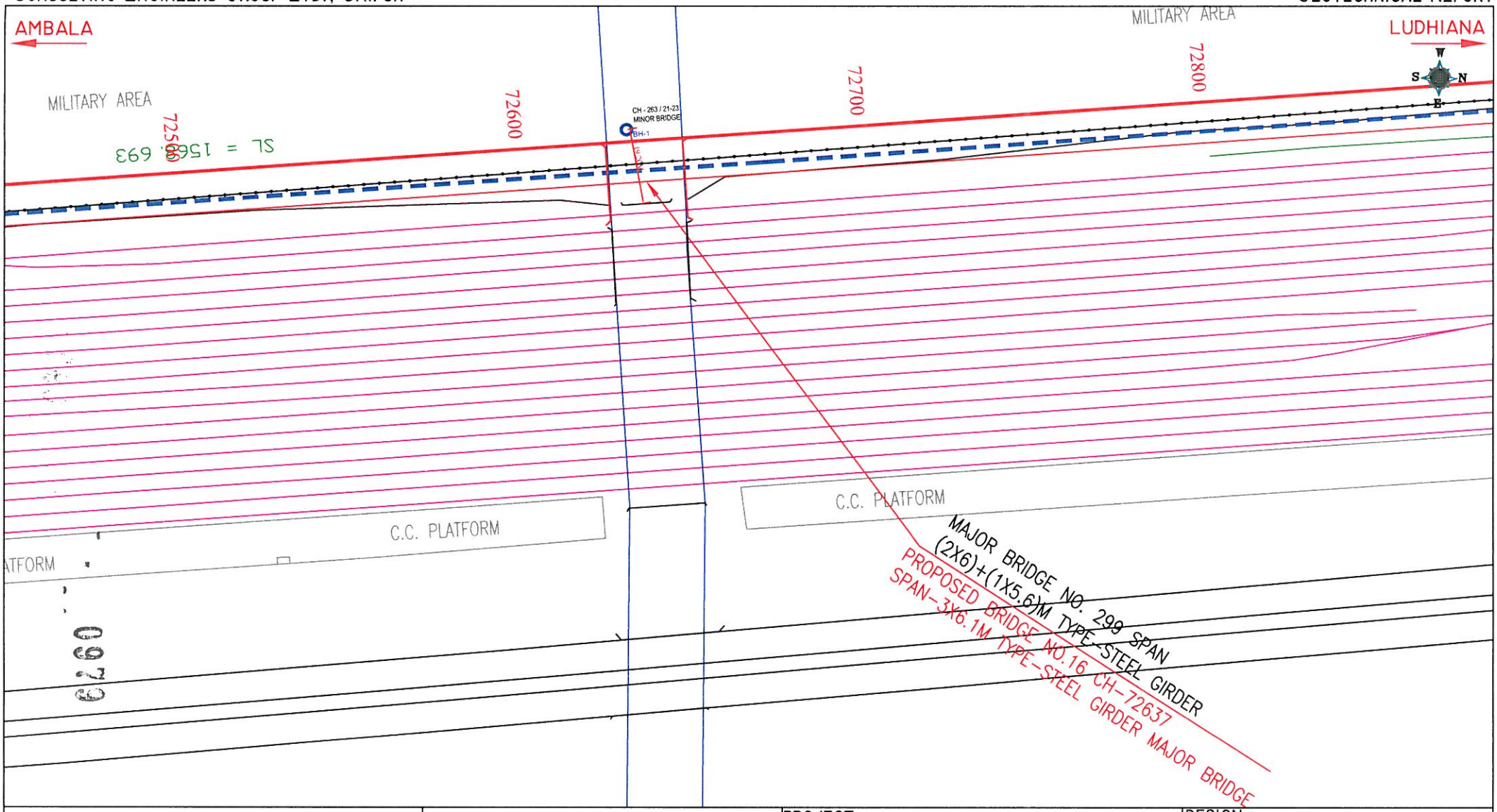

ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED MINOR BRIDGE CH. 263/21-23	RL OF BH-I = 267.325	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 FOR MINOR BRIDGE No. 299 AT CHAINAGE 263/21-23

Project :	Chainage 263/21-23 Bridge No. 299			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				10.12.2009 to 10.12.2009	1	1	01.00 m.	12.00mtr	267.325

Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Sandy Silt with Clay	9.52	66.89	22.43	0.68	0.48	0.00	0.00	27	19	8	-	-	-	-	-	-
1.50	7	1.43	10.01	Sandy Silt with Clay	8.14	69.01	21.34	1.12	0.39	0.00	0.00	26	19	7	-	-	-	-	-	-
3.00	UDS	-	-	Clayey Silt with Sand	10.10	79.93	8.45	0.75	0.52	0.25	0.00	28	19	9	1.83	18.45	1.54	2.65	0.11	20.0
4.50	8	1.07	8.56	Clayey Silt with Sand	16.24	77.31	4.91	1.31	0.06	0.17	0.00	33	19	14	-	-	-	-	-	-
6.00	UDS	-	-	Clayey Silt with Sand	13.89	78.65	5.48	1.23	0.23	0.52	0.00	32	20	12	1.85	19.86	1.54	2.67	0.13	18.0
7.50	12	0.89	10.68	Clayey Silt with Sand	10.68	82.33	4.35	1.59	0.69	0.36	0.00	29	19	10	-	-	-	-	-	-
10.50	15	0.78	11.70	Clayey Silt with Sand	10.15	80.17	6.58	1.49	0.76	0.85	0.00	30	21	9	-	-	-	-	-	-
12.00	20	0.74	14.80	Clayey Silt with Sand	9.25	78.77	8.66	1.53	0.69	1.10	0.00	27	18	9	-	-	-	-	-	-

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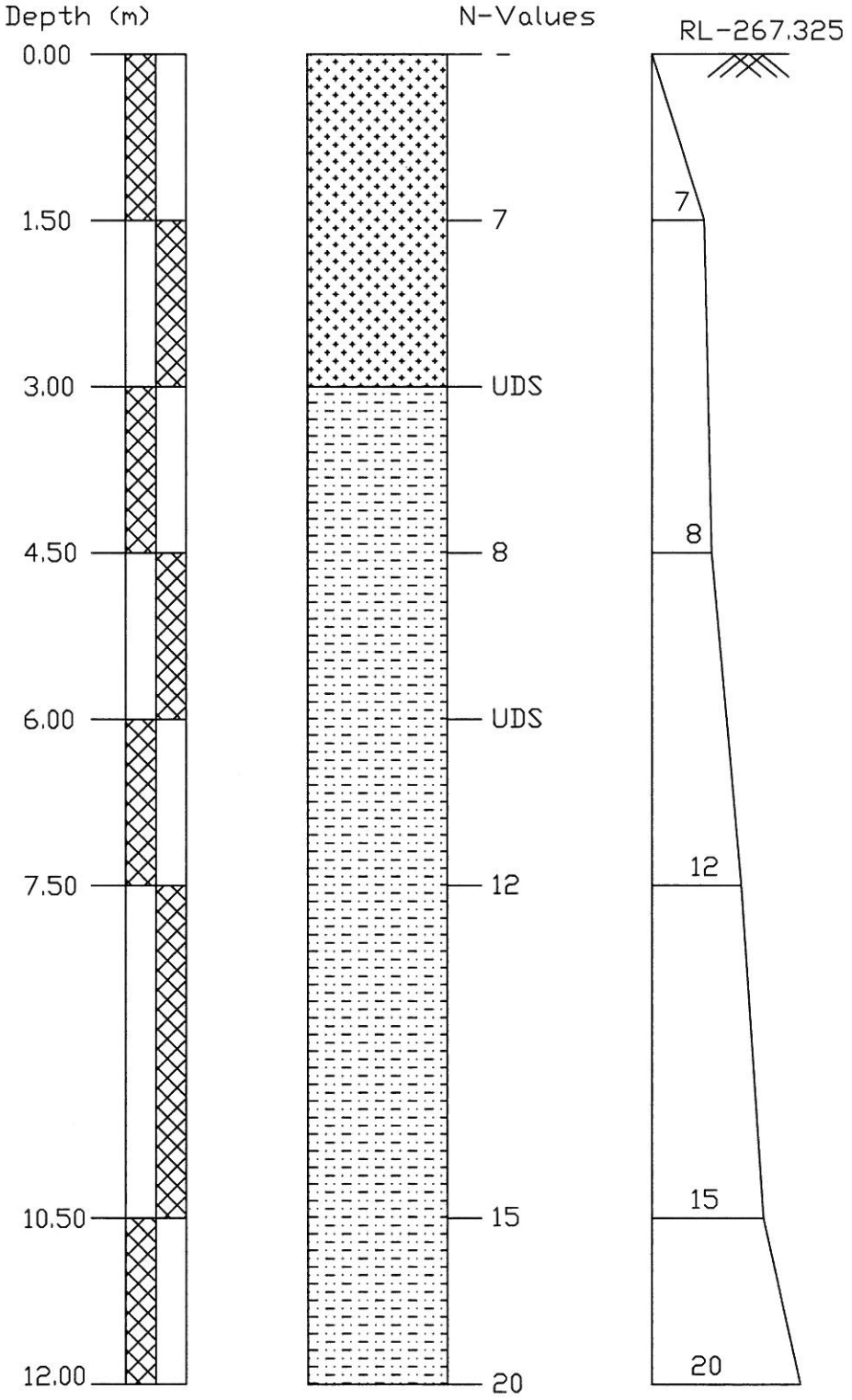
BORELOG OF BH–1 AT EXISTING KM–263/21–23 FOR MINOR BRIDGE NO.–299, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT WITH CLAY
	CLAYEY SILT WITH SAND

0981

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ANNEXURE - III

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

INPUT DATA

Ch 263 21-23 **BH-1**

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Rectangular **2**

Angle of internal friction (ϕ °)	18.00
Cohesion (c in t/m2)	1.30
Void ratio (e)	0.73
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.85
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)	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.

ANNEXURE - III

Bearing capacity factors :

ϕ	18.00	ϕ'	12.28
N_c	13.29	N'_c	9.55
N_q	5.42	N'_q	3.14
N_γ	4.29	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
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	1.14	1.07	1.07
2	3.00	3.00	1.28	1.14	1.14
3	4.50	3.00	1.41	1.21	1.21
4	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	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	13.16	6.25	6.94
2	3.00	3.00	8.00	19.00	9.07	10.06
3	4.50	3.00	8.00	20.52	9.80	10.87
4	6.00	3.00	8.00	22.04	10.53	11.68

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Minor Bridge at Ch.263/ 21-23**

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	=	6.75	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	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.73	
	$\frac{Po + \Delta p}{Po}$	=	1.21778	

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

S_f = 0.03116 m

= 31.1606 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} = **22.7** **mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Minor Bridge at Ch.263/ 21-23**

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	=	9.45	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	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.73	
	$\frac{Po + \Delta p}{Po}$	=	1.22222	

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

S_f = 0.03174 m

= 31.7368 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.

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

S_{f2} = **21.1 mm**

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Minor Bridge at Ch.263/ 21-23**

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	=	12.15	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	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.73	
	$\frac{Po + \Delta p}{Po}$	=	1.18148	

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

S_f = 0.02638 m

= 26.3751 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.

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

S_{f2} = **15.6 mm**

0986

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Minor Bridge at Ch.263/ 21-23**

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	=	15.68	t/m^2
Concentrated load *P*		=	11.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.3	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.73	
	$\frac{Po + \Delta p}{Po}$	=	1.14737	

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

S_f = 0.02174 m

= 21.7415 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.

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

S_{f2} = **11.8 mm**

CHAPTER – 126

"Minor Bridge No. 292",

Location – Existing Km. - 254/05-07

126.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 1x3x3

126.2 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 ≥15.00m below EGL.

Subsurface profile at the site

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

126.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.10	NIL	0.0018	NIL	0.0013	0.040
	6.00	9.50	0.015	0.0014	NIL	0.0011	0.035

126.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	18.00
	6.00	NIL

126.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m^2)
BH-1	1.50	06.00
	3.00	10.00
	4.50	11.00
	6.00	11.50

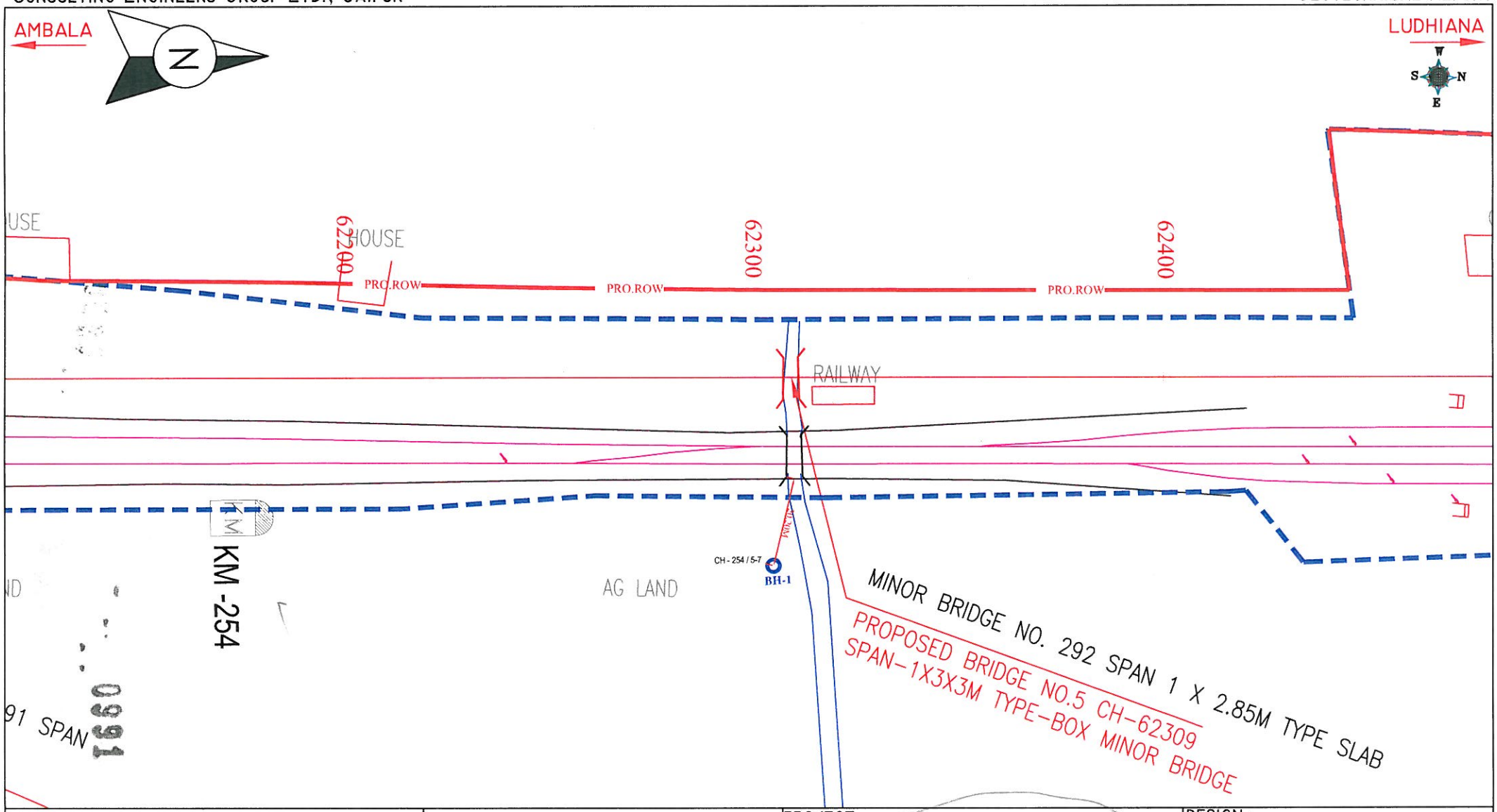
126.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

126.7 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 6.00 m from EGL

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



ALL DIMENSIONS IN METER

FIG.:-I
LOCATION PLAN OF PROPOSED MINOR BRIDGE
CH. 254/5-7

RL OF BH-I = 268.545

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 FOR MINOR BRIDGE No. 292 AT CHAINAGE 254/5-7

Project :	Chainage 254/5-7 Bridge No. 292			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				27.07.2009 to 27.07.2009	1	1 (RHS)	below 15.00 m.	12.00mtr	268.545

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	14.86	55.44	20.398	6.24	2.11	0.95	0.00	32	20	12	-	-	-	-	-	-
1.50	7	1.45	10.15	Clayey silt with sand	12.69	46.61	28.68	1.24	0.46	10.32	0.00	29	19	10	-	-	-	-	-	-
3.00	UDS	-	-	Clayey silt with sand	18.99	47.82	31.18	0.96	0.53	0.52	0.00	27	16	11	1.73	12.33	1.54	2.65	0.13	20.00
4.50	11	1.09	11.99	Clayey silt	33.56	62.17	2.00	0.38	0.29	1.60	0.00	52	22	30	-	-	-	-	-	-
6.00	UDS	-	-	Clayey silt	21.15	70.71	5.94	0.66	0.54	1.00	0.00	36	18	18	1.77	15.53	1.53	2.64	0.23	14.00
7.50	16	0.90	14.40	Clayey silt	38.23	58.39	1.64	0.70	0.42	0.62	0.00	59	23	36	-	-	-	-	-	-
10.50	15	0.79	11.85	Clayey silt	36.88	58.34	2.27	0.86	0.35	1.30	0.00	55	21	34	-	-	-	-	-	-
12.00	18	0.74	13.32	Clayey silt	38.10	57.82	1.95	0.78	0.39	0.96	0.00	60	25	35	-	-	-	-	-	-

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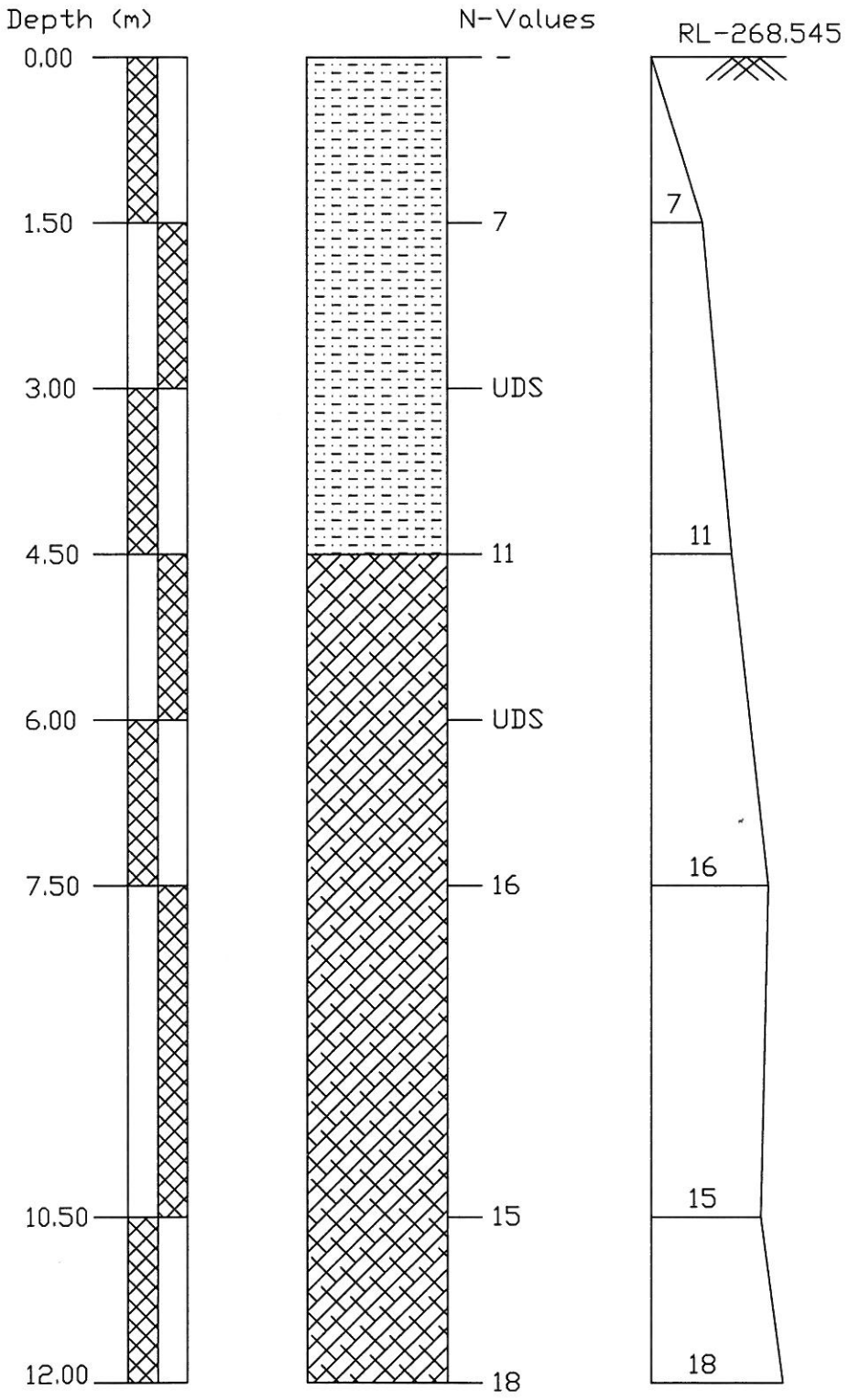
BORELOG OF BH–1 AT EXISTING KM–254/5–7 FOR MINOR BRIDGE NO.–292,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	CLAYEY SILT

0993

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ANNEXURE -III

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

INPUT DATA

Ch 254 5-7 **BH-1**

Type of footing

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

Angle of internal friction (ϕ°)	14.00
Cohesion (c in t/m2)	2.30
Void ratio (e)	0.72
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

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

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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0994

ANNEXURE -III

Bearing capacity factors :

ϕ	14.00	ϕ'	9.48
N_c	10.45	N'_c	8.16
N_q	3.65	N'_q	2.38
N_γ	2.36	N'_γ	1.14

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	1.13	1.06	1.06
2	3.00	3.00	1.26	1.13	1.13
3	4.50	3.00	1.38	1.19	1.19
4	6.00	3.00	1.51	1.26	1.26

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	13.20	6.83	7.79
2	3.00	3.00	8.00	17.24	8.93	10.18
3	4.50	3.00	8.00	18.71	9.69	11.05
4	6.00	3.00	8.00	20.17	10.46	11.91

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Minor Bridge at Ch.254/ 5-7**

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	t/m^2
Concentrated load *P*		=	6.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.3	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.72	
	$\frac{Po + \Delta p}{Po}$	=	1.21	

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

S_f = 0.03032 m

= 30.3225 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} = **22.1** **mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Minor Bridge at Ch.254/ 5-7**

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	=	8.4	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	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.72	
	$\frac{Po + \Delta p}{Po}$	=	1.225	

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

S_f = 0.03228 m

= 32.2824 mm

Correction for Depth and Rigidity of foundation 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.

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

S_{f2} = **21.4** **mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Minor Bridge at Ch.254/ 5-7**

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	=	10.8	t/m^2
Concentrated load *P*		=	11.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.3	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.72	
	$\frac{Po + \Delta p}{Po}$	=	1.21389	

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

S_f = 0.03083 m

= 30.833 mm

Correction for Depth and Rigidity of foundation 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.

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

S_{f2} = **18.3** **mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Minor Bridge at Ch.254/ 5-7**

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	=	14.85	t/m^2
Concentrated load *P*		=	11.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.4	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.72	
	$\frac{Po + \Delta p}{Po}$	=	1.16263	

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

S_f = 0.02397 m

= 23.9693 mm

Correction for Depth and Rigidity of foundation 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.

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

S_{f2} = **13.0 mm**

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CHAPTER – 127

"Major Bridge No. 304",

Location – Existing Km. - 267/25-27

127.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 3x6.1

127.2 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 10.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1(A1)	0.00 to 4.50	Clayey Silt	Loose
	4.50 to 7.50	Sandy Silt with Clay	Loose
	7.50 to 10.50	Sandy Silt with Clay	Medium Dense
	10.50 to 19.50	Silty Sand	Medium Dense
	19.50 to 28.50	Clayey Silt	Medium Dense
	28.50 to 30.00	Clayey Silt	Dense
BH-2(A2)	0.00 to 7.50	Clayey Silt	Loose
	7.50 to 13.50	Sandy Silt with Clay	Medium Dense
	13.50 to 19.50	Silty Sand	Medium Dense
	19.50 to 25.50	Clayey Silt	Medium Dense
	25.50 to 30.00	Clayey Silt	Dense

127.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.70	0.007	0.0032	NIL	0.0014	0.082
	12.00	8.80	0.005	0.0041	NIL	0.0014	0.090
	21.00	8.60	NIL	0.0038	NIL	0.0013	0.061
BH-2 (A2)	3.00	8.30	0.002	0.0032	NIL	0.0013	0.055
	12.00	8.20	NIL	0.0035	NIL	0.0011	0.095
	24.00	8.40	0.005	0.0042	NIL	0.0010	0.052

127.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1(A1)	3.00	19.00
	12.00	NIL
	21.00	23.00
BH-2 (A2)	3.00	16.00
	12.00	16.00
	24.00	33.00

127.5 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	122	102	161	845	0.2	2.3	1020	653
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	-	-

127.6 PILE LOAD CARRYING CAPACITY

127.6.1 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	11.50
	4.50m	12.00
	6.00m	13.00
BH-2 (A2)	1.50m	07.00
	3.00m	10.00
	4.50m	11.00
	6.00m	13.00

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	130.00
	20.00	160.00
	23.00	190.00
BH-2 (A2)	17.00	115.00
	20.00	140.00
	23.00	170.00

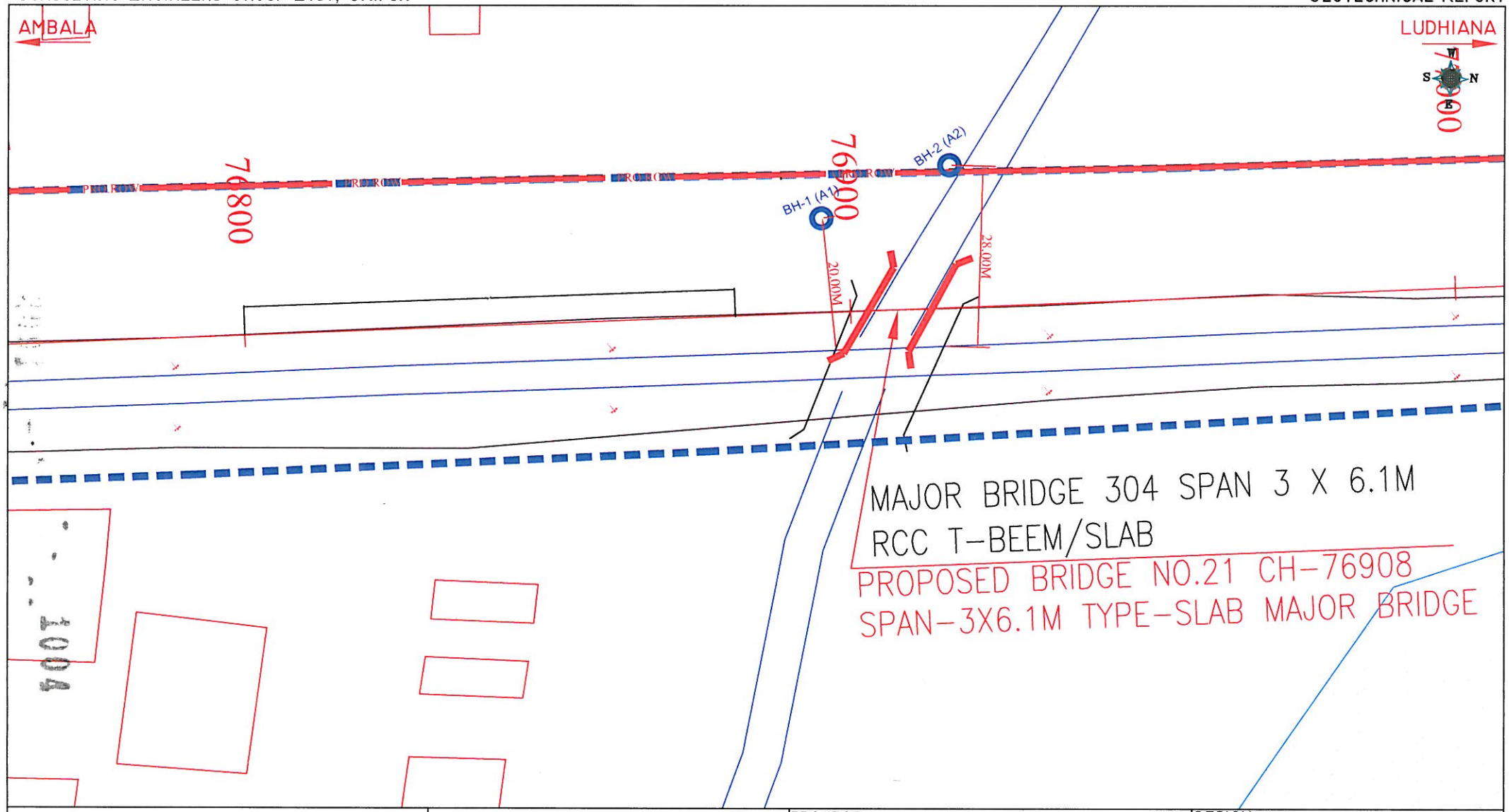
127.7 CONCLUSIONS

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

127.8 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-267/25-27

RL OF BH (AI) = 268.726
RL OF BH (A2) = 267.251

PROJECT :-

LUDHIANA-AMBALA (DFCCIL)

DESIGN :-

CONSULTING
ENGINEERS GROUP LTD.
E-12,Moji Colony,Malviya Nagar Jaipur-17
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SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (A1) OF MAJOR BRIDGE No. 304 AT CHAINAGE 267/25-27

Project :	Chainage 267/25-27 Bridge No. 304			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				05.12.2009 to 06.12.2009	A1	1	10.00 m.	30.00mtr	268.726

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	-	-	-	Clayey silt	14.20	82.13	1.69	1.28	0.35	0.35	0.00	32	20	12	-	-	-	-	-	-
1.50	5	1.45	7.25	Clayey silt	16.21	78.13	3.94	0.76	0.54	0.42	0.00	35	20	15	-	-	-	-	-	-
3.00	UDS	-	-	Clayey silt	17.52	77.59	2.68	1.24	0.45	0.52	0.00	35	19	16	1.76	12.12	1.57	2.68	0.19	16.0
4.50	8	1.08	8.64	Sandy Silt with Clay	12.63	50.66	33.26	0.85	1.34	1.26	0.00	32	21	11	-	-	-	-	-	-
7.50	13	0.91	11.83	Sandy Silt with Clay	14.29	47.97	35.26	1.35	0.27	0.86	0.00	33	21	12	-	-	-	-	-	-
10.50	17	0.80	13.60	Silty Sand	3.26	29.80	60.16	5.68	0.00	1.10	0.00	23	NIL	NP	-	-	-	-	-	-
12.00	UDS	-	-	Silty Sand	4.26	13.55	78.26	3.25	0.00	0.68	0.00	25	NIL	NP	1.91	17.21	1.63	2.65	0.00	28.0
13.50	25	0.71	16.38	Silty Sand	3.49	9.88	80.36	5.48	0.00	0.79	0.00	24	NIL	NP	-	-	-	-	-	-
16.50	20	0.64	12.80	Silty Sand	4.61	14.90	77.64	1.35	0.25	1.25	0.00	26	NIL	NP	-	-	-	-	-	-
19.50	22	0.58	12.76	Clayey silt	16.98	77.67	3.65	0.65	0.39	0.66	0.00	36	21	15	-	-	-	-	-	-
21.00	UDS	-	-	Clayey silt	20.41	73.74	3.16	0.85	1.36	0.48	0.00	38	20	18	2.00	20.13	1.66	2.67	0.20	15.0
22.50	26	0.52	13.52	Clayey silt	22.14	73.16	2.69	1.15	0.49	0.37	0.00	41	21	20	-	-	-	-	-	-
25.50	29	0.48	13.92	Clayey silt	19.83	74.20	3.34	1.35	0.82	0.46	0.00	37	19	18	-	-	-	-	-	-
28.50	32	0.44	14.08	Clayey silt	16.44	78.38	2.56	0.42	1.52	0.68	0.00	35	21	14	-	-	-	-	-	-
30.00	36	0.42	15.06	Clayey silt	18.62	75.40	3.61	1.16	0.46	0.75	0.00	37	21	16	-	-	-	-	-	-

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ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (A2) OF MAJOR BRIDGE No. 304 AT CHAINAGE 267/25-27

Project :	Chainage 267/25-27 Bridge No. 304			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				06.12.2009 to 06.12.2009	A2	2	10.00 m.	30.00mtr	267.251

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	16.24	82.19	1.10	0.32	0.15	0.00	0.00	30	20	15	-	-	-	-	-	-
1.50	4	1.44	5.76	Clayey silt	18.42	80.26	0.72	0.15	0.45	0.00	0.00	36	20	16	-	-	-	-	-	-
3.00	UDS	-	-	Clayey silt	14.93	81.35	3.22	0.35	0.15	0.00	0.00	33	20	13	1.78	14.86	1.55	2.67	0.14	18.0
4.50	7	1.07	7.49	Clayey silt	22.20	74.55	2.28	0.70	0.27	0.00	0.00	41	22	19	-	-	-	-	-	-
7.50	14	0.90	12.60	Sandy Silt with Clay	21.10	46.00	32.51	0.13	0.26	0.00	0.00	39	20	19	-	-	-	-	-	-
10.50	20	0.79	15.80	Sandy Silt with Clay	16.24	42.66	40.26	0.32	0.52	0.00	0.00	34	20	14	-	-	-	-	-	-
12.00	UDS	-	-	Sandy Silt with Clay	14.25	49.00	35.10	0.55	1.10	0.00	0.00	29	17	12	2.12	24.85	1.70	2.68	0.12	19.0
13.50	25	0.69	16.13	Silty Sand	0.00	9.75	82.87	7.38	0.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
16.50	20	0.62	12.40	Silty Sand	0.00	6.01	87.20	6.79	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
19.50	24	0.56	13.44	Clayey silt	23.68	72.50	2.93	0.63	0.26	0.00	0.00	47	26	21	-	-	-	-	-	-
22.50	28	0.50	14.00	Clayey silt	35.41	62.30	1.52	0.44	0.04	0.29	0.00	54	24	30	-	-	-	-	-	-
24.00	UDS	-	-	Clayey silt	30.52	66.91	1.43	0.62	0.10	0.42	0.00	52	24	28	2.10	22.18	1.72	2.67	0.30	12.0
25.50	32	0.46	14.72	Clayey silt	29.48	67.40	1.64	0.55	0.38	0.55	0.00	52	25	27	-	-	-	-	-	-
28.50	36	0.42	15.06	Clayey silt	26.85	67.84	1.65	0.71	0.50	2.45	0.00	50	27	23	-	-	-	-	-	-
30.00	39	0.40	15.30	Clayey silt	24.15	72.68	1.56	0.68	0.55	0.38	0.00	45	24	21	-	-	-	-	-	-

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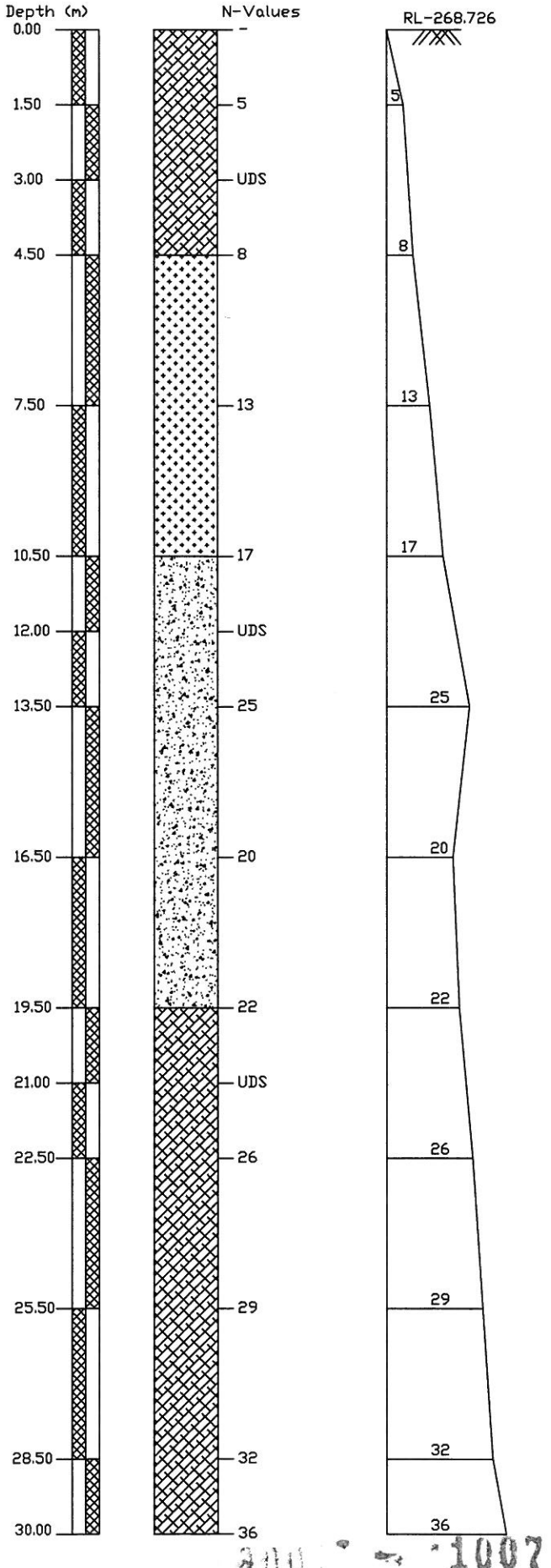
BORELOG OF BH–1(A1) AT EXISTING KM–267/25–27 FOR MAJOR BRIDGE NO.–304,
ON KESARI TO SANEHWAL, LUDHIANA

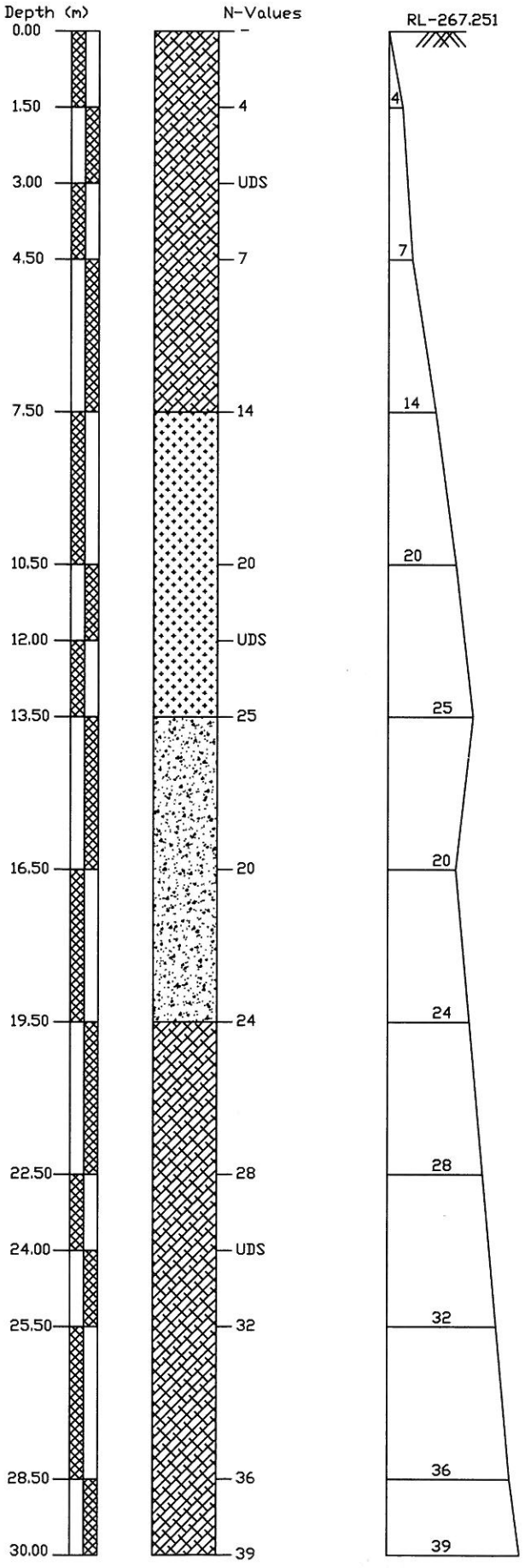


LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT
	SANDY SILT WITH CLAY
	SILTY SAND

1007

BORELOG OF BH–2(A2) AT EXISTING KM–267/25–27 FOR MAJOR BRIDGE NO.–304,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT
	SANDY SILT WITH CLAY
	SILTY SAND

1008

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ANNEXURE - III

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

INPUT DATA

Ch 267 25-27 **BH-A1**

Type of footing

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

Angle of internal friction (ϕ °)	16.00
Cohesion (c in t/m2)	1.90
Void ratio (e)	0.71
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.78
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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1009

ANNEXURE - III

Bearing capacity factors :

ϕ	16.00	ϕ'	10.88
N_c	11.75	N'_c	8.81
N_q	4.43	N'_q	2.73
N_γ	3.20	N'_γ	1.47

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	1.13	1.07	1.07
2	3.00	3.00	1.27	1.13	1.13
3	4.50	3.00	1.40	1.20	1.20
4	6.00	3.00	1.53	1.27	1.27

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	13.70	6.81	8.18
2	3.00	3.00	8.00	18.60	9.27	11.13
3	4.50	3.00	8.00	20.16	10.04	12.07
4	6.00	3.00	8.00	21.71	10.82	13.00

ANNEXURE - III

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

INPUT DATA

Ch 267 25-27 **BH-A2**

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)	1.40
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)	1.80
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	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
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	1.14	1.07	1.07
2	3.00	3.00	1.28	1.14	1.14
3	4.50	3.00	1.41	1.21	1.21
4	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	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	13.65	6.49	7.56
2	3.00	3.00	8.00	19.55	9.34	10.87
3	4.50	3.00	8.00	21.14	10.10	11.75
4	6.00	3.00	8.00	22.72	10.85	12.64

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.267/ 25-27**

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	=	6.75	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	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.71	
	$\frac{Po + \Delta p}{Po}$	=	1.24889	

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

S_f = 0.03302 m

= 33.0213 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 = $\frac{\text{Total Settlement of Rigid foundation}}{\text{Pore water pressure correction}}$ = N.A.

= $\frac{\text{Total Settlement at the centre of Flexible foundation}}{0.8}$

Pore Pr. Correction = N.A.

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

S_{f2} = **24.0 mm**

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1013

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.267/ 25-27**

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	=	9.45	t/m^2
Concentrated load *P*		=	11.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.3	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.71	
	$\frac{Po + \Delta p}{Po}$	=	1.24444	

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

S_f = 0.03249 m

= 32.4916 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} = **21.6** **mm**

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1014

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.267/ 25-27**

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	=	12.15	t/m^2
Concentrated load *P*		=	12.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.5	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.71	
	$\frac{Po + \Delta p}{Po}$	=	1.20741	

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

S_f = 0.028 m

= 28.0026 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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1015

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.267/ 25-27**

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	=	14.85	t/m^2
Concentrated load *P*		=	13.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.7	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.71	
	$\frac{Po + \Delta p}{Po}$	=	1.18384	

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

S_f = 0.02507 m

= 25.0737 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} = **13.6 mm**

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1016

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.267/ 25-27**

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	=	6.75	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	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.72	
	$\frac{Po + \Delta p}{Po}$	=	1.21778	

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

S_f = 0.03134 m

= 31.3418 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} = **22.8 mm**

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1017

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.267/ 25-27**

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	=	9.45	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	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.72	
	$\frac{Po + \Delta p}{Po}$	=	1.22222	

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

S_f = 0.03192 m

= 31.9213 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} = **21.2 mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.267/ 25-27**

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	=	12.15	t/m^2
Concentrated load *P*		=	11.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.3	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.72	
	$\frac{Po + \Delta p}{Po}$	=	1.19012	

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

S_f = 0.02769 m

= 27.6878 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} = **16.4** **mm**

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1019

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.267/ 25-27**

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	=	14.85	t/m^2
Concentrated load *P*		=	12.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.5	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.72	
	$\frac{Po + \Delta p}{Po}$	=	1.1697	

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

S_f = 0.02493 m

= 24.9338 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} = **13.6** **mm**

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1020

CHAPTER – 128

"Major Bridge No. 302",

Location – Existing Km. - 266/19-21

128.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 4x12.20

128.2 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 08.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1(A1)	0.00 to 1.50	Silty Sand	Loose
	1.50 to 3.00	Silty Sand with Clay	Loose
	3.00 to 7.50	Clayey Silt	Loose
	7.50 to 12.00	Clayey Silt	Medium Dense
	12.00 to 25.50	Clayey Silt with Sand	Medium Dense
	25.50 to 30.00	Clayey Silt with Sand	Dense
BH-2(A2)	0.00 to 4.50	Sandy Silt with Clay	Loose
	4.50 to 12.00	Clayey Silt with Sand	Loose
	12.00 to 13.50	Sandy Silt with Clay	Medium Dense
	13.50 to 24.00	Clayey Silt with Sand	Medium Dense
	24.00 to 25.50	Sandy Silt	Medium Dense
	25.50 to 30.00	Clayey Silt with Sand	Dense

128.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.50	NIL	0.0028	NIL	0.0011	0.082
	12.00	8.60	NIL	0.0031	NIL	0.0011	0.077
	21.00	8.10	NIL	0.0041	NIL	0.0010	0.061
BH-2 (A2)	3.00	8.80	NIL	0.0038	NIL	0.0012	0.069
	12.00	8.10	NIL	0.0031	NIL	0.0011	0.065
	18.00	8.30	NIL	0.0038	NIL	0.0010	0.078
	24.00	8.80	NIL	0.0042	NIL	0.0014	0.042

128.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1(A1)	3.00	18.00
	12.00	14.00
	21.00	14.00

BH-2 (A2)	3.00	11.00
	12.00	09.00
	18.00	15.00
	24.00	NIL

128.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BORE HOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (µS/cm)
Test Result	7.3	100	130	168	750	0.2	2.1	960	636
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	-	-

128.6 PILE LOAD CARRYING CAPACITY

128.6.1 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	10.50
	4.50m	11.50
	6.00m	12.00
BH-2 (A2)	1.50m	08.00
	3.00m	12.00
	4.50m	13.00
	6.00m	14.00

1023

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	130.00
	23.00	170.00
BH-2 (A2)	17.00	90.00
	20.00	120.00
	23.00	135.00

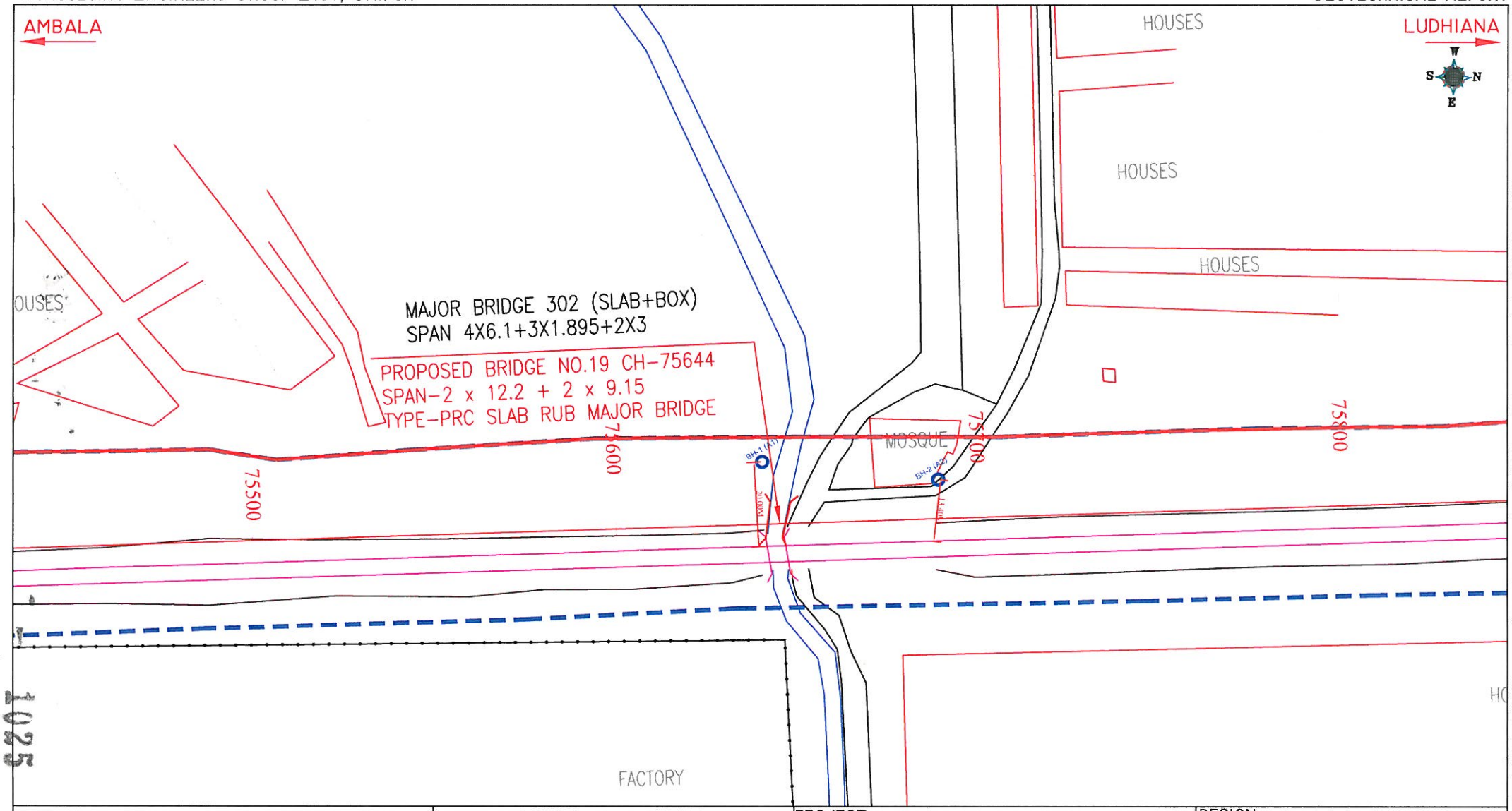
128.7 CONCLUSIONS

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

128.8 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-266/19-21	RL OF BH (A1) = 267.327 RL OF BH (A2) = 268.558	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. 302 AT CHAINAGE 266/19-21

Project :	Chainage 266/19-21 Bridge No. 302			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				07.12.2009 to 07.12.2009	A1	1	08.00 m.	30.00mtr	267.327

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	2.41	5.38	86.34	5.32	0.55	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
1.50	5	1.43	7.15	Silty Sandwirh clay	3.25	6.30	85.63	4.37	0.45	0.00	0.00	30	20	10	-	-	-	-	-	-
3.00	UDS	-	-	Clayey Silt	16.89	79.63	2.10	0.69	0.44	0.25	0.00	35	20	15	1.83	15.84	1.58	2.67	0.18	15.0
4.50	9	1.07	9.63	Clayey Silt	10.24	87.29	1.59	0.55	0.24	0.09	0.00	30	21	9	-	-	-	-	-	-
7.50	16	0.90	14.40	Clayey Silt	14.58	80.55	2.69	0.68	0.55	0.95	0.00	31	19	12	-	-	-	-	-	-
10.50	12	0.78	9.36	Clayey Silt	9.68	87.84	1.84	0.46	0.18	0.00	0.00	32	23	9	-	-	-	-	-	-
12.00	UDS	-	-	Clayey Silt with Sand	12.82	73.09	10.31	0.31	0.00	3.47	0.00	28	17	11	2.00	19.18	1.68	2.68	0.13	19.0
13.50	15	0.69	10.35	Clayey Silt with Sand	14.22	76.02	8.59	0.36	0.56	0.25	0.00	30	18	12	-	-	-	-	-	-
16.50	19	0.62	11.78	Clayey Silt with Sand	15.41	75.34	7.58	0.48	0.85	0.34	0.00	32	19	13	-	-	-	-	-	-
19.50	22	0.56	12.32	Clayey Silt with Sand	16.24	72.45	10.35	0.52	0.26	0.18	0.00	35	21	14	-	-	-	-	-	-
21.00	UDS	-	-	Clayey Silt with Sand	13.52	74.07	9.56	0.85	0.75	1.25	0.00	31	19	12	2.10	20.19	1.74	2.66	0.13	18.0
22.50	25	0.51	12.75	Clayey Silt with Sand	12.41	73.66	10.68	0.62	0.49	2.14	0.00	30	19	11	-	-	-	-	-	-
25.50	30	0.46	13.80	Clayey Silt with Sand	17.22	71.52	9.55	0.35	0.68	0.68	0.00	35	20	15	-	-	-	-	-	-
28.50	34	0.43	14.62	Clayey Silt with Sand	15.65	74.77	8.58	0.36	0.38	0.26	0.00	34	21	13	-	-	-	-	-	-
30.00	37	0.41	15.09	Clayey Silt with Sand	13.25	75.81	9.35	0.56	0.58	0.45	0.00	32	20	12	-	-	-	-	-	-

1026

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ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (A2) OF MAJOR BRIDGE No. 302 AT CHAINAGE 266/19-21

Project :	Chainage 266/19-21 Bridge No. 302			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				08.12.2009 to 08.12.2009	A2	2	08.00 m.	30.00mtr	268.558

Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Sandy Silt with Clay	9.73	73.57	15.33	0.64	0.21	0.52	0.00	27	18	9	-	-	-	-	-	-
1.50	7	1.45	10.15	Sandy Silt with Clay	8.42	78.19	12.37	0.54	0.14	0.34	0.00	26	18	8	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt with Clay	10.15	52.64	37.05	0.16	0.00	0.00	0.00	29	20	9	1.75	10.72	1.58	2.67	0.10	20.0
4.50	15	1.08	16.20	Clayey Silt with Sand	18.49	69.33	8.00	0.87	0.43	2.88	0.00	38	22	16	-	-	-	-	-	-
7.50	12	0.91	10.92	Clayey Silt with Sand	25.86	68.29	4.08	0.80	0.36	0.61	0.00	43	20	23	-	-	-	-	-	-
10.50	14	0.80	11.20	Clayey Silt with Sand	11.21	78.46	8.84	0.48	0.38	0.63	0.00	27	17	10	-	-	-	-	-	-
12.00	UDS	-	-	Sandy Silt with Clay	7.16	77.23	14.90	0.34	0.37	0.00	0.00	25	18	7	1.75	19.17	1.47	2.67	0.09	21.0
13.50	16	0.71	11.36	Clayey Silt with Sand	15.11	79.00	4.53	0.67	0.42	0.27	0.00	36	23	13	-	-	-	-	-	-
16.50	20	0.65	13.00	Clayey Silt with Sand	17.38	77.13	4.85	0.29	0.08	0.27	0.00	36	20	16	-	-	-	-	-	-
18.00	UDS	-	-	Clayey Silt with Sand	14.58	76.51	5.10	2.13	0.78	0.90	0.00	32	20	12	1.77	21.13	1.46	2.66	0.12	19.0
19.50	23	0.59	13.57	Clayey Silt with Sand	13.22	78.44	4.90	1.84	0.84	0.76	0.00	30	18	12	-	-	-	-	-	-
22.50	26	0.54	14.04	Clayey Silt with Sand	8.32	82.60	8.11	0.18	0.19	0.60	0.00	24	16	8	-	-	-	-	-	-
24.00	UDS	-	-	Sandy Silt	2.54	55.39	41.87	0.20	0.00	0.00	0.00	24	NIL	NP	2.03	22.40	1.66	2.68	0.00	29.0
25.50	30	0.49	14.70	Clayey Silt with Sand	8.63	84.06	7.26	0.05	0.00	0.00	0.00	28	20	8	-	-	-	-	-	-
28.50	33	0.45	14.85	Clayey Silt with Sand	7.10	74.85	10.04	6.46	0.72	0.41	0.42	26	19	7	-	-	-	-	-	-
30.00	35	0.43	15.03	Clayey Silt with Sand	7.25	83.07	7.55	1.10	0.53	0.50	0.00	25	17	8	-	-	-	-	-	-

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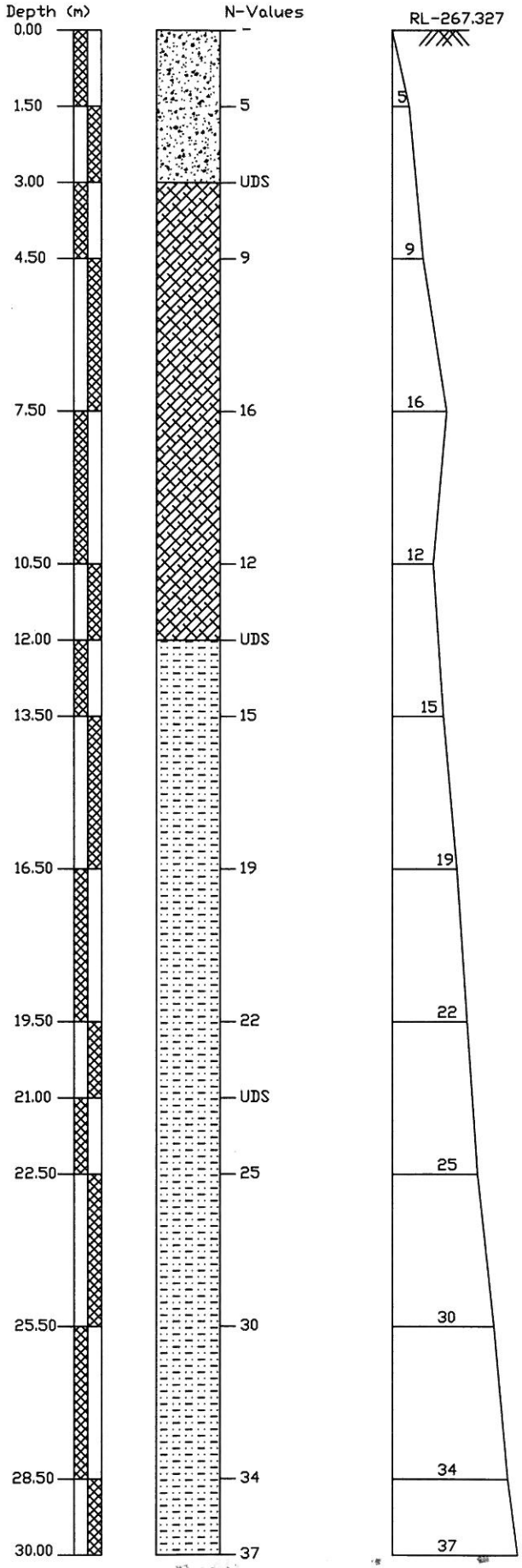
BORELOG OF BH–1(A1) AT EXISTING KM–266/19–21 FOR MAJOR BRIDGE NO.–302,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SILTY SAND
	CLAYEY SILT
	CLAYEY SILT WITH SAND

1028

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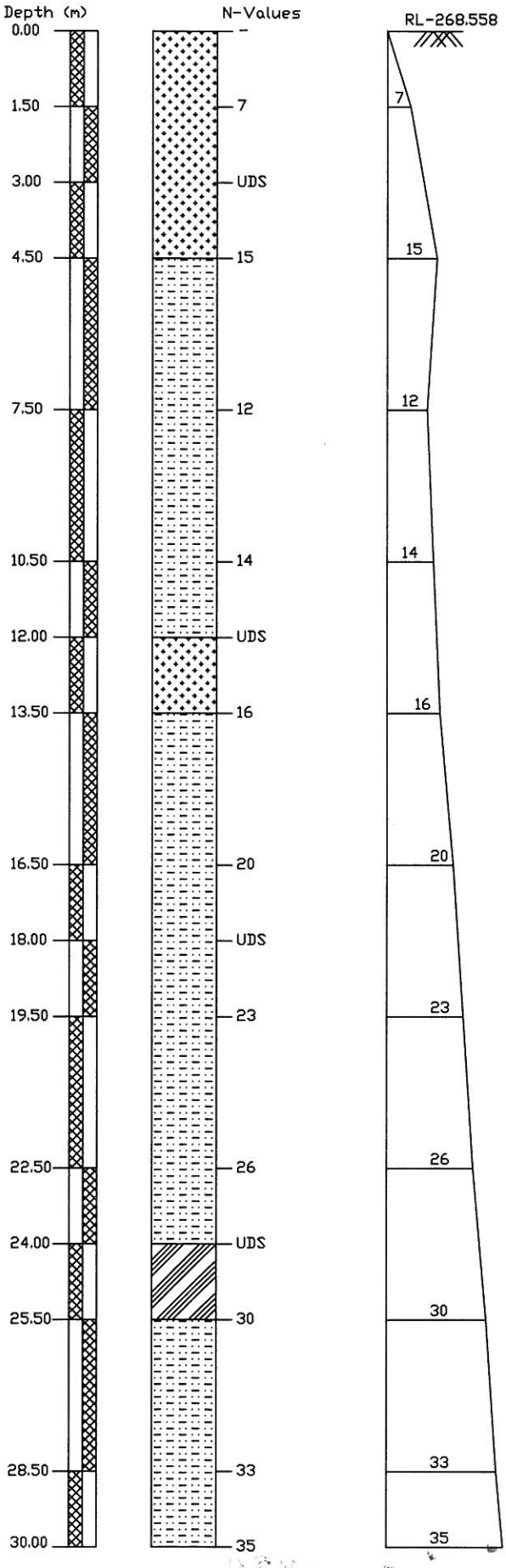
BORELOG OF BH–2(A2) AT EXISTING KM–266/19–21 FOR MAJOR BRIDGE NO.–302,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

1029

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ANNEXURE - III

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

INPUT DATA

Ch 266 19-21 **BH-A1**

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Rectangular **2**

Angle of internal friction (ϕ °)	15.00
Cohesion (c in t/m2)	1.80
Void ratio (e)	0.69
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.80
Depth of water table(m)	3.00
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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1030

ANNEXURE - III

Bearing capacity factors :

ϕ	15.00
N_c	10.98
N_q	3.94
N_γ	2.65

ϕ'	10.18
N'_c	8.44
N'_q	2.52
N'_γ	1.27

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	1.13	1.07	1.07
2	3.00	3.00	1.26	1.13	1.13
3	4.50	3.00	1.39	1.20	1.20
4	6.00	3.00	1.52	1.26	1.26

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	0.50	0.75
2	3.00	3.00	0.00	0.50
3	4.50	3.00	-0.50	0.50
4	6.00	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	12.49	6.36	8.20
2	3.00	3.00	8.00	16.15	8.27	10.63
3	4.50	3.00	8.00	17.49	8.96	11.52
4	6.00	3.00	8.00	18.83	9.64	12.40

ANNEXURE - III

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

INPUT DATA

Ch 266 19-21 **BH-A2**

Type of footing

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

Angle of internal friction (ϕ °)	20.00
Cohesion (c in t/m2)	1.00
Void ratio (e)	0.69
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.75
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)*SQRT(N_\phi)$ 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	20.00
N_c	14.83
N_q	6.40
N_γ	5.39

ϕ'	13.70
N'_c	10.30
N'_q	3.56
N'_γ	2.28

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	1.14	1.07	1.07
2	3.00	3.00	1.29	1.14	1.14
3	4.50	3.00	1.43	1.21	1.21
4	6.00	3.00	1.57	1.29	1.29

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	13.51	6.23	8.41
2	3.00	3.00	8.00	20.40	9.48	12.75
3	4.50	3.00	8.00	22.01	10.22	13.76
4	6.00	3.00	8.00	23.61	10.97	14.76

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.266/19-21**

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	=	7.125	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	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.69	
	$\frac{Po + \Delta p}{Po}$	=	1.23579	

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

S_f = 0.03183 m

= 31.8269 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 = $\frac{\text{Total Settlement of Rigid foundation}}{\text{Pore water pressure correction}}$ = N.A.

= $\frac{\text{Total Settlement at the centre of Flexible foundation}}{0.8}$

Pore pr. Correction = N.A.

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

S_{f2} = **23.2** **mm**

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.266/19-21**

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	=	9.975	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	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.69	
	$\frac{Po + \Delta p}{Po}$	=	1.22105	

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

S_f = 0.03002 m

= 30.0234 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} = **19.9** **mm**

1035

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.266/19-21**

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	=	12.825	t/m^2
Concentrated load *P*		=	11.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.4	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.69	
	$\frac{Po + \Delta p}{Po}$	=	1.1883	

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

S_f = 0.02594 m

= 25.9365 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} = **15.4 mm**

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1036

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.266/19-21**

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	=	15.675	t/m^2
Concentrated load *P*		=	12.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.5	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.69	
	$\frac{Po + \Delta p}{Po}$	=	1.16077	

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

S_f = 0.02241 m

= 22.4116 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} = **12.2 mm**

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1037

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.267/19-21**

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	=	6.5625	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	=	0.126	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.69	
	$\frac{Po + \Delta p}{Po}$	=	1.256	

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

S_f = 0.03321 m

= 33.2113 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} = **24.2 mm**

1038

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.267/19-21**

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	=	9.1875	t/m^2
Concentrated load *P*		=	12.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.5	t/m^2
Compression Index	Cc	=	0.126	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.69	
	$\frac{Po + \Delta p}{Po}$	=	1.27429	

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

S_f = 0.03532 m

= 35.3173 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} = **23.5** **mm**

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.267/ 19-21**

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	=	11.8125	t/m^2
Concentrated load *P*		=	13.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.7	t/m^2
Compression Index	Cc	=	0.126	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.69	
	$\frac{Po + \Delta p}{Po}$	=	1.23111	

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

S_f = 0.03029 m

= 30.295 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} = **17.9** **mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.267/ 19-21**

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	=	14.4375	t/m^2
Concentrated load *P*		=	14.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.9	t/m^2
Compression Index	Cc	=	0.126	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.69	
	$\frac{Po + \Delta p}{Po}$	=	1.20364	

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

S_f = 0.02701 m

= 27.0064 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} = **14.7** **mm**

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1041

CHAPTER – 129

"Major Bridge No. 300",

Location – Existing Km. - 264/21-23

129.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 3x6.1

129.2 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 01.50m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1(A1)	0.00 to 1.50	Filled up Strata	Loose
	1.50 to 4.50	Sandy Silt with Clay	Loose
	4.50 to 7.50	Silty Sand	Loose
	7.50 to 10.50	Clayey Silt with Sand	Loose
	10.50 to 25.50	Clayey Silt with Sand	Medium Dense
	25.50 to 30.00	Clayey Silt with Sand	Dense
BH-2(A2)	0.00 to 1.50	Filled up Strata	Loose
	1.50 to 7.50	Sandy Silt with Clay	Loose
	7.50 to 19.50	Clayey Silt with Sand	Medium Dense
	19.50 to 25.50	Sandy Silt with Clay	Medium Dense
	25.50 to 30.00	Clayey Silt with Sand	Dense

129.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.30	NIL	0.0028	NIL	0.0012	0.076
	6.00	8.40	NIL	0.0025	NIL	0.0012	0.088
	18.00	8.80	NIL	0.0021	NIL	0.0013	0.065
	24.00	8.70	NIL	0.0025	NIL	0.0013	0.055
BH-2 (A2)	3.00	8.10	NIL	0.0031	NIL	0.0014	0.107
	9.00	8.80	NIL	0.0035	NIL	0.0012	0.125
	21.00	8.20	NIL	0.0029	NIL	0.0014	0.101

129.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1(A1)	3.00	11.00
	6.00	NIL
	18.00	NIL
	24.00	NIL

BH-2 (A2)	3.00	9.00
	9.00	20.00
	21.00	16.00

129.5 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	109	93	151	823	0.2	2.3	1000	669
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	-	-

129.6 PILE LOAD CARRYING CAPACITY

129.6.1 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	08.50
	3.00m	12.50
	4.50m	08.00
	6.00m	08.50
BH-2 (A2)	1.50m	08.00
	3.00m	10.50
	4.50m	11.50
	6.00m	12.50

Pile load carrying capacity in t

BH -NO.	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	175.00
BH-2 (A2)	17.00	90.00
	20.00	120.00
	23.00	160.00

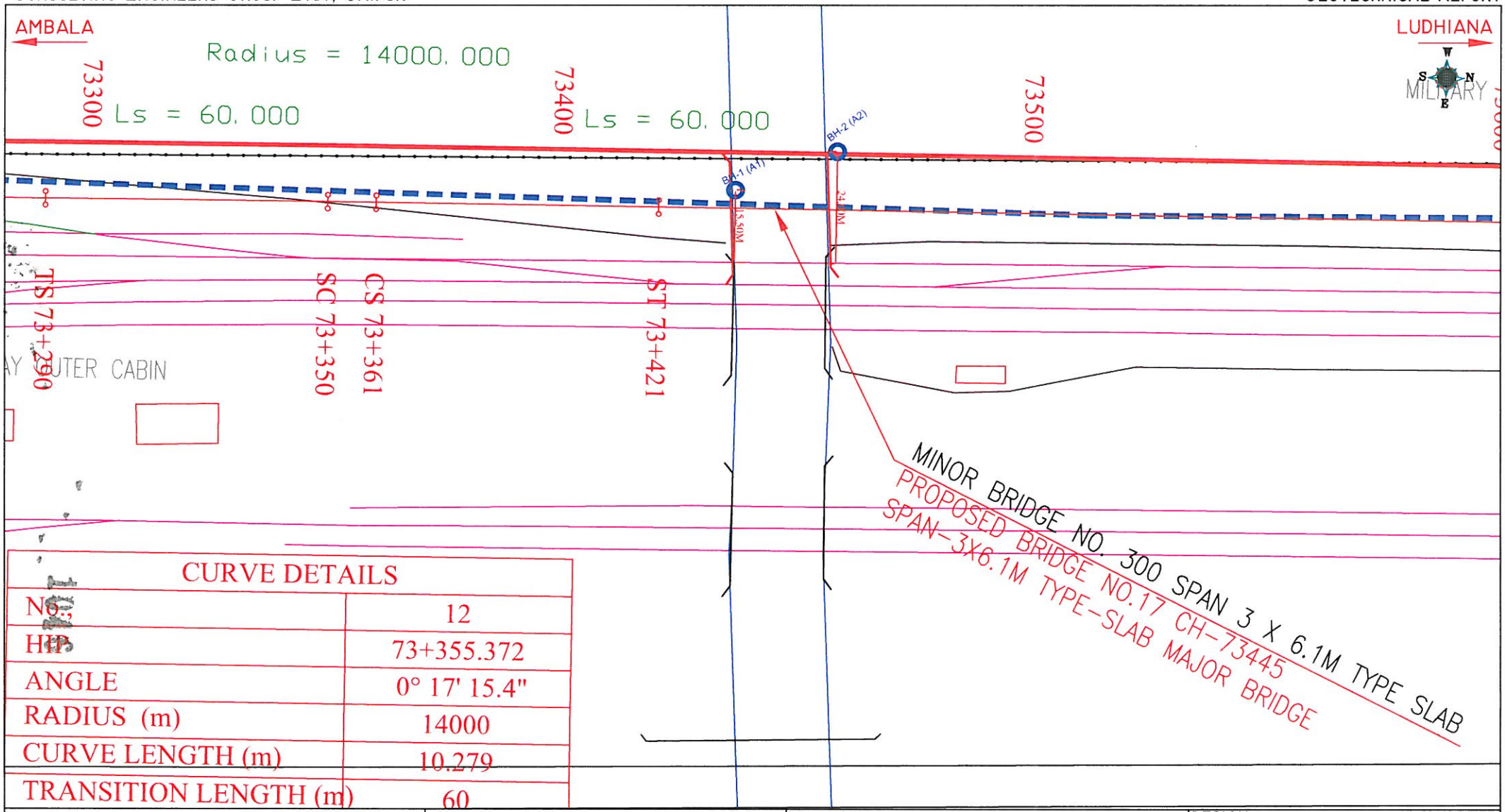
129.7 CONCLUSIONS

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

129.8 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.



CURVE DETAILS	
NO.	12
HIP	73+355.372
ANGLE	0° 17' 15.4"
RADIUS (m)	14000
CURVE LENGTH (m)	10.279
TRANSITION LENGTH (m)	60

ALL DIMENSIONS IN METER

FIG.:-I
LOCATION PLAN OF PROPOSED MAJOR BRIDGE
CH. 264/21-23

RL OF BH-AI = 268.315
RL OF BH-A2 = 267.458

PROJECT :-
LUDHIANA-AMBALA (DFCCIL)

DESIGN :-
CONSULTING
ENGINEERS GROUP LTD.
E-12,Moji Colony,Malviya Nagar Jaipur-17
Tel: +91-141- 2520899, 2521899, 2520556
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SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (A1) OF MAJOR BRIDGE No. 300 AT CHAINAGE 264/21-23

Project :	Chainage 264/21-23 Bridge No. 300			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				09.12.2009 to 09.12.2009	A1	1	01.50 m.	30.00mtr	268.315

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	-	-	-	Filled up Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.50	4	1.44	5.76	Sandy Silt with clay	8.56	57.02	23.71	4.30	1.88	4.53	0.00	28	20	8	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt with clay	10.24	74.05	14.96	0.63	0.12	0.00	0.00	26	17	9	1.79	14.82	1.56	2.66	0.09	21.0
4.50	7	1.07	7.49	Silty Sand	2.25	31.26	64.25	1.35	0.27	0.62	0.00	23	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	3.14	38.08	56.36	1.20	0.36	0.86	0.00	22	NIL	NP	1.80	15.36	1.56	2.66	0.00	29.0
7.50	9	0.90	8.10	Clayey Silt with Sand	18.00	65.14	6.60	2.82	1.79	5.65	0.00	38	21	17	-	-	-	-	-	-
10.50	12	0.79	9.48	Clayey Silt with Sand	18.46	72.67	5.65	1.12	1.14	0.96	0.00	37	20	17	-	-	-	-	-	-
13.50	16	0.71	11.36	Clayey Silt with Sand	19.28	71.86	4.65	1.43	1.21	1.57	0.00	39	22	17	-	-	-	-	-	-
16.50	19	0.64	12.16	Clayey Silt with Sand	16.10	69.12	9.08	2.86	1.62	1.22	0.00	34	21	13	-	-	-	-	-	-
18.00	UDS	-	-	Clayey Silt with Sand	13.67	70.05	10.38	2.68	1.70	1.52	0.00	33	21	12	2.01	18.94	1.69	2.68	0.12	18.0
19.50	23	0.58	13.34	Clayey Silt with Sand	16.50	60.82	14.08	2.48	1.94	4.18	0.00	33	18	15	-	-	-	-	-	-
22.50	26	0.52	13.52	Clayey Silt with Sand	16.87	59.27	14.30	2.09	2.35	5.12	0.00	34	19	15	-	-	-	-	-	-
24.00	UDS	-	-	Clayey Silt with Sand	15.48	69.84	6.59	2.43	2.40	3.26	0.00	34	21	13	2.05	18.63	1.73	2.68	0.14	17.0
25.50	30	0.48	14.40	Clayey Silt with Sand	14.65	69.29	4.51	2.45	2.70	6.40	0.00	35	23	12	-	-	-	-	-	-
28.50	34	0.44	14.96	Clayey Silt with Sand	11.52	76.36	10.04	1.52	0.32	0.24	0.00	29	19	10	-	-	-	-	-	-
30.00	41	0.42	16.11	Clayey Silt with Sand	16.21	63.24	10.24	3.08	2.23	5.00	0.00	34	20	14	-	-	-	-	-	-

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SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (A2) OF MAJOR BRIDGE No. 300 AT CHAINAGE 264/21-23

Project :	Chainage 264/21-23 Bridge No. 300			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	01.50 m.	30.00mtr	267.458

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	-	-	-	Filled up Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.50	6	1.45	8.70	Sandy Silt with Clay	8.32	60.07	30.20	0.87	0.38	0.16	0.00	25	17	8	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt with Clay	6.42	66.19	25.92	0.75	0.52	0.20	0.00	22	16	6	1.76	12.26	1.57	2.67	0.08	22.0
4.50	9	1.08	9.72	Sandy Silt with Clay	7.11	67.27	24.06	1.14	0.42	0.00	0.00	23	17	6	-	-	-	-	-	-
7.50	11	0.91	10.01	Clayey Silt with Sand	18.89	66.22	9.73	1.72	1.12	2.32	0.00	38	21	17	-	-	-	-	-	-
9.00	UDS	-	-	Clayey Silt with Sand	18.41	67.10	7.63	1.86	1.32	3.68	0.00	37	21	16	1.84	18.69	1.55	2.66	0.20	15.0
10.50	13	0.79	10.27	Clayey Silt with Sand	20.36	64.22	6.66	1.72	0.97	6.07	0.00	40	22	18	-	-	-	-	-	-
13.50	UDS	-	-	Clayey Silt with Sand	19.67	69.53	4.58	0.78	1.02	4.42	0.00	40	22	18	1.96	20.36	1.63	2.67	0.22	15.0
16.50	19	0.63	11.97	Clayey Silt with Sand	20.93	68.32	3.05	2.40	1.33	3.97	0.00	42	23	19	-	-	-	-	-	-
19.50	23	0.57	13.11	Sandy Silt with Clay	17.26	56.75	24.21	0.90	0.54	0.34	0.00	35	20	15	-	-	-	-	-	-
21.00	UDS	-	-	Sandy Silt with Clay	16.58	54.28	27.46	0.76	0.46	0.46	0.00	35	21	14	2.06	20.16	1.71	2.67	0.16	17.0
22.50	28	0.52	14.56	Sandy Silt with Clay	13.69	54.21	30.96	0.80	0.34	0.00	0.00	33	21	12	-	-	-	-	-	-
25.50	32	0.47	15.02	Clayey Silt with Sand	14.68	67.71	11.69	2.26	1.86	1.80	0.00	35	22	13	-	-	-	-	-	-
28.50	36	0.43	15.24	Clayey Silt with Sand	18.36	74.43	5.17	0.81	0.52	0.71	0.00	38	22	16	-	-	-	-	-	-
30.00	45	0.41	16.73	Clayey Silt with Sand	19.85	67.26	4.03	1.38	1.13	6.35	0.00	37	19	18	-	-	-	-	-	-

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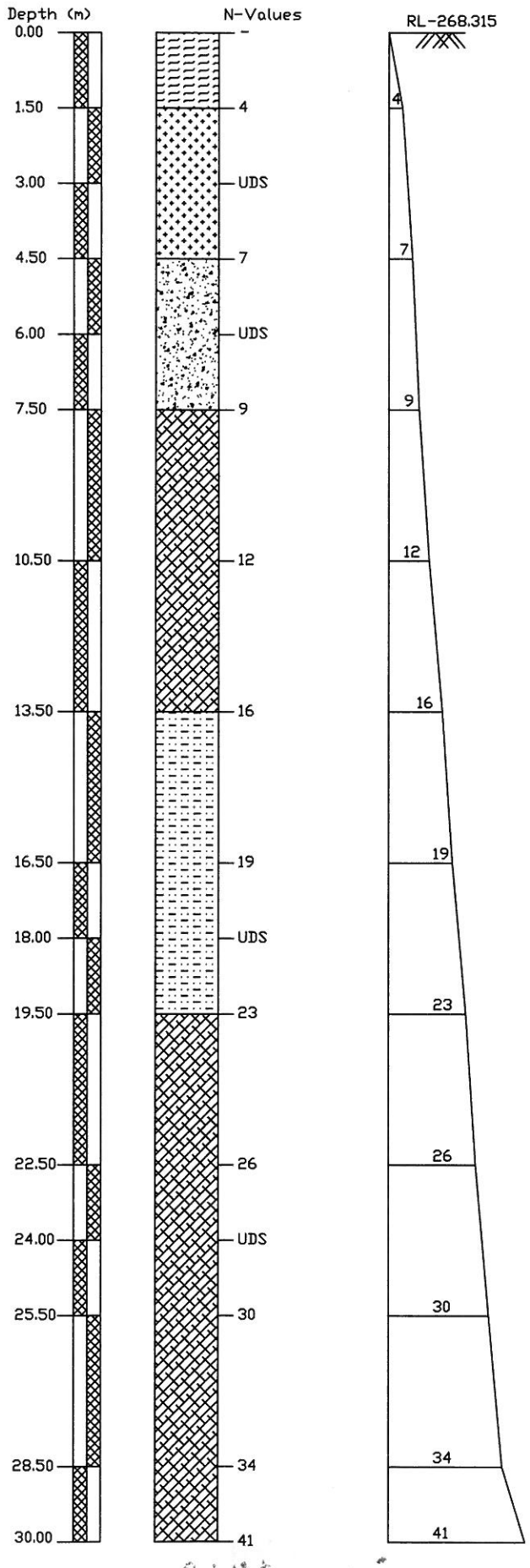
BORELOG OF BH–1(A1) AT EXISTING KM–264/21–23 FOR MAJOR BRIDGE NO.–300,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	FILLED UP STRATA
	SANDY SILT WITH CLAY
	SILTY SAND
	CLAYEY SILT
	CLAYEY SILT WITH SAND

1049

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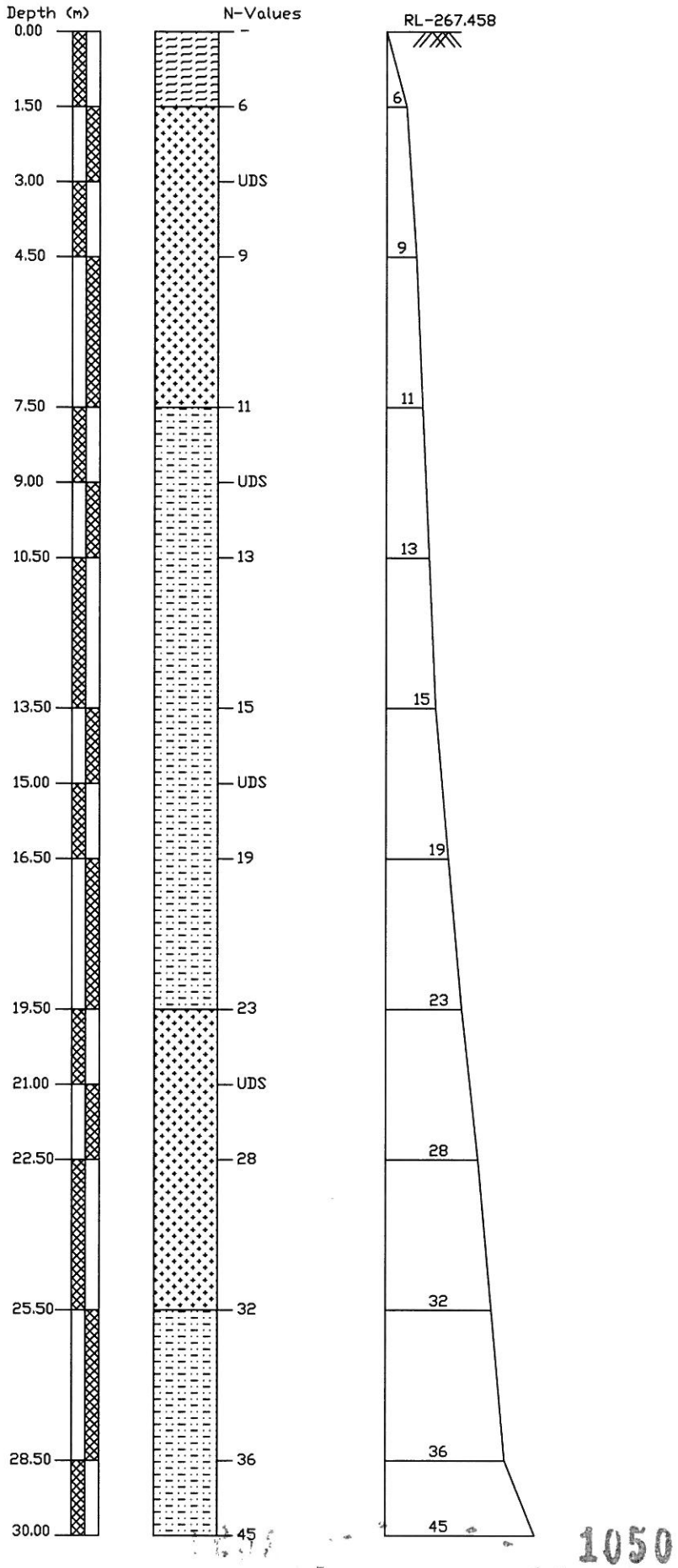
BORELOG OF BH–2(A2) AT EXISTING KM–264/21–23 FOR MAJOR BRIDGE NO.–300,
ON KESARI TO SANEHWAL, LUDHIANA



1050

LEGEND

SYMBOL	DESCRIPTION
	FILLED UP STRATA
	SANDY SILT WITH CLAY
	CLAYEY SILT WITH SAND

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ANNEXURE - III

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

INPUT DATA

Ch 264 21-23 **BH-A1**

Type of footing

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

Angle of internal friction (ϕ°)	21.00
Cohesion (c in t/m2)	0.90
Void ratio (e)	0.71
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.79
Depth of water table(m)	3.00
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

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	21.00
N_c	16.01
N_q	7.25
N_γ	6.49

ϕ'	14.42
N'_c	10.68
N'_q	3.77
N'_γ	2.49

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.15	1.07	1.07
2	3.00	3.00	1.29	1.15	1.15

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	0.50	0.75
2	3.00	3.00	0.00	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	16.01	6.87	8.70
2	3.00	3.00	8.00	22.58	9.85	12.39

1052

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ANNEXURE - III

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

INPUT DATA

Ch 264 21-23 **BH-A1**

Type of footing

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

Angle of internal friction (ϕ °)	27.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.71
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.79
Depth of water table(m)	3.00
Factor of safety	3.00

S.no.	Depth (m)	Width (m)	Length (m)
1	4.50	3.00	8.00
2	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	27.00
N_c	24.49
N_q	13.76
N_γ	15.49

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

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	4.50	3.00	-0.50	0.50
2	6.00	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	4.50	3.00	8.00	36.35	13.25	17.87
2	6.00	3.00	8.00	38.73	14.12	19.04

ANNEXURE - III

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

INPUT DATA

	Ch 264 21-23	BH-A2
Type of footing		
1 Continuous Strip		
2 Rectangular	***Rectangular***	2
3 Square		
4 Circular		

Angle of internal friction (ϕ °)	15.00
Cohesion (c in t/m2)	2.00
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)	1.86
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.

1055

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ANNEXURE - III

Bearing capacity factors :

ϕ	15.00
N_c	10.98
N_q	3.94
N_γ	2.65

ϕ'	10.18
N'_c	8.44
N'_q	2.52
N'_γ	1.27

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	1.13	1.07	1.07
2	3.00	3.00	1.26	1.13	1.13
3	4.50	3.00	1.39	1.20	1.20
4	6.00	3.00	1.52	1.26	1.26

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	12.87	6.58	8.15
2	3.00	3.00	8.00	17.18	8.80	10.89
3	4.50	3.00	8.00	18.62	9.54	11.81
4	6.00	3.00	8.00	20.06	10.28	12.72

1056

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) for coh. soil **Major Bridge at Ch.264/ 21-23**

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	=	5.7	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	=	0.13	
Thickness of clay layer	H	=	3	m
Initial Void ratio	e_o	=	0.71	
	$\frac{Po + \Delta p}{Po}$	=	1.25789	

Settlement of clay layer

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

S_f = 0.02273 m

= 22.7259 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 = 0.85

Corrected Total Settlement = S_f x D.F.x R.F.x pore pr. Corr.

S_{f2} = **14.1 mm**

Settlement Calculation As per IS 8009 (Part 1) for cohesionless soil

Footing Depth (m)	**1.50**
Effective Pressure (t/m2)	1.40
Average N value	8
Settlement for 10 t/m2 (mm)	56.00
Total Settlement (mm)	7.84
Depth Correction	0.91
Rigidity Factor	0.80
Corrected Settlement (mm)	**5.71**

Total settlement	**19.8 mm**

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1057

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.264/ 21-23**

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	=	7.125	t/m^2
Concentrated load *P*		=	7.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.6	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.71	
	$\frac{Po + \Delta p}{Po}$	=	1.22105	

Settlement of clay layer

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

S_f = 0.00989 m

= 9.89076 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

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

= 0.8

Pore Pr. Correction = 0.85

Corrected Total Settlement = S_f x D.F.x R.F.x pore pr. Corr.

S_{f2} = **5.6 mm**

Settlement Calculation As per IS 8009 (Part 1) for cohesionless soil

Footing Depth (m)	**3.00**
Effective Pressure (t/m2)	1.73
Average N value	8
Settlement for 10 t/m2 (mm)	56.00
Settlement (mm) for SBC	9.66
Depth Correction	0.83
Rigidity Factor	0.80
Corrected Settlement (mm)	**6.41**

Total settlement	**12.0 mm**

1058

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.264/ 21-23**

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	=	16.17	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	=	0.13	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.71	
	$\frac{Po + \Delta p}{Po}$	=	1.1039	

Settlement of clay layer

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

S_f = 0.0049 m

= 4.90 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

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

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = **2.9 mm**

Settlement Calculation As per IS 8009 (Part 1) for cohesionless soil

Footing Depth (m)	**4.50**
Effective Pressure (t/m2)	8.00
Average N value	8
Settlement for 10 t/m2 (mm)	54.00
Settlement (mm) for SBC	43.20
Depth Correction	0.74
Rigidity Factor	0.80
Corrected Settlement (mm)	**25.57**

Total settlement	**28.5 mm**

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1059

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.264/ 21-23**

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	=	17.1	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	=	0.13	
Thickness of clay layer	H	=	3.0	m
Initial Void ratio	e_o	=	0.71	
	$\frac{Po + \Delta p}{Po}$	=	1.10439	

Settlement of clay layer

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

S_f = 0.00983 m

= 9.83459 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} = 5.4 mm

Settlement Calculation As per IS 8009 (Part 1) for cohesionless soil

Footing Depth (m)	**8.00**
Effective Pressure (t/m2)	8.50
Average N value	8
Settlement for 10 t/m2 (mm)	56.00
Settlement (mm) for SBC	47.60
Depth Correction	0.68
Rigidity Factor	0.80
Corrected Settlement (mm)	**25.89**

Total settlement	**31.2 mm**

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1060

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.264/ 21-23**

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	=	6.975	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	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.7	
	$\frac{Po + \Delta p}{Po}$	=	1.24086	

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

S_f = 0.03225 m

= 32.2517 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} = **23.5 mm**

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1061

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.264/ 21-23**

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	=	9.765	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	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.7	
	$\frac{Po + \Delta p}{Po}$	=	1.22581	

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

S_f = 0.03043 m

= 30.4275 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} = 20.2 mm

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1062

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.264/ 21-23**

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	=	12.555	t/m^2
Concentrated load *P*		=	11.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.4	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.7	
	$\frac{Po + \Delta p}{Po}$	=	1.19235	

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

S_f = 0.02629 m

= 26.2923 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} = **15.6** **mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.264/ 21-23**

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	=	15.345	t/m^2
Concentrated load *P*		=	12.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.6	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.7	
	$\frac{Po + \Delta p}{Po}$	=	1.17107	

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

S_f = 0.0236 m

= 23.6 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} = **12.8** **mm**

1064

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CHAPTER - 130

"Major Bridge No. 294",

Location - Existing Km. - 257/300

130.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 3x47.5

130.2 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 8.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1(A1)	0.00 to 4.50	Silty Sand	Loose
	4.50 to 12.00	Silty Sand	Medium Dense
	12.00 to 19.50	Clayey Silt with Sand	Medium Dense
	19.50 to 28.50	Clayey Silt with Sand	Dense
	28.50 to 30.00	Clayey Silt with Sand	Very Dense
BH-2 (P1-P2)	0.00 to 7.50	Silty Sand	Loose
	7.50 to 9.00	Silty Sand	Medium Dense
	9.00 to 10.50	Sandy Silt with Clay	Medium Dense
	10.50 to 19.50	Clayey Silt with Sand	Medium Dense
	19.50 to 30.00	Clayey Silt with Sand	Dense
BH-3(A2)	0.00 to 3.00	Sandy Silt	Loose
	3.00 to 7.50	Silty Sand	Loose
	7.50 to 12.00	Silty Sand	Medium Dense
	12.00 to 16.50	Clayey Silt	Medium Dense
	16.50 to 19.50	Clayey Silt with Sand	Medium Dense
	19.50 to 30.00	Clayey Silt with Sand	Dense

130.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.70	0.005	0.0015	NIL	0.0010	0.055
	6.00	8.60	0.002	0.0017	NIL	0.0011	0.044
	12.00	8.80	0.010	0.0014	NIL	0.0011	0.045
	24.00	8.80	0.010	0.0025	NIL	0.0013	0.049
BH-2 (P1-P2)	3.00	8.80	0.010	0.0021	NIL	0.0014	0.041
	9.00	8.60	0.005	0.0017	NIL	0.0013	0.051
	12.00	8.10	0.002	0.0018	NIL	0.0015	0.062
	21.00	8.30	0.004	0.0021	NIL	0.0017	0.052

BH-3 (A2)	3.00	8.30	NIL	0.0017	NIL	0.0011	0.039
	12.00	8.70	0.005	0.0021	NIL	0.0012	0.046
	18.00	8.70	0.010	0.0017	NIL	0.0012	0.049
	24.00	9.30	0.012	0.0031	NIL	0.0012	0.081

130.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1(A1)	3.00	NIL
	6.00	NIL
	12.00	12.00
	24.00	24.00
BH-2 (P1-P2)	3.00	NIL
	9.00	14.00
	12.00	23.00
	21.00	25.00
BH-3(A2)	3.00	NIL
	12.00	19.00
	18.00	23.00
	24.00	15.00

130.5 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	123	83	159	783	0.1	2.1	986	643
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	-	-

130.6 PILE LOAD CARRYING CAPACITY

130.6.1 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	10.00
	3.00m	11.00
	4.50m	11.50
	6.00m	12.00
BH-3 (A2)	1.50m	09.00
	3.00m	10.50
	4.50m	11.00
	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	110.00
	20.00	140.00
	23.00	170.00
BH- 2 (P1-P2)	17.00	100.00
	20.00	130.00
	23.00	170.00
BH-3 (A2)	17.00	100.00
	20.00	130.00
	23.00	170.00

130.7 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

- Chemical contents of Water are within the safe limits for construction purpose.

130.8 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.

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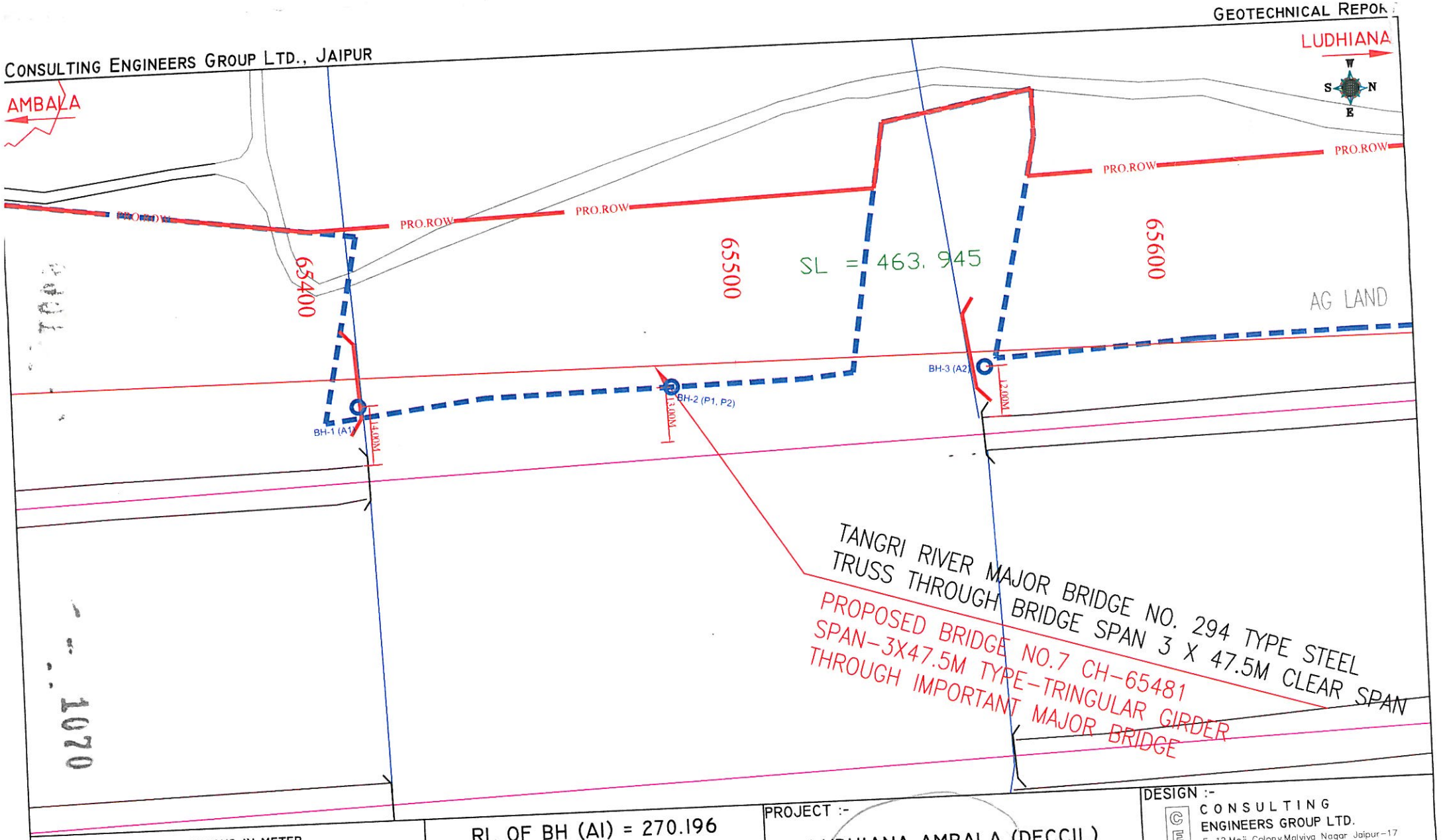

ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED MAJOR BRIDGE CH. 257/5-17	RL OF BH (AI) = 270.196 RL OF BH (PI-P2) = 267.561 RL OF BH (A2) = 270.300	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com