ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (A1) OF MAJOR BRIDGE No. 294 AT CHAINAGE 257 5-17

Project :	Chainage 257.300 Bridge No. 294			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				13.12.2009 to 15.12.2009	A1	1	08.00 m.	30.00mtr	270.196

Depth from GL (m)	Observ-ed 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	-	-	-	Silty Sand	3.26	29.87	65.29	0.22	1.36	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
1.50	8	1.46	11.68	Silty Sand	3.65	32.93	63.25	0.17	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	3.55	34.31	60.52	0.52	1.10	0.00	0.00	24	NIL	NP	1.70	6.68	1.59	2.66	0.00	28.0
4.50	10	1.09	10.90	Silty Sand	4.25	42.08	51.94	0.68	1.05	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	2.52	36.49	59.48	0.86	0.65	0.00	0.00	22	NIL	NP	1.79	14.56	1.74	2.67	0.00	28.0
7.50	12	0.91	10.92	Silty Sand	2.89	22.07	72.11	1.85	0.66	0.42	0.00	23	NIL	NP	-	-	-	-	-	-
10.50	15	0.80	12.00	Silty Sand	3.84	28.20	57.53	5.54	1.32	3.57	0.00	24	NIL	NP	-	-	-	-	-	-
12.00	UDS	-	-	Clayey Silt with Sand	12.25	76.67	3.26	4.26	1.20	2.36	0.00	31	21	10	2.06	19.68	1.72	2.65	0.11	20.0
13.50	23	0.70	15.55	Clayey Silt with Sand	16.22	75.43	4.16	3.25	0.36	0.58	0.00	34	20	14	-	-	-	-	-	-
16.50	28	0.63	16.32	Clayey Silt with Sand	18.45	72.57	5.26	1.68	0.52	1.52	0.00	37	21	16	-	-	-	-	-	-
19.50	32	0.56	16.46	Clayey Silt with Sand	21.65	69.44	4.25	2.36	1.65	0.65	0.00	39	20	19	-	-	-	-	-	-
22.50	41	0.51	17.96	Clayey Silt with Sand	19.95	70.22	3.65	4.58	0.45	1.15	0.00	36	19	17	-	-	-	-	-	-
24.00	UDS	-	-	Clayey Silt with Sand	22.88	66.59	3.25	5.67	1.25	0.36	0.00	41	21	20	2.06	21.26	1.70	2.64	0.23	14.0
25.50	45	0.47	18.08	Clayey Silt with Sand	17.53	70.03	4.52	4.98	1.64	1.30	0.00	35	20	15	-	-	-	-	-	-
28.50	50	0.43	18.25	Clayey Silt with Sand	14.67	70.75	6.35	6.25	1.41	0.57	0.00	33	21	12	-	-	-	-	-	-
30.00	60	0.41	19.80	Clayey Silt with Sand	15.98	75.56	4.15	2.69	0.68	0.94	0.00	35	21	14	-	-	-	-	-	-

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SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (IN BETWEEN P1 & P2) OF MAJOR BRIDGE No. 294 AT CHAINAGE 257.5-17

Project :	Chainage 257.300 Bridge No. 294			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				16.12.2009 to 16.12.2009	In Between P1 & P2	2	10.00 m.	30.00mtr	267.561

Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
				Description	Clay	Silt	Sand			Gravel									Gravity	c kg/cm^2	ϕ
from	ed	Factor					Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						degree
GL (m)	N	C_n	N_n	(Soil Group)											gm/cc	%	gm/cc			
0.00	-	-	-	Silty Sand	2.65	8.36	80.35	8.22	0.42	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
1.50	6	1.43	8.58	Silty Sand	3.55	6.36	82.07	7.65	0.37	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	4.28	2.80	91.67	1.15	0.10	0.00	0.00	28	NIL	NP	1.85	13.62	1.63	2.62	0.00	28.0
4.50	8	1.06	8.48	Silty Sand	3.85	8.70	85.51	1.58	0.21	0.15	0.00	26	NIL	NP	-	-	-	-	-	-
7.50	15	0.88	13.20	Silty Sand	0.00	8.12	91.34	0.54	0.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Sandy Silt with Clay	12.18	61.18	26.21	0.20	0.23	0.00	0.00	30	19	11	1.95	15.66	1.69	2.63	0.11	20.0
10.50	20	0.77	15.20	Clayey Silt with Sand	21.52	72.94	3.95	1.20	0.23	0.16	0.00	37	18	19	-	-	-	-	-	-
12.00	UDS	-	-	Clayey Silt with Sand	19.92	73.90	4.25	1.42	0.26	0.25	0.00	37	19	18	2.07	20.24	1.72	2.68	0.21	16.0
13.50	24	0.68	15.66	Clayey Silt with Sand	22.85	70.64	5.52	0.65	0.34	0.00	0.00	42	22	20	-	-	-	-	-	-
16.50	29	0.61	16.35	Clayey Silt with Sand	17.68	76.05	3.45	2.25	0.42	0.15	0.00	37	21	16	-	-	-	-	-	-
19.50	33	0.55	16.58	Clayey Silt with Sand	20.64	71.89	4.25	2.35	0.52	0.35	0.00	37	19	18	-	-	-	-	-	-
21.00	UDS	-	-	Clayey Silt with Sand	22.35	71.04	5.25	0.68	0.68	0.00	0.00	41	21	20	2.09	20.82	1.73	2.67	0.27	12.0
22.50	40	0.50	17.50	Clayey Silt with Sand	17.68	74.46	6.15	1.15	0.41	0.15	0.00	36	21	15	-	-	-	-	-	-
25.50	45	0.45	17.63	Clayey Silt with Sand	18.44	73.13	7.25	0.25	0.68	0.25	0.00	37	21	16	-	-	-	-	-	-
28.50	48	0.42	17.58	Clayey Silt with Sand	20.45	71.58	6.14	1.39	0.44	0.00	0.00	38	20	18	-	-	-	-	-	-
30.00	53	0.40	18.10	Clayey Silt with Sand	15.85	75.35	6.26	1.65	0.56	0.33	0.00	33	19	14	-	-	-	-	-	-

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ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-3 (A2) OF MAJOR BRIDGE No.294 AT CHAINAGE 257.5-17

Project :	Chainage 257.300 Bridge No. 294			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				09.12.2009 to 09.12.2009	A2	3	09.50 m.	30.00mtr	270.300

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	-	-	-	Sandy Silt	2.26	60.93	36.58	0.23	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
1.50	7	1.46	10.22	Sandy Silt	3.89	61.71	34.30	0.10	0.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	4.28	1.81	93.60	0.31	0.00	0.00	0.00	27	NIL	NP	1.70	8.54	1.57	2.69	0.00	28.0
4.50	9	1.09	9.81	Silty Sand	3.14	12.31	83.73	0.82	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
7.50	12	0.92	11.04	Silty Sand	3.26	44.34	47.00	1.25	0.74	3.41	0.00	24	NIL	NP	-	-	-	-	-	-
10.50	15	0.81	12.15	Silty Sand	3.72	10.17	83.63	1.41	0.44	0.63	0.00	24	NIL	NP	-	-	-	-	-	-
12.00	UDS	-	-	Clayey Silt	18.45	79.02	2.53	0.00	0.00	0.00	0.00	38	22	16	2.00	22.78	1.63	2.67	0.19	16.0
13.50	21	0.71	14.91	Clayey Silt	21.52	70.68	3.69	0.63	0.70	2.78	0.00	38	19	19	-	-	-	-	-	-
16.50	27	0.64	16.14	Clayey Silt with Sand	19.23	68.60	6.67	2.00	1.47	2.03	0.00	38	21	17	-	-	-	-	-	-
18.00	UDS	-	-	Clayey Silt with Sand	20.91	70.62	7.20	0.19	0.08	1.00	0.00	38	19	19	2.04	22.28	1.67	2.64	0.22	14.0
19.50	35	0.57	17.48	Clayey Silt with Sand	27.18	67.84	3.22	1.39	0.37	0.00	0.00	48	24	24	-	-	-	-	-	-
22.50	39	0.52	17.64	Clayey Silt with Sand	14.26	73.66	7.92	1.55	0.77	1.84	0.00	29	17	12	-	-	-	-	-	-
24.00	UDS	-	-	Clayey Silt with Sand	15.22	74.52	4.57	4.85	0.67	0.17	0.00	31	18	13	2.08	18.98	1.75	2.66	0.13	17.0
25.50	45	0.47	18.08	Clayey Silt with Sand	18.65	75.44	4.07	1.25	0.59	0.00	0.00	36	19	17	-	-	-	-	-	-
28.50	48	0.43	17.82	Clayey Silt with Sand	10.15	81.10	3.32	2.54	2.20	0.69	0.00	28	19	9	-	-	-	-	-	-
30.00	54	0.42	18.84	Clayey Silt with Sand	8.26	81.68	3.87	3.70	1.79	0.70	0.00	26	18	8	-	-	-	-	-	-

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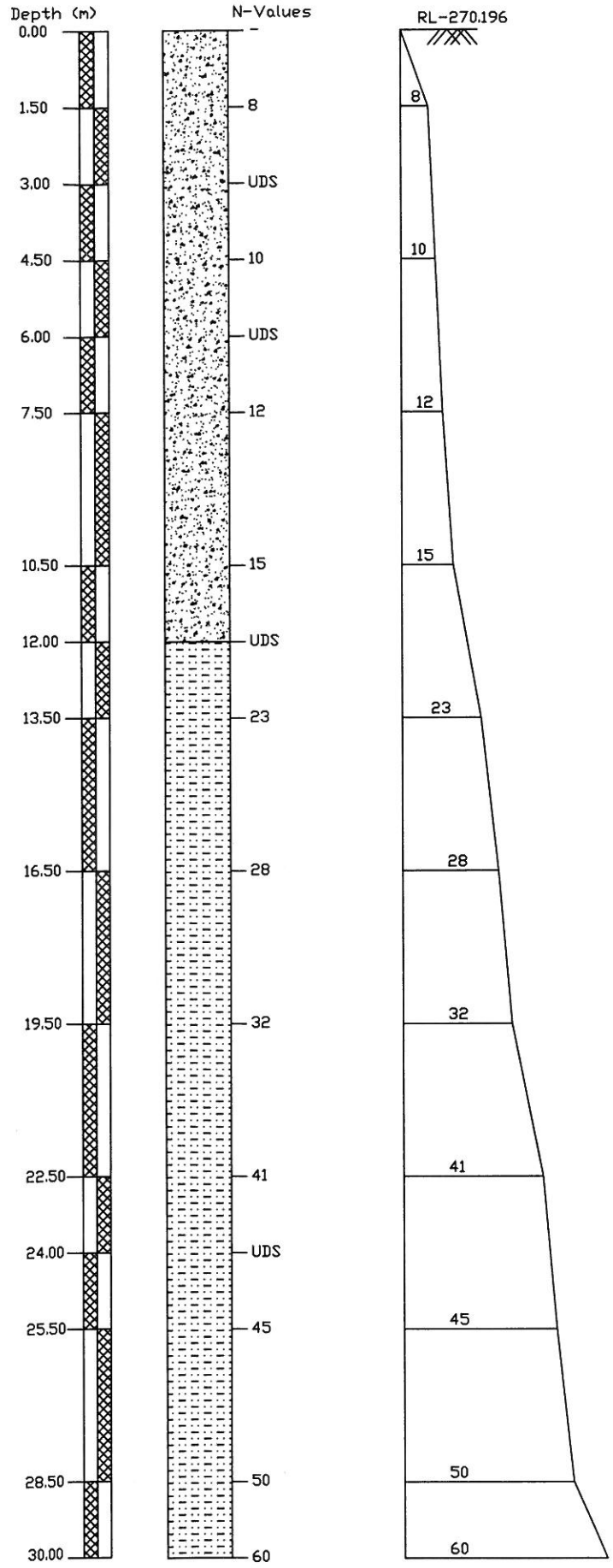
BORELOG OF BH–1(A1) AT EXISTING KM–257/5–17 FOR IMPORTANT MAJOR BRIDGE NO.–294, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SILTY SAND
	CLAYEY SILT WITH SAND

1074

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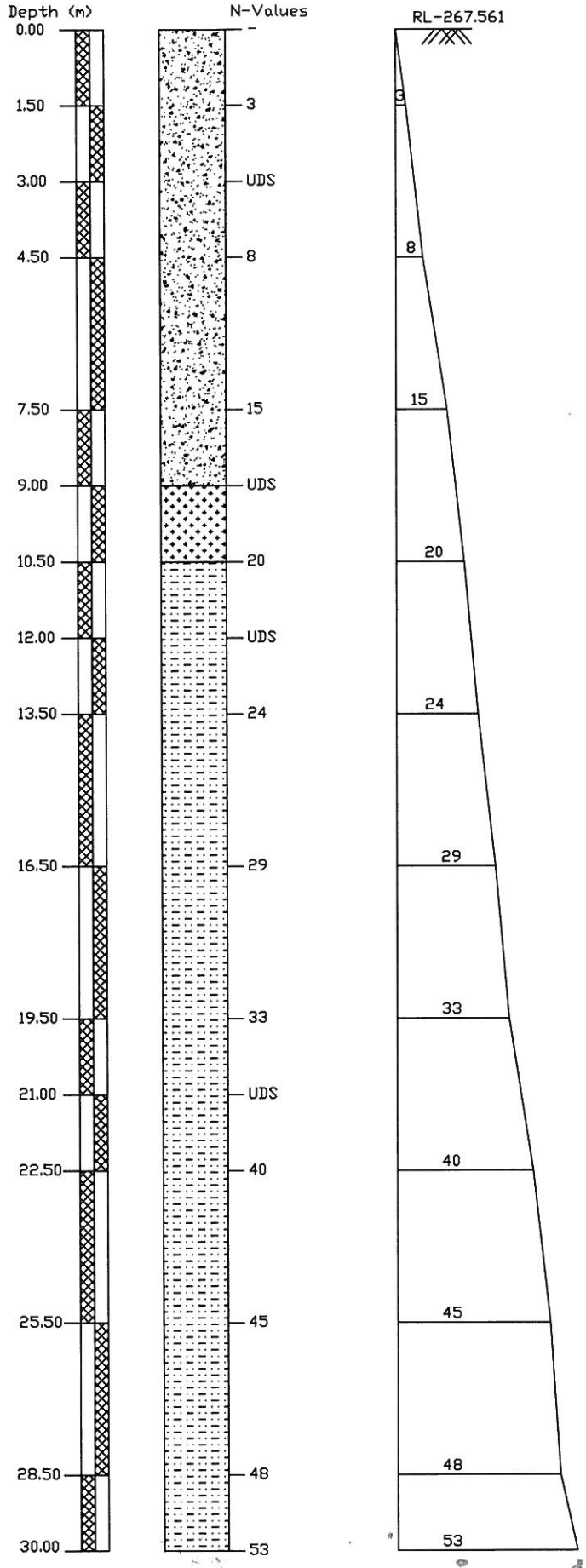
BORELOG OF BH–2(P1&P2) AT EXISTING KM–257/5–17 FOR IMPORTANT MAJOR BRIDGE NO.–294, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SILTY SAND
	SANDY SILT WITH CLAY
	CLAYEY SILT WITH SAND

1075

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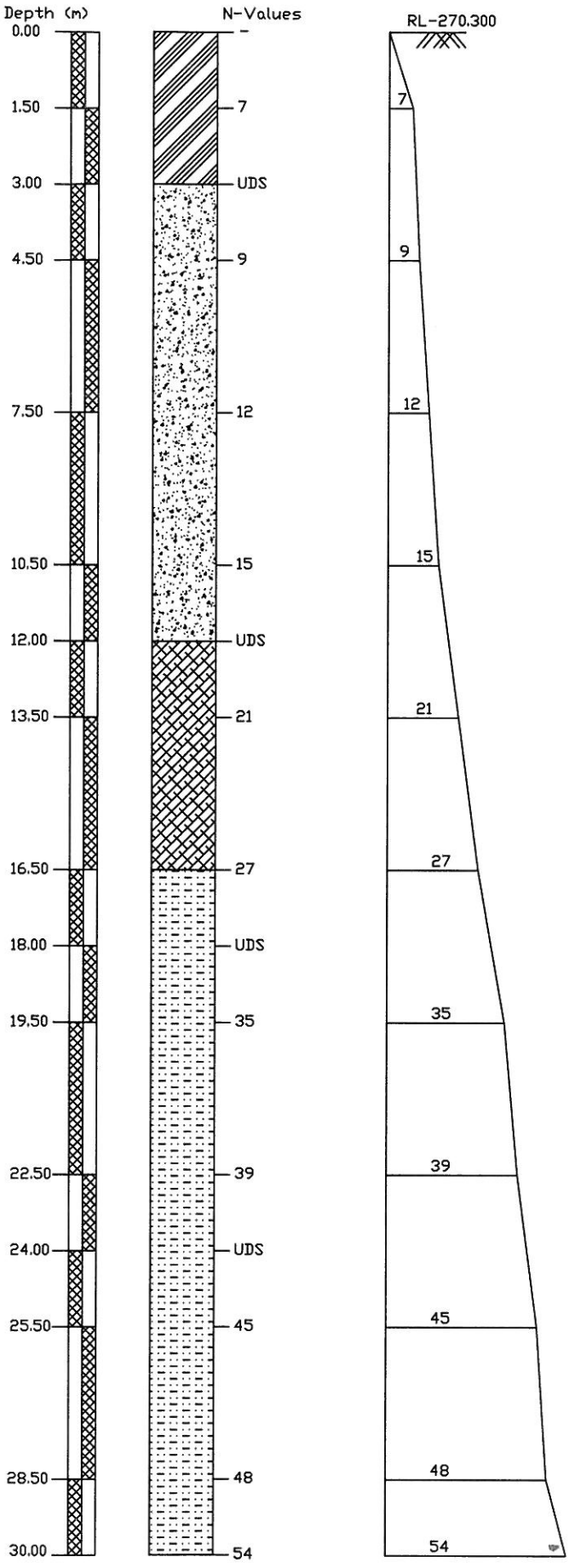
BORELOG OF BH–3(A2) AT EXISTING KM–257/5–17 FOR MAJOR BRIDGE NO.–294,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT
	SILTY SAND
	CLAYEY SILT
	CLAYEY SILT WITH SAND

1078

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ANNEXURE - III

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

INPUT DATA

		Ch 257 5-17	BH-A1
Type of footing			
1	Continuous Strip		
2	Rectangular	***Rectangular***	**2**
3	Square		
4	Circular		

Angle of internal friction (ϕ°)	28.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.67
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	28.00
N_c	26.37
N_q	15.30
N_γ	17.79

ϕ'	19.61
N'_c	14.53
N'_q	6.21
N'_γ	5.18

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	1.17	1.08	1.08
2	3.00	3.00	1.33	1.17	1.17
3	4.50	3.00	1.50	1.25	1.25
4	6.00	3.00	1.67	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 shear	Local shear	Actual
1	1.50	3.00	8.00	21.12	7.18	12.76
2	3.00	3.00	8.00	37.99	13.28	23.16
3	4.50	3.00	8.00	40.70	14.23	24.82
4	6.00	3.00	8.00	43.41	15.18	26.47

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ANNEXURE - III

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

INPUT DATA

	Ch 257 5-17	BH-A2
Type of footing		
1 Continuous Strip		
2 Rectangular	***Rectangular***	**2**
3 Square		
4 Circular		

Angle of internal friction (ϕ °)	28.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.72
Direction of load with vertical (°)	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

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

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.

CONSULTING Engineers Group Ltd.

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ANNEXURE - III

Bearing capacity factors :

ϕ	28.00
N_c	26.37
N_q	15.30
N_γ	17.79

ϕ'	19.61
N'_c	14.53
N'_q	6.21
N'_γ	5.18

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	1.17	1.08	1.08
2	3.00	3.00	1.33	1.17	1.17
3	4.50	3.00	1.50	1.25	1.25
4	6.00	3.00	1.67	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 shear	Local shear	Actual
1	1.50	3.00	8.00	21.12	7.18	9.27
2	3.00	3.00	8.00	37.99	13.28	16.99
3	4.50	3.00	8.00	40.70	14.23	18.20
4	6.00	3.00	8.00	43.41	15.18	19.41

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Major Bridge
Chainage	257/05-17
Bore Hole No.	A1

Footing Depth (m)	1.50
SBC (t/m2)	10.00
Average N value	11
Settlement for 10 t/m2 (mm)	31.00
Settlement (mm) for SBC	31.00
Depth Correction	0.91
Regidity Factor	0.80
Corrected Settlement (mm)	22.6

Footing Depth (m)	3.00
SBC (t/m2)	11.00
Average N value	11
Settlement for 10 t/m2 (mm)	31.00
Settlement (mm) for SBC	34.10
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	22.6

Footing Depth (m)	4.50
SBC (t/m2)	11.50
Average N value	11
Settlement for 10 t/m2 (mm)	31.00
Settlement (mm) for SBC	35.65
Depth Correction	0.74
Regidity Factor	0.80
Corrected Settlement (mm)	21.1

Footing Depth (m)	6.00
SBC (t/m2)	12.00
Average N value	11
Settlement for 10 t/m2 (mm)	31.00
Settlement (mm) for SBC	37.20
Depth Correction	0.68
Regidity Factor	0.80
Corrected Settlement (mm)	20.2

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Major Bridge
Chainage	257/05-17
Bore Hole No.	A2

Footing Depth (m)	1.50
SBC (t/m2)	9.00
Average N value	10
Settlement for 10 t/m2 (mm)	36.00
Settlement (mm) for SBC	32.40
Depth Correction	0.91
Regidity Factor	0.80
Corrected Settlement (mm)	23.6

Footing Depth (m)	3.00
SBC (t/m2)	10.50
Average N value	10
Settlement for 10 t/m2 (mm)	36.00
Settlement (mm) for SBC	37.80
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	25

Footing Depth (m)	4.50
SBC (t/m2)	11.00
Average N value	10
Settlement for 10 t/m2 (mm)	36.00
Settlement (mm) for SBC	39.60
Depth Correction	0.74
Regidity Factor	0.80
Corrected Settlement (mm)	23.4

Footing Depth (m)	6.00
SBC (t/m2)	11.50
Average N value	11
Settlement for 10 t/m2 (mm)	31.00
Settlement (mm) for SBC	35.65
Depth Correction	0.68
Regidity Factor	0.80
Corrected Settlement (mm)	19.4

CHAPTER – 131

"Major Bridge No. 293",

Location – Existing Km. - 256/05-07

131.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 1x30.50

131.2 BOREHOLE DESCRIPTIONS:

(a) Location of Structure, Boreholes with RL 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 07.50m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1(A1)	0.00 to 6.00	Silty Sand	Loose
	6.00 to 7.50	Clayey Silt with Sand	Loose
	7.50 to 10.50	Silty Sand	Medium Dense
	10.50 to 25.50	Clayey Silt with Sand	Medium Dense
	25.50 to 30.00	Clayey Silt	Medium Dense
	Below 30.00	Clayey Silt with Sand	Medium Dense
BH-2(A2)	0.00 to 4.50	Silty Sand	Loose
	4.50 to 16.50	Silty Sand	Medium Dense
	16.50 to 24.00	Clayey Silt with Sand	Medium Dense
	24.00 to 30.00	Clayey Silt	Medium Dense

131.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.10	0.010	0.0022	NIL	0.0010	0.082
	9.00	8.50	0.006	0.0024	NIL	0.0011	0.062
	12.00	8.20	0.010	0.0023	NIL	0.0014	0.060
	21.00	8.70	0.008	0.0025	NIL	0.0012	0.049
BH-2 (A2)	3.00	8.40	0.008	0.0020	NIL	0.0012	0.085
	9.00	8.20	0.011	0.0028	NIL	0.0011	0.098
	24.00	9.20	0.015	0.0021	NIL	0.0012	0.097

131.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1(A1)	3.00	NIL
	6.00	15.00
	12.00	19.00
	21.00	NIL

BH-2 (A2)	24.00	

131.5 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	7.6	81	98	177	788	0.1	2.0	1003	668
Requirement as per IS:456 / Mosrth's	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	-	-

131.6 PILE LOAD CARRYING CAPACITY

131.6.1 Normal Bored Cast in- situ Pile Foundations:

Normal bored cast in situ RCC pile foundation is envisaged for the proposed bridge and have been analysed in the subsequent paragraphs. The Axial load carrying capacity of Pile in Rock is determined as per IRC- 78: 2000 appendix-5.

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 IS: 2911 should be 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.

Safe bearing capacity in t/m²

BH -NO.	DEPTH (mtr)	Net Allowable Bearing Pressure (t/m²)
BH-1 (A1)	1.50m	09.00
	3.00m	09.50
	4.50m	10.00
	6.00m	11.00
BH-3 (A2)	1.50m	11.00
	3.00m	12.00
	4.50m	13.00
	6.00m	14.00

Pile load carrying capacity in t

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE
		Pile Diameter= 1.0 m
BH-1 (A1)	17.00	100.00
	20.00	135.00
	23.00	180.00
BH-2 (A2)	17.00	130.00
	20.00	160.00
	23.00	200.00

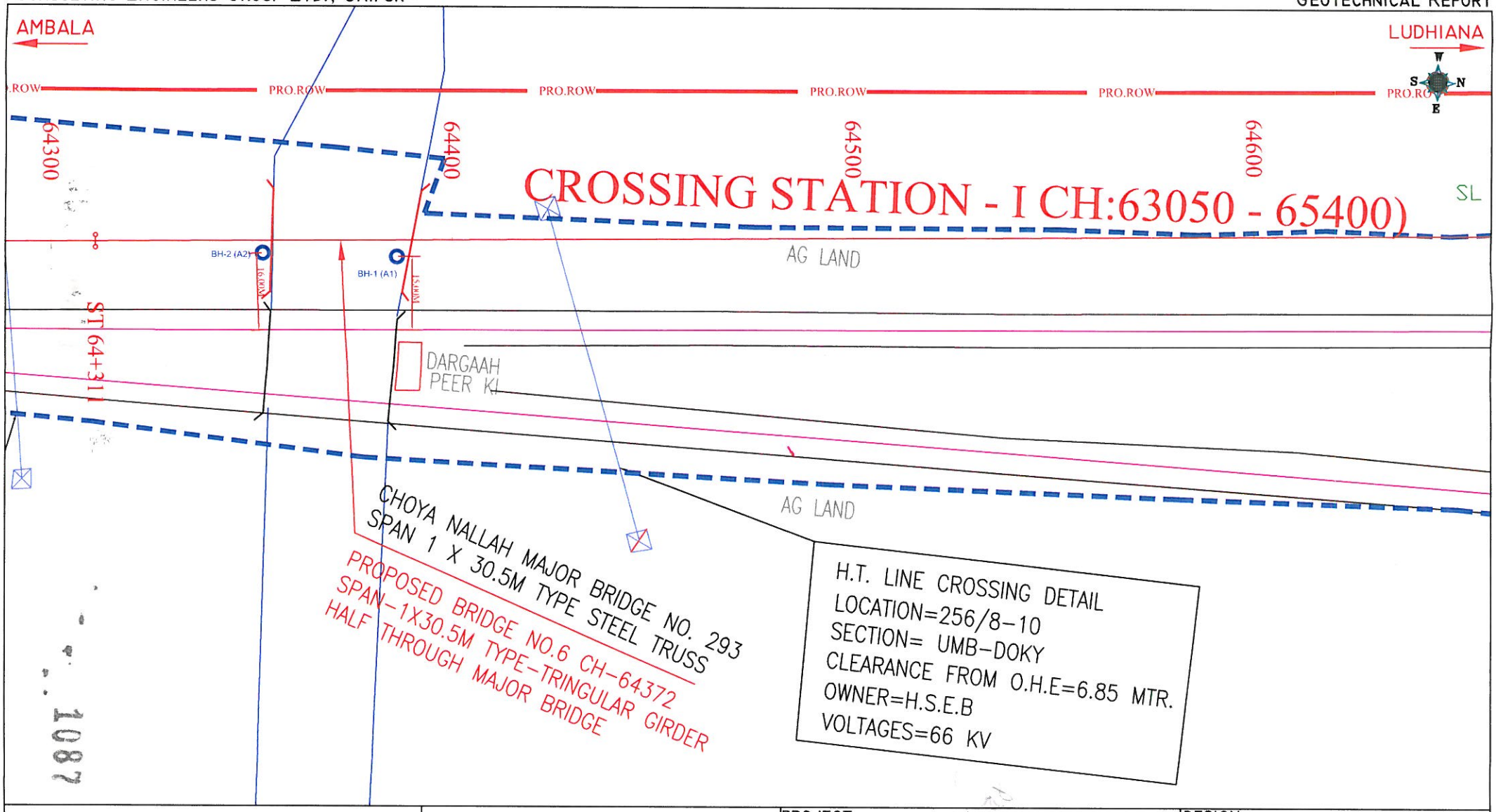
131.7 CONCLUSIONS

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

131.8 RECOMMENDATIONS

(i)	*Type of foundation*	Pile foundation

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 MAJOR BRIDGE
CH. 256/5-7

RL OF BH (AI) = 270.315
RL OF BH (A2) = 268.532

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 (A1) OF MAJOR BRIDGE No. 293 AT CHAINAGE 256/5-7

Project :	Chainage 256/5-7 Bridge No. 293			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				18.12.2009 to 18.12.2009	A1	1	07.50 m.	30.00mtr	270.315

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	-	-	-	Silty Sand	3.25	16.19	80.44	0.12	0.00	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
1.50	8	1.46	11.68	Silty Sand	3.82	20.27	75.87	0.04	0.00	0.00	0.00	27	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	2.41	20.51	75.98	0.45	0.65	0.00	0.00	23	NIL	NP	1.70	8.15	1.57	2.67	0.00	28.0
4.50	9	1.09	9.81	Silty Sand	3.22	19.38	76.73	0.37	0.30	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Clayey Silt with Sand	14.25	71.36	10.90	0.94	1.10	1.45	0.00	31	19	12	1.77	12.32	1.58	2.68	0.13	18.0
7.50	10	0.92	9.20	Silty Sand	2.15	47.81	49.56	0.35	0.13	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
10.50	15	0.80	12.00	Clayey Silt with Sand	18.95	64.62	13.50	1.05	0.87	1.01	0.00	37	20	17	-	-	-	-	-	-
12.00	UDS	-	-	Clayey Silt with Sand	18.21	70.22	10.42	1.15	0.00	0.00	0.00	38	21	17	2.01	20.21	1.67	2.66	0.20	15.0
13.50	21	0.70	14.70	Clayey Silt with Sand	17.82	76.77	5.01	0.40	0.00	0.00	0.00	38	22	16	-	-	-	-	-	-
16.50	15	0.63	9.45	Clayey Silt with Sand	14.15	71.98	10.11	1.11	0.97	1.68	0.00	30	18	12	-	-	-	-	-	-
19.50	18	0.57	10.26	Clayey Silt with Sand	9.10	77.61	8.20	1.11	1.20	2.78	0.00	32	24	8	-	-	-	-	-	-
21.00	UDS	-	-	Silty Sand	10.59	77.03	8.65	0.74	0.85	2.14	0.00	32	23	9	2.07	18.13	1.75	2.68	0.00	20.0
22.50	16	0.52	8.32	Silty Sand	15.48	69.84	6.59	2.43	2.40	3.26	0.00	34	21	13	-	-	-	-	-	-
25.50	19	0.47	8.93	Clayey Silt	13.24	85.12	1.39	0.25	0.00	0.00	0.00	32	20	12	-	-	-	-	-	-
28.50	23	0.43	9.89	Clayey Silt	20.14	78.79	0.99	0.08	0.00	0.00	0.00	37	19	18	-	-	-	-	-	-
30.00	26	0.41	10.66	Clayey Silt with Sand	15.43	69.58	9.56	1.54	1.57	2.32	0.00	34	21	13	-	-	-	-	-	-

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ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (A2) OF MAJOR BRIDGE No. 293 AT CHAINAGE 256/5-7

Project :	Chainage 256/5-7 Bridge No. 293			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				10.12.2009 to 10.12.2009	A2	2	08.00 m.	30.00mtr	268.532

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	-	-	-	Silty Sand	3.49	15.12	80.26	0.55	0.00	0.58	0.00	23	NIL	NP	-	-	-	-	-	-
1.50	7	1.46	10.22	Silty Sand	3.58	18.16	77.76	0.14	0.05	0.31	0.00	24	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	4.14	18.65	76.52	0.63	0.06	0.00	0.00	24	NIL	NP	1.69	9.45	1.54	2.67	0.00	28.0
4.50	12	1.09	13.08	Silty Sand	3.89	18.78	77.01	0.32	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
7.50	11	0.92	10.12	Silty Sand	3.69	5.88	89.87	0.26	0.30	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand	2.86	14.70	80.66	0.68	1.10	0.00	0.00	23	NIL	NP	2.00	18.22	1.69	2.67	0.00	28.0
10.50	22	0.79	16.19	Silty Sand	3.68	20.30	74.37	0.72	0.93	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
13.50	27	0.70	16.95	Silty Sand	3.25	84.46	8.65	0.53	0.85	2.26	0.00	22	NIL	NP	-	-	-	-	-	-
16.50	13	0.63	8.19	Clayey Silt with Sand	13.68	79.23	5.02	0.36	0.45	1.26	0.00	33	21	12	-	-	-	-	-	-
19.50	16	0.57	9.12	Clayey Silt with Sand	16.22	75.07	7.48	0.43	0.15	0.65	0.00	35	21	14	-	-	-	-	-	-
22.50	15	0.52	7.80	Clayey Silt with Sand	17.65	75.26	6.35	0.32	0.42	0.00	0.00	36	21	15	-	-	-	-	-	-
24.00	UDS	-	-	Clayey Silt	12.48	83.29	3.87	0.26	0.10	0.00	0.00	30	19	11	2.09	18.65	1.76	2.69	0.12	19.0
25.50	19	0.47	8.93	Clayey Silt	15.22	81.25	2.52	0.68	0.33	0.00	0.00	34	21	13	-	-	-	-	-	-
28.50	21	0.43	9.03	Clayey Silt	18.45	77.72	2.25	0.75	0.41	0.42	0.00	38	22	16	-	-	-	-	-	-
30.00	23	0.41	9.43	Clayey Silt	13.58	84.20	1.65	0.33	0.24	0.00	0.00	31	19	12	-	-	-	-	-	-

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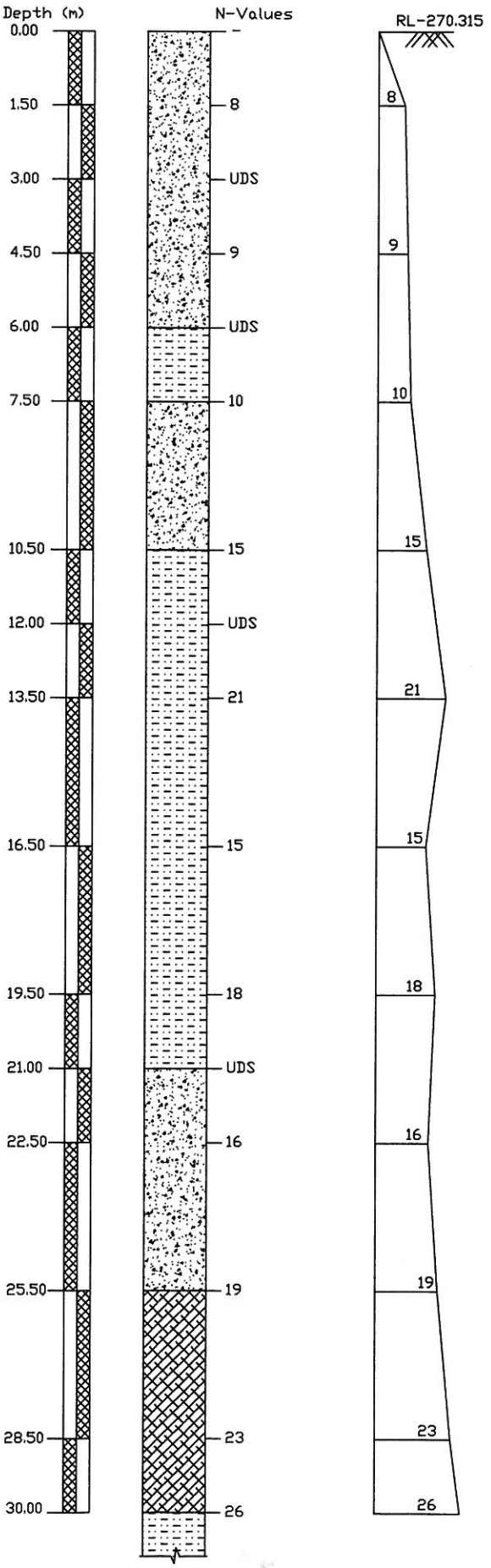
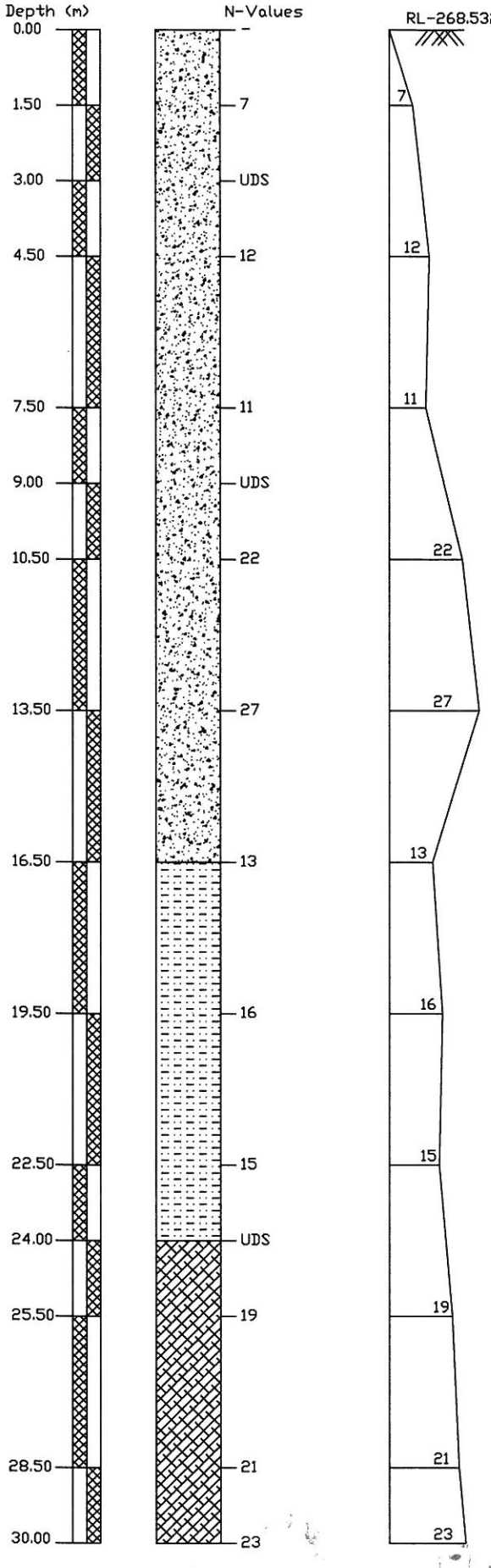
BORELOG OF BH–1(A1) AT EXISTING KM–256/5–7 FOR MAJOR BRIDGE NO.–293,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SILTY SAND
	CLAYEY SILT WITH SAND
	CLAYEY SILT

BORELOG OF BH–2(A2) AT EXISTING KM–256/5–7 FOR MAJOR BRIDGE NO.–293,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SILTY SAND
	CLAYEY SILT WITH SAND
	CLAYEY SILT

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ANNEXURE - III

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

INPUT DATA **Ch. 256 5-7** **BH-A1**

Type of footing

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

Angle of internal friction (ϕ °)	28.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.70
Direction of load with vertical (°)	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

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 $\phi < 10°$

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

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

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	28.00
N_c	26.37
N_q	15.30
N_γ	17.79

ϕ'	19.61
N'_c	14.53
N'_q	6.21
N'_γ	5.18

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.17	1.08	1.08
2	3.00	3.00	1.33	1.17	1.17
3	4.50	3.00	1.50	1.25	1.25

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	35.28	12.33	18.07
2	3.00	3.00	8.00	37.99	13.28	19.46
3	4.50	3.00	8.00	40.70	14.23	20.85

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ANNEXURE - III

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

INPUT DATA **Ch. 256 5-7** **BH-A1**

Type of footing

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

Angle of internal friction (ϕ °)	18.00
Cohesion (c in t/m2)	1.30
Void ratio (e)	0.70
Direction of load with vertical (°)	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)	(m)
1	6.00	3.00	

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 $\phi < 10°$

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

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

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	18.00
N_c	13.29
N_q	5.42
N_γ	4.29

ϕ'	12.28
N'_c	9.55
N'_q	3.14
N'_γ	1.87

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	6.00	3.00	1.55	1.28	1.28

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	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 shear	Local shear	Actual
1	6.00	3.00	8.00	21.87	10.45	13.31

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ANNEXURE - III

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

INPUT DATA **Ch. 256 5-7** **BH-A2**

Type of footing

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

Angle of internal friction (ϕ °)	28.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.73
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.69
Density of foundation soil (t/m^3)	1.69
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.

ANNEXURE - III

Bearing capacity factors :

ϕ	28.00
N_c	26.37
N_q	15.30
N_γ	17.79

ϕ'	19.61
N'_c	14.53
N'_q	6.21
N'_γ	5.18

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	1.17	1.08	1.08
2	3.00	3.00	1.33	1.17	1.17
3	4.50	3.00	1.50	1.25	1.25
4	6.00	3.00	1.67	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 shear	Local shear	Actual
1	1.50	3.00	8.00	35.07	12.26	14.54
2	3.00	3.00	8.00	37.76	13.20	15.66
3	4.50	3.00	8.00	40.46	14.14	16.78
4	6.00	3.00	8.00	43.15	15.09	17.89

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Major Bridge
Chainage	256/05-7
Bore Hole No.	A1

Footing Depth (m)	1.50
SBC (t/m2)	9.00
Average N value	10
Settlement for 10 t/m2 (mm)	36.00
Settlement (mm) for SBC	32.40
Depth Correction	0.91
Regidity Factor	0.80
Corrected Settlement (mm)	**23.6**

Footing Depth (m)	3.00
SBC (t/m2)	9.50
Average N value	10
Settlement for 10 t/m2 (mm)	36.00
Settlement (mm) for SBC	34.20
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	**22.7**

Footing Depth (m)	4.50
SBC (t/m2)	10.00
Average N value	9
Settlement for 10 t/m2 (mm)	42.00
Settlement (mm) for SBC	42.00
Depth Correction	0.74
Regidity Factor	0.80
Corrected Settlement (mm)	**24.9**

Footing Depth (m)	6.00
SBC (t/m2)	11.00
Average N value	9
Settlement for 10 t/m2 (mm)	42.00
Settlement (mm) for SBC	46.20
Depth Correction	0.68
Regidity Factor	0.80
Corrected Settlement (mm)	**25**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Major Bridge
Chainage	256/05-7
Bore Hole No.	A2

Footing Depth (m)	1.50
SBC (t/m2)	11.00
Average N value	11
Settlement for 10 t/m2 (mm)	31.00
Settlement (mm) for SBC	34.10
Depth Correction	0.91
Regidity Factor	0.80
Corrected Settlement (mm)	**24.8**

Footing Depth (m)	3.00
SBC (t/m2)	12.00
Average N value	11
Settlement for 10 t/m2 (mm)	31.00
Settlement (mm) for SBC	37.20
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	**24.7**

Footing Depth (m)	4.50
SBC (t/m2)	13.00
Average N value	12
Settlement for 10 t/m2 (mm)	29.00
Settlement (mm) for SBC	37.70
Depth Correction	0.74
Regidity Factor	0.80
Corrected Settlement (mm)	**22.3**

Footing Depth (m)	6.00
SBC (t/m2)	14.00
Average N value	12
Settlement for 10 t/m2 (mm)	29.00
Settlement (mm) for SBC	40.60
Depth Correction	0.68
Regidity Factor	0.80
Corrected Settlement (mm)	**22.1**

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CHAPTER – 132

"Major Bridge No. 291",

Location – Existing Km. - 253/23-25

132.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 1x24.40

132.2 BOREHOLE DESCRIPTIONS:

(a) Location of Structure, Boreholes with RL 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 13.30m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1(A1)	0.00 to 3.00	Clayey Silt with Sand	Loose
	3.00 to 4.50	Clayey Silt	Loose
	4.50 to 22.50	Clayey Silt	Medium Dense
	22.50 to 24.00	Clayey Silt with Sand	Medium Dense
	24.00 to 25.50	Clayey Silt	Medium Dense
	25.50 to 30.00	Clayey Silt with Sand	Dense
BH-2(A2)	0.00 to 1.50	Silty Sand	Loose
	1.50 to 7.50	Silty Sand	Medium Dense
	7.50 to 10.50	Sandy Silt	Medium Dense
	10.50 to 12.00	Clayey Silt	Medium Dense
	12.00 to 25.50	Clayey Silt with Sand	Medium Dense
	25.50 to 28.50	Clayey Silt	Medium Dense
	28.50 to 30.00	Clayey Silt	Dense

132.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.80	0.007	0.0032	NIL	0.0014	0.082
	9.00	8.80	0.007	0.0011	NIL	0.0011	0.033
	18.00	9.10	0.010	0.0021	NIL	0.0013	0.056
	24.00	8.80	0.007	0.0025	NIL	0.0013	0.049
BH-2 (A2)	12.00	8.50	NIL	0.0021	NIL	0.0013	0.055

132.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1(A1)	3.00	28.00
	9.00	21.00
	18.00	26.00
	24.00	29.00
BH-2 (A2)	3.00	NIL
	12.00	28.00
	21.00	25.00

132.5 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	90	90	169	812	0.2	2.5	1020	650
Requirement as per IS:456 / Mosrth's	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	-	-

132.6 PILE LOAD CARRYING CAPACITY

132.6.1 Normal Bored Cast in- situ Pile Foundations:

Normal bored cast in situ RCC pile foundation is envisaged for the proposed bridge and have been analysed in the subsequent paragraphs. The Axial load carrying capacity of Pile in Rock is determined as per IRC- 78: 2000 appendix-5.

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 IS: 2911 should be 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.

Safe bearing capacity in t/m²

BH -NO.	DEPTH (mtr)	Net Allowable Bearing Pressure (t/m²)
BH-1 (A1)	1.50m	07.00
	3.00m	09.00
	4.50m	10.00
	6.00m	10.50
BH-3 (A2)	1.50m	12.50
	3.00m	13.50
	4.50m	14.50
	6.00m	15.50

Pile load carrying capacity in t

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE	
		Pile Diameter= 1.0 m	Pile Diameter= 1.2 m
BH-1 (A1)	17.00	90.00	110.00
	20.00	110.00	140.00
	23.00	140.00	170.00
BH-2 (A2)	17.00	70.00	90.00
	20.00	90.00	110.00
	23.00	120.00	140.00

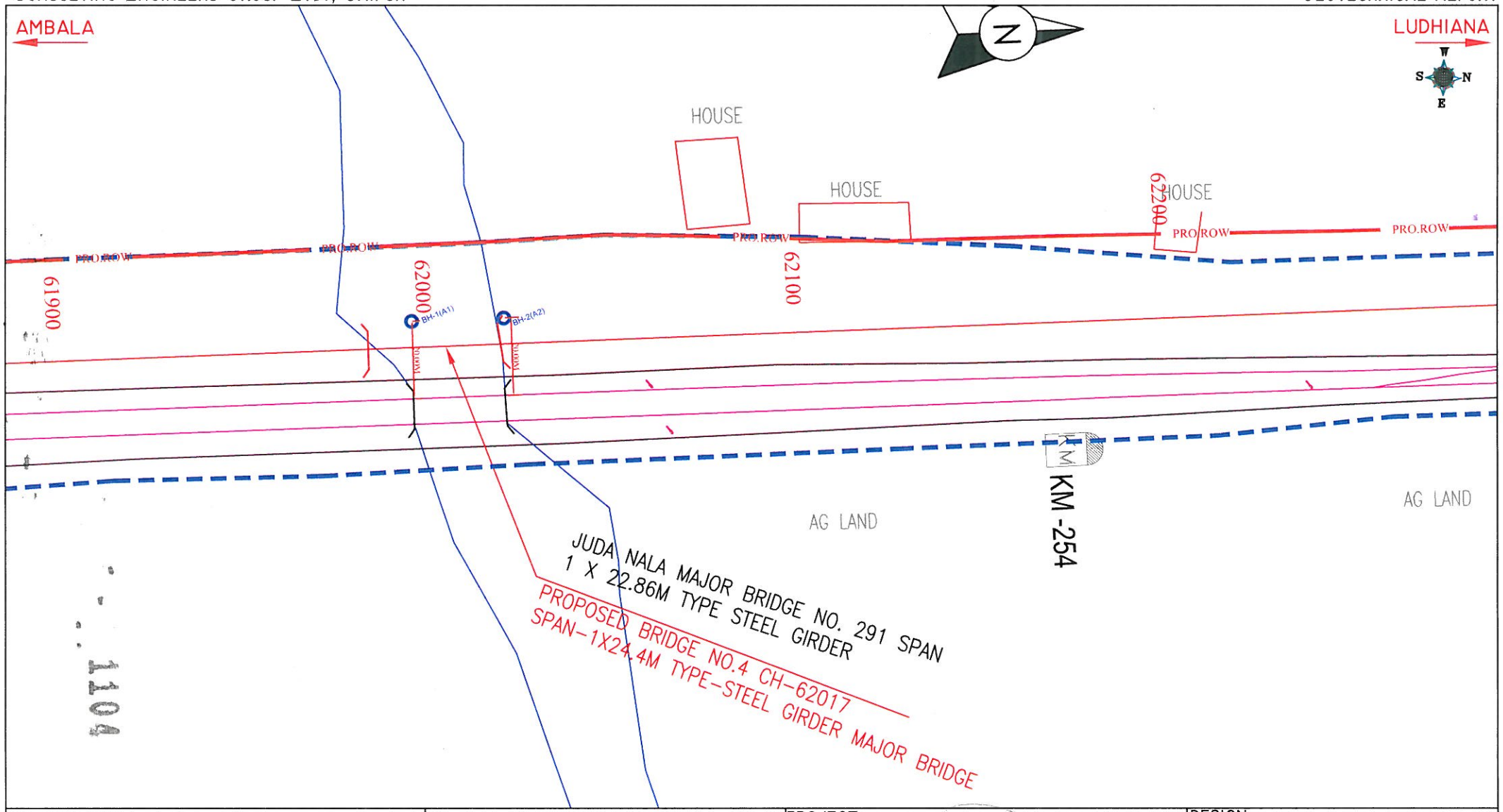
132.7 CONCLUSIONS

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

132.8 RECOMMENDATIONS

(i)	*Type of foundation*	Pile foundation

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 MAJOR BRIDGE CH. 253/23-25	RL OF BH (AI) = 267.507 RL OF BH (A2) = 264.485	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 (A1) RHS OF MAJOR BRIDGE No. 291 AT CHAINAGE 253/23-25

Project :	Chainage 253/23-25 Bridge No. 291			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				25.07.2009 to 26.07.2009	A1	1(RHS)	13.30 m.	30.00mtr	267.507

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	26.69	64.24	6.26	0.66	0.95	1.2	0	45	20	25	-	-	-	-	-	-
1.50	7	1.51	10.57	Clayey silt with sand	27.85	65.57	4.84	0.76	0.31	0.67	0.00	46	21	25	-	-	-	-	-	-
3.00	UDS	-	-	Clayey silt	32.22	62.78	3.14	0.49	0.85	0.52	0.00	52	23	29	1.63	6.23	1.53	2.68	0.34	10.00
4.50	11	1.11	12.21	Clayey silt	23.26	73.15	1.54	1.73	0.32	0.00	0.00	41	20	21	-	-	-	-	-	-
7.50	14	0.93	13.02	Clayey silt	25.65	73.23	1.07	0.05	0.00	0.00	0.00	43	20	23		-	-	-	-	-
9.00	UDS	-	-	Clayey silt	13.25	85.99	0.76	0.00	0.00	0.00	0.00	31	20	11	1.84	15.62	1.59	2.68	0.10	20.00
10.50	13	0.81	10.53	Clayey silt	24.59	74.23	1.06	0.12	0.00	0.00	0.00	41	19	22	-	-	-	-	-	-
13.50	16	0.72	11.52	Clayey silt	25.62	72.94	0.76	0.30	0.10	0.28	0.00	44	21	23	-	-	-	-	-	-
16.50	17	0.65	11.05	Clayey silt	23.12	74.32	2.14	0.28	0.14	0.00	0.00	40	19	21	-	-	-	-	-	-
18.00	UDS	-	-	Clayey silt	22.94	75.57	0.87	0.62	0.00	0.00	0.00	43	22	21	1.96	20.33	1.63	2.68	0.26	13.00
19.50	19	0.59	11.21	Clayey silt	24.10	72.17	1.79	1.81	0.13	0.00	0.00	42	20	22	-	-	-	-	-	-
22.50	25	0.53	13.25	Clayey silt with sand	20.59	59.66	19.33	0.42	0.00	0.00	0.00	37	19	18	-	-	-	-	-	-
24.00	UDS	-	-	Clayey silt	23.94	74.14	1.76	0.16	0.00	0.00	0.00	42	20	22	2.11	22.12	1.73	2.66	0.27	12.00
25.50	43	0.49	18.04	Clayey silt with sand	23.69	70.34	4.32	1.11	0.54	0.00	0.00	41	20	21	-	-	-	-	-	-
28.50	45	0.44	17.40	Clayey silt with sand	21.89	72.20	3.85	1.25	0.66	0.15	0.00	39	19	20	-	-	-	-	-	-
30.00	43	0.42	16.53	Clayey silt with sand	24.59	70.60	3.92	0.67	0.22	0.00	0.00	42	20	22	-	-	-	-	-	-

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SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (A2) RHS OF MAJOR BRIDGE No. 291 AT CHAINAGE 253/23-25

Project :	Chainage 253/23-25 Bridge No. 291			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				24.07.2009 to 25.07.2009	A2	2(RHS)	14.00 m.	30.00mtr	264.485

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	-	-	-	Silty Sand	2.16	10.68	75.61	6.23	2.11	3.21	0.00	23	NIL	NP	-	-	-	-	-	-
1.50	14	1.46	20.44	Silty Sand	2.34	7.69	80.86	4.64	2.91	1.56	0.00	26	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	3.22	7.23	82.70	2.49	1.21	3.15	0.00	26	NIL	NP	1.69	8.56	1.56	2.68	0.00	26.00
4.50	19	1.09	20.71	Silty Sand	2.68	6.34	87.27	3.30	0.41	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
7.50	16	0.92	14.72	Sandy Silt	4.52	77.19	15.37	0.51	0.25	2.16	0.00	28	NIL	NP	-	-	-	-	-	-
10.50	14	0.81	11.34	Clayey silt	18.68	79.58	1.54	0.08	0.12	0.00	0.00	34	18	16	-	-	-	-	-	-
12.00	UDS	-	-	Clayey silt with sand	25.62	67.54	4.61	0.73	0.94	0.56	0.00	45	22	23	1.80	10.33	1.63	2.68	0.27	11.00
13.50	16	0.72	11.52	Clayey silt with sand	26.21	64.30	5.23	2.09	1.40	0.77	0.00	43	20	23	-	-	-	-	-	-
16.50	16	0.65	10.40	Clayey silt with sand	23.88	61.12	8.63	2.25	1.82	2.30	0.00	41	19	22	-	-	-	-	-	-
19.50	19	0.59	11.21	Clayey silt with sand	26.58	65.77	4.37	1.37	1.08	0.83	0.00	44	20	24	-	-	-	-	-	-
21.00	UDS	-	-	Clayey silt with sand	23.11	68.03	5.23	2.11	0.83	0.69	0.00	41	21	20	2.03	19.65	1.70	2.67	0.22	14.00
22.50	23	0.54	12.42	Clayey silt with sand	26.94	61.83	4.97	1.56	1.86	2.84	0.00	46	21	25	-	-	-	-	-	-
25.50	26	0.49	12.74	Clayey silt	23.97	71.53	3.43	0.60	0.37	0.10	0.00	41	19	22	-	-	-	-	-	-
28.50	33	0.45	14.85	Clayey silt	22.68	70.83	3.87	1.16	0.82	0.64	0.00	39	19	20	-	-	-	-	-	-
30.00	41	0.43	16.32	Clayey silt	21.67	74.72	3.32	0.21	0.08	0.00	0.00	38	19	19	-	-	-	-	-	-

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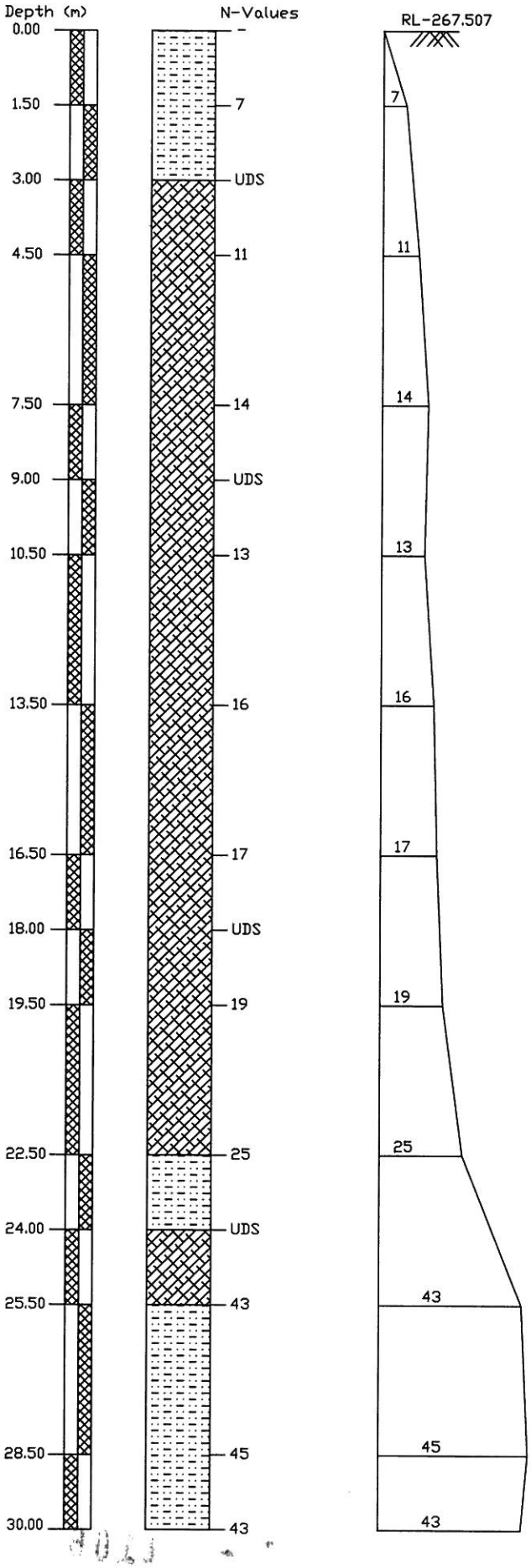
BORELOG OF BH–1(A1) RHS AT EXISTING KM–253/23–25 FOR MAJOR BRIDGE NO.–291, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	CLAYEY SILT

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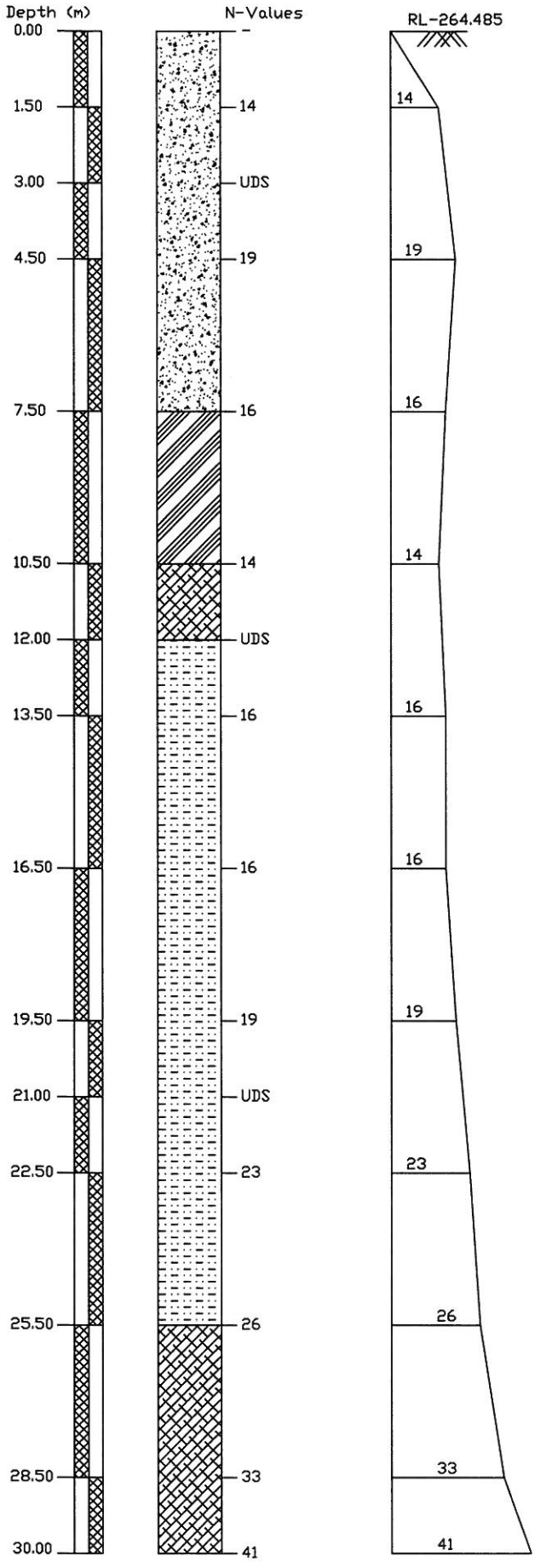
BORELOG OF BH–2(A2) RHS AT EXISTING KM–253/23–25 FOR MAJOR BRIDGE NO.–291,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SILTY SAND
	SANDY SLIT
	CLAYEY SILT
	CLAYEY SILT WITH SAND

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ANNEXURE - III

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

INPUT DATA **Ch. 253 23-25** **BH-A1**

Type of footing

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

Angle of internal friction (ϕ °)	10.00
Cohesion (c in t/m2)	3.40
Void ratio (e)	0.75
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.63
Density of foundation soil (t/m^3)	1.63
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 $\phi < 10^o$

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)^*SQRT(N_\phi)$ 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	10.00
N_c	8.35
N_q	2.47
N_γ	1.22

ϕ'	6.74
N'_c	7.14
N'_q	1.88
N'_γ	0.72

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	1.12	1.06	1.06
2	3.00	3.00	1.24	1.12	1.12
3	4.50	3.00	1.36	1.18	1.18
4	6.00	3.00	1.48	1.24	1.24

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 shear	Local shear	Actual
1	1.50	3.00	8.00	14.56	8.39	8.39
2	3.00	3.00	8.00	15.95	9.19	9.19
3	4.50	3.00	8.00	17.34	9.99	9.99
4	6.00	3.00	8.00	18.74	10.78	10.78

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ANNEXURE - III

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

INPUT DATA **Ch. 253 23-25** **BH-A2**

Type of footing

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

Angle of internal friction (ϕ °)	26.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.72
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.69
Density of foundation soil (t/m^3)	1.69
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 $\phi < 10°$

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

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

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)	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	1.64	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 shear	Local shear	Actual
1	1.50	3.00	8.00	27.11	10.44	12.94
2	3.00	3.00	8.00	29.11	11.22	13.90
3	4.50	3.00	8.00	31.12	11.99	14.86
4	6.00	3.00	8.00	33.13	12.77	15.82

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/ 23-25**

BH No. (A1)

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	6.1	t/m^2
Concentrated load *P*		=	7.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.5	t/m^2
Compression Index	Cc	=	0.144	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.24049	

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

S_f = 0.03466 m

= 34.6564 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.31

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore Pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **25** **mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/ 23-25**

BH No. (A1)

Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	8.5575	t/m^2
Concentrated load *P*		=	9.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.9	t/m^2
Compression Index	Cc	=	0.144	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.22086	

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

S_f = 0.03209 m

= 32.091 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.61

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore Pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **21.3 mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/ 23-25**

BH No. (A1)

Depth of foundation		=	4.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	11.0025	t/m^2
Concentrated load *P*		=	10.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.1	t/m^2
Compression Index	Cc	=	0.144	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.19087	

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

S_f = 0.02809 m

= 28.0909 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.92

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.74

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

= 0.8

Pore Pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **16.6 mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/ 23-25**

BH No. (A1)

Depth of foundation		=	6.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	13.4475	t/m^2
Concentrated load *P*		=	10.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.2	t/m^2
Compression Index	Cc	=	0.144	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.16397	

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

S_f = 0.02442 m

= 24.4174 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$(LB)^{\wedge 0.5}/D$ = 0.82

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

= 0.8

Pore Pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **13.3 mm**

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Major Bridge
Chainage	253/23-25
Bore Hole No.	A2

Footing Depth (m)	1.50
SBC (t/m2)	12.50
Average N value	20
Settlement for 10 t/m2 (mm)	16.00
Settlement (mm) for SBC	20.00
Depth Correction	0.91
Regidity Factor	0.80
Corrected Settlement (mm)	**14.6**

Footing Depth (m)	3.00
SBC (t/m2)	13.50
Average N value	19
Settlement for 10 t/m2 (mm)	17.00
Settlement (mm) for SBC	22.95
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	**15.2**

Footing Depth (m)	4.50
SBC (t/m2)	14.50
Average N value	17
Settlement for 10 t/m2 (mm)	19.00
Settlement (mm) for SBC	27.55
Depth Correction	0.74
Regidity Factor	0.80
Corrected Settlement (mm)	**16.3**

Footing Depth (m)	6.00
SBC (t/m2)	15.50
Average N value	15
Settlement for 10 t/m2 (mm)	21.00
Settlement (mm) for SBC	32.55
Depth Correction	0.68
Regidity Factor	0.80
Corrected Settlement (mm)	**17.7**

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CHAPTER – 133

"Major Bridge No. 290",

Location – Existing Km. - 253/1-3

133.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 1x24.4

133.2 BOREHOLE DESCRIPTIONS:

(a) Location of Structure, Boreholes with RL 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 13.50m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1(A1)	0.00 to 3.00	Clayey Silt with Sand	Loose
	3.00 to 4.50	Clayey Silt	Loose
	4.50 to 13.50	Clayey Silt	Medium Dense
	13.50 to 16.50	Clayey Silt with Sand	Medium Dense
	16.50 to 19.50	Clayey Silt	Medium Dense
	19.50 to 22.50	Clayey Silt with Sand	Dense
	22.50 to 28.50	Clayey Silt	Dense
	28.50 to 30.00	Clayey Silt with Sand	Dense
BH-2(A2)	0.00 to 3.00	Clayey Silt with Sand	Loose
	3.00 to 4.50	Clayey Silt	Loose
	4.50 to 7.50	Clayey Silt	Medium Dense
	7.50 to 10.50	Clayey Silt with Sand	Medium Dense
	10.50 to 19.50	Clayey Silt	Medium Dense
	19.50 to 30.00	Clayey Silt	Dense

133.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.00	NIL	0.0028	NIL	0.0013	0.054
	12.00	8.80	0.005	0.0018	NIL	0.0012	0.034
	18.00	8.70	0.005	0.0018	NIL	0.0012	0.037
	24.00	8.30	NIL	0.0021	NIL	0.0012	0.046
BH-2 (A2)	3.00	8.50	0.002	0.0021	NIL	0.0014	0.062
	12.00	8.40	NIL	0.0025	NIL	0.0012	0.045

133.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1 (A1)	3.00	40.00
	12.00	27.00
	18.00	21.00
	24.00	25.00

BH-2 (A2)	3.00	41.00
	12.00	26.00
	21.00	28.00

133.5 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	7.5	110	102	150	810	0.1	2.5	980	625
Requirement as per IS:456 / Mosrth's	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	-	-

133.6 PILE LOAD CARRYING CAPACITY

133.6.1 Normal Bored Cast in- situ Pile Foundations:

Normal bored cast in situ RCC pile foundation is envisaged for the proposed bridge and have been analysed in the subsequent paragraphs. The Axial load carrying capacity of Pile in Rock is determined as per IRC- 78: 2000 appendix-5.

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 IS: 2911 should be 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.

Safe bearing capacity in t/m²

BH -NO.	DEPTH (mtr)	Net Allowable Bearing Pressure (t/m²)
BH-1 (A1)	1.50m	07.00
	3.00m	08.00
	4.50m	08.50
	6.00m	09.50
BH-3 (A2)	1.50m	07.00
	3.00m	08.50
	4.50m	09.50
	6.00m	10.00

Pile load carrying capacity in t

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE	
		Pile Diameter= 1.0 m	Pile Diameter= 1.2 m
BH-1 (A1)	17.00	80.00	100.00
	20.00	110.00	130.00
	23.00	140.00	170.00
BH-2 (A2)	17.00	80.00	90.00
	20.00	100.00	120.00
	23.00	130.00	150.00

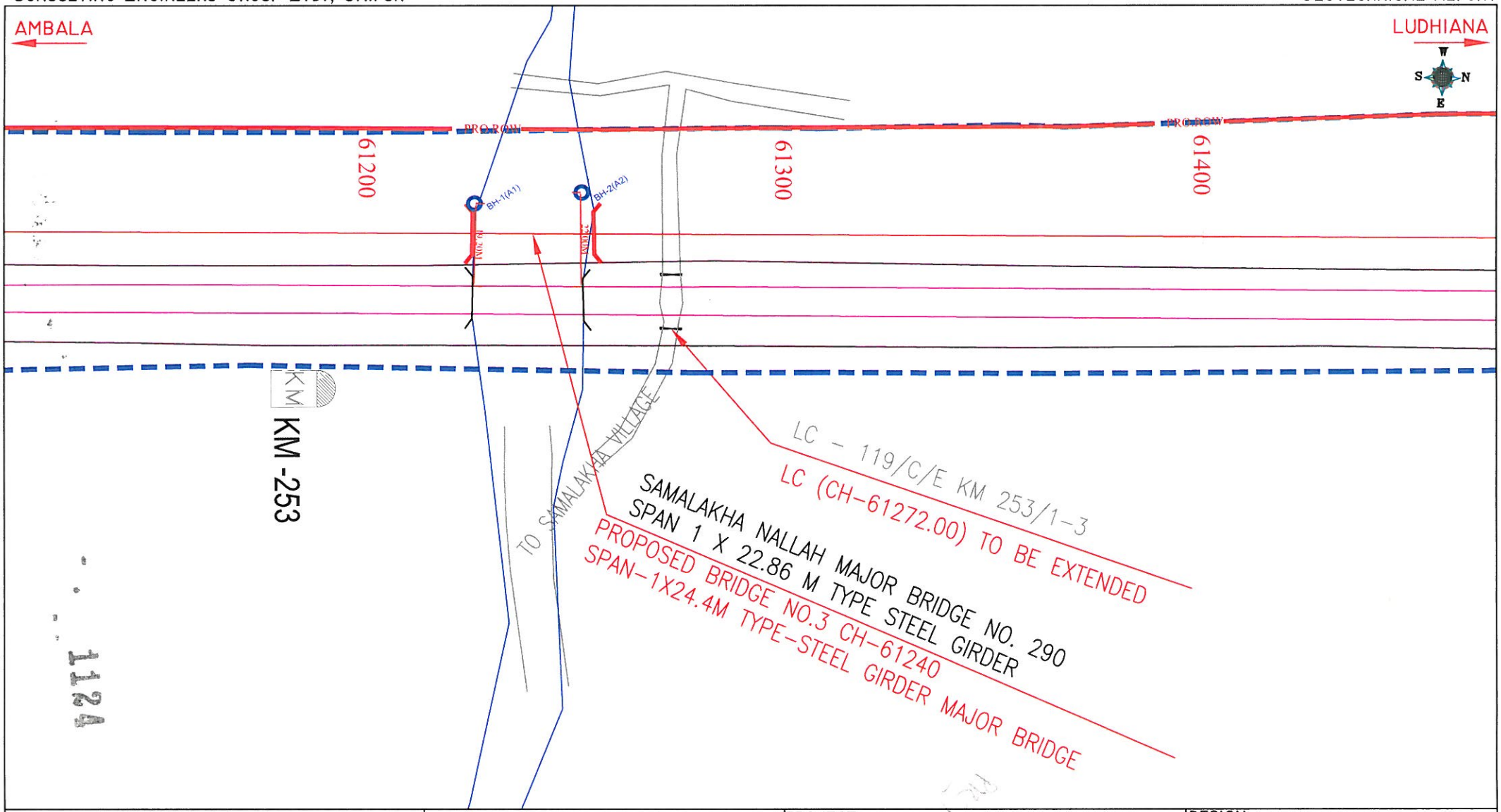
133.7 CONCLUSIONS

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

133.8 RECOMMENDATIONS

(i)	*Type of foundation*	Pile foundation

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 MAJOR BRIDGE CH. 253/1-3	RL OF BH (AI) = 267.467 RL OF BH (A2) = 267.436	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 (A1) RHS OF MAJOR BRIDGE No. 290 AT CHAINAGE 253/1-3

Project :	Chainage 253/1-3 Bridge No. 290			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				21.07.2009 to 22.07.2009	A1	1(RHS)	13.50 m.	30.00mtr	267.467

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	20.5	64.17	6.22	3.21	2.64	3.26	0.00	36	18	18	-	-	-	-	-	-
1.50	7	1.51	10.57	Clayey silt with sand	22.69	63.18	6.20	2.32	2.53	3.08	0.00	36	16	20	-	-	-	-	-	-
3.00	UDS	-	-	Clayey silt	32.69	65.99	1.11	0.16	0.05	0.00	0.00	55	25	30	1.63	6.65	1.53	2.67	0.38	7.00
4.50	12	1.11	13.32	Clayey silt	22.10	75.86	1.29	0.75	0.00	0.00	0.00	37	18	19	-	-	-	-	-	-
7.50	14	0.93	13.02	Clayey silt	18.95	79.59	1.08	0.26	0.12	0.00	0.00	34	18	16	-	-	-	-	-	-
10.50	17	0.82	13.94	Clayey silt	20.11	78.27	1.59	0.03	0.00	0.00	0.00	32	15	17	-	-	-	-	-	-
12.00	UDS	-	-	Clayey silt	21.65	76.49	1.25	0.30	0.12	0.19	0.00	39	21	19	1.69	6.55	1.59	2.66	0.25	13.00
13.50	20	0.74	14.80	Clayey silt with sand	16.65	76.49	5.61	0.80	0.30	0.15	0.00	30	16	14	-	-	-	-	-	-
16.50	28	0.67	16.88	Clayey silt	24.12	74.97	0.74	0.17	0.00	0.00	0.00	41	20	21	-	-	-	-	-	-
18.00	UDS	-	-	Clayey silt	18.95	79.72	1.33	0.00	0.00	0.00	0.00	38	22	16	2.00	20.59	1.66	2.68	0.19	17.00
19.50	32	0.60	17.10	Clayey silt with sand	16.82	68.62	12.33	0.35	0.10	1.78	0.00	31	17	14	-	-	-	-	-	-
22.50	13	0.54	7.02	Clayey silt	20.31	75.38	3.80	0.29	0.22	0.00	0.00	35	18	17	-	-	-	-	-	-
24.00	UDS	-	-	Clayey silt	22.19	74.30	2.14	0.76	0.33	0.28	0.00	39	20	19	2.09	20.85	1.73	2.67	0.23	14.00
25.50	35	0.49	16.08	Clayey silt	21.33	76.36	1.07	0.67	0.57	0.00	0.00	37	19	18	-	-	-	-	-	-
28.50	38	0.45	16.05	Clayey silt with sand	16.83	75.34	5.61	1.52	0.70	0.00	0.00	31	17	14	-	-	-	-	-	-
30.00	38	0.43	15.67	Clayey silt with sand	17.44	72.02	3.20	1.91	1.65	3.78	0.00	32	17	15	-	-	-	-	-	-

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SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (A2) RHS OF MAJOR BRIDGE No. 290 AT CHAINAGE 253/1-3

Project :	Chainage 253/1-3 Bridge No. 290			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				22.07.2009 to 23.07.2009	A2	2(RHS)	13.50 m.	30.00mtr	267.436

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	22.56	66.14	4.56	2.15	0.39	4.2	0.00	40	20	20	-	-	-	-	-	-
1.50	6	1.46	8.76	Clayey silt with sand	18.55	70.52	5.22	1.16	0.56	3.99	0.00	32	16	16	-	-	-	-	-	-
3.00	UDS	-	-	Clayey silt	33.42	64.35	0.69	0.26	0.28	1.00	0.00	55	25	30	1.70	9.64	1.55	2.69	0.36	8.00
4.50	14	1.09	15.26	Clayey silt	20.59	74.81	0.66	0.77	0.92	2.25	0.00	36	18	18	-	-	-	-	-	-
7.50	16	0.92	14.72	Clayey silt with sand	21.58	72.33	5.97	0.04	0.08	0.00	0.00	39	20	19		-	-	-	-	-
10.50	11	0.81	8.91	Clayey silt	23.15	76.10	0.68	0.07	0.00	0.00	0.00	40	20	20	-	-	-	-	-	-
12.00	UDS	-	-	Clayey silt	21.56	76.40	1.97	0.07	0.00	0.00	0.00	40	20	20	1.80	9.36	1.65	2.68	0.24	13.00
13.50	18	0.72	12.96	Clayey silt	26.59	72.57	0.76	0.08	0.00	0.00	0.00	50	26	24	-	-	-	-	-	-
16.50	25	0.65	15.63	Clayey silt	25.26	74.07	0.52	0.15	0.00	0.00	0.00	45	22	23	-	-	-	-	-	-
19.50	31	0.59	16.65	Clayey silt	23.58	74.99	0.53	0.58	0.32	0.00	0.00	41	20	21	-	-	-	-	-	-
21.00	UDS	-	-	Clayey silt	23.10	74.43	1.23	0.59	0.65	0.00	0.00	40	20	20	2.10	20.61	1.74	2.67	0.24	13.00
22.50	15	0.54	8.10	Clayey silt	23.58	75.56	0.49	0.37	0.00	0.00	0.00	40	20	20	-	-	-	-	-	-
25.50	25	0.49	12.25	Clayey silt	26.54	71.90	0.46	0.66	0.16	0.28	0.00	46	21	25	-	-	-	-	-	-
28.50	29	0.44	12.76	Clayey silt	23.15	75.98	0.79	0.08	0.00	0.00	0.00	39	19	20	-	-	-	-	-	-
30.00	36	0.43	15.24	Clayey silt	21.29	77.94	0.67	0.10	0.00	0.00	0.00	39	20	19	-	-	-	-	-	-

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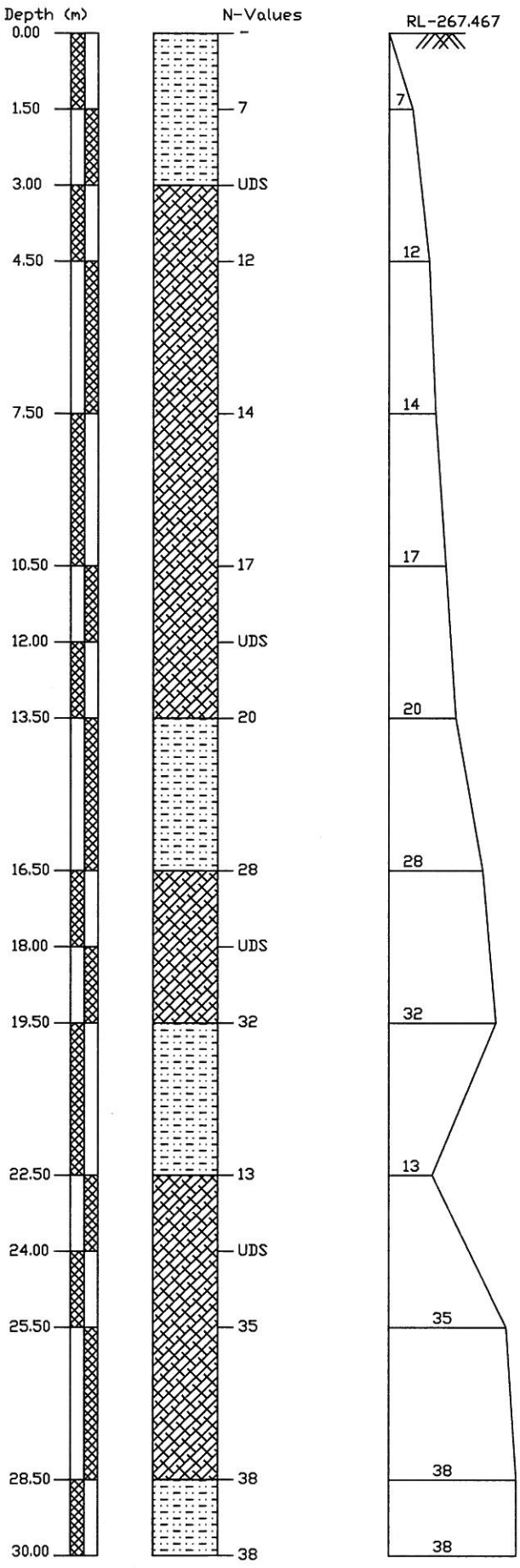
BORELOG OF BH–1(A1) RHS AT EXISTING KM–253/1–3 FOR MAJOR BRIDGE NO.–290,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	CLAYEY SILT

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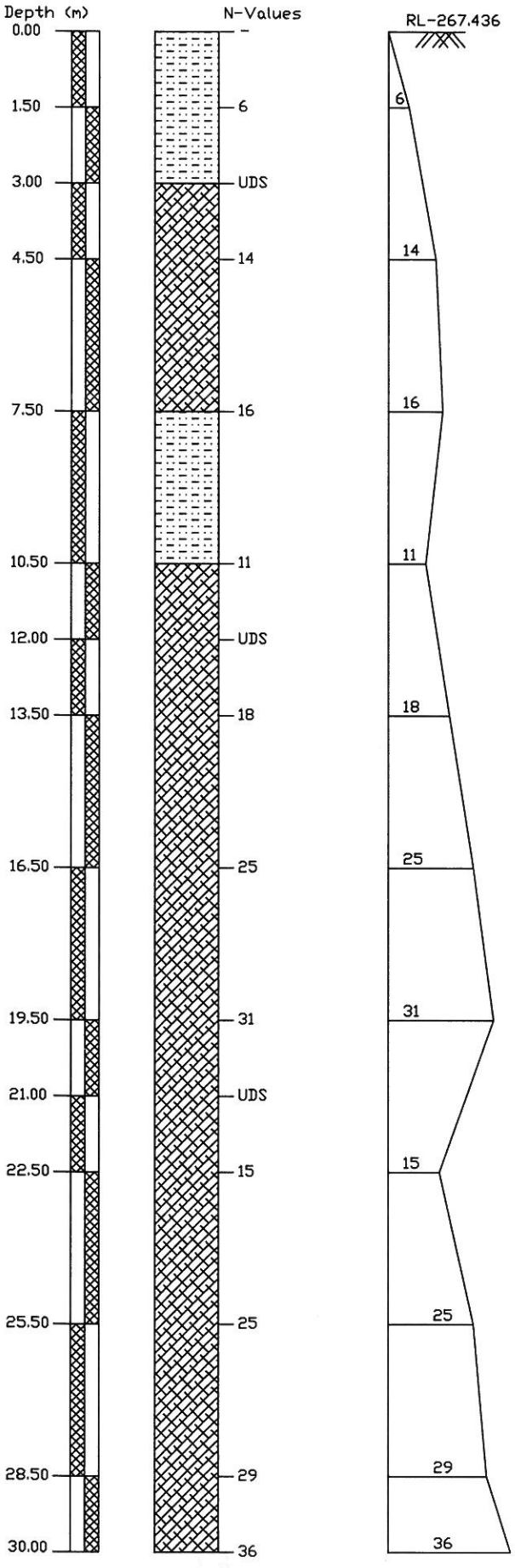
BORELOG OF BH–2(A2) RHS AT EXISTING KM–253/1–3 FOR MAJOR BRIDGE NO.–290,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	CLAYEY SILT

CONSULTING Engineers Group Ltd.

ANNEXURE - III

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

INPUT DATA **Ch. 253 1-3** **BH-A1**

Type of footing

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

Angle of internal friction (ϕ °)	7.00
Cohesion (c in t/m2)	3.80
Void ratio (e)	0.75
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.63
Density of foundation soil (t/m^3)	1.63
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	7.00
N_c	7.23
N_q	1.93
N_γ	0.76

ϕ'	4.70
N'_c	6.41
N'_q	1.54
N'_γ	0.42

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	1.11	1.00	1.00
2	3.00	3.00	1.23	1.00	1.00
3	4.50	3.00	1.34	1.00	1.00
4	6.00	3.00	1.45	1.00	1.00

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 shear	Local shear	Actual
1	1.50	3.00	8.00	12.86	7.56	7.56
2	3.00	3.00	8.00	13.97	8.22	8.22
3	4.50	3.00	8.00	15.08	8.88	8.88
4	6.00	3.00	8.00	16.20	9.54	9.54

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ANNEXURE - III

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

INPUT DATA **Ch. 253 1-3** **BH-A2**

Type of footing

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

Angle of internal friction (ϕ °)	8.00
Cohesion (c in t/m2)	3.60
Void ratio (e)	0.74
Direction of load with vertical (°)	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

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

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	8.00
N_c	7.61
N_q	2.11
N_γ	0.91

ϕ'	5.38
N'_c	6.63
N'_q	1.64
N'_γ	0.51

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	1.12	1.00	1.00
2	3.00	3.00	1.23	1.00	1.00
3	4.50	3.00	1.35	1.00	1.00
4	6.00	3.00	1.46	1.00	1.00

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 shear	Local shear	Actual
1	1.50	3.00	8.00	13.30	7.71	7.99
2	3.00	3.00	8.00	14.43	8.36	8.67
3	4.50	3.00	8.00	15.56	9.02	9.35
4	6.00	3.00	8.00	16.68	9.68	10.03

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/ 1-3**

BH No. (A1)

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	6.1	t/m^2
Concentrated load *P*		=	7.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.5	t/m^2
Compression Index	Cc	=	0.144	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.24049	

Settlement of clay layer

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

S_f = 0.03466 m

= 34.6564 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.31

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **25** **mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/1-3**

BH No. (A1)

Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	8.5575	t/m^2
Concentrated load *P*		=	8.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.7	t/m^2
Compression Index	Cc	=	0.144	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.19632	

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

S_f = 0.02883 m

= 28.8256 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.61

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **19.1 mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/ 1-3**

BH No. (A1)

Depth of foundation		=	4.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	11.0025	t/m^2
Concentrated load *P*		=	8.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.8	t/m^2
Compression Index	Cc	=	0.144	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.16224	

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

S_f = 0.02418 m

= 24.1775 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.92

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.74

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **14.3** **mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/ 1-3**

BH No. (A1)

Depth of foundation		=	6.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	13.4475	t/m^2
Concentrated load *P*		=	9.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.0	t/m^2
Compression Index	Cc	=	0.144	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.14835	

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

S_f = 0.02225 m

= 22.2453 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$(LB)^{\wedge 0.5}/D$ = 0.82

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **12.1** **mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/1-3**

BH No. (A2)

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	6.4	t/m^2
Concentrated load *P*		=	7.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.5	t/m^2
Compression Index	Cc	=	0.141	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.74	
	$\frac{Po + \Delta p}{Po}$	=	1.23059	

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

S_f = 0.03286 m

= 32.8601 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.31

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **23.9** **mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/ 1-3**

BH No. (A2)

Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	8.925	t/m^2
Concentrated load *P*		=	8.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.8	t/m^2
Compression Index	Cc	=	0.141	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.74	
	$\frac{Po + \Delta p}{Po}$	=	1.2	

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

S_f = 0.02887 m

= 28.8739 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.61

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **19.2 mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/ 1-3**

BH No. (A2)

Depth of foundation		=	4.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	11.475	t/m^2
Concentrated load *P*		=	9.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.0	t/m^2
Compression Index	Cc	=	0.141	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.74	
	$\frac{Po + \Delta p}{Po}$	=	1.17386	

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

S_f = 0.02539 m

= 25.3854 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.92

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.74

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = $S_f \times D.F. \times R.F.$

S_{f2} = **15.0 mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/ 1-3**

BH No. (A2)

Depth of foundation		=	6.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	14.025	t/m^2
Concentrated load *P*		=	10.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.1	t/m^2
Compression Index	Cc	=	0.141	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.74	
	$\frac{Po + \Delta p}{Po}$	=	1.14973	

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

S_f = 0.0221 m

= 22.097 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$(LB)^{\wedge 0.5}/D$ = 0.82

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **12.0 mm**

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133.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 1x24.4

133.2 BOREHOLE DESCRIPTIONS:

(a) Location of Structure, Boreholes with RL 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 13.50m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1(A1)	0.00 to 3.00	Clayey Silt with Sand	Loose
	3.00 to 4.50	Clayey Silt	Loose
	4.50 to 13.50	Clayey Silt	Medium Dense
	13.50 to 16.50	Clayey Silt with Sand	Medium Dense
	16.50 to 19.50	Clayey Silt	Medium Dense
	19.50 to 22.50	Clayey Silt with Sand	Dense
	22.50 to 28.50	Clayey Silt	Dense
	28.50 to 30.00	Clayey Silt with Sand	Dense
BH-2(A2)	0.00 to 3.00	Clayey Silt with Sand	Loose
	3.00 to 4.50	Clayey Silt	Loose
	4.50 to 7.50	Clayey Silt	Medium Dense
	7.50 to 10.50	Clayey Silt with Sand	Medium Dense
	10.50 to 19.50	Clayey Silt	Medium Dense
	19.50 to 30.00	Clayey Silt	Dense

133.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.00	NIL	0.0028	NIL	0.0013	0.054
	12.00	8.80	0.005	0.0018	NIL	0.0012	0.034
	18.00	8.70	0.005	0.0018	NIL	0.0012	0.037
	24.00	8.30	NIL	0.0021	NIL	0.0012	0.046
BH-2 (A2)	3.00	8.50	0.002	0.0021	NIL	0.0014	0.062
	12.00	8.40	NIL	0.0025	NIL	0.0012	0.045

133.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1 (A1)	3.00	40.00
	12.00	27.00
	18.00	21.00
	24.00	25.00

BH-2 (A2)	3.00	41.00
	12.00	26.00
	21.00	28.00

133.5 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	7.5	110	102	150	810	0.1	2.5	980	625
Requirement as per IS:456 / Mosrth's	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	-	-

133.6 PILE LOAD CARRYING CAPACITY

133.6.1 Normal Bored Cast in- situ Pile Foundations:

Normal bored cast in situ RCC pile foundation is envisaged for the proposed bridge and have been analysed in the subsequent paragraphs. The Axial load carrying capacity of Pile in Rock is determined as per IRC- 78: 2000 appendix-5.

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 IS: 2911 should be 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.

Safe bearing capacity in t/m²

BH -NO.	DEPTH (mtr)	Net Allowable Bearing Pressure (t/m²)
BH-1 (A1)	1.50m	07.00
	3.00m	08.00
	4.50m	08.50
	6.00m	09.50
BH-3 (A2)	1.50m	07.00
	3.00m	08.50
	4.50m	09.50
	6.00m	10.00

Pile load carrying capacity in t

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE	
		Pile Diameter= 1.0 m	Pile Diameter= 1.2 m
BH-1 (A1)	17.00	80.00	100.00
	20.00	110.00	130.00
	23.00	140.00	170.00
BH-2 (A2)	17.00	80.00	90.00
	20.00	100.00	120.00
	23.00	130.00	150.00

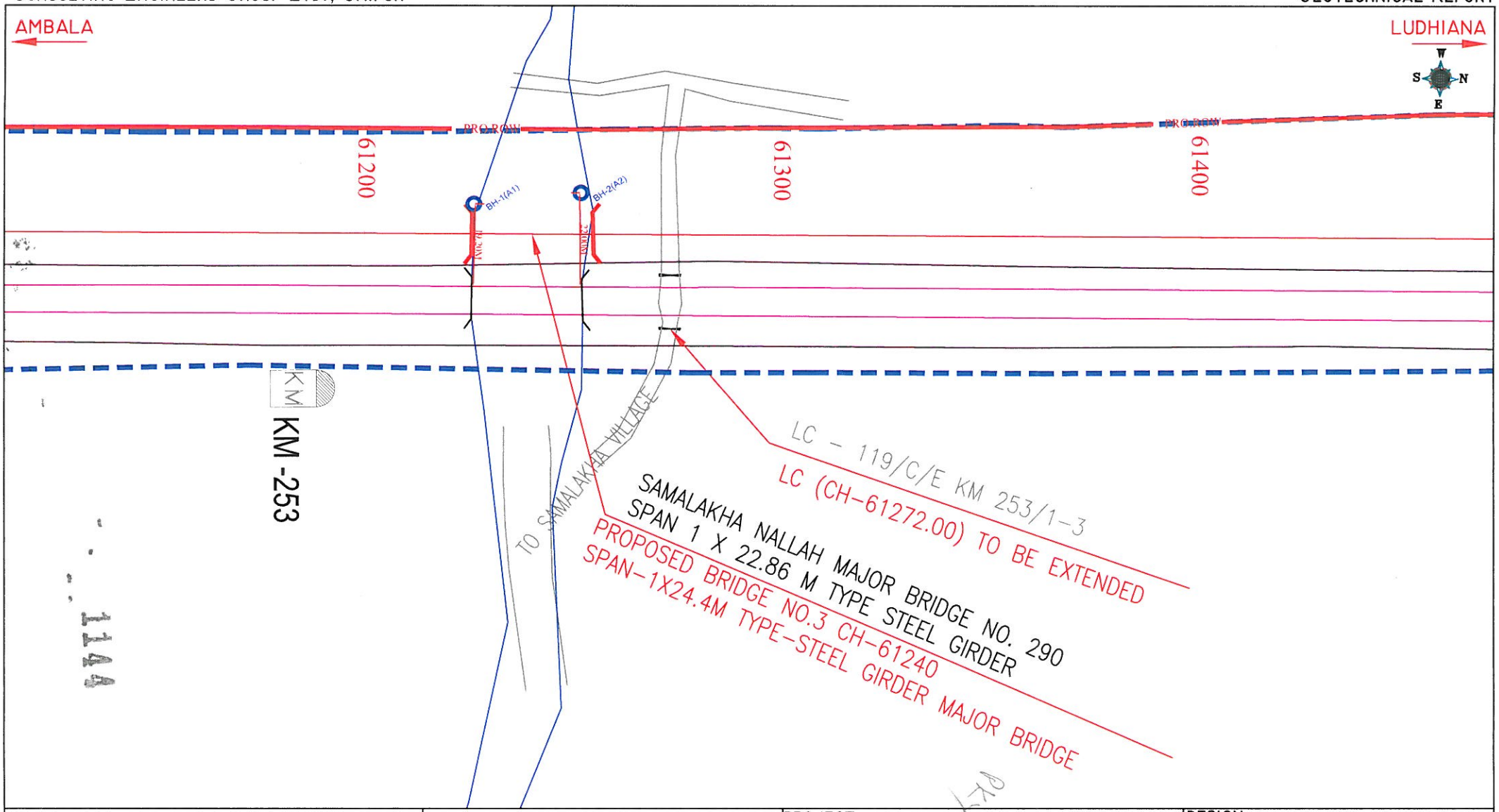
133.7 CONCLUSIONS

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

133.8 RECOMMENDATIONS

(i)	*Type of foundation*	Pile foundation

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 MAJOR BRIDGE CH. 253/1-3	RL OF BH (AI) = 267.467 RL OF BH (A2) = 267.436	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 (A1) RHS OF MAJOR BRIDGE No. 290 AT CHAINAGE 253/1-3

Project :	Chainage 253/1-3 Bridge No. 290	Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
		21.07.2009 to 22.07.2009	A1	1(RHS)	13.50 m.	30.00mtr	267.467

Depth from GL (m)	Observed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Clay	Silt	Sand Fine	Sand Medium	Sand Coarse	Gravel Fine	Gravel Coarse	L.L.	P.L.	P.I.	B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength c kg/cm^2	Shear Strength ϕ degree
0.00	-	-	-	Clayey silt with sand	20.5	64.17	6.22	3.21	2.64	3.26	0.00	36	18	18	-	-	-	-	-	-
1.50	7	1.51	10.57	Clayey silt with sand	22.69	63.18	6.20	2.32	2.53	3.08	0.00	36	16	20	-	-	-	-	-	-
3.00	UDS	-	-	Clayey silt	32.69	65.99	1.11	0.16	0.05	0.00	0.00	55	25	30	1.63	6.65	1.53	2.67	0.38	7.00
4.50	12	1.11	13.32	Clayey silt	22.10	75.86	1.29	0.75	0.00	0.00	0.00	37	18	19	-	-	-	-	-	-
7.50	14	0.93	13.02	Clayey silt	18.95	79.59	1.08	0.26	0.12	0.00	0.00	34	18	16	-	-	-	-	-	-
10.50	17	0.82	13.94	Clayey silt	20.11	78.27	1.59	0.03	0.00	0.00	0.00	32	15	17	-	-	-	-	-	-
12.00	UDS	-	-	Clayey silt	21.65	76.49	1.25	0.30	0.12	0.19	0.00	39	21	19	1.69	6.55	1.59	2.66	0.25	13.00
13.50	20	0.74	14.80	Clayey silt with sand	16.65	76.49	5.61	0.80	0.30	0.15	0.00	30	16	14	-	-	-	-	-	-
16.50	28	0.67	16.88	Clayey silt	24.12	74.97	0.74	0.17	0.00	0.00	0.00	41	20	21	-	-	-	-	-	-
18.00	UDS	-	-	Clayey silt	18.95	79.72	1.33	0.00	0.00	0.00	0.00	38	22	16	2.00	20.59	1.66	2.68	0.19	17.00
19.50	32	0.60	17.10	Clayey silt with sand	16.82	68.62	12.33	0.35	0.10	1.78	0.00	31	17	14	-	-	-	-	-	-
22.50	13	0.54	7.02	Clayey silt	20.31	75.38	3.80	0.29	0.22	0.00	0.00	35	18	17	-	-	-	-	-	-
24.00	UDS	-	-	Clayey silt	22.19	74.30	2.14	0.76	0.33	0.28	0.00	39	20	19	2.09	20.85	1.73	2.67	0.23	14.00
25.50	35	0.49	16.08	Clayey silt	21.33	76.36	1.07	0.67	0.57	0.00	0.00	37	19	18	-	-	-	-	-	-
28.50	38	0.45	16.05	Clayey silt with sand	16.83	75.34	5.61	1.52	0.70	0.00	0.00	31	17	14	-	-	-	-	-	-
30.00	38	0.43	15.67	Clayey silt with sand	17.44	72.02	3.20	1.91	1.65	3.78	0.00	32	17	15	-	-	-	-	-	-

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SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (A2) RHS OF MAJOR BRIDGE No. 290 AT CHAINAGE 253/1-3

Project :	Chainage 253/1-3 Bridge No. 290			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				22.07.2009 to 23.07.2009	A2	2(RHS)	13.50 m.	30.00mtr	267.436

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	22.56	66.14	4.56	2.15	0.39	4.2	0.00	40	20	20	-	-	-	-	-	-
1.50	6	1.46	8.76	Clayey silt with sand	18.55	70.52	5.22	1.16	0.56	3.99	0.00	32	16	16	-	-	-	-	-	-
3.00	UDS	-	-	Clayey silt	33.42	64.35	0.69	0.26	0.28	1.00	0.00	55	25	30	1.70	9.64	1.55	2.69	0.36	8.00
4.50	14	1.09	15.26	Clayey silt	20.59	74.81	0.66	0.77	0.92	2.25	0.00	36	18	18	-	-	-	-	-	-
7.50	16	0.92	14.72	Clayey silt with sand	21.58	72.33	5.97	0.04	0.08	0.00	0.00	39	20	19		-	-	-	-	-
10.50	11	0.81	8.91	Clayey silt	23.15	76.10	0.68	0.07	0.00	0.00	0.00	40	20	20	-	-	-	-	-	-
12.00	UDS	-	-	Clayey silt	21.56	76.40	1.97	0.07	0.00	0.00	0.00	40	20	20	1.80	9.36	1.65	2.68	0.24	13.00
13.50	18	0.72	12.96	Clayey silt	26.59	72.57	0.76	0.08	0.00	0.00	0.00	50	26	24	-	-	-	-	-	-
16.50	25	0.65	15.63	Clayey silt	25.26	74.07	0.52	0.15	0.00	0.00	0.00	45	22	23	-	-	-	-	-	-
19.50	31	0.59	16.65	Clayey silt	23.58	74.99	0.53	0.58	0.32	0.00	0.00	41	20	21	-	-	-	-	-	-
21.00	UDS	-	-	Clayey silt	23.10	74.43	1.23	0.59	0.65	0.00	0.00	40	20	20	2.10	20.61	1.74	2.67	0.24	13.00
22.50	15	0.54	8.10	Clayey silt	23.58	75.56	0.49	0.37	0.00	0.00	0.00	40	20	20	-	-	-	-	-	-
25.50	25	0.49	12.25	Clayey silt	26.54	71.90	0.46	0.66	0.16	0.28	0.00	46	21	25	-	-	-	-	-	-
28.50	29	0.44	12.76	Clayey silt	23.15	75.98	0.79	0.08	0.00	0.00	0.00	39	19	20	-	-	-	-	-	-
30.00	36	0.43	15.24	Clayey silt	21.29	77.94	0.67	0.10	0.00	0.00	0.00	39	20	19	-	-	-	-	-	-

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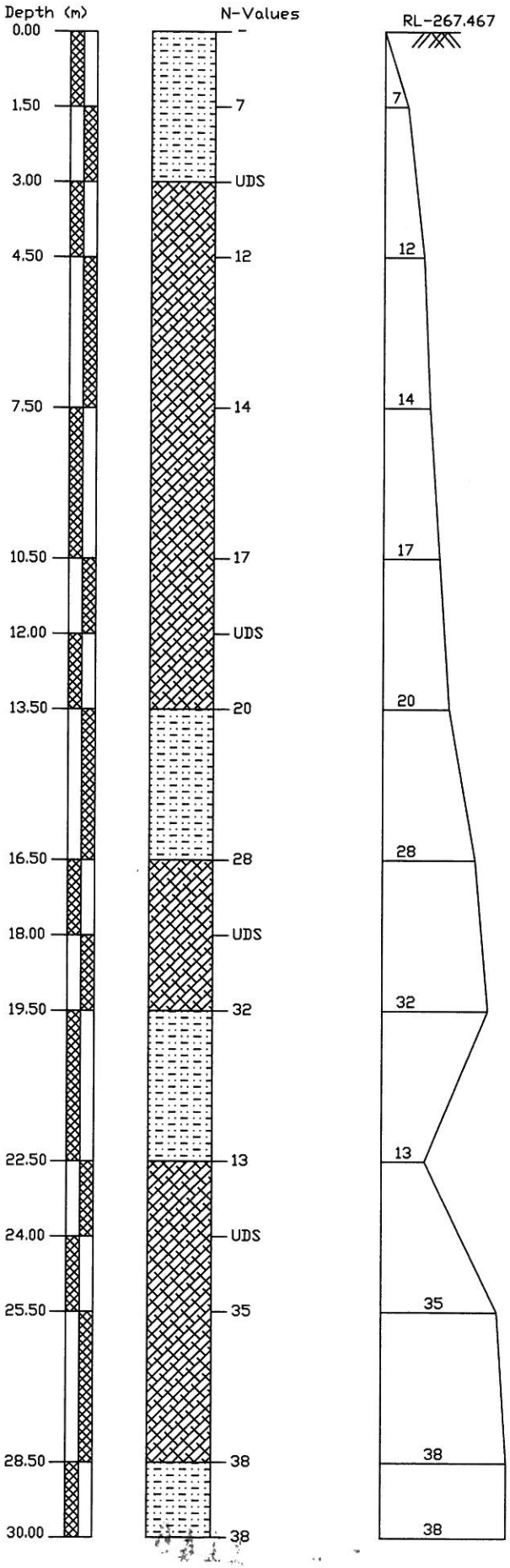
BORELOG OF BH–1(A1) RHS AT EXISTING KM–253/1–3 FOR MAJOR BRIDGE NO.–290, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	CLAYEY SILT

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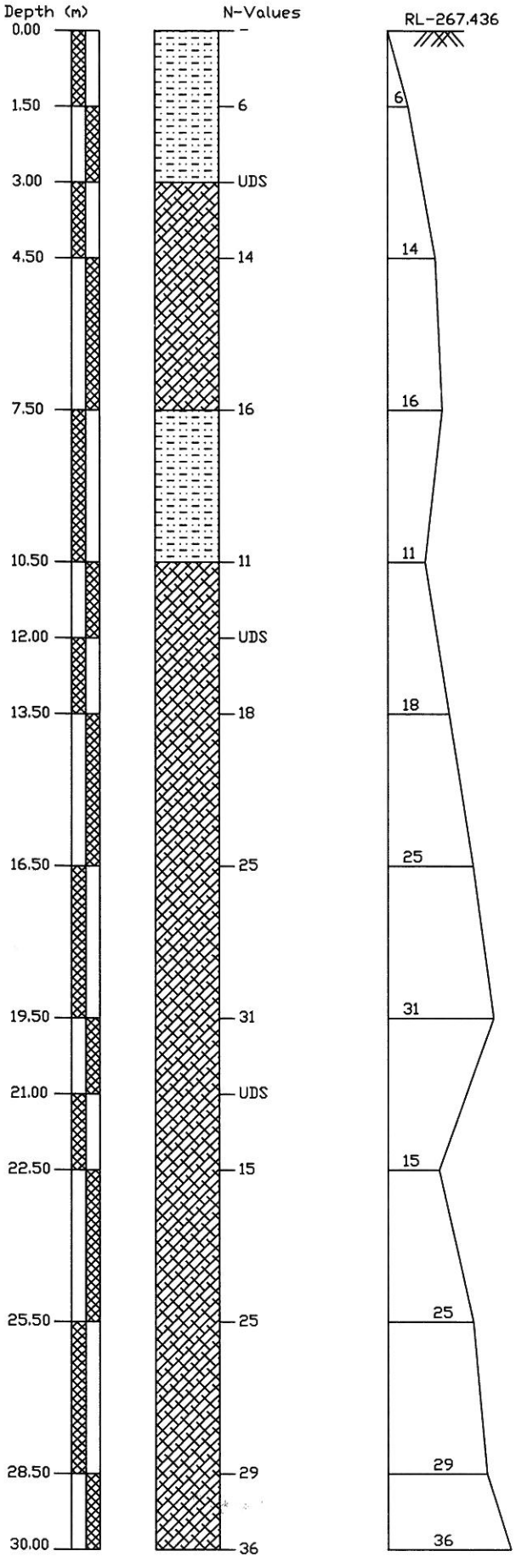
BORELOG OF BH–2(A2) RHS AT EXISTING KM–253/1–3 FOR MAJOR BRIDGE NO.–290, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	CLAYEY SILT

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ANNEXURE - III

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

INPUT DATA **Ch. 253 1-3** **BH-A1**

Type of footing

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

Angle of internal friction (ϕ °)	7.00
Cohesion (c in t/m2)	3.80
Void ratio (e)	0.75
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.63
Density of foundation soil (t/m^3)	1.63
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	7.00
N_c	7.23
N_q	1.93
N_γ	0.76

ϕ'	4.70
N'_c	6.41
N'_q	1.54
N'_γ	0.42

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	1.11	1.00	1.00
2	3.00	3.00	1.23	1.00	1.00
3	4.50	3.00	1.34	1.00	1.00
4	6.00	3.00	1.45	1.00	1.00

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 shear	Local shear	Actual
1	1.50	3.00	8.00	12.86	7.56	7.56
2	3.00	3.00	8.00	13.97	8.22	8.22
3	4.50	3.00	8.00	15.08	8.88	8.88
4	6.00	3.00	8.00	16.20	9.54	9.54

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ANNEXURE - III

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

INPUT DATA **Ch. 253 1-3** **BH-A2**

Type of footing

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

Angle of internal friction (ϕ °)	8.00
Cohesion (c in t/m2)	3.60
Void ratio (e)	0.74
Direction of load with vertical (°)	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

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

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.

ANNEXURE - III

Bearing capacity factors :

ϕ	8.00	ϕ'	5.38
N_c	7.61	N'_c	6.63
N_q	2.11	N'_q	1.64
N_γ	0.91	N'_γ	0.51

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	1.12	1.00	1.00
2	3.00	3.00	1.23	1.00	1.00
3	4.50	3.00	1.35	1.00	1.00
4	6.00	3.00	1.46	1.00	1.00

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 shear	Local shear	Actual
1	1.50	3.00	8.00	13.30	7.71	7.99
2	3.00	3.00	8.00	14.43	8.36	8.67
3	4.50	3.00	8.00	15.56	9.02	9.35
4	6.00	3.00	8.00	16.68	9.68	10.03

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/1-3**

BH No. (A1)

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	6.1	t/m^2
Concentrated load *P*		=	7.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.5	t/m^2
Compression Index	Cc	=	0.144	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.24049	

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

S_f = 0.03466 m

= 34.6564 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.31

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **25** **mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/1-3**

BH No. (A1)

Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	8.5575	t/m^2
Concentrated load *P*		=	8.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.7	t/m^2
Compression Index	Cc	=	0.144	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.19632	

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

S_f = 0.02883 m

= 28.8256 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.61

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **19.1 mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/ 1-3**

BH No. (A1)

Depth of foundation		=	4.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	11.0025	t/m^2
Concentrated load *P*		=	8.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.8	t/m^2
Compression Index	Cc	=	0.144	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.16224	

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

S_f = 0.02418 m

= 24.1775 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.92

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.74

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = $S_f \times D.F. \times R.F.$

S_{f2} = **14.3 mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/ 1-3**

BH No. (A1)

Depth of foundation		=	6.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	13.4475	t/m^2
Concentrated load *P*		=	9.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.0	t/m^2
Compression Index	Cc	=	0.144	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.14835	

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

S_f = 0.02225 m

= 22.2453 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$(LB)^{\wedge 0.5}/D$ = 0.82

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **12.1 mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/1-3**

BH No. (A2)

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	6.4	t/m^2
Concentrated load *P*		=	7.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.5	t/m^2
Compression Index	Cc	=	0.141	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.74	
	$\frac{Po + \Delta p}{Po}$	=	1.23059	

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

S_f = 0.03286 m

= 32.8601 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.31

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **23.9 mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/ 1-3**

BH No. (A2)

Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	8.925	t/m^2
Concentrated load *P*		=	8.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.8	t/m^2
Compression Index	Cc	=	0.141	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.74	
	$\frac{Po + \Delta p}{Po}$	=	1.2	

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

S_f = 0.02887 m

= 28.8739 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.61

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **19.2 mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/ 1-3**

BH No. (A2)

Depth of foundation		=	4.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	11.475	t/m^2
Concentrated load *P*		=	9.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.0	t/m^2
Compression Index	Cc	=	0.141	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.74	
	$\frac{Po + \Delta p}{Po}$	=	1.17386	

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

S_f = 0.02539 m

= 25.3854 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.92

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.74

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = $S_f \times D.F. \times R.F.$

S_{f2} = **15.0 mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.253/1-3**

BH No. (A2)

Depth of foundation		=	6.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	14.025	t/m^2
Concentrated load *P*		=	10.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.1	t/m^2
Compression Index	Cc	=	0.141	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.74	
	$\frac{Po + \Delta p}{Po}$	=	1.14973	

Settlement of clay layer

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

S_f = 0.0221 m

= 22.097 mm

Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement

Depth Factor Calculation

$(LB)^{\wedge 0.5}/D$ = 0.82

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

= 0.8

Pore pr. Correction = N.A.

Corrected Total Settlement = S_f x D.F.x R.F.

S_{f2} = **12.0** **mm**

CHAPTER – 134

"Major Bridge No. 289",

Location – Existing Km. - 251/05-07

134.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 5x6.10

134.2 BOREHOLE DESCRIPTIONS:

(a) Location of Structure, Boreholes with RL 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 07.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1(A1)	0.00 to 3.00	Sandy Silt with Clay	Loose
	6.00 to 7.50	Clayey Silt with Sand	Loose
	7.50 to 10.50	Clayey Silt with Sand	Medium Dense
	10.50 to 12.00	Silty Sand	Medium Dense
	12.00 to 13.50	Clayey Silt with Sand	Medium Dense
	13.50 to 30.00	Clayey Silt	Medium Dense
BH-2(A2)	0.00 to 3.00	Clayey Silt with Sand	Loose
	3.00 to 4.50	Sandy Silt with Clay	Loose
	4.50 to 7.50	Silty Sand	Loose
	7.50 to 12.00	Silty Sand	Medium Dense
	12.00 to 19.50	Clayey Silt with Sand	Medium Dense
	19.50 to 30.00	Clayey Silt	Medium Dense

134.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.20	NIL	0.0021	NIL	0.0012	0.087
	12.00	8.70	0.005	0.0021	NIL	0.0011	0.059
	18.00	8.80	0.007	0.0017	NIL	0.0012	0.067
	21.00	8.70	0.005	0.018	NIL	0.0012	0.049
BH-2 (A2)	3.00	8.10	NIL	0.0021	NIL	0.0012	0.051
	12.00	8.40	NIL	0.0024	NIL	0.0012	0.055
	24.00	8.30	NIL	0.0028	NIL	0.0011	0.0065

134.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1(A1)	3.00	16.00
	12.00	22.00
	18.00	27.00
	21.00	19.00

BH-2 (A2)	3.00	16.00
	12.00	13.00
	24.00	21.00

134.5 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	128	83	165	852	0.1	2.4	1043	672
Requirement as per IS:456 / Mosrth's	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	-	-

134.6 PILE LOAD CARRYING CAPACITY

134.6.1 Normal Bored Cast in- situ Pile Foundations:

Normal bored cast in situ RCC pile foundation is envisaged for the proposed bridge and have been analysed in the subsequent paragraphs. The Axial load carrying capacity of Pile in Rock is determined as per IRC- 78: 2000 appendix-5.

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 IS: 2911 should be 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.

Safe bearing capacity in t/m²

BH -NO.	DEPTH (mtr)	Net Allowable Bearing Pressure (t/m²)
BH-1 (A1)	1.50m	08.00
	3.00m	09.50
	4.50m	10.00
	6.00m	10.50
BH-2 (A2)	1.50m	08.50
	3.00m	09.50
	4.50m	10.50
	6.00m	11.50

Pile load carrying capacity in t

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE
		Pile Diameter= 1.0 m
BH-1 (A1)	17.00	100.00
	20.00	135.00
	23.00	170.00
BH-2 (A2)	17.00	120.00
	20.00	150.00
	23.00	180.00

134.7 CONCLUSIONS

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

134.8 RECOMMENDATIONS

(i)	*Type of foundation*	Pile foundation

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.