.08	4.47	30	18	12	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt	4.22	65.27	26.25	0.84	0.54	2.88	0.00	28	NP	NIL	1.78	3.12	1.73	2.60	0.00	26.50
6.00	27	0.98	26.46	Silty Sand	2.12	9.26	87.40	0.97	0.25	0.00	0.00	23	NP	NIL	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand with Gravels	4.69	27.71	55.94	0.65	1.46	6.56	2.99	31	NP	NIL	1.90	6.38	1.79	2.62	0.00	29.50
12.00	32	0.74	19.34	Silty Sand	2.21	25.60	68.52	3.06	0.06	0.55	0.00	22	NP	NIL	-	-	-	-	-	-

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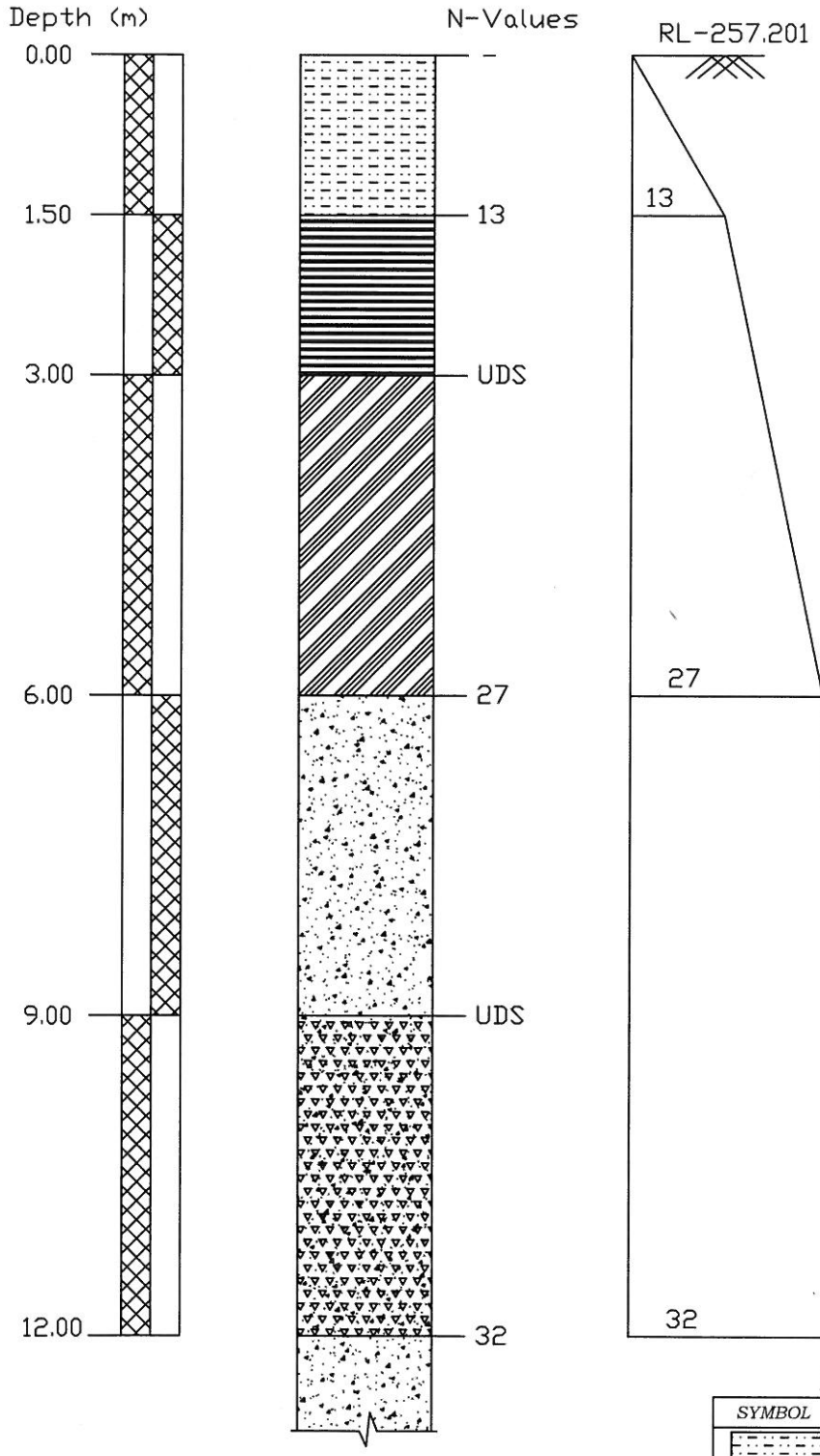
BORELOG OF BH–1(LHS) AT EXISTING KM–352/21–23 FOR MINOR BRIDGE NO.–383,

ON KESARI TO SANEHWAL, LUDHIANA



ANNEXURE - III

Calculation of SBC for shallow foundations as per IS : 6403 - 1981

INPUT DATA

Minor Bridge No 352/21-23 BH-1

Type of footing

1	Continuous Strip		
2	Rectangular	***Continuous Strip***	1
3	Square		
4	Circular		

Angle of internal friction (ϕ °)	26.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.50
Direction of load with vertical (^{o})	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.78
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)
1	1.50	1.20
2	3.00	1.20
3	4.50	1.20
4	6.00	1.20

SHEAR FAILURE CRITERIA

Assumptions and formula used in calculation as per IS:6403-1981 are given below -

The ultimate net bearing capacity in case of general shear failure is given by

$$q_d = c\,N_c\,s_c\,d_c\,i_c + q\,(N_q-1)\,s_q\,d_q\,i_q + (1/2)\,B\,\gamma\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma\,W'$$

The ultimate net bearing capacity in case of local shear failure is given by

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

Where,

$d_c = 1 + 0.2\,(D_f/B)*SQRT(N_\phi)$

$d_q = d_\gamma = 1$ for $\phi < 10^{o}$

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)*SQRT(N_\phi)$ for $\phi > 10^{o}$

$N_\phi = \tan^2(\pi/4 + \phi/2)$

ϕ' for local shear failure = $\tan^{-1}(0.67\tan\phi)$

OUTPUT

The computer aided results for shear failure criteria are tabulated below. The results are interpolated values of bearing capacity obtained from general and local shear failure criteria.

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.50
N_c	23.55
N_q	12.98
N_γ	14.34

ϕ'	18.47
N'_c	13.65
N'_q	5.65
N'_γ	4.55

Shape factors :

S.no.	Width(m)	S_c	S_q	S_γ
1	1.20	1.00	1.00	1.00
2	1.20	1.00	1.00	1.00
3	1.20	1.00	1.00	1.00
4	1.20	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	1.20	1.40	1.20	1.20
2	3.00	1.20	1.81	1.40	1.40
3	4.50	1.20	2.21	1.61	1.61
4	6.00	1.20	2.62	1.81	1.81

Inclination factors :

$i_c = (1-\alpha / 90)^2$	$i_q = (1-\alpha / 90)^2$	$i_\gamma = (1-\alpha / \phi)^2$
1.00	1.00	1.00

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	1.50	1.20	0.00	0.50
2	3.00	1.20	-1.25	0.50
3	4.50	1.20	-2.50	0.50
4	6.00	1.20	-3.75	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shea	Local shear	Actual
1	1.50	1.20	12.86	4.77	12.86
2	3.00	1.20	15.02	5.58	15.02
3	4.50	1.20	17.18	6.38	17.18
4	6.00	1.20	19.34	7.18	19.34

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Settlement Calculation for Cohesive As per IS 8009 (Part 1)

BH No. (A1) — **Minor Bridge at Ch. 352 (21-23)**

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	1.2	m
Initial effective stress at mid of layer	Po	=	4.05	t/m^2
Concentrated load *P*		=	13.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.9	t/m^2
Compression Index	Cc	=	0.08	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.55	
	$\frac{Po + \Delta p}{Po}$	=	1.70617	

Settlement of clay layer

$$S_f = \frac{Cc}{1+ eo} \; H \; \log_{10} \frac{Po + \Delta P}{Po}$$

S_f = 0.01796 m

= 17.9631 mm

Correction for Depth and Rigidity of foundation on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.48 $(LB)^{\wedge 0.5}/D$ = 2.07

D = Depth of Foundation

L/B = 6.67

Depth Factor = 0.83

$$\text{Rigidity Factor} = \frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$$

= 0.80

Pore Pressure correction = 0.85

Total Settlement = S_f x D.F.x R.F.x Pore Pr. Correction

S_{f2} = **10.1 mm**

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)

Footing Depth (m)	**1.50**
Effective Pr. (t/m2)	2.41
Average N value	23.00
Settlement for 10 t/m2 (mm)	9.00
Total Settlement (mm)	2.16
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**1.4**

Total Settlement (mm) **11.6**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Minor BridgeNo. 383
Chainage	352/21-23
Bore Hole No.	1

Footing Depth (m)	3.00
SBC (t/m2)	15.00
Average N value	22.00
Settlement for 10 t/m2 (mm)	13.00
Total Settlement (mm)	19.50
Depth Correction	0.73
Rigidity Correction	0.8
Corrected Total Settlement (mm)	11.4

Footing Depth (m)	4.50
SBC (t/m2)	17.00
Average N value	22.00
Settlement for 10 t/m2 (mm)	13.00
Total Settlement (mm)	22.10
Depth Correction	0.675
Rigidity Correction	0.8
Corrected Total Settlement (mm)	11.9

Footing Depth (m)	6.00
SBC (t/m2)	19.00
Average N value	23.00
Settlement for 10 t/m2 (mm)	12.00
Total Settlement (mm)	22.80
Depth Correction	0.63
Rigidity Correction	0.8
Corrected Total Settlement (mm)	11.5

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CHAPTER – 04

"Minor Bridge No. 382",

Location – Existing Km. - 351/15-17

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4.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge No. 382 at Chaniage 351/15-17

4.2 BOREHOLE DESCRIPTIONS:

(a) Location of Structure, Boreholes with RL of existing GL shown in **FIGURE-1**.

(b) Subsurface Characteristic of Soil/Rock shown in *ANNEXURE-I.*

(c) Borelogs and sub soil profile shown in *ANNEXURE-II.*

(d) Calculation of Safe Bearing Capacities in *ANNEXURE-III.*

(e) Calculation of Probable Settlement in *ANNEXURE-IV.*

(f) Depth of water Table 11.80m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.50	Sandy Silt with Clay	Loose
	1.50 to 4.50	Sandy Silt	Medium Dense
	4.50 to 6.00	Silty Sand	Medium Dense
	6.00 to 12.00	Silty Sand	Dense

4.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.60	0.002	0.0011	NIL	0.0009	0.022

4.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	NIL

4.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BORE HOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (µS/cm)
Test Result	7.0	60	83	170	755	0.1	2.9	950	609
Permissible limit as per IS 456/ Morth	Not less then 6.0	2000 for CC and 500 for RCC	400	200	3000	5 ml of 0.02 normal NaoH	25 ml of 0.02 normal H_2SO_4	-	-

4.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m^2)
BH-1	1.50	12.00
	3.00	14.00
	4.50	16.00
	6.00	18.00

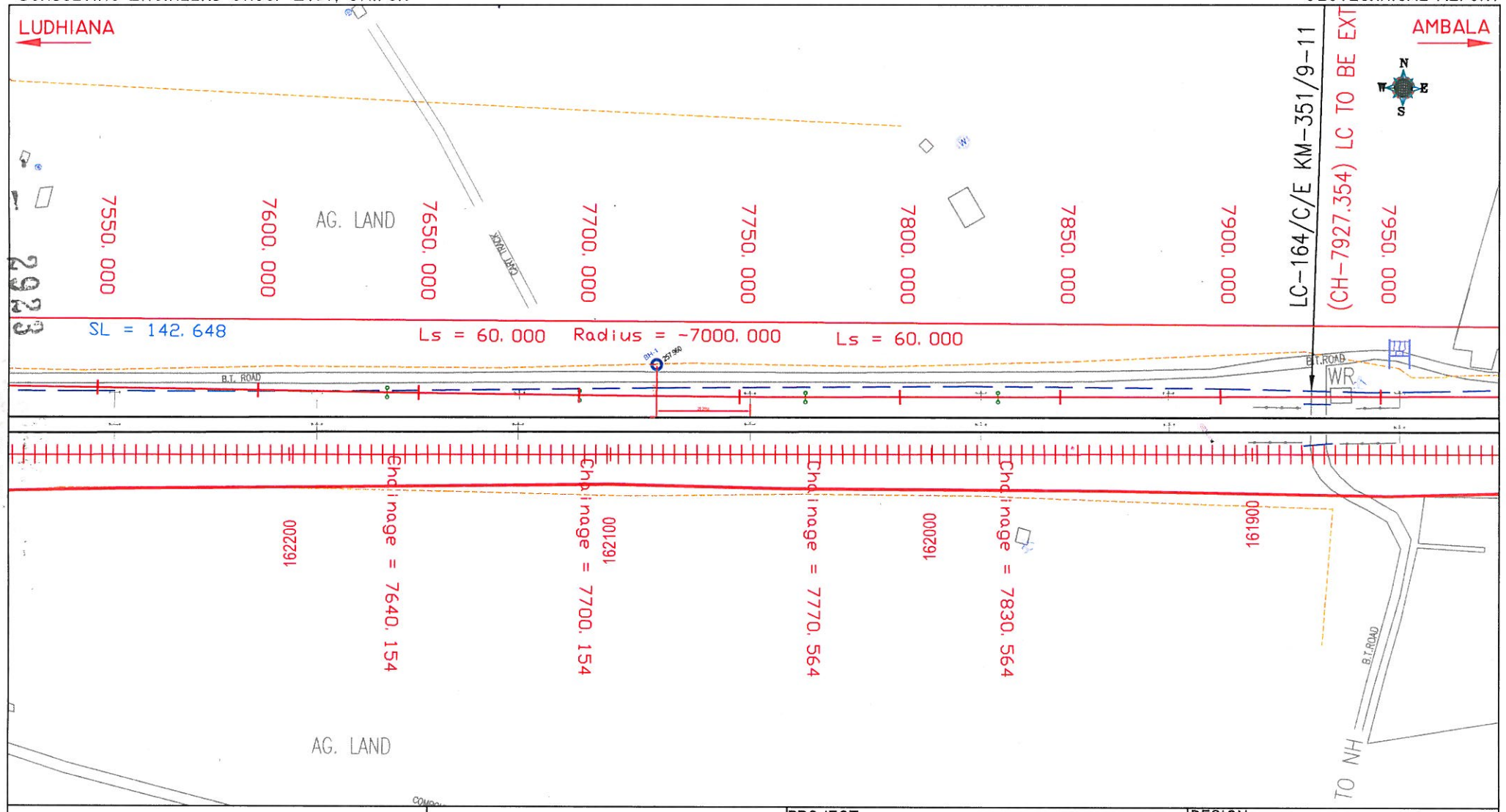
4.7 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.
- Chemical contents of Water are within the safe limits for construction purpose.

4.8 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 3.00m from EGL

Note- The above recommendations are based on the field and laboratory tests conducted on the soil, and our experience in this regard. If the actual subsoil conditions during excavation for the foundation differ from the observations reported here, the design experts/consultants should be referred for suggestion, further investigations. However, the Depth and Type of foundation is to be decided by the structure designer depending upon the type of loading/structure and site conditions.



ALL DIMENSIONS IN METER			
FIG.:-I LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 351/15-17	RL OF BH-I = 257.96	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 382 AT CHAINAGE 351/15-17

Project :	Chainage 351/15-17 Bridge No. 382			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				26.05.2009 to 26.05.2009	1	1 (LHS)	below 11.00 m.	12.00mtr	257.960

Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Sandy Silt with clay	13.20	56.03	20.69	3.36	1.97	3.65	1.10	32	21	11	-	-	-	-	-	-
1.50	11	1.44	15.84	Sandy Silt	2.33	74.87	17.68	0.88	0.77	3.47	0.00	26	NP	NIL	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt	3.67	61.36	34.01	0.60	0.36	0.00	0.00	27	NP	NIL	1.82	6.50	1.71	2.65	0.00	26.00
4.50	-			Silty Sand	2.30	34.21	55.32	6.97	1.20	0.00	0.00	25	NP	NIL						
6.00	32	0.97	31.04	Silty Sand	1.36	7.89	85.51	5.09	0.15	0.00	0.00	24	NP	NIL	-	-	-	-	-	-
9.00	34	0.84	28.56	Silty Sand	1.68	24.83	70.80	1.81	0.70	0.18	0.00	21	NP	NIL	-	-	-	-	-	-
12.00	36	0.74	20.82	Silty Sand	2.31	25.64	68.93	2.37	0.59	0.16	0.00	22	NP	NIL	-	-	-	-	-	-

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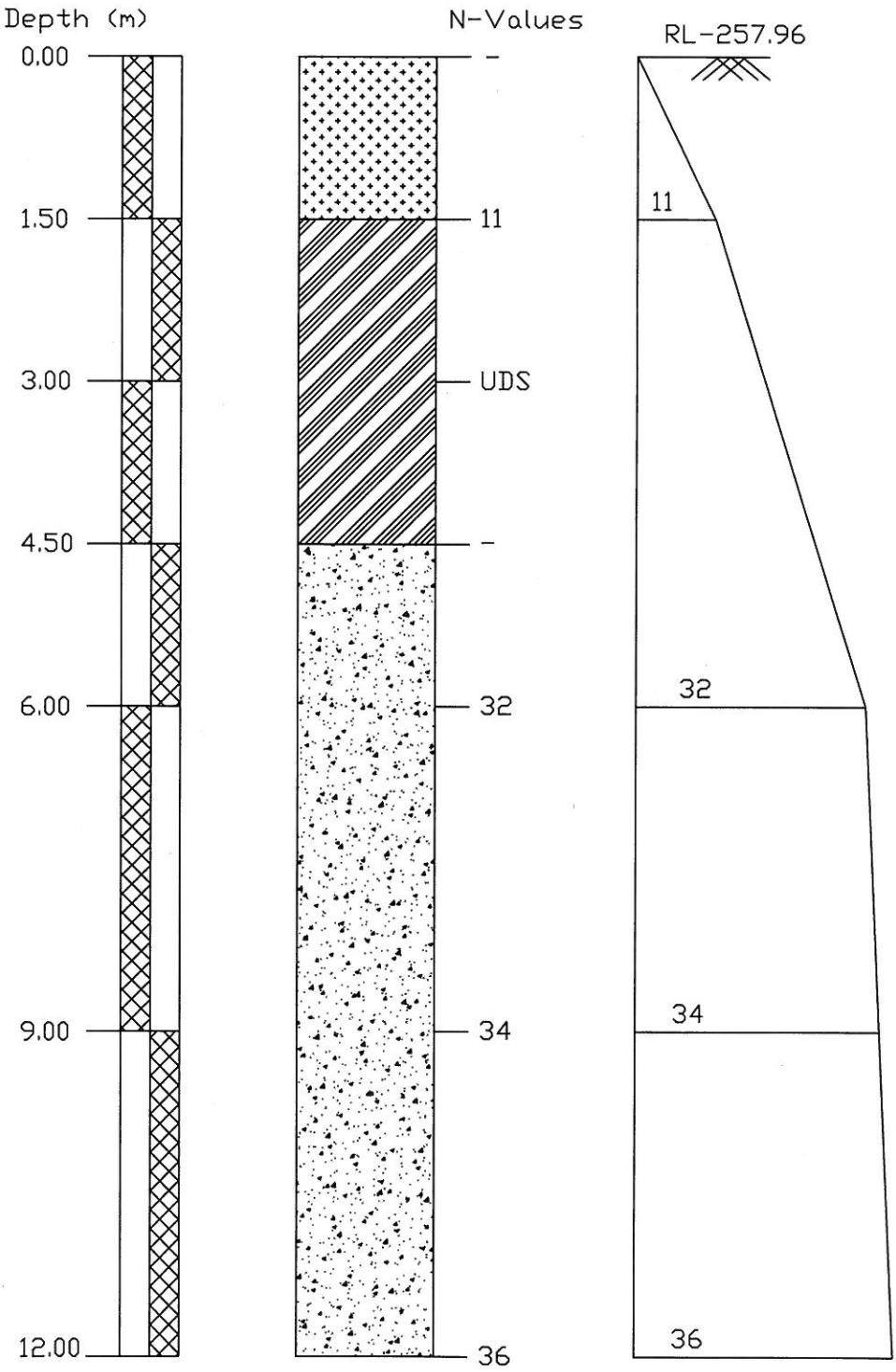
BORELOG OF BH–1(LHS) AT EXISTING KM–351/15–17 FOR MINOR BRIDGE NO.–382,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT WITH CLAY
	SANDY SILT
	SILTY SAND

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ANNEXURE - III

Calculation of SBC for shallow foundations as per IS : 6403 - 1981

INPUT DATA

Minor Bridge No 351/15-17 BH-1

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Continuous Strip | 1

Angle of internal friction (ϕ°)	26.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.55
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.80
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)
1	1.50	1.20
2	3.00	1.20
3	4.50	1.20
4	6.00	1.20

SHEAR FAILURE CRITERIA

Assumptions and formula used in calculation as per IS:6403-1981 are given below -

The ultimate net bearing capacity in case of general shear failure is given by

$$q_d = c\,N_c\,s_c\,d_c\,i_c + q\,(N_q-1)\,s_q\,d_q\,i_q + (1/2)\,B\,\gamma\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma\,W'$$

The ultimate net bearing capacity in case of local shear failure is given by

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

Where,

$d_c = 1 + 0.2\,(D_f/B)*SQRT(N_\phi)$

$d_q = d_\gamma = 1$ for $\phi < 10^\circ$

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)*SQRT(N_\phi)$ for $\phi > 10^\circ$

$N_\phi = \tan^2(\pi/4 + \phi/2)$

ϕ' for local shear failure $= \tan^{-1}(0.67\tan\phi)$

OUTPUT

The computer aided results for shear failure criteria are tabulated below. The results are interpolated values of bearing capacity obtained from general and local shear failure criteria.

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.00
N_c	22.60
N_q	12.21
N_γ	13.18

ϕ'	18.10
N'_c	13.36
N'_q	5.46
N'_γ	4.35

Shape factors :

S.no.	Width(m)	S_c	S_q	S_γ
1	1.20	1.00	1.00	1.00
2	1.20	1.00	1.00	1.00
3	1.20	1.00	1.00	1.00
4	1.20	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	1.20	1.40	1.20	1.20
2	3.00	1.20	1.80	1.40	1.40
3	4.50	1.20	2.20	1.60	1.60
4	6.00	1.20	2.60	1.80	1.80

Inclination factors :

$i_c = (1-\alpha / 90)^2$	$i_q = (1-\alpha / 90)^2$	$i_\gamma = (1-\alpha / \phi)^2$
1.00	1.00	1.00

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	1.50	1.20	0.00	0.50
2	3.00	1.20	-1.25	0.50
3	4.50	1.20	-2.50	0.50
4	6.00	1.20	-3.75	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shea	Local shear	Actual
1	1.50	1.20	11.99	4.58	11.99
2	3.00	1.20	13.99	5.34	13.99
3	4.50	1.20	15.99	6.11	15.99
4	6.00	1.20	17.99	6.87	17.99

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Minor BridgeNo. 382
Chainage	351/15-17
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	12.00
Average N value	20.00
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	18.00
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	13.1

Footing Depth (m)	3.00
SBC (t/m2)	14.00
Average N value	21.00
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	21.00
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	13.9

Footing Depth (m)	4.50
SBC (t/m2)	16.00
Average N value	25.00
Settlement for 10 t/m2 (mm)	13.00
Total Settlement (mm)	20.80
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	12.3

Footing Depth (m)	6.00
SBC (t/m2)	18.00
Average N value	25.00
Settlement for 10 t/m2 (mm)	11.00
Total Settlement (mm)	19.80
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	10.8

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4.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge No. 382 at Chaniage 351/15-17

4.2 BOREHOLE DESCRIPTIONS:

(a) Location of Structure, Boreholes with RL of existing GL shown in **FIGURE-1**.

(b) Subsurface Characteristic of Soil/Rock shown in *ANNEXURE-I.*

(c) Borelogs and sub soil profile shown in *ANNEXURE-II.*

(d) Calculation of Safe Bearing Capacities in *ANNEXURE-III.*

(e) Calculation of Probable Settlement in *ANNEXURE-IV.*

(f) Depth of water Table 11.80m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.50	Sandy Silt with Clay	Loose
	1.50 to 4.50	Sandy Silt	Medium Dense
	4.50 to 6.00	Silty Sand	Medium Dense
	6.00 to 12.00	Silty Sand	Dense

4.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.60	0.002	0.0011	NIL	0.0009	0.022

4.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	NIL

4.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BORE HOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (µS/cm)
Test Result	7.0	60	83	170	755	0.1	2.9	950	609
Permissible limit as per IS 456/ Morth	Not less then 6.0	2000 for CC and 500 for RCC	400	200	3000	5 ml of 0.02 normal NaoH	25 ml of 0.02 normal H_2SO_4	-	-

4.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m^2)
BH-1	1.50	12.00
	3.00	14.00
	4.50	16.00
	6.00	18.00

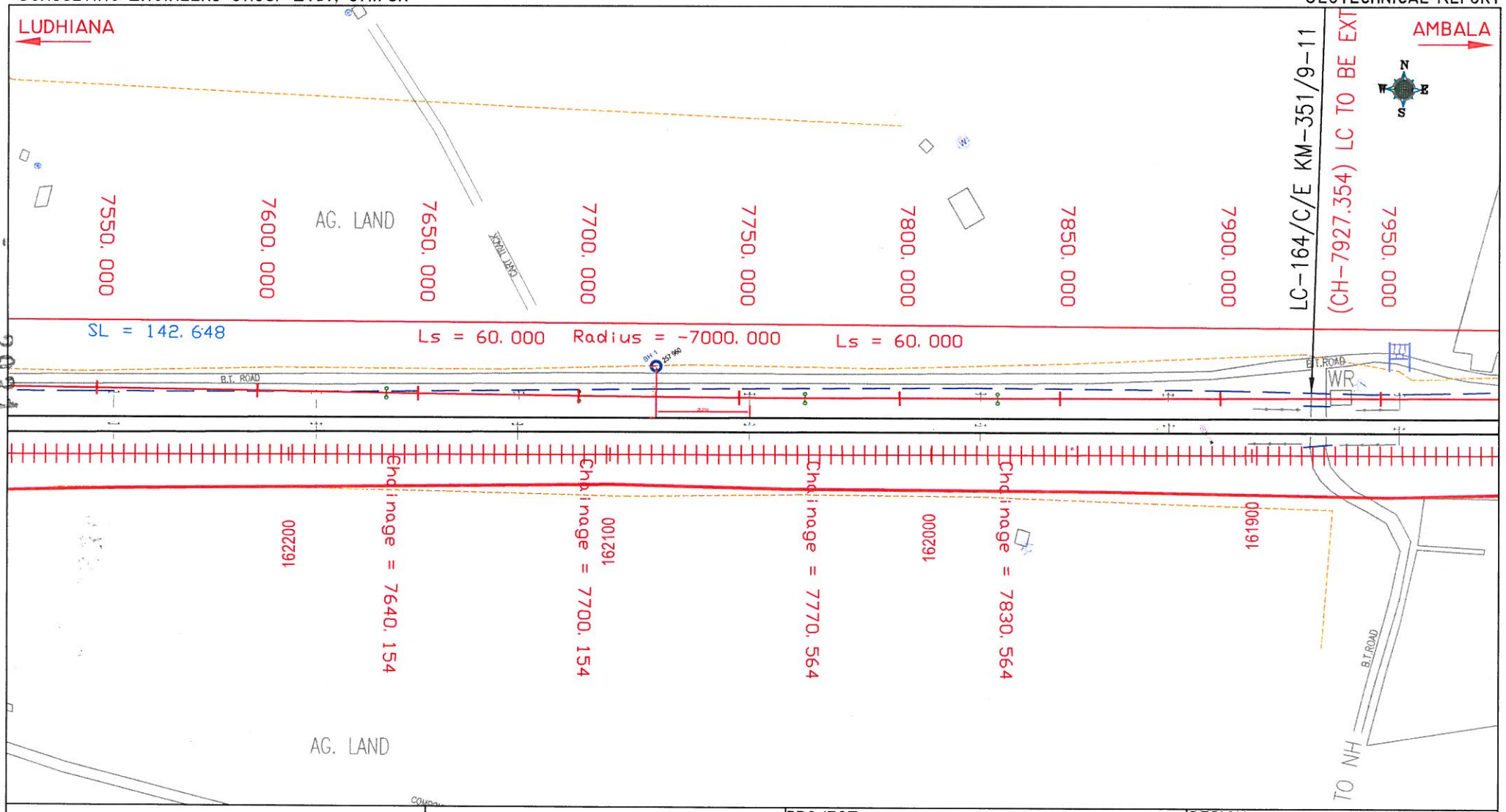
4.7 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.
- Chemical contents of Water are within the safe limits for construction purpose.

4.8 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 3.00m from EGL

Note- The above recommendations are based on the field and laboratory tests conducted on the soil, and our experience in this regard. If the actual subsoil conditions during excavation for the foundation differ from the observations reported here, the design experts/consultants should be referred for suggestion, further investigations. However, the Depth and Type of foundation is to be decided by the structure designer depending upon the type of loading/structure and site conditions.



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 351/15-17	RL OF BH-I = 257.96	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 382 AT CHAINAGE 351/15-17

Project :	Chainage 351/15-17 Bridge No. 382			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				26.05.2009 to 26.05.2009	1	1 (LHS)	below 11.00 m.	12.00mtr	257.960

Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Sandy Silt with clay	13.20	56.03	20.69	3.36	1.97	3.65	1.10	32	21	11	-	-	-	-	-	-
1.50	11	1.44	15.84	Sandy Silt	2.33	74.87	17.68	0.88	0.77	3.47	0.00	26	NP	NIL	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt	3.67	61.36	34.01	0.60	0.36	0.00	0.00	27	NP	NIL	1.82	6.50	1.71	2.65	0.00	26.00
4.50	-			Silty Sand	2.30	34.21	55.32	6.97	1.20	0.00	0.00	25	NP	NIL						
6.00	32	0.97	31.04	Silty Sand	1.36	7.89	85.51	5.09	0.15	0.00	0.00	24	NP	NIL	-	-	-	-	-	-
9.00	34	0.84	28.56	Silty Sand	1.68	24.83	70.80	1.81	0.70	0.18	0.00	21	NP	NIL	-	-	-	-	-	-
12.00	36	0.74	20.82	Silty Sand	2.31	25.64	68.93	2.37	0.59	0.16	0.00	22	NP	NIL	-	-	-	-	-	-

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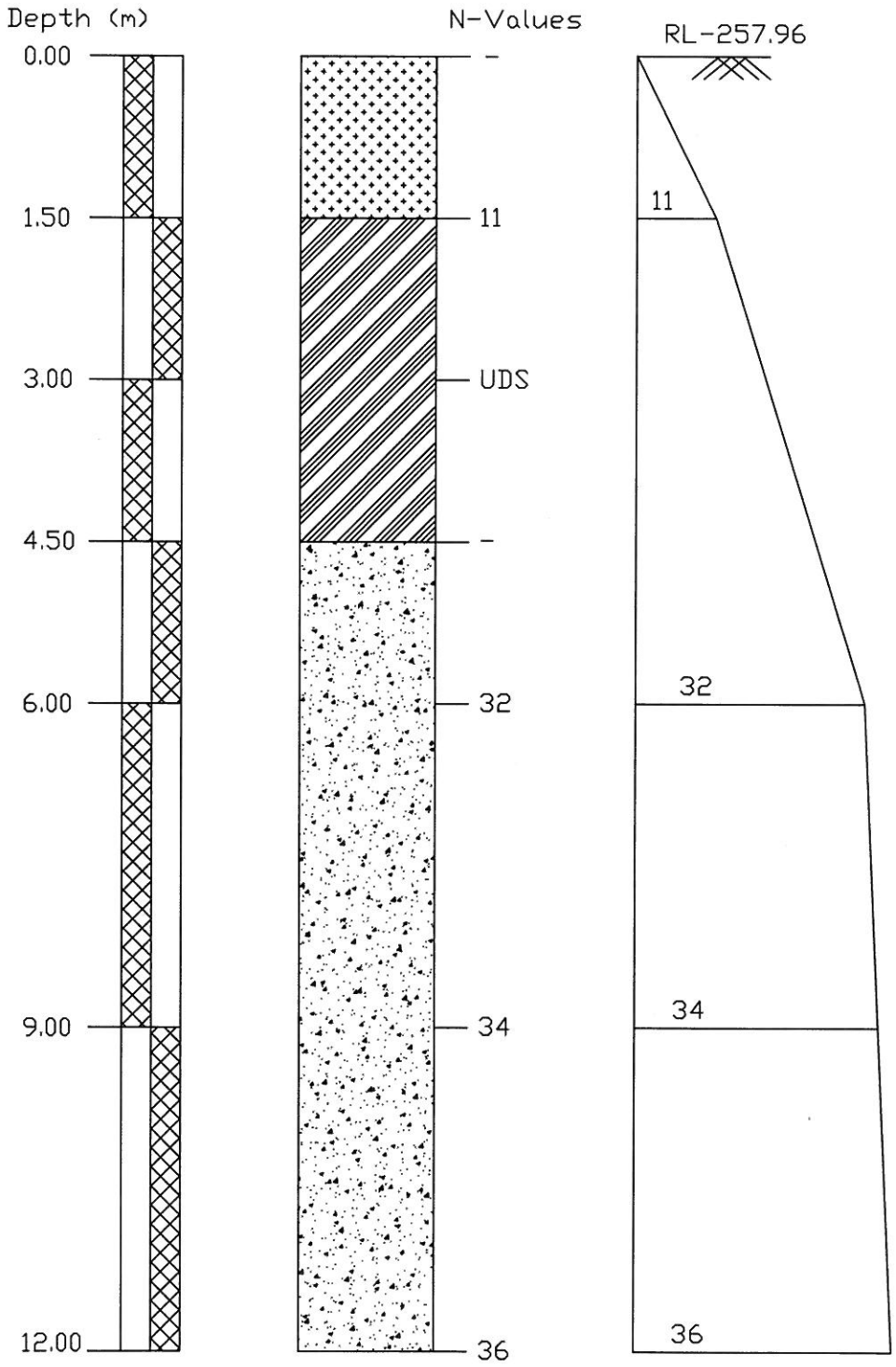
BORELOG OF BH–1(LHS) AT EXISTING KM–351/15–17 FOR MINOR BRIDGE NO.–382, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT WITH CLAY
	SANDY SILT
	SILTY SAND

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ANNEXURE - III

Calculation of SBC for shallow foundations as per IS : 6403 - 1981

INPUT DATA

Minor Bridge No 351/15-17 BH-1

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Continuous Strip | 1

Angle of internal friction (ϕ°)	26.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.55
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.80
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)
1	1.50	1.20
2	3.00	1.20
3	4.50	1.20
4	6.00	1.20

SHEAR FAILURE CRITERIA

Assumptions and formula used in calculation as per IS:6403-1981 are given below -

The ultimate net bearing capacity in case of general shear failure is given by

$$q_d = c\,N_c\,s_c\,d_c\,i_c + q\,(N_q-1)\,s_q\,d_q\,i_q + (1/2)\,B\,\gamma\,N_\gamma\,s_\gamma\,d_f\,i_\gamma\,W'$$

The ultimate net bearing capacity in case of local shear failure is given by

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

Where,

$d_c = 1 + 0.2\,(D_f/B)*SQRT(N_\phi)$

$d_q = d_\gamma = 1$ for $\phi < 10^\circ$

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)*SQRT(N_\phi)$ for $\phi > 10^\circ$

$N_\phi = \tan^2(\pi/4 + \phi/2)$

ϕ' for local shear failure = $\tan^{-1}(0.67\tan\phi)$

OUTPUT

The computer aided results for shear failure criteria are tabulated below. The results are interpolated values of bearing capacity obtained from general and local shear failure criteria.

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.00
N_c	22.60
N_q	12.21
N_γ	13.18

ϕ'	18.10
N'_c	13.36
N'_q	5.46
N'_γ	4.35

Shape factors :

S.no.	Width(m)	S_c	S_q	S_γ
1	1.20	1.00	1.00	1.00
2	1.20	1.00	1.00	1.00
3	1.20	1.00	1.00	1.00
4	1.20	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	1.20	1.40	1.20	1.20
2	3.00	1.20	1.80	1.40	1.40
3	4.50	1.20	2.20	1.60	1.60
4	6.00	1.20	2.60	1.80	1.80

Inclination factors :

$i_c = (1-\alpha / 90)^2$	$i_q = (1-\alpha / 90)^2$	$i_\gamma = (1- \alpha / \phi)^2$
1.00	1.00	1.00

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	1.50	1.20	0.00	0.50
2	3.00	1.20	-1.25	0.50
3	4.50	1.20	-2.50	0.50
4	6.00	1.20	-3.75	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shea	Local shear	Actual
1	1.50	1.20	11.99	4.58	11.99
2	3.00	1.20	13.99	5.34	13.99
3	4.50	1.20	15.99	6.11	15.99
4	6.00	1.20	17.99	6.87	17.99

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Minor,BridgeNo. 382
Chainage	351/15-17
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	12.00
Average N value	20.00
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	18.00
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	13.1

Footing Depth (m)	3.00
SBC (t/m2)	14.00
Average N value	21.00
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	21.00
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	13.9

Footing Depth (m)	4.50
SBC (t/m2)	16.00
Average N value	25.00
Settlement for 10 t/m2 (mm)	13.00
Total Settlement (mm)	20.80
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	12.3

Footing Depth (m)	6.00
SBC (t/m2)	18.00
Average N value	25.00
Settlement for 10 t/m2 (mm)	11.00
Total Settlement (mm)	19.80
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	10.8

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CHAPTER – 05

"Minor Bridge No. 380",

Location – Existing Km. - 350/19-21

5.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 1x1.2x1.2

5.2 BOREHOLE DESCRIPTIONS:

(a) Location of Structure, Boreholes with RL of existing GL shown in **FIGURE-1**.

(b) Subsurface Characteristic of Soil/Rock shown in *ANNEXURE-I.*

(c) Borelogs and sub soil profile shown in *ANNEXURE-II.*

(d) Calculation of Safe Bearing Capacities in *ANNEXURE-III.*

(e) Calculation of Probable Settlement in *ANNEXURE-IV.*

(f) Depth of water Table 9.75m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 3.00	Clayey Silt	Loose
	3.00 to 3.80	Sandy Silt	Medium Dense
	3.80 to 6.00	Silty Sand	Medium Dense
	6.00 to 12.00	Silty Sand	Dense

5.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.70	0.005	0.0014	NIL	0.0009	0.046

5.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	NIL

5.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BORE HOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (µS/cm)
Test Result	7.2	26	50	180	318	0.2	1.5	512	301
Permissible limit as per IS 456/ Morth	Not less then 6.0	2000 for CC and 500 for RCC	400	200	3000	5 ml of 0.02 normal NaoH	25 ml of 0.02 normal H_2SO_4	-	-

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5.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	11.00
	3.00	15.00
	4.50	17.00
	6.00	19.00

5.7 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.
- Chemical contents of Water are within the safe limits for construction purpose.

5.8 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 3.00m from EGL

Note- The above recommendations are based on the field and laboratory tests conducted on the soil, and our experience in this regard. If the actual subsoil conditions during excavation for the foundation differ from the observations reported here, the design experts/consultants should be referred for suggestion, further investigations. However, the Depth and Type of foundation is to be decided by the structure designer depending upon the type of loading/structure and site conditions.

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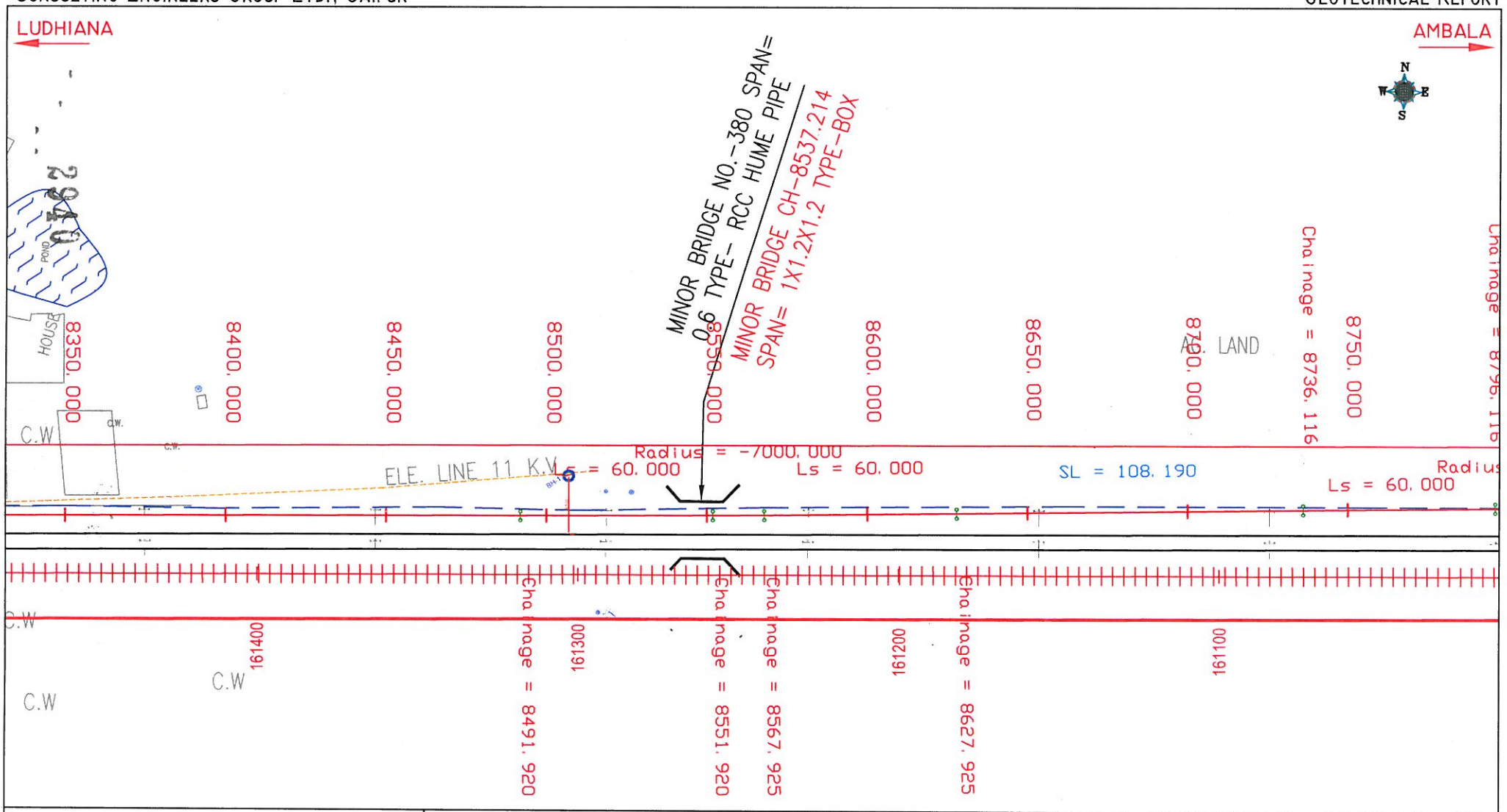

ALL DIMENSIONS IN METER			
FIG.:-I LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 350/19-21	RL OF BH-I = 257.043	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 380 AT CHAINAGE 350/19-21

Project :	Chainage 350/19-21 Bridge No. 380			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				26.05.2009 to 26.05.2009	1	1 (LHS)	9.75 m.	12.00mtr	257.043

Depth from GL (m)	Observed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel										c kg/cm^2	ϕ degree
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
0.00	-	-	-	Clayey Silt	11.64	81.34	2.68	1.96	1.02	1.36	0.00	32	21	11	-	-	-	-	-	-
1.50	7	1.44	10.08	Clayey Silt	13.38	80.23	4.25	0.56	0.63	0.95	0.00	32	20	12	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt	4.59	72.51	19.68	1.13	0.55	1.54	0.00	31	NIL	NP	1.82	5.01	1.73	2.67	0.00	26.50
3.80				Silty Sand	2.29	30.64	58.69	6.59	1.10	0.69	0.00	26	NIL	NP						
6.00	31	0.97	30.07	Silty Sand	3.11	32.14	64.43	0.32	0.00	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
9.00	36	0.84	22.62	Silty Sand	2.69	20.79	70.68	3.64	2.20	0.00	0.00	23	NIL	NP		-	-	-	-	-
12.00	37	0.74	21.19	Silty Sand	2.98	29.67	59.69	3.67	3.99	0.00	0.00	25	NIL	NP	-	-	-	-	-	-

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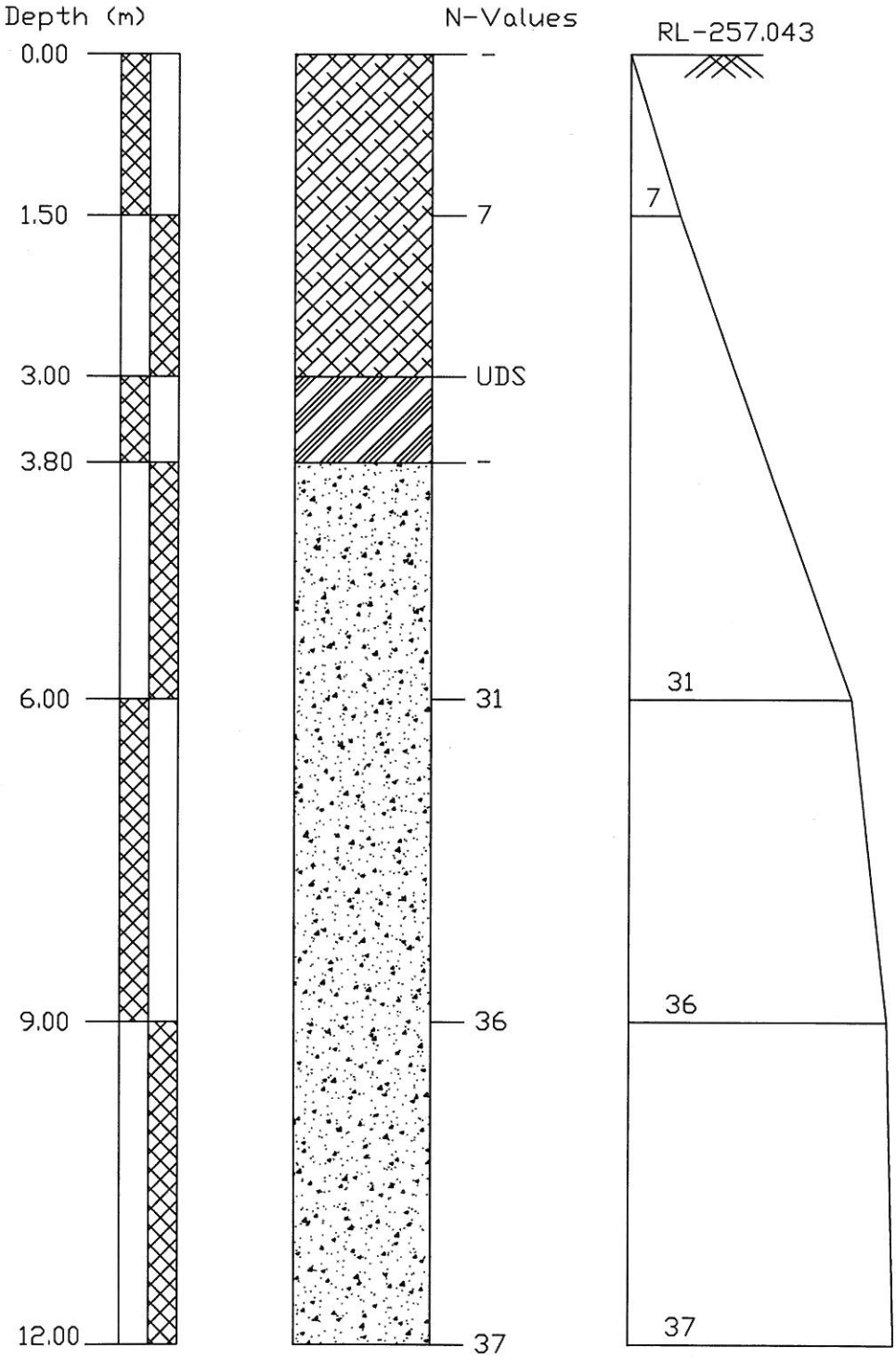
BORELOG OF BH–1(LHS) AT EXISTING KM–350/19–21 FOR MINOR BRIDGE NO.–380,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT
	SANDY SILT
	SILTY SAND

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ANNEXURE - III

Calculation of SBC for shallow foundations as per IS : 6403 - 1981

INPUT DATA

Minor Bridge No 350/19-21 BH-1

Type of footing

1	Continuous Strip		
2	Rectangular	***Continuous Strip***	1
3	Square		
4	Circular		

Angle of internal friction (ϕ °)	26.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.54
Direction of load with vertical ($^{\circ}$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.80
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)
1	1.50	1.20
2	3.00	1.20
3	4.50	1.20
4	6.00	1.20

SHEAR FAILURE CRITERIA

Assumptions and formula used in calculation as per IS:6403-1981 are given below -

The ultimate net bearing capacity in case of general shear failure is given by

$$q_d = c\,N_c\,s_c\,d_c\,i_c + q\,(N_q-1)\,s_q\,d_q\,i_q + (1/2)\,B\,\gamma\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma\,W'$$

The ultimate net bearing capacity in case of local shear failure is given by

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

Where,

$d_c = 1 + 0.2\,(D_f/B)*SQRT(N_\phi)$

$d_q = d_\gamma = 1$ for $\phi < 10^\circ$

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)*SQRT(N_\phi)$ for $\phi > 10^\circ$

$N_\phi = \tan^2(\pi/4 + \phi/2)$

ϕ' for local shear failure = $\tan^{-1}(0.67\tan\phi)$

OUTPUT

The computer aided results for shear failure criteria are tabulated below. The results are interpolated values of bearing capacity obtained from general and local shear failure criteria.

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.50
N_c	23.55
N_q	12.98
N_γ	14.34

ϕ'	18.47
N'_c	13.65
N'_q	5.65
N'_γ	4.55

Shape factors :

S.no.	Width(m)	S_c	S_q	S_γ
1	1.20	1.00	1.00	1.00
2	1.20	1.00	1.00	1.00
3	1.20	1.00	1.00	1.00
4	1.20	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	1.20	1.40	1.20	1.20
2	3.00	1.20	1.81	1.40	1.40
3	4.50	1.20	2.21	1.61	1.61
4	6.00	1.20	2.62	1.81	1.81

Inclination factors :

$i_c = (1-\alpha / 90)^2$	$i_q = (1-\alpha / 90)^2$	$i_\gamma = (1-\alpha / \phi)^2$
1.00	1.00	1.00

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	1.50	1.20	0.00	0.50
2	3.00	1.20	-1.25	0.50
3	4.50	1.20	-2.50	0.50
4	6.00	1.20	-3.75	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shea	Local shear	Actual
1	1.50	1.20	12.90	4.78	12.90
2	3.00	1.20	15.06	5.59	15.06
3	4.50	1.20	17.23	6.39	17.23
4	6.00	1.20	19.40	7.20	19.40

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ANNEXURE - IV

Settlement Calculation for Cohesive Soil As per IS 8009 (Part 1)

BH No. (A1) — **Minor Bridge at Ch. 350(19-21)**

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	1.2	m
Initial effective stress at mid of layer	Po	=	3.87	t/m^2
Concentrated load *P*		=	11.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.4	t/m^2
Compression Index	Cc	=	0.11	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.63	
	$\frac{Po + \Delta p}{Po}$	=	1.62532	

Settlement of clay layer

$$S_f = \frac{Cc}{1+ eo} \; H \; \log_{10} \frac{Po + \Delta P}{Po}$$

S_f = 0.02135 m

= 21.3528 mm

Correction for Depth and Rigidity of foundation on total settlement

Depth Factor Calculation

$D/(LB)^{0.5}$ = 0.48 $(LB)^{0.5}/D$ = 2.07

D = Depth of Foundation

L/B = 6.67

Depth Factor = 0.83

$$\text{Rigidity Factor} = \frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$$

= 0.80

Pore Pressure correction = 0.85

Total Settlement = S_f x D.F.x R.F.x Pore Pr. Correction

S_{f2} = **12.1 mm**

Footing Depth (m)	**1.50**
SBC (t/m2)	2.04
Average N value	18.00
Settlement for 10 t/m2 (mm)	12.00
Total Settlement (mm)	2.44
Depth Correction	0.63
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**1.2**

Total Settlement (mm) 13.3

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Minor BridgeNo. 380
Chainage	350/19-21
Bore Hole No.	1

Footing Depth (m)	3.00
SBC (t/m2)	15.00
Average N value	19.25
Settlement for 10 t/m2 (mm)	13.00
Total Settlement (mm)	19.50
Depth Correction	0.73
Rigidity Correction	0.8
Corrected Total Settlement (mm)	11.4

Footing Depth (m)	4.50
SBC (t/m2)	17.00
Average N value	23.00
Settlement for 10 t/m2 (mm)	10.00
Total Settlement (mm)	17.00
Depth Correction	0.675
Rigidity Correction	0.8
Corrected Total Settlement (mm)	9.2

Footing Depth (m)	6.00
SBC (t/m2)	19.00
Average N value	24.00
Settlement for 10 t/m2 (mm)	9.00
Total Settlement (mm)	17.10
Depth Correction	0.63
Rigidity Correction	0.8
Corrected Total Settlement (mm)	8.6

CHAPTER – 06

"Minor Bridge No. 379",

Location – Existing Km. - 349/15-17

6.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge No. 379 at Chainage 349/15-17

6.2 BOREHOLE DESCRIPTIONS:

(a) Location of Structure, Boreholes with RL of existing GL shown in **FIGURE-1**.

(b) Subsurface Characteristic of Soil/Rock shown in *ANNEXURE-I.*

(c) Borelogs and sub soil profile shown in *ANNEXURE-II.*

(d) Calculations of Safe Bearing Capacities in *ANNEXURE-III.*

(e) Calculations of Probable Settlement in *ANNEXURE-IV.*

(f) Depth of water Table ≥13.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.00	Clayey Silt with Sand	Loose
	1.00 to 1.50	Sandy Silt	Loose
	1.50 to 9.00	Sandy Silt	Medium Dense
	9.00 to 12.00	Clayey Silt	Medium Dense

6.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	6.00	8.50	0.005	0.0014	NIL	0.0009	0.032

6.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	6.00	NIL

6.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	8.50
	3.00	16.00
	4.50	17.00
	6.00	18.00

6.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

6.7 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 3.00m from EGL

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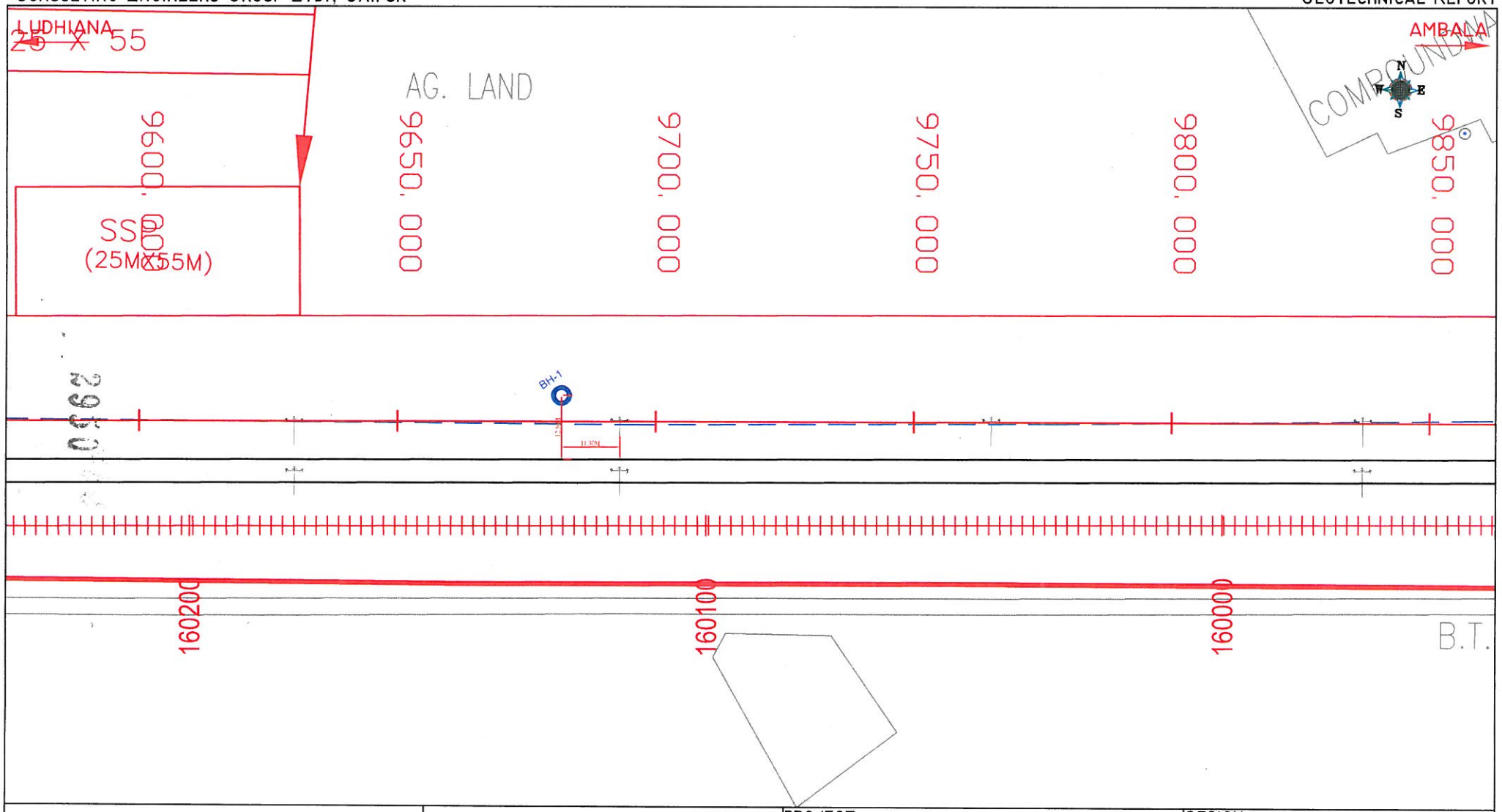
Note- The above recommendations are based on the field and laboratory tests conducted on the soil, and our experience in this regard. If the actual subsoil conditions during excavation for the foundation differ from the observations reported here, the design experts/consultants should be referred for suggestion, further investigations. However, the Depth and Type of foundation is to be decided by the structure designer depending upon the type of loading/structure and site conditions.



ALL DIMENSIONS IN METER			
FIG.:-I LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 349/15-17	RL OF BH-I = 257.816	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel. +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 379 AT CHAINAGE 349/15-17

Project :	Chainage 349/15-17 Bridge No. 379			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				30.05.2009 to 30.05.2009	1	1 (LHS)	below 13.00 m.	12.00mtr	257.816

Depth from GL (m)	Observed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel										c kg/cm^2	ϕ degree
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
0.00	-	-	-	Clayey Silt with Sand	10.21	77.06	8.67	2.28	1.19	0.59	0.00	30	22	8	-	-	-	-	-	-
1.00	-	-	-	Sandy Silt	2.65	75.49	16.25	3.29	1.22	1.10	0.00	23	NIL	NP						
1.50	12	1.45	17.40	Sandy Silt	2.28	83.70	11.91	0.94	1.17	0.00	0.00	21	NIL	NP	-	-	-	-	-	-
3.00	18	1.21	21.78	Sandy Silt	1.66	70.08	5.33	1.57	4.01	17.35	0.00	20	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Sandy Silt	4.59	80.69	13.38	0.43	0.00	0.91	0.00	30	NIL	NP	1.77	15.45	1.53	2.62	0.00	26.50
9.00	21	0.85	17.85	Clayey Silt	10.69	85.96	2.58	0.77	0.00	0.00	0.00	30	21	9	-	-	-	-	-	-
12.00	27	0.75	20.25	Clayey Silt	15.22	82.79	1.99	0.00	0.00	0.00	0.00	35	23	12	-	-	-	-	-	-

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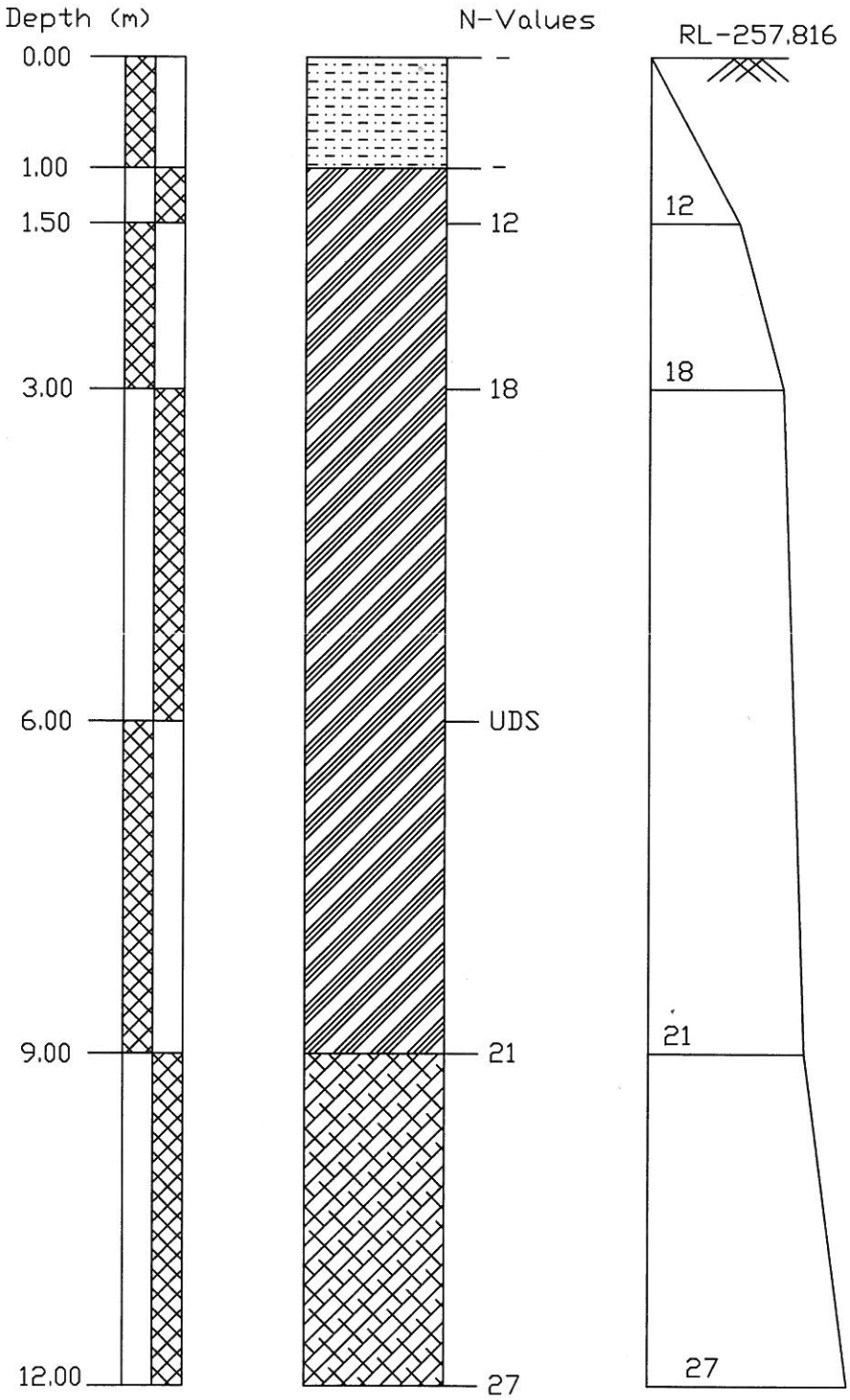
BORELOG OF BH–1(LHS) AT EXISTING KM–349/15–17 FOR MINOR BRIDGE NO.–379, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	SANDY SILT
	CLAYEY SILT

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ANNEXURE - III

Calculation of SBC for shallow foundations as per IS : 6403 - 1981

INPUT DATA

Minor Bridge No 349/15-17 BH-1

Type of footing

1	Continuous Strip		
2	Rectangular	***Rectangular***	**2**
3	Square		
4	Circular		

Angle of internal friction (ϕ °)	26.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.71
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.75
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)	Length (m)
1	1.50	3.00	8.00
2	3.00	3.00	8.00
3	4.50	3.00	8.00
4	6.00	3.00	8.00

SHEAR FAILURE CRITERIA

Assumptions and formula used in calculation as per IS:6403-1981 are given below -

The ultimate net bearing capacity in case of general shear failure is given by

$$q_d = c\,N_c\,s_c\,d_c\,i_c + q\,(N_q-1)\,s_q\,d_q\,i_q + (1/2)\,B\,\gamma\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma\,W'$$

The ultimate net bearing capacity in case of local shear failure is given by

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

Where,

$d_c = 1 + 0.2\,(D_f/B)*SQRT(N_\phi)$

$d_q = d_\gamma = 1$ for $\phi < 10^\circ$

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)*SQRT(N_\phi)$ for $\phi > 10^\circ$

$N_\phi = \tan^2(\pi/4 + \phi/2)$

ϕ' for local shear failure = $\tan^{-1}(0.67\tan\phi)$

OUTPUT

The computer aided results for shear failure criteria are tabulated below. The results are interpolated values of bearing capacity obtained from general and local shear failure criteria.

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.50
N_c	23.55
N_q	12.98
N_γ	14.34

ϕ'	18.47
N'_c	13.65
N'_q	5.65
N'_γ	4.55

Shape factors :

S.no.	Width(m)	Length (m)	S_c	S_q	S_γ
1	3.00	8.00	1.08	1.08	0.85
2	3.00	8.00	1.08	1.08	0.85
3	3.00	8.00	1.08	1.08	0.85
4	3.00	8.00	1.08	1.08	0.85

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.16	1.08	1.08
2	3.00	3.00	1.32	1.16	1.16
3	4.50	3.00	1.48	1.24	1.24
4	6.00	3.00	1.65	1.32	1.32

Inclination factors :

$i_c = (1-\alpha / 90)^2$	$i_q = (1-\alpha / 90)^2$	$i_\gamma = (1-\alpha / \phi)^2$
1.00	1.00	1.00

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	1.50	3.00	0.00	0.50
2	3.00	3.00	-0.50	0.50
3	4.50	3.00	-1.00	0.50
4	6.00	3.00	-1.50	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	17.60	6.42	8.66
2	3.00	3.00	8.00	31.63	11.83	15.79
3	4.50	3.00	8.00	33.83	12.66	16.89
4	6.00	3.00	8.00	36.03	13.48	17.99

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Minor Bridge No. 379
Chainage	349/15-17
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	8.50
Average N value	19.00
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	12.75
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	9.3

Footing Depth (m)	3.00
SBC (t/m2)	16.00
Average N value	19.00
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	24.00
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	15.9

Footing Depth (m)	4.50
SBC (t/m2)	17.00
Average N value	19.00
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	25.50
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	15.1

Footing Depth (m)	6.00
SBC (t/m2)	18.00
Average N value	19.00
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	27.00
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	14.7

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CHAPTER – 07

"Minor Bridge No. 377",

Location – Existing Km. - 348/25-27

7.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 1x1.2x1.2

7.2 BOREHOLE DESCRIPTIONS:

(a) Location of Structure, Boreholes with RL of existing GL shown in **FIGURE-1**.

(b) Subsurface Characteristic of Soil/Rock shown in *ANNEXURE-I.*

(c) Borelogs and sub soil profile shown in *ANNEXURE-II.*

(d) Calculations of Safe Bearing Capacities in *ANNEXURE-III.*

(e) Calculations of Probable Settlement in *ANNEXURE-IV.*

(f) Depth of water Table ≥13.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.50	Clayey Silt with Sand	Loose
	1.50 to 3.00	Clayey Silt with Sand & Gravels	Loose
	3.00 to 4.60	Silty gravels with clay and sand	Medium Dense
	4.60 to 12.00	Silty Sand	Medium Dense

7.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.60	0.010	0.0018	NIL	0.0011	0.049

7.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	22
	9.00	NIL

7.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	13.00
	3.00	18.00
	4.50	20.00
	6.00	22.00

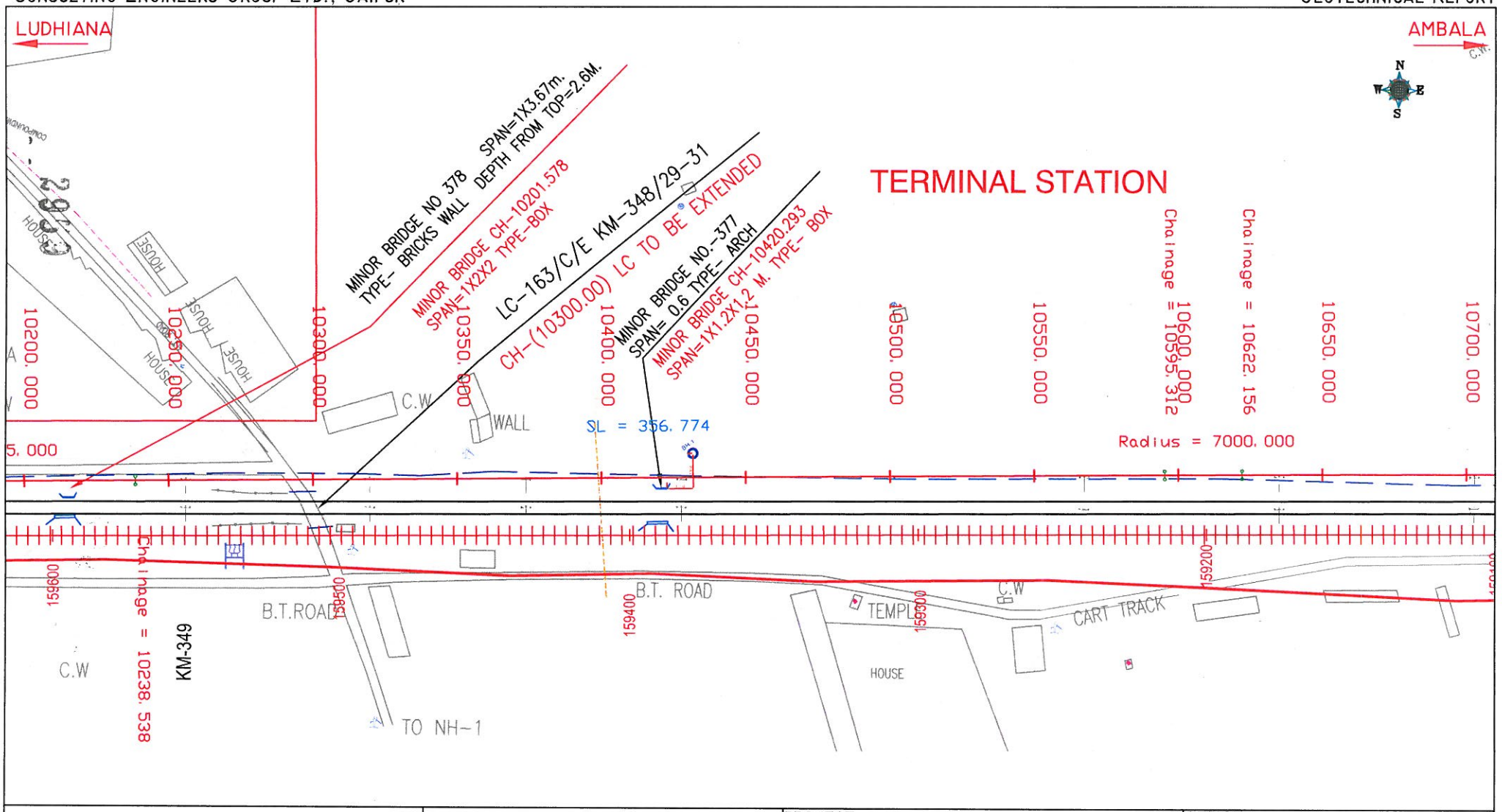
7.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

7.7 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 3.00m from EGL

Note- The above recommendations are based on the field and laboratory tests conducted on the soil, and our experience in this regard. If the actual subsoil conditions during excavation for the foundation differ from the observations reported here, the design experts/consultants should be referred for suggestion, further investigations. However, the Depth and Type of foundation is to be decided by the structure designer depending upon the type of loading/structure and site conditions.



ALL DIMENSIONS IN METER			
FIG.:-I LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 348/25-27	RL OF BH-I = 258.575	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 377 AT CHAINAGE 348/26-27

Project :	Chainage 348/26-27 Bridge No. 377			Date of Testing	Location at		B.H. No.		Depth of Water Table			Termination Depth			Surface Elevation					
				30.05.2009 to 30.05.2009	1		1 (LHS)		below 13.00 m.			12.00mtr			258.575					
Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Clayey Silt with Sand	13.25	73.41	5.66	3.95	1.2	2.53	0.00	30	19	11	-	-	-	-	-	-
1.50	7	1.44	10.08	Clayey Silt with Sand & Gravels	15.95	57.78	15.91	1.11	2.24	7.01	0.00	30	17	13	-	-	-	-	-	-
3.00	UDS	-	-	Clayey Silt with Sand & Gravels	17.83	39.26	19.80	2.15	2.41	9.75	8.80	34	19	15	1.82	4.87	1.73	2.62	0.19	19.00
4.60				Silty Sand	3.21	18.96	62.39	9.33	2.67	3.44	0.00	27	NIL	NP						
6.00	20	0.97	19.40	Silty Sand	2.99	19.71	75.96	0.91	0.29	0.14	0.00	25	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand	4.10	13.94	80.31	1.32	0.33	0.00	0.00	27	NIL	NP	2.08	6.97	1.94	2.68	0.00	28.50
12.00	29	0.72	20.88	Silty Sand	2.65	11.54	77.95	6.65	1.21	0.00	0.00	25	NIL	NP	-	-	-	-	-	-

DFCCIL *KESARI TO SANEHWAL*

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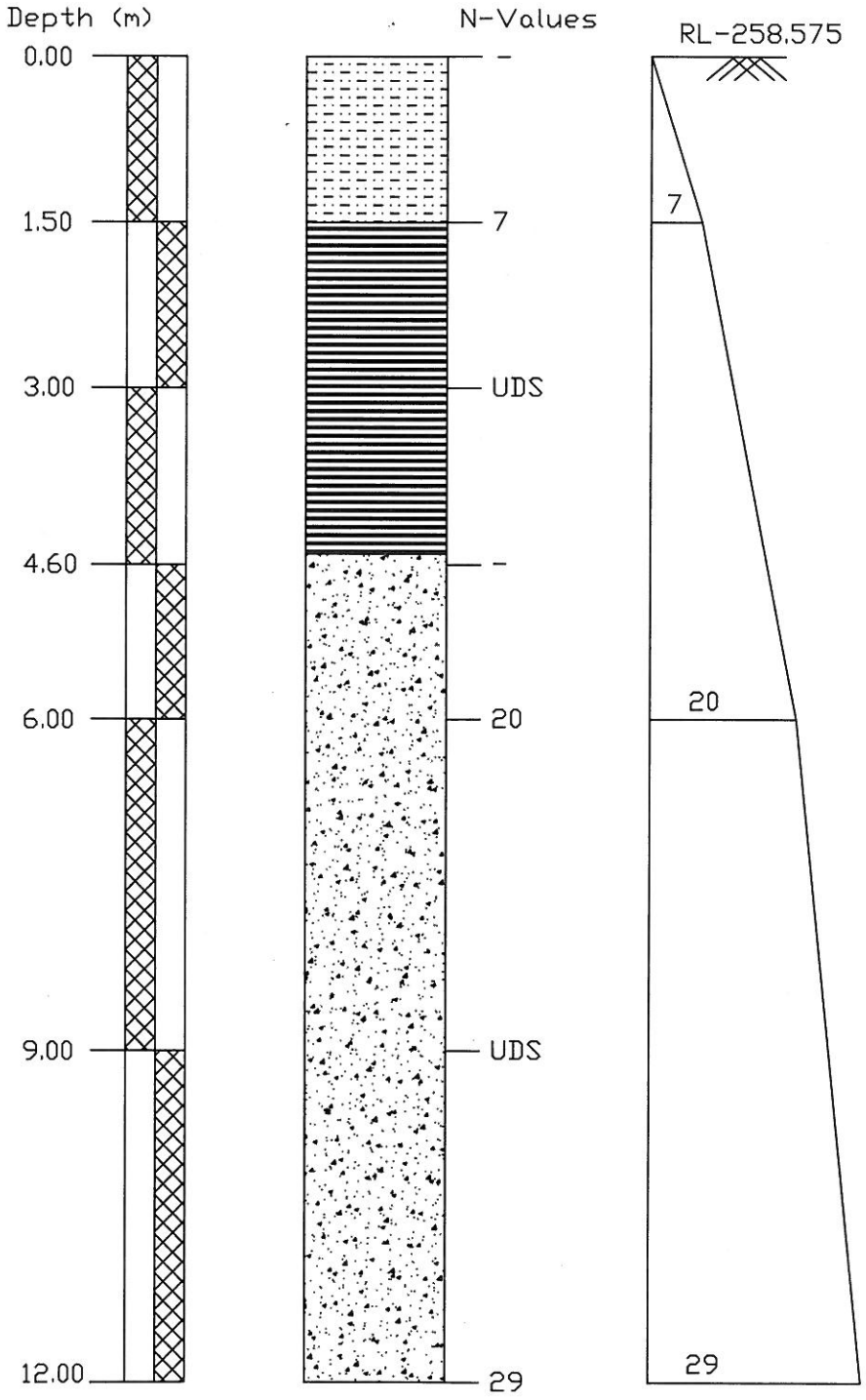
BORELOG OF BH–1(LHS) AT EXISTING KM–348/25–27 FOR MINOR BRIDGE NO.–377, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	CLAYEY SILT WITH SAND & GRAVELS
	SILTY SAND

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ANNEXURE - III

Calculation of SBC for shallow foundations as per IS : 6403 - 1981

INPUT DATA

Minor Bridge No 348/26-27 . BH-1

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Continuous Strip | 1

Angle of internal friction (ϕ °)	19.00
Cohesion (c in t/m2)	1.90
Void ratio (e)	0.51
Direction of load with vertical (^{o})	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.82
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)
1	1.50	1.20
2	3.00	1.20

SHEAR FAILURE CRITERIA

Assumptions and formula used in calculation as per IS:6403-1981 are given below -

The ultimate net bearing capacity in case of general shear failure is given by

$$q_d = c\,N_c\,s_c\,d_c\,i_c + q\,(N_q-1)\,s_q\,d_q\,i_q + (1/2)\,B\,\gamma\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma\,W'$$

The ultimate net bearing capacity in case of local shear failure is given by

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

Where,

$d_c = 1 + 0.2\,(D_f/B)*SQRT(N_\phi)$

$d_q = d_\gamma = 1$ for $\phi < 10^{o}$

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)*SQRT(N_\phi)$ for $\phi > 10^{o}$

$N_\phi = \tan^2(\pi/4 + \phi/2)$

ϕ' for local shear failure = $\tan^{-1}(0.67\tan\phi)$

OUTPUT

The computer aided results for shear failure criteria are tabulated below. The results are interpolated values of bearing capacity obtained from general and local shear failure criteria.

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ANNEXURE - III

Bearing capacity factors :

ϕ	19.00
N_c	14.06
N_q	5.91
N_γ	4.84

ϕ'	12.99
N'_c	9.92
N'_q	3.35
N'_γ	2.08

Shape factors :

S.no.	Width(m)	S_c	S_q	S_γ
1	1.20	1.00	1.00	1.00
2	1.20	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	1.20	1.35	1.18	1.18
2	3.00	1.20	1.70	1.35	1.35

Inclination factors :

$i_c = (1-\alpha / 90)^2$	$i_q = (1-\alpha / 90)^2$	$i_\gamma = (1-\alpha / \phi)^2$
1.00	1.00	1.00

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	1.50	1.20	0.00	0.50
2	3.00	1.20	-1.25	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shea	Local shear	Actual
1	1.50	1.20	16.98	7.98	16.98
2	3.00	1.20	20.84	9.79	20.84

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ANNEXURE - III

Calculation of SBC for shallow foundations as per IS : 6403 - 1981

INPUT DATA

Minor Bridge No 348/26-27 BH-1

Type of footing

1	Continuous Strip		
2	Rectangular	***Continuous Strip***	1
3	Square		
4	Circular		

Angle of internal friction (ϕ °)	28.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.38
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.85
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)
1	4.50	1.20
2	6.00	1.20

SHEAR FAILURE CRITERIA

Assumptions and formula used in calculation as per IS:6403-1981 are given below -

The ultimate net bearing capacity in case of general shear failure is given by

$$q_d = c\,N_c\,s_c\,d_c\,i_c + q\,(N_q-1)\,s_q\,d_q\,i_q + (1/2)\,B\,\gamma\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma\,W'$$

The ultimate net bearing capacity in case of local shear failure is given by

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

Where,

$d_c = 1 + 0.2\,(D_f/B)*SQRT(N_\phi)$

$d_q = d_\gamma = 1$ for $\phi < 10^\circ$

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)*SQRT(N_\phi)$ for $\phi > 10^\circ$

$N_\phi = \tan^2(\pi/4 + \phi/2)$

ϕ' for local shear failure = $\tan^{-1}(0.67\tan\phi)$

OUTPUT

The computer aided results for shear failure criteria are tabulated below. The results are interpolated values of bearing capacity obtained from general and local shear failure criteria.

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ANNEXURE - III

Bearing capacity factors :

ϕ	28.50
N_c	27.31
N_q	16.08
N_γ	18.94

ϕ'	19.99
N'_c	14.82
N'_q	6.40
N'_γ	5.38

Shape factors :

S.no.	Width(m)	S_c	S_q	S_γ
1	1.20	1.00	1.00	1.00
2	1.20	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	4.50	1.20	2.26	1.63	1.63
2	6.00	1.20	2.68	1.84	1.84

Inclination factors :

$i_c = (1-\alpha / 90)^2$	$i_q = (1-\alpha / 90)^2$	$i_\gamma = (1-\alpha / \phi)^2$
1.00	1.00	1.00

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	4.50	1.20	-2.50	0.50
2	6.00	1.20	-3.75	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shea	Local shear	Actual
1	4.50	1.20	22.43	7.61	22.43
2	6.00	1.20	25.32	8.59	25.32

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ANNEXURE - IV

Settlement Calculation for Cohesive Soil As per IS 8009 (Part 1)

BH No. (A1)			**Minor Bridge at Ch. 348 (26-27)**	
Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	1.2	m
Initial effective stress at mid of layer	Po	=	4.32	t/m^2
Concentrated load *P*		=	13.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.9	t/m^2
Compression Index	Cc	=	0.07	
Thickness of clay layer	H	=	1.8	m
Initial Void ratio	e_o	=	0.51	
	$\frac{Po + \Delta p}{Po}$	=	1.66204	

Settlement of clay layer $S_f = \frac{Cc}{1+ eo} \; H \; \log_{10} \frac{Po + \Delta P}{Po}$

S_f = 0.01841 m

= 18.4111 mm

Correction for Depth and Rigidity of foundation on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.48 $(LB)^{\wedge 0.5}/D$ = 2.07

D = Depth of Foundation

L/B = 6.67

Depth Factor = 0.83

Rigidity Factor = $\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$

= 0.80

Pore Pressure correction = N.A.

Total Settlement = S_f x D.F.x R.F.x Pore Pr. Correction

S_{f2} = **12.2 mm**

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Settlement Calculation for Cohesive Soil As per IS 8009 (Part 1)

BH No. (A1)			**Minor Bridge at Ch. 348 (26-27)**	
Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	1.2	m
Initial effective stress at mid of layer	Po	=	7.02	t/m^2
Concentrated load *P*		=	18.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	4.0	t/m^2
Compression Index	Cc	=	0.073	
Thickness of clay layer	H	=	1.8	m
Initial Void ratio	e_o	=	0.51	
	$\frac{Po + \Delta p}{Po}$	=	1.5641	

Settlement of clay layer $S_f = \frac{Cc}{1+ eo} \; H \; \log_{10} \frac{Po + \Delta P}{Po}$

S_f = 0.0169 m

= 16.9049 mm

Correction for Depth and Rigidity of foundation on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.97 $(LB)^{\wedge 0.5}/D$ = 1.03

D = Depth of Foundation

L/B = 6.67

Depth Factor = 0.73

Rigidity Factor = $\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$

= 0.80

Pore Pressure correction = 0.85

Total Settlement = S_f x D.F.x R.F.x Pore Pr. Correction

S_{f2} = **8.4** **mm**

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Minor Bridge No. 377
Chainage	348/26-27
Bore Hole No.	1

Footing Depth (m)	**4.50**
SBC (t/m2)	20.00
Average N value	19.00
Settlement for 10 t/m2 (mm)	13.00
Total Settlement (mm)	26.00
Depth Correction	0.675
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**14.0**

Footing Depth (m)	**6.00**
SBC (t/m2)	22.00
Average N value	20.00
Settlement for 10 t/m2 (mm)	11.00
Total Settlement (mm)	24.20
Depth Correction	0.63
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**12.2**

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CHAPTER – 08

"Minor Bridge No. 376 A",

Location – Existing Km. - 345/04-06