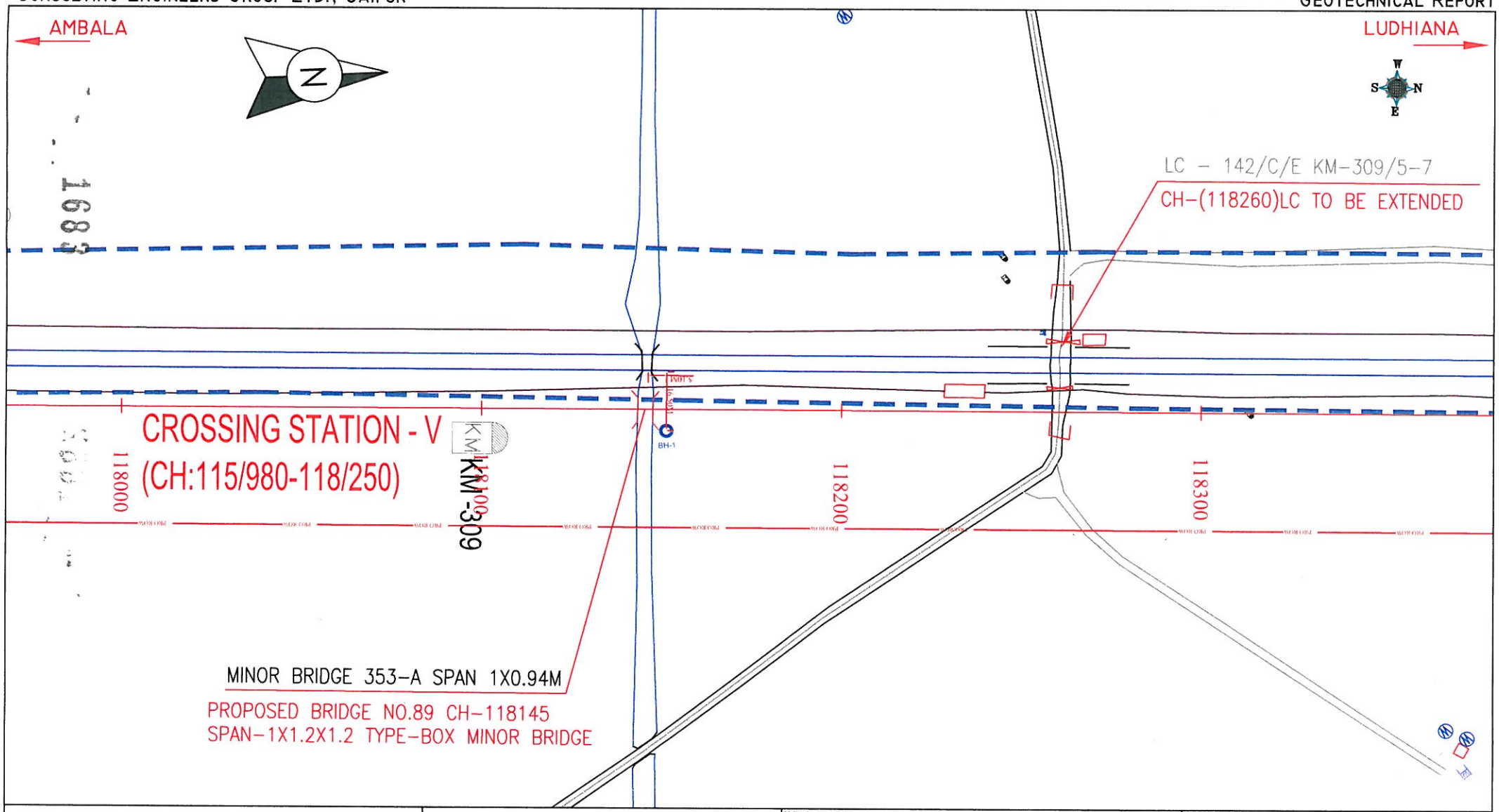

ALL DIMENSIONS IN METER

FIG.:-I
LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 309/2-4

RL OF BH-I =264.033

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(LHS) FOR MINOR BRIDGE No. 353-A AT CHAINAGE 309/2-4

Project :	Chainage 309/2-4 Bridge No. 353-A			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				09.06.2009 to 10.06.2009	1	1(LHS)	below 20.00 m.	12.00mtr	264.033

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	12.21	66.17	16.52	1.62	1.33	2.15	0.00	28	18	10	-	-	-	-	-	-
1.50	12	1.46	17.52	Sandy Silt with Clay	13.85	65.90	17.90	0.63	0.38	1.34	0.00	28	17	11	-	-	-	-	-	
3.00	UDS	-	-	Silty Sand	2.19	34.35	60.74	1.20	0.12	1.40	0.00	24	NIL	NP	1.69	5.21	1.61	2.62	0.00	27.50
4.50	16	1.09	17.44	Silty Sand	4.21	9.69	79.60	3.99	1.21	1.30	0.00	29	NIL	NP	-	-	-	-	-	
6.00	UDS	-	-	Silty Sand	2.53	12.66	80.97	3.84	0.00	0.00	0.00	27	NIL	NP	1.76	6.79	1.65	2.62	0.00	28.50
7.50	23	0.92	21.16	Silty Sand	4.10	5.97	81.40	3.42	2.26	2.85	0.00	31	NIL	NP	-	-	-	-	-	-
10.50	24	0.80	19.20	Silty Sand	4.11	5.07	86.70	3.00	0.73	0.39	0.00	30	NIL	NP	-	-	-	-	-	-
12.00	30	0.76	22.80	Silty Sand	2.28	13.74	72.35	3.16	3.20	5.27	0.00	27	NIL	NP	-	-	-	-	-	-

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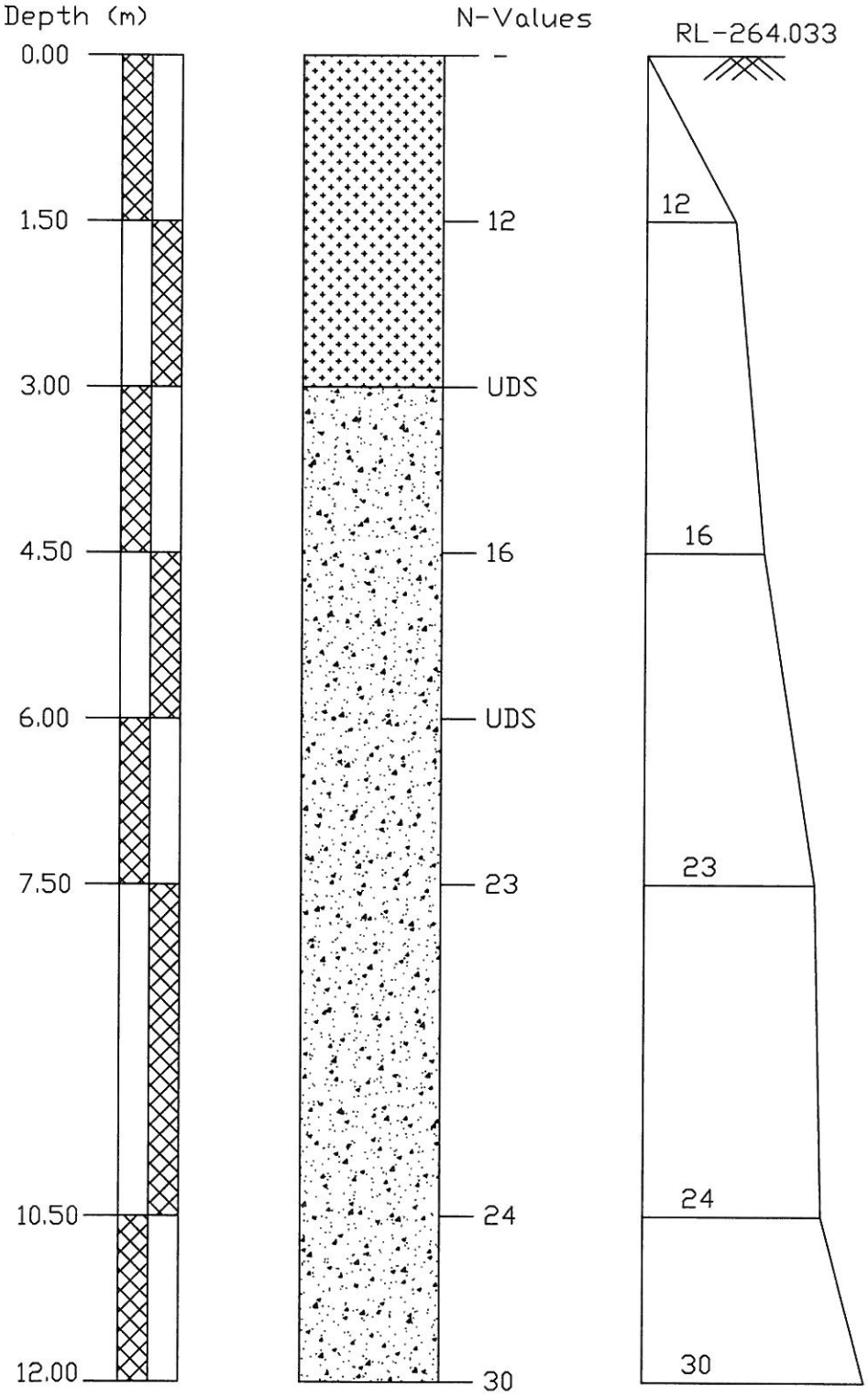
BORELOG OF BH–1(LHS) AT EXISTING KM–309/2–4 FOR MINOR BRIDGE NO.–353 A, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT WITH CLAY
	SILTY SAND

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 309/2-4 BH-1

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Continuous Strip | 1

Angle of internal friction (ϕ°)	23.00
Cohesion (c in t/m2)	0.13
Void ratio (e)	0.63
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.69
Density of foundation soil (t/m^3)	1.69
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	23.00
N_c	18.36
N_q	8.96
N_γ	8.68

ϕ'	15.88
N'_c	11.65
N'_q	4.37
N'_γ	3.13

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	1.20	1.38	1.19	1.19

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shear	Local shear	Actual
1	1.50	1.20	9.24	3.80	7.06

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 309/2-4 BH-1

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Continuous Strip | 1

Angle of internal friction (ϕ°)	27.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.63
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.69
Density of foundation soil (t/m^3)	1.69
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)*SQRT(N_\phi)$ 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.

1688

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ANNEXURE - III

Bearing capacity factors :

ϕ	27.50
N_c	25.43
N_q	14.53
N_γ	16.64

ϕ'	19.23
N'_c	14.24
N'_q	6.02
N'_γ	4.97

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	3.00	1.20	1.82	1.41	1.41

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	3.00	1.20	-1.25	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shear	Local shear	Actual
1	3.00	1.20	16.89	5.98	12.52

1689

ANNEXURE - III

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

INPUT DATA

Minor Bridge No 309/2-4 BH-1

Type of footing

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

Angle of internal friction (ϕ°)	28.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.59
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.69
Density of foundation soil (t/m^3)	1.76
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

1690

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ANNEXURE - III

Bearing capacity factors :

ϕ	28.50
N_c	27.31
N_q	16.08
N_γ	18.94

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

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shear	Local shear	Actual
1	4.50	1.20	22.05	7.49	19.14
2	6.00	1.20	24.90	8.46	21.61

1691

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Minor Bridge
Chainage	309/02-04
Bore Hole No.	1

Footing Depth (m)	**1.50**
SBC (t/m2)	7.00
Average N value	17
Settlement for 10 t/m2 (mm)	17.00
Total Settlement (mm)	11.90
Depth Correction	0.83
Rigidity factor	0.8
Corrected Settlement (mm)	**7.9**

Footing Depth (m)	**3.00**
SBC (t/m2)	12.00
Average N value	17
Settlement for 10 t/m2 (mm)	17.00
Total Settlement (mm)	20.40
Depth Correction	0.73
Rigidity factor	0.8
Corrected Settlement (mm)	**11.9**

Footing Depth (m)	**4.50**
SBC (t/m2)	19.00
Average N value	18
Settlement for 10 t/m2 (mm)	17.00
Total Settlement (mm)	32.30
Depth Correction	0.675
Rigidity factor	0.8
Corrected Settlement (mm)	**17.4**

Footing Depth (m)	**6.00**
SBC (t/m2)	21.00
Average N value	20
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	31.50
Depth Correction	0.63
Rigidity factor	0.8
Corrected Settlement (mm)	**15.9**

1692

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CHAPTER – 55

"Minor Bridge No. 353",

Location – Existing Km. - 307/24-26

1693

55.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 2 x 3.66

55.2 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 ≥20.00m below EGL.

Subsurface profile at the site

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

55.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	9.00	0.012	0.0024	NIL	0.0011	0.029
	6.00	8.90	0.012	0.0028	NIL	0.0012	0.036

55.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

55.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m^2)
BH-1	1.50	07.00
	3.00	13.00
	4.50	21.00
	6.00	22.00

55.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

55.7 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 4.50 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.

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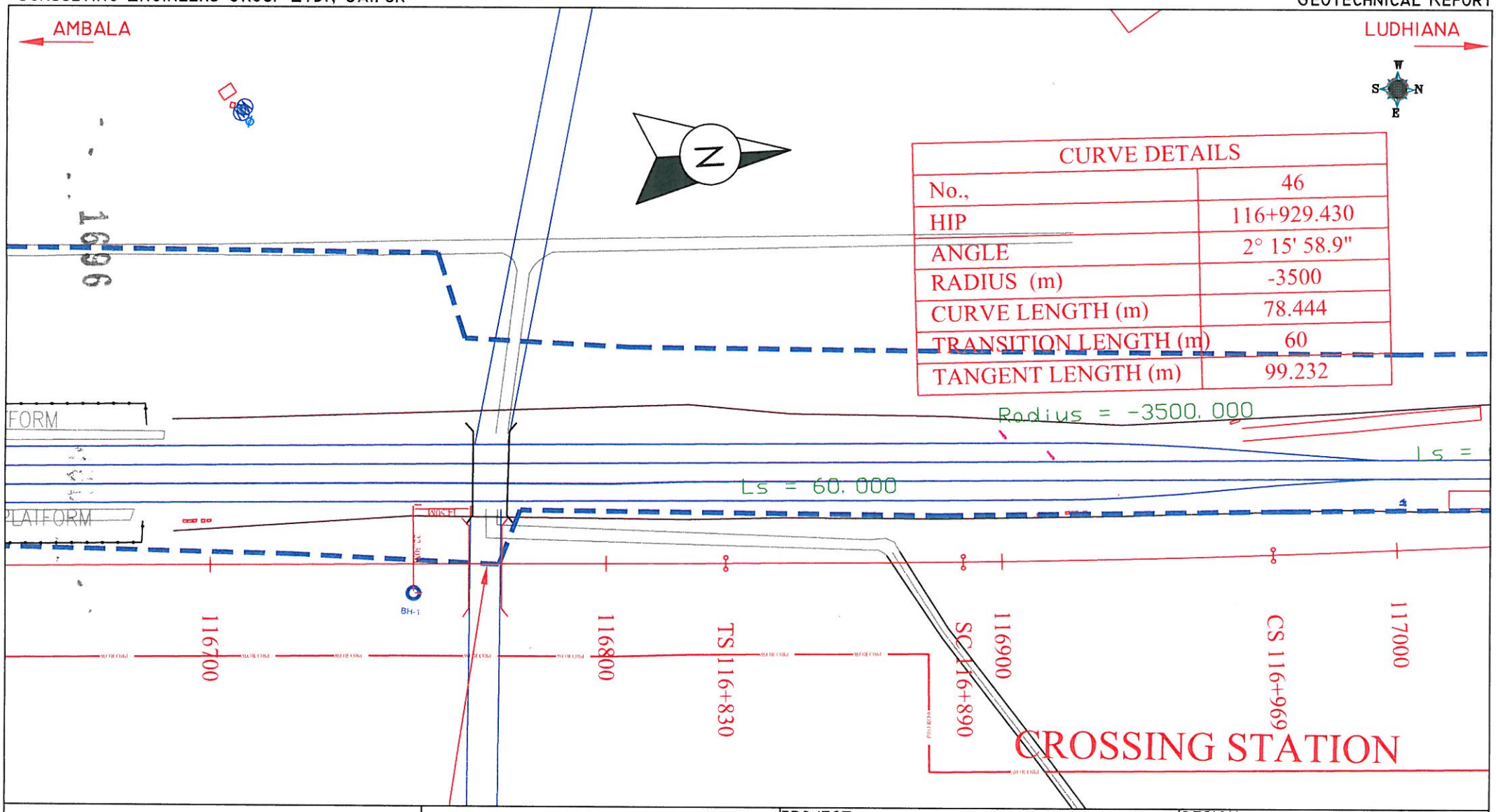

ALL DIMENSIONS IN METER

FIG.:-I

LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 307/24-26

RL OF BH-I = 263.615

PROJECT :-

LUDHIANA-AMBALA (DFCCIL)

DESIGN :-

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SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 353 AT CHAINAGE 307/24-26

Project :	Chainage 307/24-26 Bridge No. 353			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				10.06.2009 to 10.06.2009	1	1(LHS)	below 20.00 m.	12.00mtr	263.615

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	12.69	57.41	25.26	3.24	1.2	0.2	0	31	21	9	-	-	-	-	-	-
1.50	26	1.51	39.26	Silty Sand	2.10	19.05	75.57	2.34	0.32	0.62	0.00	24	NIL	NP	-	-	-	-	-	
3.00	UDS	-	-	Silty Sand	2.21	7.12	82.18	7.49	0.38	0.62	0.00	25	NIL	NP	1.62	5.26	1.54	2.65	0.00	26.00
4.50	30	1.11	33.30	Silty Sand	4.12	6.56	81.97	5.51	0.54	1.30	0.00	31	NIL	NP	-	-	-	-	-	
6.00	UDS	-	-	Silty Sand	2.11	5.45	76.57	11.14	1.21	3.52	0.00	25	NIL	NP	1.76	9.52	1.61	2.65	0.00	27.50
7.50	41	0.93	38.13	Silty Sand	3.54	7.27	78.55	8.38	0.67	1.59	0.00	29	NIL	NP	-	-	-	-	-	-
10.50	43	0.81	34.83	Silty Sand	3.69	4.16	80.42	7.91	1.20	2.62	0.00	29	NIL	NP	-	-	-	-	-	-
12.00	49	0.76	37.24	Silty Sand	3.11	5.59	80.44	8.22	1.40	1.24	0.00	28	NIL	NP	-	-	-	-	-	-

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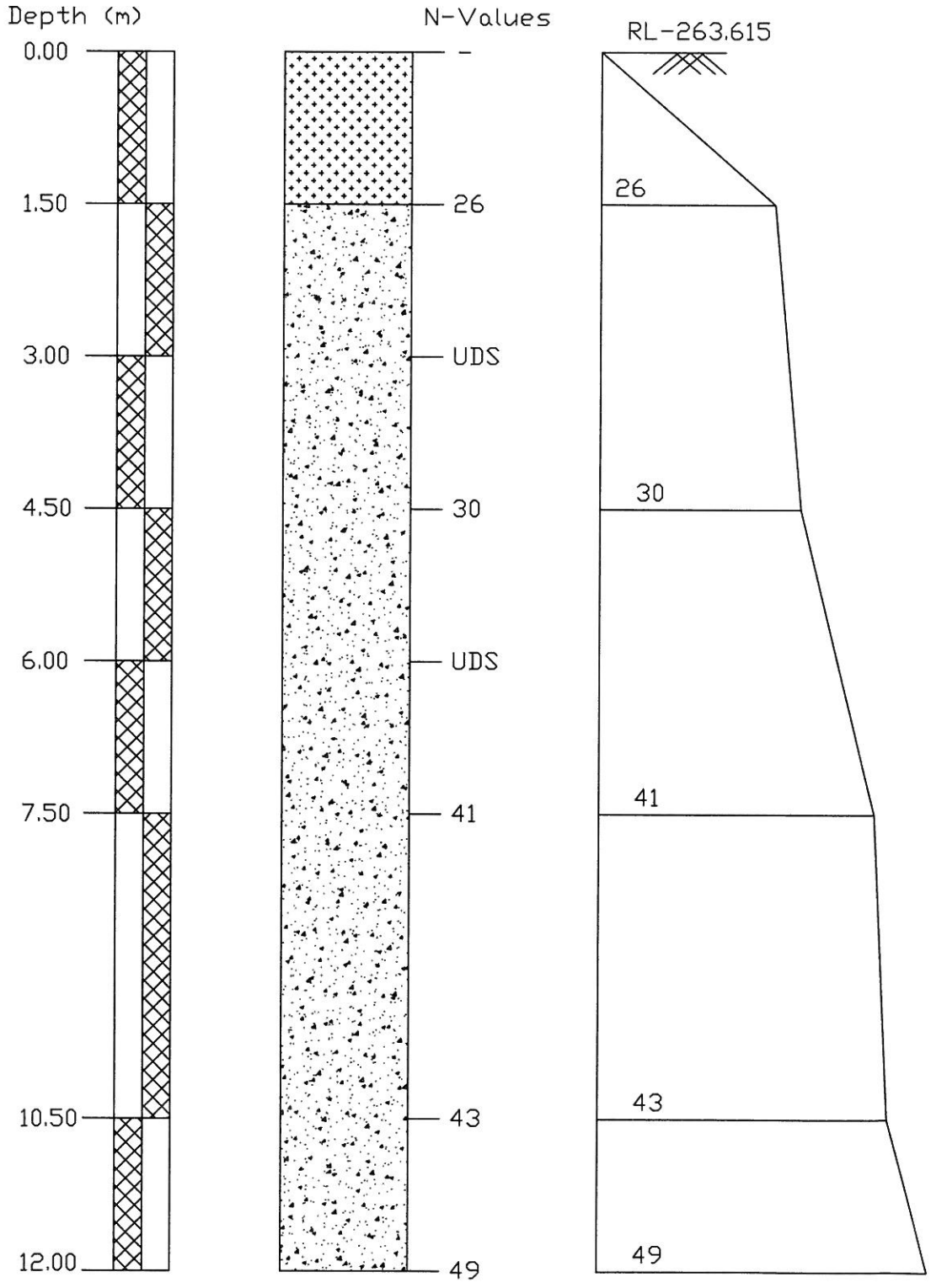
BORELOG OF BH–1(LHS) AT EXISTING KM–307/24–26 FOR MINOR BRIDGE NO.–353, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT WITH CLAY
	SILTY SAND

1698

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 307/24-26 BH-1

Type of footing

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

Angle of internal friction (ϕ°)	26.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.72
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.62
Density of foundation soil (t/m^3)	1.62
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

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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1699

ANNEXURE - III

Bearing capacity factors :

ϕ	26.00
N_c	22.60
N_q	12.21
N_γ	13.18

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.16	1.08	1.08
2	3.00	3.00	1.32	1.16	1.16

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

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	15.44	5.81	7.26
2	3.00	3.00	8.00	27.91	10.75	13.33

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1706

ANNEXURE - III

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

INPUT DATA

Minor Bridge No 307/24-26 BH-1

Type of footing

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

Angle of internal friction (ϕ°)	27.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.65
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.62
Density of foundation soil (t/m^3)	1.76
Depth of water table(m)	1.50
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 $\phi < 10^\circ$

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)*SQRT(N_\phi)$ 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.

1701

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ANNEXURE - III

Bearing capacity factors :

ϕ	27.50
N_c	25.43
N_q	14.53
N_γ	16.64

ϕ'	19.23
N'_c	14.24
N'_q	6.02
N'_γ	4.97

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	1.25	1.25
2	6.00	3.00	1.66	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	-1.00	0.50
2	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	4.50	3.00	8.00	37.15	13.22	25.18
2	6.00	3.00	8.00	39.60	14.09	26.85

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Minor Bridge
Chainage	307/24-26
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	7.00
Average N value	35
Settlement for 10 t/m2 (mm)	7.50
Total Settlement (mm)	5.25
Depth Correction	0.91
Rigidity factor	0.8
Corrected Settlement (mm)	**3.8**

Footing Depth (m)	3.00
SBC (t/m2)	13.00
Average N value	35
Settlement for 10 t/m2 (mm)	7.50
Total Settlement (mm)	9.75
Depth Correction	0.83
Rigidity factor	0.8
Corrected Settlement (mm)	**6.5**

Footing Depth (m)	4.50
SBC (t/m2)	25.00
Average N value	35
Settlement for 10 t/m2 (mm)	7.50
Total Settlement (mm)	18.75
Depth Correction	0.74
Rigidity factor	0.8
Corrected Settlement (mm)	**11.1**

Footing Depth (m)	6.00
SBC (t/m2)	26.00
Average N value	35
Settlement for 10 t/m2 (mm)	7.50
Total Settlement (mm)	19.50
Depth Correction	0.68
Rigidity factor	0.8
Corrected Settlement (mm)	**10.6**

1703

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CHAPTER – 56

"Minor Bridge No. 352",

Location – Existing Km. - 307/05-07

1704

56.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 1x3x3

56.2 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 ≥20.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.50	Sandy Silt with Clay	Loose
	1.50 to 3.00	Silty Sand	Medium Dense
	3.00 to 6.00	Silty Sand with Gravels	Medium Dense
	6.00 to 7.50	Silty Sand	Medium Dense
	7.50 to 12.00	Silty Sand	Dense

56.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.90	0.007	0.0017	NIL	0.0011	0.027

56.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

56.5 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	11.00
	4.50	15.00
	6.00	16.00

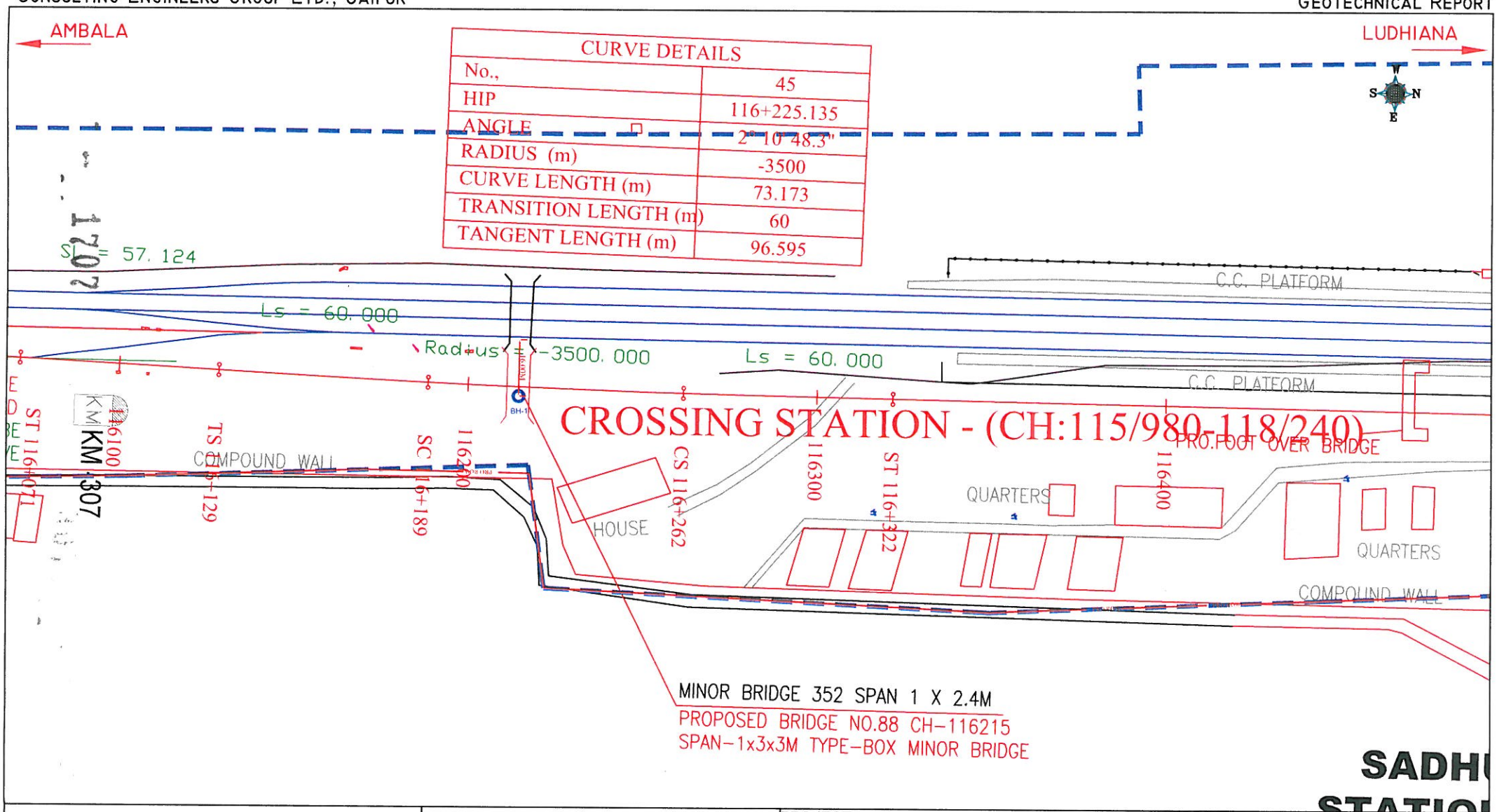
56.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

56.7 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 4.50 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 AT CH. 307/5-7	RL OF BH-I = 263.677	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 352 AT CHAINAGE 307/5-7

Project :	Chainage 307/5-7 Bridge No. 352			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				10.06.2009 to 10.06.2009	1	1(LHS)	below 20.00 m.	12.00mtr	263.677

Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Sandy Silt with Clay	13.28	47.40	32.25	2.28	1.45	2.22	1.12	32	22	10	-	-	-	-	-	-
1.50	13	1.52	19.76	Silty Sand	2.26	14.71	60.77	12.44	5.24	4.58	0.00	25	NIL	NP	-	-	-	-	-	
3.00	UDS	-	-	Silty Sand with Gravels	0.00	6.27	62.64	23.37	2.51	5.21	0.00	28	NIL	NP	1.60	7.59	1.49	2.60	0.00	26.00
4.50	26	1.11	28.86	Silty Sand with Gravels	0.00	6.59	62.34	23.31	2.48	5.28	0.00	27	NIL	NP	-	-	-	-	-	
6.00	UDS	-	-	Silty Sand	0.00	7.29	65.29	20.33	3.15	3.94	0.00	25	NIL	NP	1.65	8.52	1.52	2.62	0.00	27.00
7.50	32	0.94	30.08	Silty Sand	0.00	7.47	71.71	17.42	3.40	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
10.50	34	0.82	27.88	Silty Sand	0.00	8.00	71.52	17.35	3.13	0.00	0.00	21	NIL	NP	-	-	-	-	-	-
12.00	39	0.78	30.42	Silty Sand	0.00	7.84	71.85	17.21	3.10	0.00	0.00	24	NIL	NP	-	-	-	-	-	-

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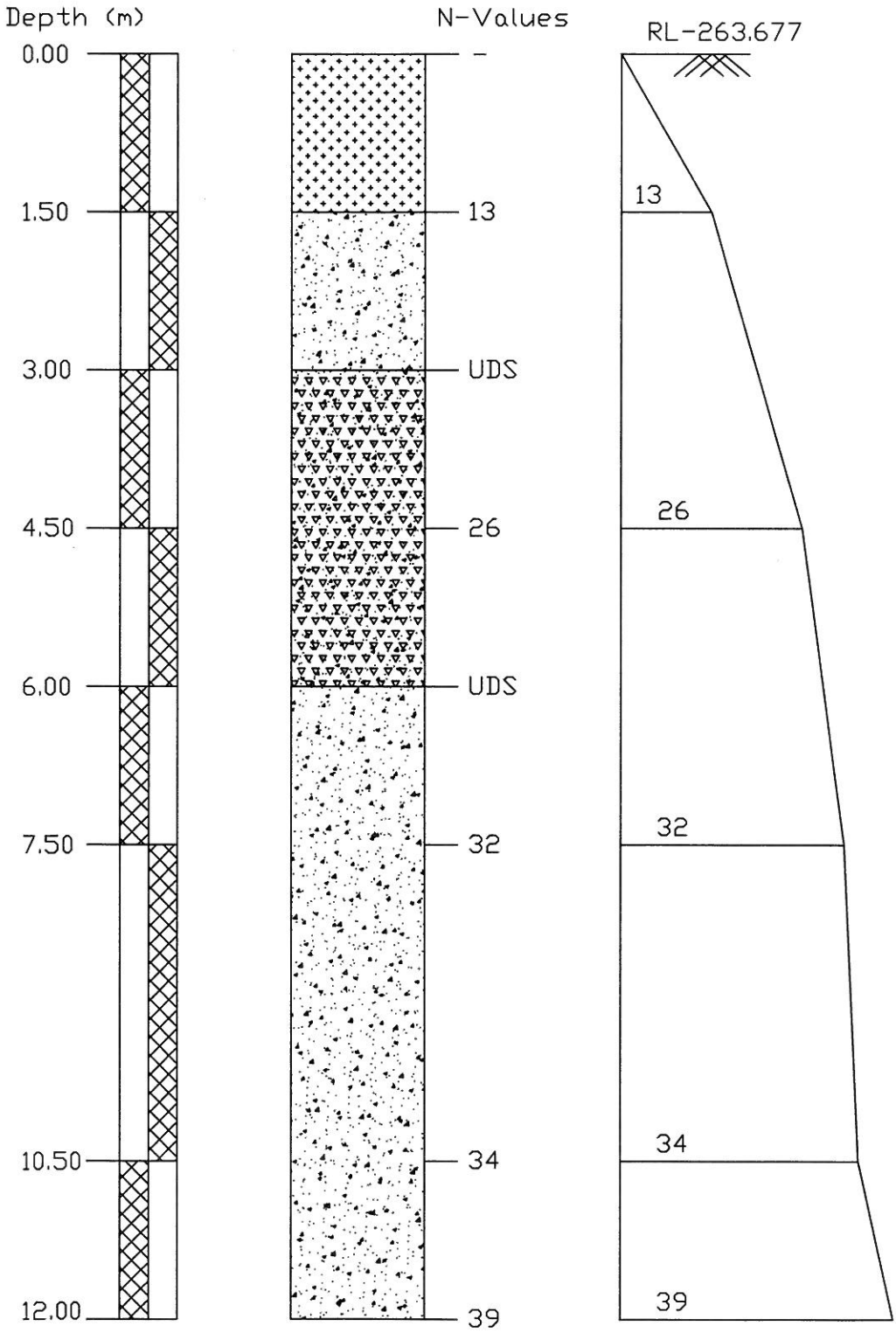
BORELOG OF BH–1(LHS) AT EXISTING KM–307/5–7 FOR MINOR BRIDGE NO.–352,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

1709

ANNEXURE - III

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

INPUT DATA

Minor Bridge No 307/5-7 BH-1

Type of footing

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

Angle of internal friction (ϕ°)	26.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.74
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.60
Density of foundation soil (t/m^3)	1.60
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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.00	ϕ'	18.10
N_c	22.60	N'_c	13.36
N_q	12.21	N'_q	5.46
N_γ	13.18	N'_γ	4.35

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.16	1.08	1.08
2	3.00	3.00	1.32	1.16	1.16

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

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	15.25	5.74	6.22
2	3.00	3.00	8.00	27.56	10.62	11.47

1711

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 307/5-7 BH-1

Type of footing

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

Angle of internal friction (ϕ°)	27.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.72
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.60
Density of foundation soil (t/m^3)	1.65
Depth of water table(m)	1.50
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 $\phi < 10^\circ$

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	27.00	ϕ'	18.85
N_c	24.49	N'_c	13.94
N_q	13.76	N'_q	5.83
N_γ	15.49	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	-1.00	0.50
2	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	4.50	3.00	8.00	34.07	12.43	15.67
2	6.00	3.00	8.00	36.30	13.24	16.70

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1713

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Minor Bridge
Chainage	307/05-07
Bore Hole No.	1

Footing Depth (m)	**1.50**
SBC (t/m2)	6.00
Average N value	22
Settlement for 10 t/m2 (mm)	13.80
Total Settlement (mm)	8.28
Depth Correction	0.91
Rigidity factor	0.8
Corrected Settlement (mm)	**6.0**

Footing Depth (m)	**3.00**
SBC (t/m2)	11.00
Average N value	28
Settlement for 10 t/m2 (mm)	10.00
Total Settlement (mm)	11.00
Depth Correction	0.83
Rigidity factor	0.8
Corrected Settlement (mm)	**7.3**

Footing Depth (m)	**4.50**
SBC (t/m2)	15.00
Average N value	29
Settlement for 10 t/m2 (mm)	9.50
Total Settlement (mm)	14.25
Depth Correction	0.74
Rigidity factor	0.8
Corrected Settlement (mm)	**8.4**

Footing Depth (m)	**6.00**
SBC (t/m2)	16.00
Average N value	29
Settlement for 10 t/m2 (mm)	9.50
Total Settlement (mm)	15.20
Depth Correction	0.68
Rigidity factor	0.8
Corrected Settlement (mm)	**8.3**

1714

CHAPTER - 57

"Minor Bridge No. 350",

Location – Existing Km. - 306/03-05

1715

57.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 2x3x3

57.2 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 ≥20.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.50	Sandy Silt with Clay	Loose
	1.50 to 3.00	Silty Sand with Clay	Medium Dense
	3.00 to 6.00	Silty Sand	Medium Dense
	6.00 to 7.50	Silty Sand with Gravels	Dense
	7.50 to 12.00	Silty Sand	Dense

57.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.50	NIL	0.0014	NIL	0.0011	0.018
	6.00	8.90	0.007	0.0014	NIL	0.0011	0.018

57.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

57.5 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	20.00
	6.00	21.00

57.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

57.7 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 4.50 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.

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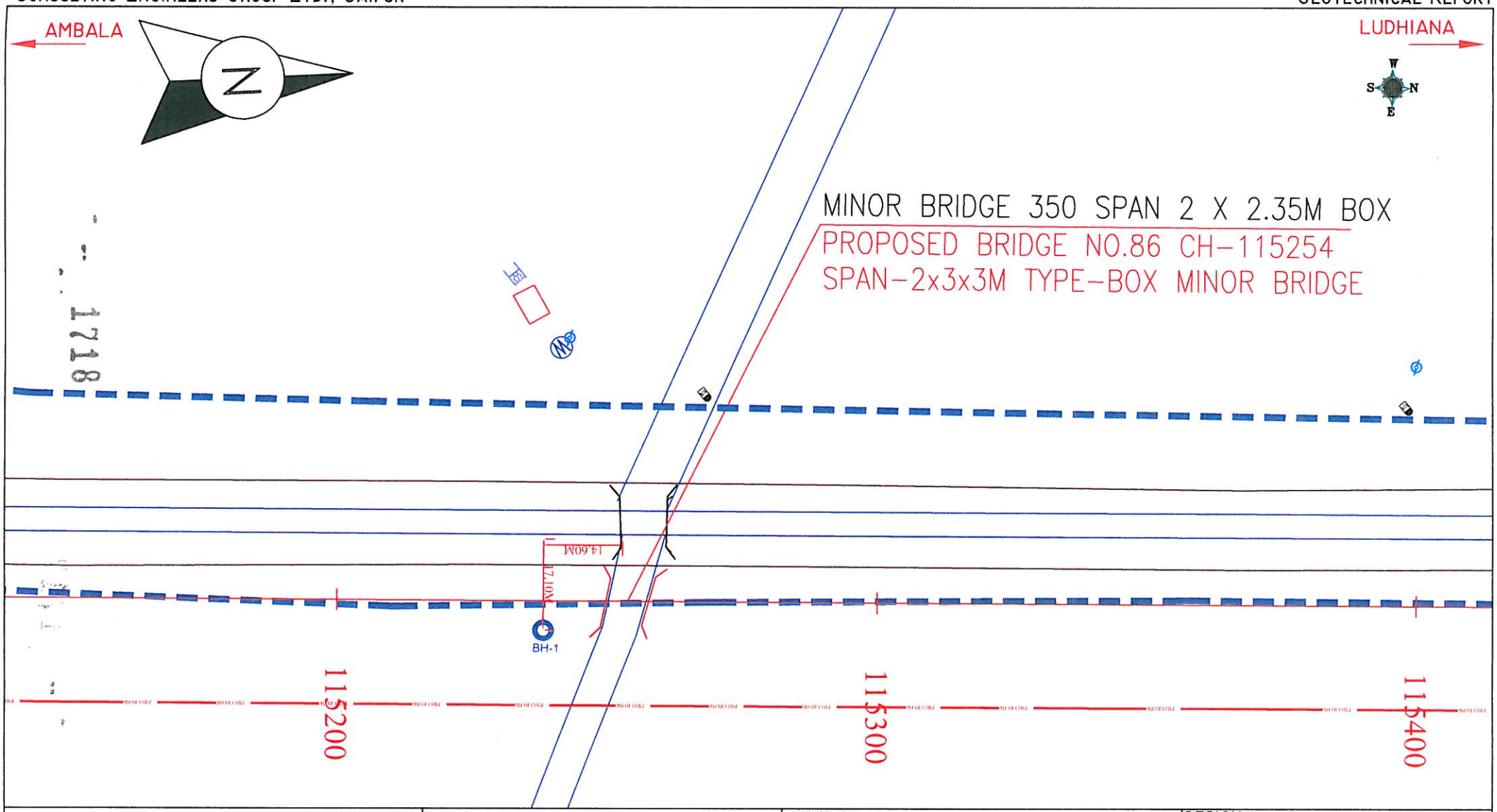

ALL DIMENSIONS IN METER		PROJECT :-	DESIGN :-
FIG.:-I LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 306/3-5	RL OF BH-I = 263.693	LUDHIANA-AMBALA (DFCCIL)	CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax. 2521348, E-Mail: ceg@cegindia.com

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 350 AT CHAINAGE 306/3-5

Project :	Chainage 306/3-5 Bridge No. 350			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				11.06.2009 to 11.06.2009	1	1(LHS)	below 20.00 m.	12.00mtr	263.693

Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Sandy Silt with Clay	13.86	51.51	30.28	2.19	0.95	1.21	0.00	28	16	12	-	-	-	-	-	-
1.50	19	1.52	28.88	Silty sand with Clay	15.83	36.03	46.70	1.10	0.34	0.00	0.00	29	15	14	-	-	-	-	-	
3.00	UDS	-	-	Silty Sand	2.15	7.39	86.35	3.45	0.06	0.60	0.00	27	NIL	NP	1.60	7.59	1.49	2.64	0.00	26.00
4.50	31	1.11	34.41	Silty Sand	2.33	8.02	84.31	3.54	0.83	0.97	0.00	27	NIL	NP	-	-	-	-	-	
6.00	UDS	-	-	Silty Sand with Gravels	2.73	18.28	59.45	10.83	2.46	6.25	0.00	28	NIL	NP	1.75	12.29	1.56	2.61	0.00	26.50
7.50	35	0.93	32.55	Silty Sand	2.10	5.77	85.11	5.47	0.80	0.75	0.00	25	NIL	NP	-	-	-	-	-	-
10.50	36	0.81	29.16	Silty Sand	1.95	6.25	83.42	6.36	0.99	1.03	0.00	25	NIL	NP	-	-	-	-	-	-
12.00	45	0.76	34.20	Silty Sand	2.66	5.54	85.84	4.80	0.80	0.36	0.00	26	NIL	NP	-	-	-	-	-	-

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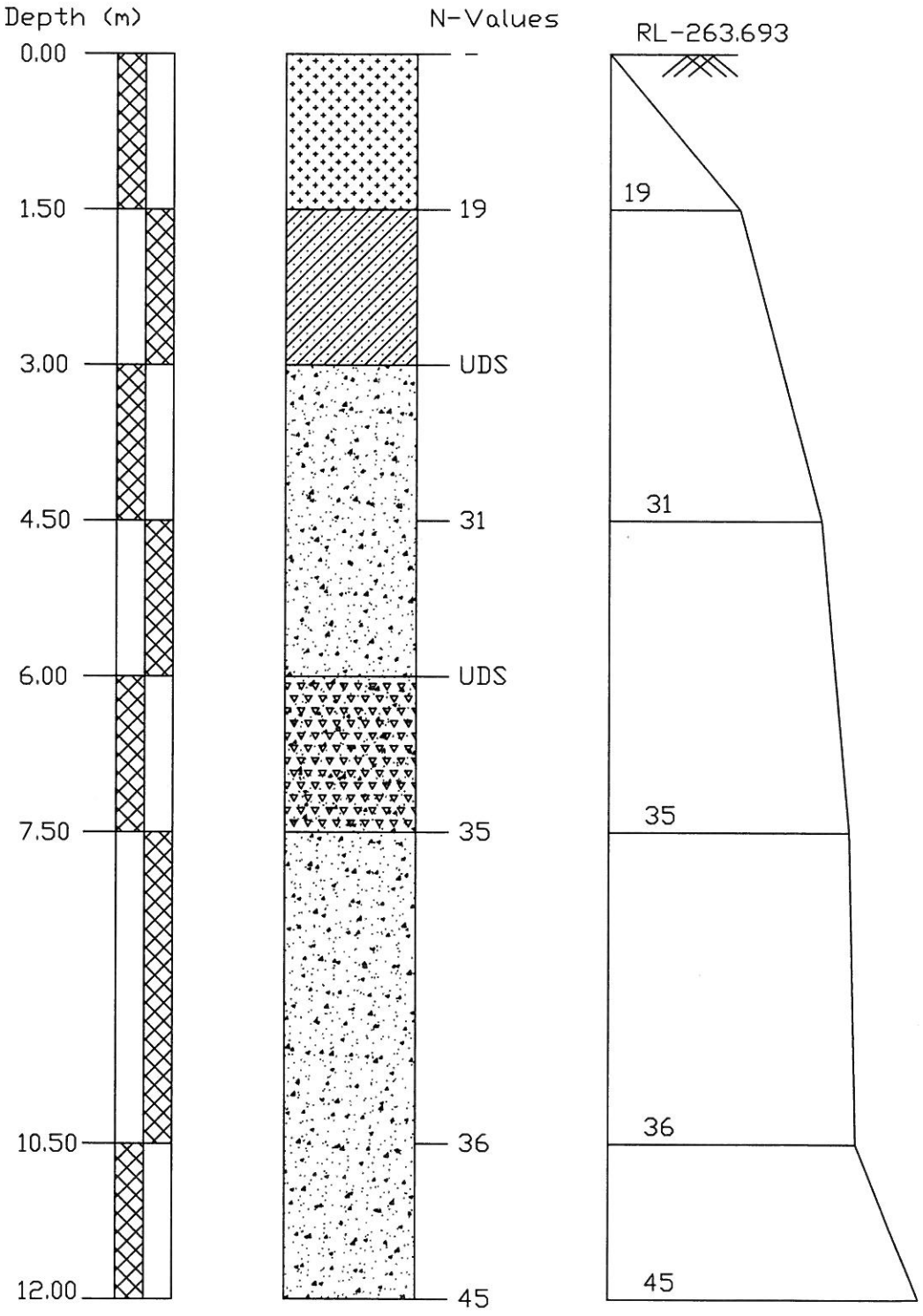
BORELOG OF BH–1(LHS) AT EXISTING KM–306/3–5 FOR MINOR BRIDGE NO.–350, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 306/3-5 BH-1

Type of footing

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

Angle of internal friction (ϕ °)	26.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.77
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.60
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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.00
N_c	22.60
N_q	12.21
N_γ	13.18

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

Shape factors :

S.no.	Width(m)	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	1.16	1.08	1.08
2	3.00	3.00	1.32	1.16	1.16

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

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	15.71	5.89	5.89
2	3.00	3.00	8.00	28.05	10.78	10.78

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 306/3-5 BH-1

Type of footing

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

Angle of internal friction (ϕ °)	26.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.67
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.60
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	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 $\phi < 10^\circ$

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.50	ϕ'	18.47
N_c	23.55	N'_c	13.65
N_q	12.98	N'_q	5.65
N_γ	14.34	N'_γ	4.55

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	4.50	3.00	-1.00	0.50
2	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	4.50	3.00	8.00	32.23	12.04	20.11
2	6.00	3.00	8.00	34.32	12.82	21.42

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Minor Bridge
Chainage	306/03-05
Bore Hole No.	1

Footing Depth (m)	**1.50**
SBC (t/m2)	6.00
Average N value	30
Settlement for 10 t/m2 (mm)	9.00
Total Settlement (mm)	5.40
Depth Correction	0.91
Rigidity factor	0.8
Corrected Settlement (mm)	**3.9**

Footing Depth (m)	**3.00**
SBC (t/m2)	10.00
Average N value	33
Settlement for 10 t/m2 (mm)	8.10
Total Settlement (mm)	8.10
Depth Correction	0.83
Rigidity factor	0.8
Corrected Settlement (mm)	**5.4**

Footing Depth (m)	**4.50**
SBC (t/m2)	20.00
Average N value	33
Settlement for 10 t/m2 (mm)	8.10
Total Settlement (mm)	16.20
Depth Correction	0.74
Rigidity factor	0.8
Corrected Settlement (mm)	**9.6**

Footing Depth (m)	**6.00**
SBC (t/m2)	21.00
Average N value	32
Settlement for 10 t/m2 (mm)	8.40
Total Settlement (mm)	17.64
Depth Correction	0.68
Rigidity factor	0.8
Corrected Settlement (mm)	**9.6**

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CHAPTER – 58

"Minor Bridge No. 348",

Location – Existing Km. - 305/15-17

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58.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 2x9.15

58.2 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 ≥20.00m below EGL.

Subsurface profile at the site

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

58.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.80	0.007	0.0024	NIL	0.0011	0.027
	6.00	8.90	0.012	0.0021	NIL	0.0013	0.022

58.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

58.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m^2)
BH-1	1.50	05.00
	3.00	10.00
	4.50	11.00
	6.00	12.00

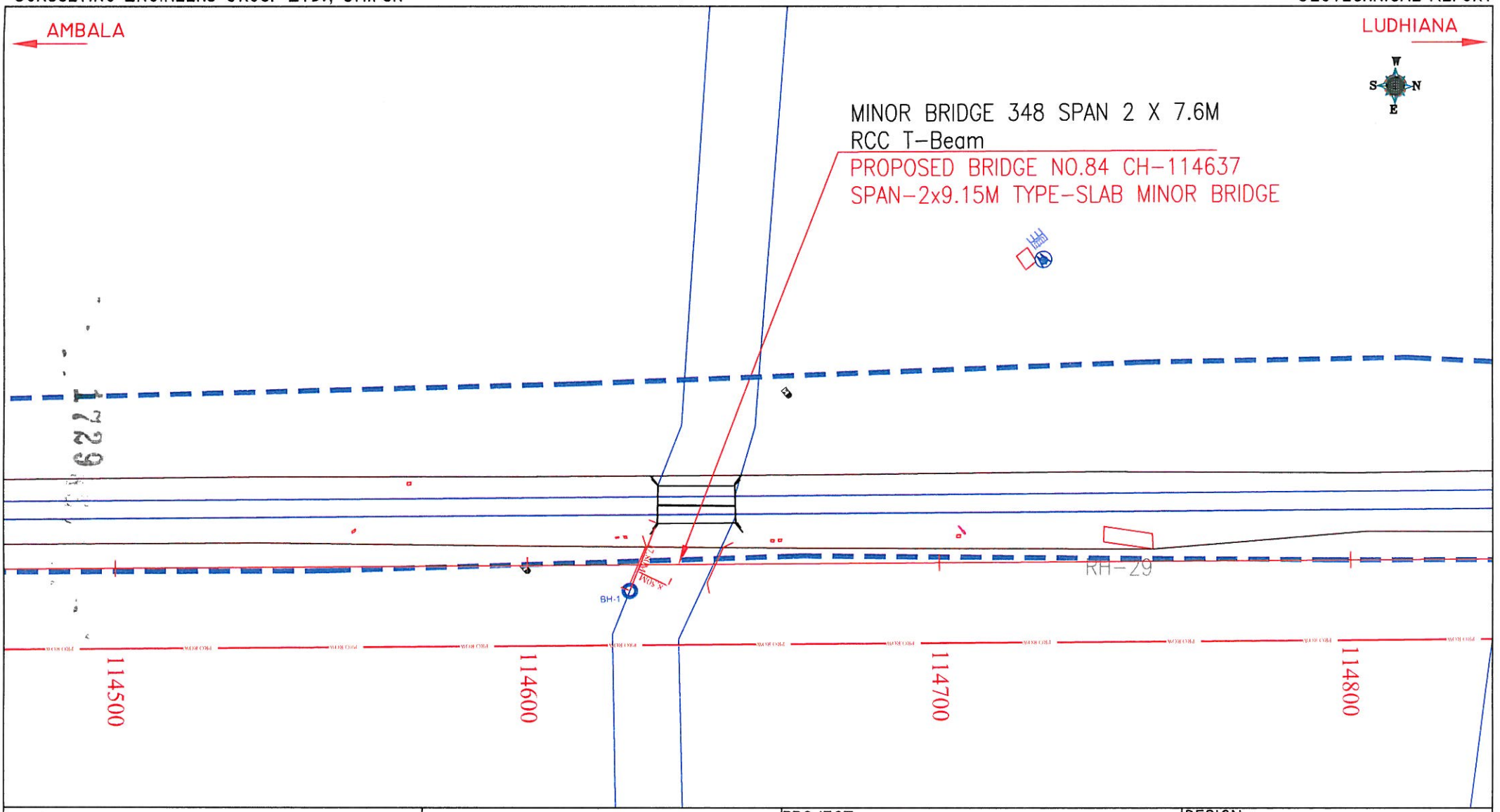
58.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

58.7 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 AT CH. 305/15-17	RL OF BH-I = 263.458	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 348 AT CHAINAGE 305/15-17

Project :	Chainage 305/15-17 Bridge No. 348			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				10.06.2009 to 11.06.2009	1	1(LHS)	below 20.00 m.	12.00mtr	263.458

Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Sandy Silt with Clay	13.11	65.63	15.25	1.69	1.1	3.22	0.00	29	18	11	-	-	-	-	-	-
1.50	16	1.53	24.48	Sandy Silt with Clay	12.62	66.64	14.04	1.38	1.14	4.18	0.00	29	18	11	-	-	-	-	-	
3.00	UDS	-	-	Silty Sand	0.00	10.24	89.29	0.35	0.12	0.00	0.00	26	NIL	NP	1.56	5.26	1.48	2.6	0.00	26.00
4.50	17	1.12	19.04	Silty Sand	2.44	6.48	83.26	6.90	0.26	0.66	0.00	27	NIL	NP	-	-	-	-	-	
6.00	UDS	-	-	Silty Sand	2.36	3.41	92.81	1.42	0.00	0.00	0.00	27	NIL	NP	1.62	8.40	1.49	2.65	0.00	26.50
7.50	28	0.94	26.32	Silty Sand	2.20	6.58	80.18	5.77	2.37	2.90	0.00	25	NIL	NP	-	-	-	-	-	-
10.50	30	0.83	24.90	Silty Sand	4.25	13.03	75.03	1.72	1.70	4.27	0.00	29	NIL	NP	-	-	-	-	-	-
12.00	17	0.78	13.26	Silty Sand	0.00	6.44	90.33	2.75	0.36	0.12	0.00	24	NIL	NP	-	-	-	-	-	-

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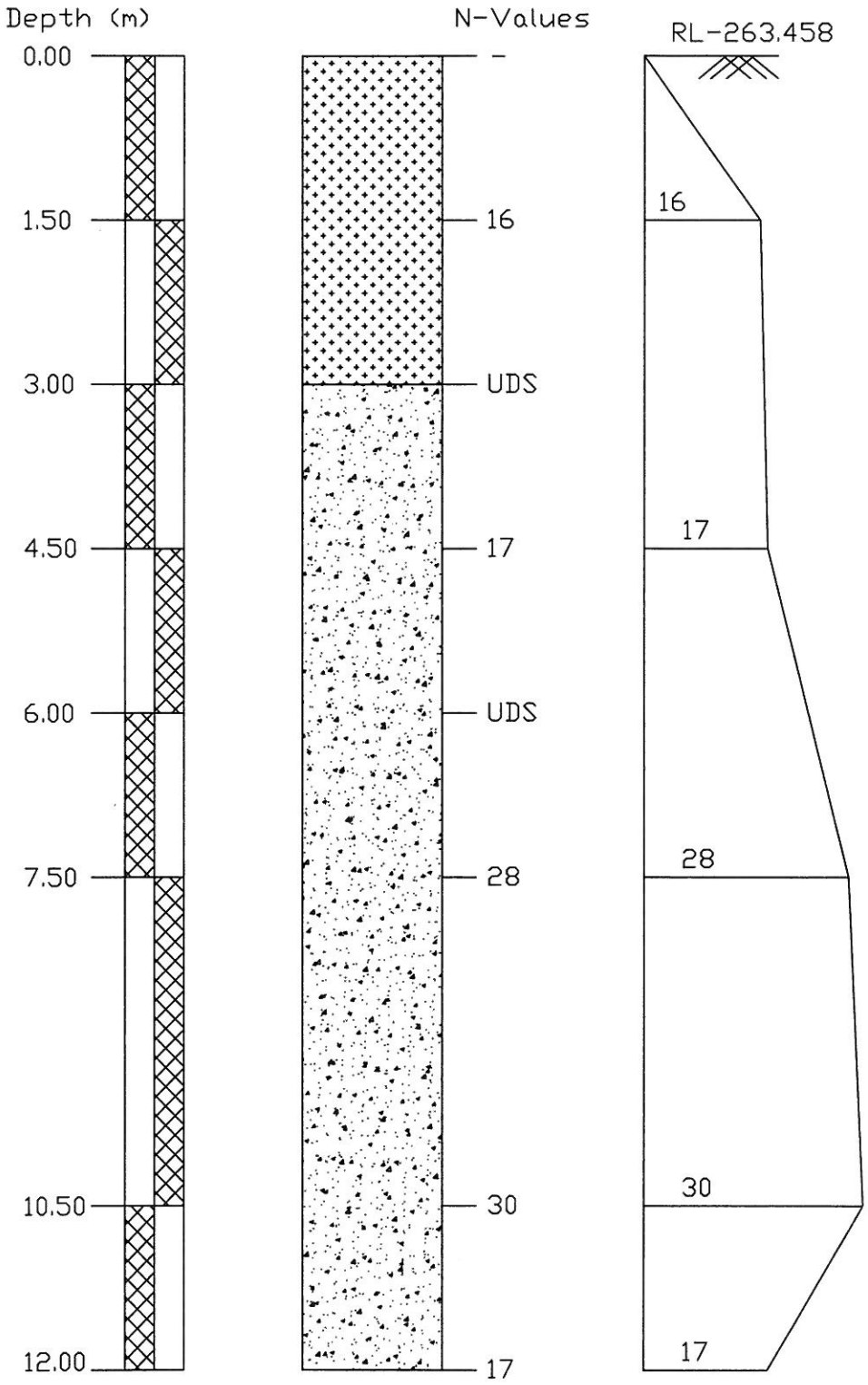
BORELOG OF BH–1(LHS) AT EXISTING KM–305/15–17 FOR MINOR BRIDGE NO.–348, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT WITH CLAY
	SILTY SAND

1731

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 305/15-17 BH-1

Type of footing

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

Angle of internal friction (ϕ°)	26.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.76
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.56
Density of foundation soil (t/m^3)	1.62
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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.00	ϕ'	18.10
N_c	22.60	N'_c	13.36
N_q	12.21	N'_q	5.46
N_γ	13.18	N'_γ	4.35

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.16	1.08	1.08
2	3.00	3.00	1.32	1.16	1.16

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

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	15.05	5.66	5.66
2	3.00	3.00	8.00	27.07	10.42	10.42

1733

CONSULTING Engineers Group Ltd.

ANNEXURE - III

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

INPUT DATA

Minor Bridge No 305/15-17 BH-1

Type of footing

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

Angle of internal friction (ϕ °)	26.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.78
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.56
Density of foundation soil (t/m^3)	1.62
Depth of water table(m)	1.50
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 $\phi < 10^\circ$

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.50	ϕ'	18.47
N_c	23.55	N'_c	13.65
N_q	12.98	N'_q	5.65
N_γ	14.34	N'_γ	4.55

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	4.50	3.00	-1.00	0.50
2	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	4.50	3.00	8.00	31.10	11.63	11.63
2	6.00	3.00	8.00	33.12	12.39	12.39

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Minor Bridge
Chainage	305/15-17
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	5.00
Average N value	20
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	7.50
Depth Correction	0.91
Rigidity factor	0.8
Corrected Settlement (mm)	5.5

Footing Depth (m)	3.00
SBC (t/m2)	10.00
Average N value	21
Settlement for 10 t/m2 (mm)	14.40
Total Settlement (mm)	14.40
Depth Correction	0.83
Rigidity factor	0.8
Corrected Settlement (mm)	9.6

Footing Depth (m)	4.50
SBC (t/m2)	11.00
Average N value	22
Settlement for 10 t/m2 (mm)	13.80
Total Settlement (mm)	15.18
Depth Correction	0.74
Rigidity factor	0.8
Corrected Settlement (mm)	9.0

Footing Depth (m)	6.00
SBC (t/m2)	12.00
Average N value	23
Settlement for 10 t/m2 (mm)	13.20
Total Settlement (mm)	15.84
Depth Correction	0.68
Rigidity factor	0.8
Corrected Settlement (mm)	8.6

1736

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CHAPTER – 59

"Minor Bridge No. 347",

Location – Existing Km. - 305/08-10

1737

59.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 1x3x3

59.2 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 1.50	Sandy Silt with Clay	Loose
	1.50 to 4.50	Sandy Silt with Clay	Medium Dense
	4.50 to 7.50	Silty Sand	Medium Dense
	7.50 to 12.00	Silty Sand	Dense

59.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.70	0.002	0.0014	NIL	0.0009	0.027
	6.00	8.90	0.010	0.0021	NIL	0.0012	0.020

59.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

59.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m^2)
BH-1	1.50	09.00
	3.00	14.00
	4.50	21.00
	6.00	22.50

59.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

59.7 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 4.50 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.

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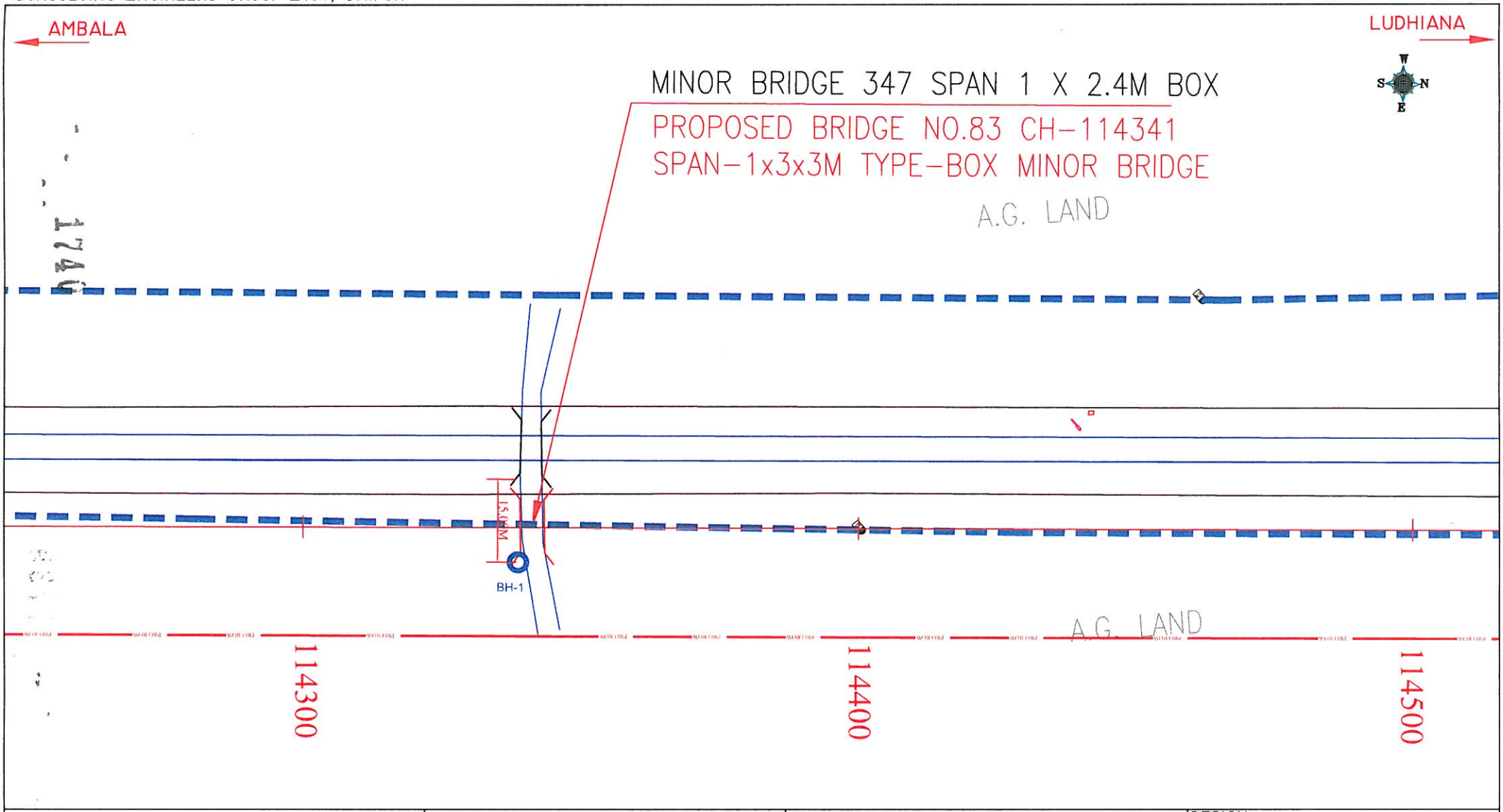

ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 305/4-6	RL OF BH-I =	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 347 AT CHAINAGE 305/4-6

Project :	Chainage 305/4-6 Bridge No. 347			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation									
				11.06.2009 to 11.06.2009	1	1(LHS)	below 15.00 m.	12.00mtr										
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	12.36	66.20	10.69	4.22	2.94	3.59	0.00	30	20	10	-	-	-	-	-	-
1.50	21	1.45	30.45	Sandy Silt with Clay	11.45	75.90	3.47	3.46	2.47	3.25	0.00	29	19	10	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt with Clay	12.47	67.34	8.62	2.01	6.90	2.66	0.00	31	20	11	1.77	11.80	1.58	2.66	0.09	21.00
4.50	24	1.08	25.92	Silty Sand	1.38	18.68	79.33	0.35	0.11	0.15	0.00	25	NIL	NP	-	-	-	-	-	
6.00	UDS	-	-	Silty Sand	2.20	6.30	88.18	0.18	1.99	1.15	0.00	28	NIL	NP	1.79	12.69	1.59	2.66	0.00	26.50
7.50	33	0.91	30.03	Silty Sand	2.26	11.22	84.26	0.18	1.69	0.39	0.00	28	NIL	NP	-	-	-	-	-	-
10.50	35	0.79	27.65	Silty Sand	0.00	6.84	66.30	23.51	2.14	1.21	0.00	26	NIL	NP	-	-	-	-	-	-
12.00	40	0.75	30.00	Silty Sand	0.00	15.55	62.36	20.56	1.17	0.36	0.00	26	NIL	NP	-	-	-	-	-	-

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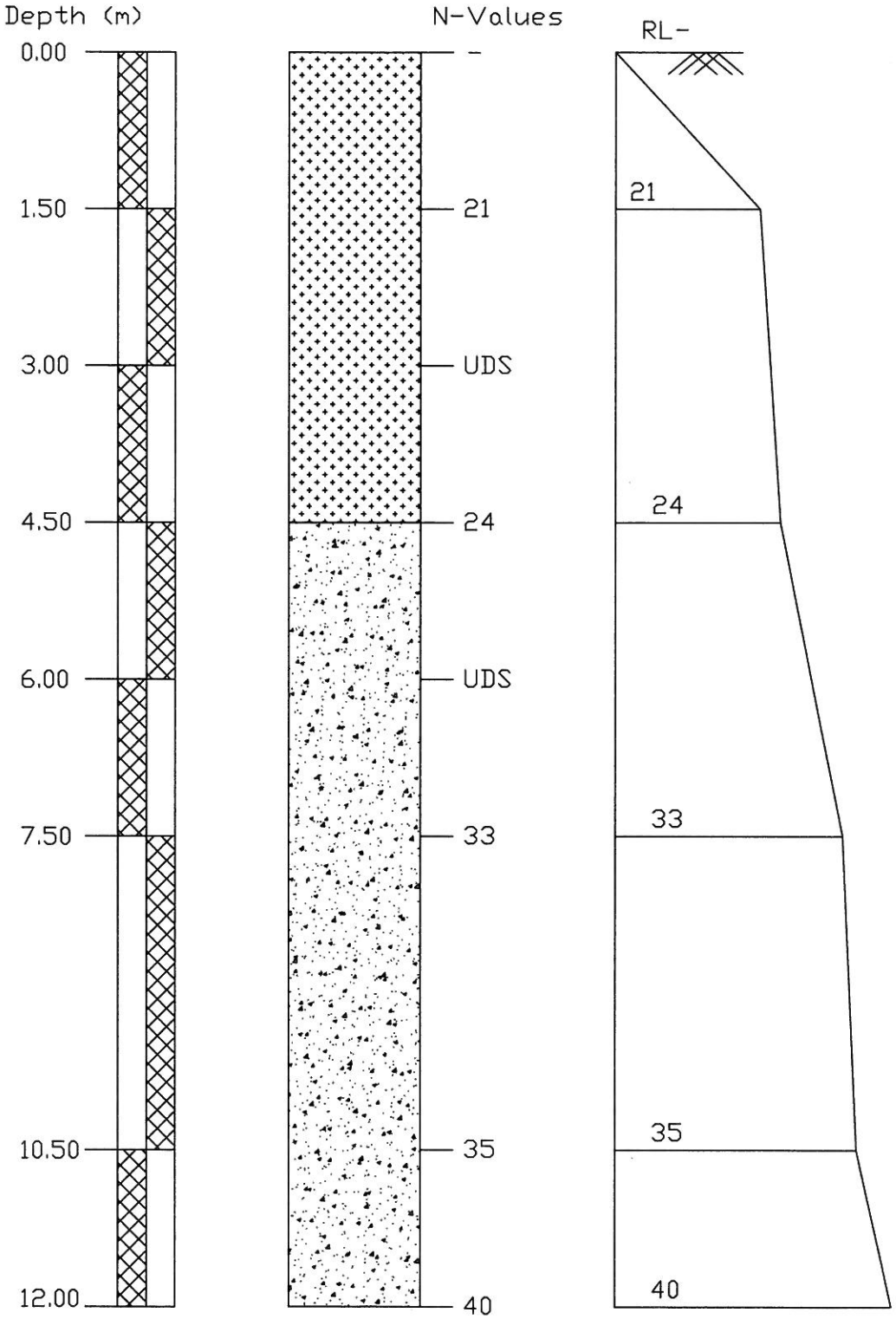
BORELOG OF BH–1(LHS) AT EXISTING KM–305/4–6 FOR MINOR BRIDGE NO.–347,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT WITH CLAY
	SILTY SAND

1742

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 305/8-10 BH-1

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)	0.68
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.77
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

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	0.00	0.50
2	3.00	3.00	-0.50	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	14.66	6.35	9.26
2	3.00	3.00	8.00	22.55	9.83	14.28

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 305/8-10 BH-1

Type of footing

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

Angle of internal friction (ϕ°)	26.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.67
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.79
Depth of water table(m)	1.50
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 $\phi < 10^\circ$

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.50	ϕ'	18.47
N_c	23.55	N'_c	13.65
N_q	12.98	N'_q	5.65
N_γ	14.34	N'_γ	4.55

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	4.50	3.00	-1.00	0.50
2	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	4.50	3.00	8.00	33.98	12.71	21.21
2	6.00	3.00	8.00	36.19	13.53	22.59

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Ch. 305 8-10**

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 = 5.1 t/m^2

Concentrated load *P* = 8.00 t/m^2

Incerase in pressure at mid of layer $\Delta P = P \times I_B$

I_B = 0.247

ΔP = 2.0 t/m^2

Compression Index Cc = 0.123

Thickness of clay layer H = 3 m

Initial Void ratio e_o = 0.68

$\frac{Po + \Delta p}{Po}$ = 1.38745

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

S_f = 0.03124 m

= 31.2371 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 = 0.91

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

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

S_{f2} = 19.3295 mm

Footing Depth (m)	**1.50**
SBC (t/m2)	8.00
Average N value	27
Settlement for 10 t/m2 (mm)	10.00
Total Settlement (mm)	8.00
Depth Correction	0.91
Rigidity factor	0.8
Corrected Settlement (mm)	**5.82**
Total Settlement (mm)	**25**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Ch. 305 8-10**

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	=	6.375	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	=	0.247	
	ΔP	=	3.5	t/m^2
Compression Index	Cc	=	0.123	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.68	
	$\frac{Po + \Delta p}{Po}$	=	1.54243	

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

S_f = 0.02067 m

= 20.669 mm

Correction for Depth and Rigidity of foundation on total settlement

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

$$\text{Rigidity Factor} = \frac{\text{Total Settlement of Rigid foundation}}{\text{Pore water pressure correction} = \text{N.A.}}$$
$$\text{Total Settlement at the centre of Flexible foundation}$$

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = 15.0 mm

Footing Depth (m)	**3.00**
SBC (t/m2)	14.00
Average N value	27
Settlement for 10 t/m2 (mm)	10.80
Total Settlement (mm)	15.12
Depth Correction	0.83
Rigidity factor	0.8
Corrected Settlement (mm)	**10.0**
Total Settlement (mm)	**25**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Minor Bridge
Chainage	305/08-10
Bore Hole No.	1

Footing Depth (m)	4.50
SBC (t/m2)	21.00
Average N value	28
Settlement for 10 t/m2 (mm)	10.20
Total Settlement (mm)	21.42
Depth Correction	0.74
Rigidity factor	0.8
Corrected Settlement (mm)	**12.7**

Footing Depth (m)	6.00
SBC (t/m2)	22.50
Average N value	28
Settlement for 10 t/m2 (mm)	10.20
Total Settlement (mm)	22.95
Depth Correction	0.68
Rigidity factor	0.8
Corrected Settlement (mm)	**12.5**

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CHAPTER – 60

"Minor Bridge No. 345",

Location – Existing Km. - 304/09-11

1750

60.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 2x4x2

60.2 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 ≥20.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.50	Clayey Silt with Sand	Loose
	1.50 to 3.00	Clayey Silt with Sand	Medium Dense
	3.00 to 7.50	Silty Sand	Medium Dense
	7.50 to 12.00	Silty Sand	Dense

60.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.80	0.007	0.0024	NIL	0.0013	0.039
	6.00	8.80	0.010	0.0021	NIL	0.0011	0.035

60.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

60.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m^2)
BH-1	1.50	05.00
	3.00	10.00
	4.50	18.00
	6.00	20.00

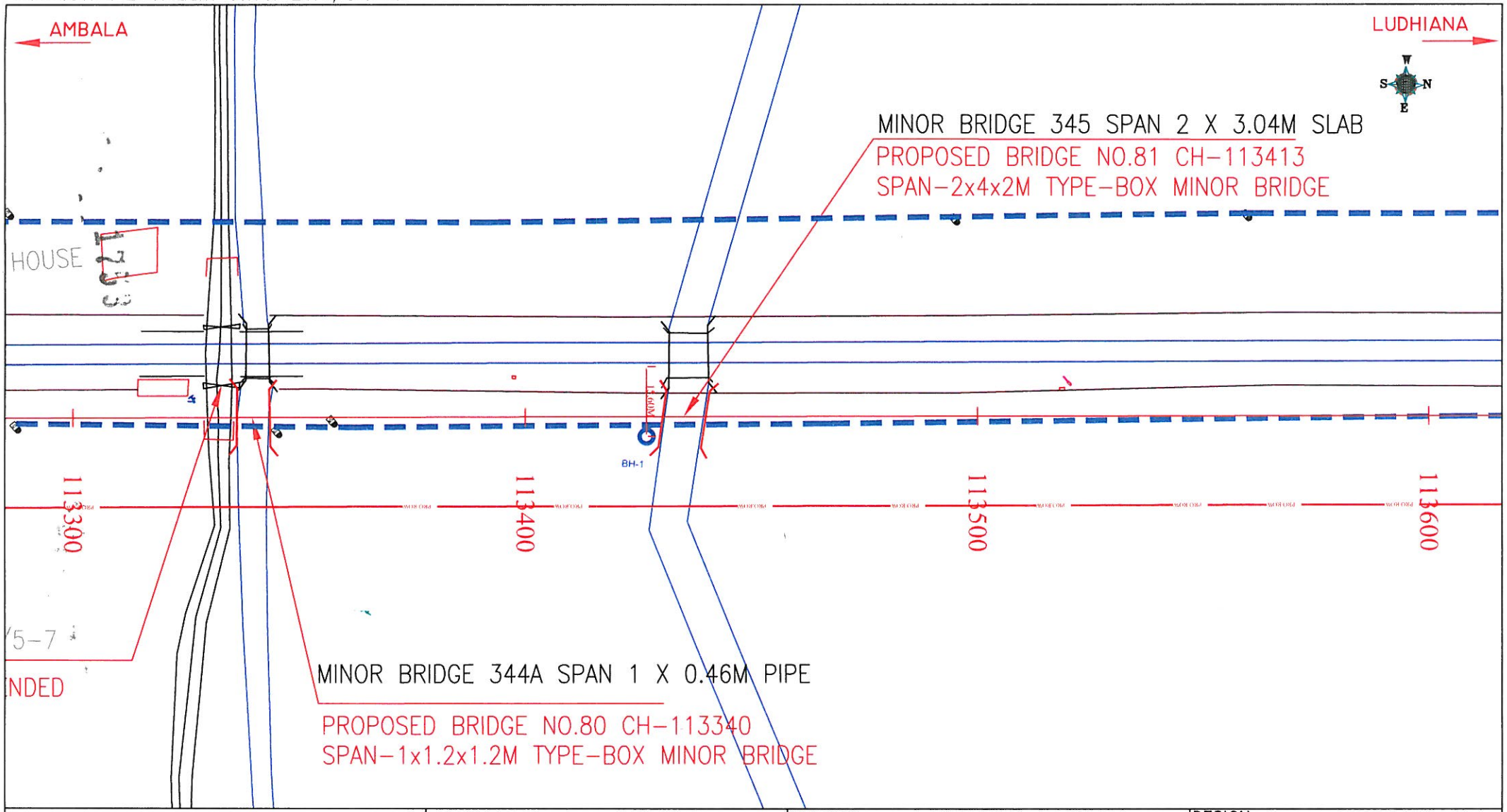
60.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

60.7 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 4.50 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 AT CH. 304/9-11

RL OF BH-I = 263.653

PROJECT :-
LUDHIANA-AMBALA (DFCCIL)

DESIGN :-

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SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 345 AT CHAINAGE 304/9-11

Project :	Chainage 304/9-11 Bridge No. 345			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				11.06.2009 to 11.06.2009	1	1(LHS)	below 20.00 m.	12.00mtr	263.653

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	16.58	66.70	10.36	3.28	2.22	0.86	0.00	31	17	14	-	-	-	-	-	-
1.50	13	1.53	19.89	Clayey Silt with Sand	18.95	60.66	11.87	4.49	2.27	1.76	0.00	39	23	16	-	-	-	-	-	
3.00	UDS	-	-	Silty Sand	2.68	18.57	78.38	0.37	0.00	0.00	0.00	27	NIL	NP	1.58	6.68	1.48	2.64	0.00	26.00
4.50	10	1.12	11.20	Silty Sand	2.67	40.21	53.50	2.22	0.48	0.92	0.00	21	NIL	NP	-	-	-	-	-	
6.00	UDS	-	-	Silty Sand	0.00	5.00	90.67	4.33	0.00	0.00	0.00	28	NIL	NP	1.72	8.59	1.58	2.66	0.00	26.50
7.50	35	0.93	32.55	Silty Sand	2.11	7.49	83.85	5.64	0.42	0.49	0.00	27	NIL	NP	-	-	-	-	-	-
10.50	44	0.82	36.08	Silty Sand	2.19	7.41	83.85	5.64	0.42	0.49	0.00	27	NIL	NP	-	-	-	-	-	-
12.00	48	0.77	36.96	Silty Sand	2.29	7.31	83.85	5.64	0.42	0.49	0.00	27	NIL	NP	-	-	-	-	-	-

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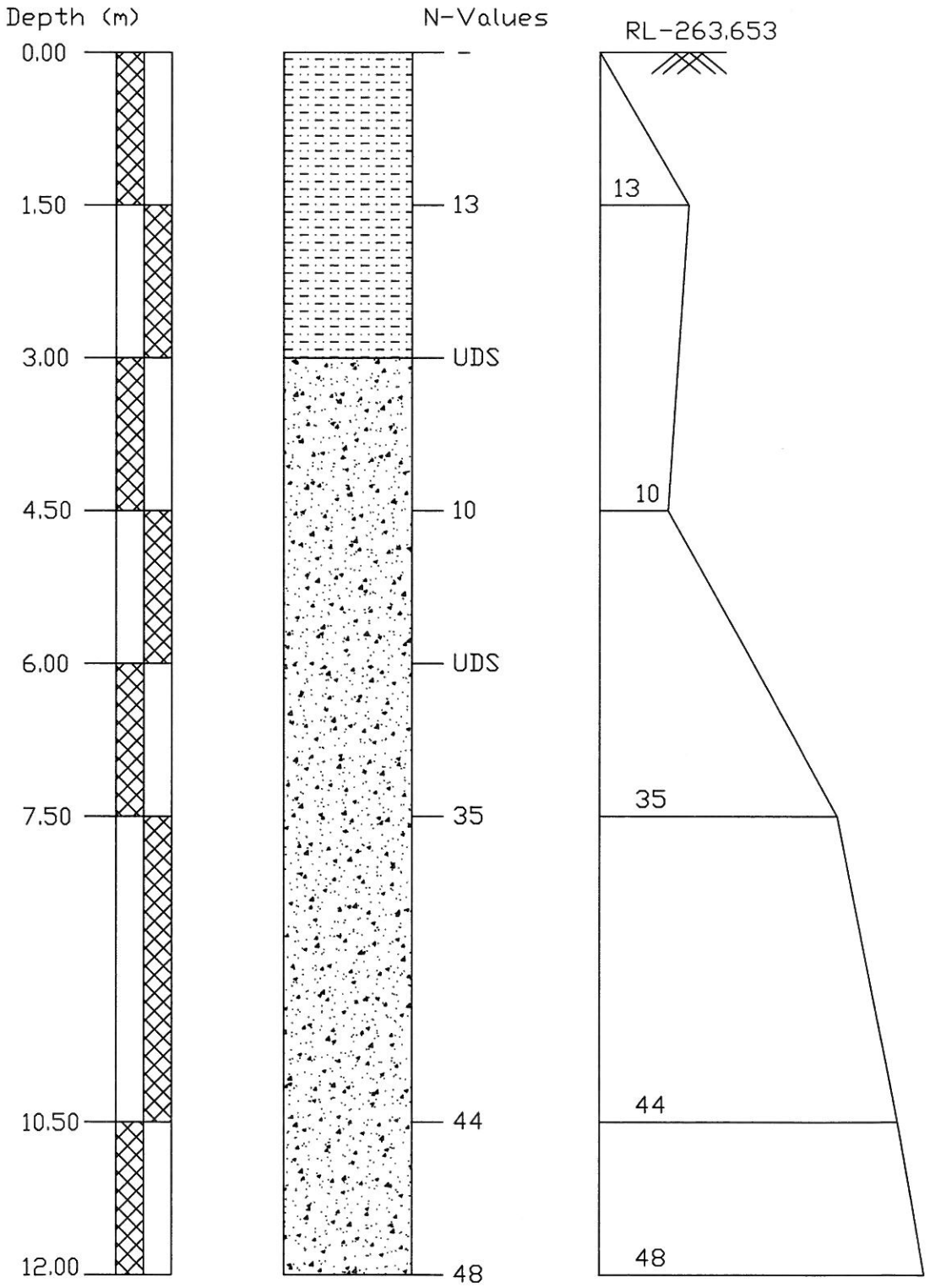
BORELOG OF BH–1(LHS) AT EXISTING KM–304/9–11 FOR MINOR BRIDGE NO.–345,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	SILTY SAND

1755

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 304/9-11 BH-1

Type of footing

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

Angle of internal friction (ϕ°)	26.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.78
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.58
Density of foundation soil (t/m^3)	1.58
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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.00	ϕ'	18.10
N_c	22.60	N'_c	13.36
N_q	12.21	N'_q	5.46
N_γ	13.18	N'_γ	4.35

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.16	1.08	1.08
2	3.00	3.00	1.32	1.16	1.16

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

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	15.06	5.67	5.67
2	3.00	3.00	8.00	27.22	10.49	10.49

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 304/9-11 BH-1

Type of footing

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

Angle of internal friction (ϕ °)	26.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.68
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.58
Density of foundation soil (t/m^3)	1.72
Depth of water table(m)	1.50
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 $\phi < 10°$

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.50
N_c	23.55
N_q	12.98
N_γ	14.34

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

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	4.50	3.00	-1.00	0.50
2	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	4.50	3.00	8.00	31.79	11.88	18.85
2	6.00	3.00	8.00	33.86	12.65	20.07

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Minor Bridge
Chainage	304/09-11
Bore Hole No.	1

Footing Depth (m)	3.00
SBC (t/m2)	10.00
Average N value	16
Settlement for 10 t/m2 (mm)	19.00
Total Settlement (mm)	19.00
Depth Correction	0.83
Rigidity factor	0.8
Corrected Settlement (mm)	12.6

Footing Depth (m)	4.50
SBC (t/m2)	18.00
Average N value	17
Settlement for 10 t/m2 (mm)	18.00
Total Settlement (mm)	32.40
Depth Correction	0.74
Rigidity factor	0.8
Corrected Settlement (mm)	19.2

As per IS:8009 Part1 Ch. 304 9-11

Footing Depth (m)	6.00
SBC (t/m2)	20.00
Average N value	27
Settlement for 10 t/m2 (mm)	10.80
Total Settlement (mm)	21.60
Depth Correction	0.68
Rigidity factor	0.8
Corrected Settlement (mm)	11.8

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Minor Bridge Ch. 304/9-11**

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	=	3.375	t/m^2
Concentrated load *P*		=	5.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.247	
	ΔP	=	1.2	t/m^2
Compression Index	Cc	=	0.15	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.78	
	$\frac{Po + \Delta p}{Po}$	=	1.36593	

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

S_f = 0.01712 m

= 17.1186 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 = 0.91

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

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

S_{f2} = 10.6 mm

Footing Depth (m)	**1.50**
SBC (t/m2)	5.00
Average N value	16
Settlement for 10 t/m2 (mm)	19.00
Total Settlement (mm)	9.50
Depth Correction	0.91
Rigidity factor	0.8
Corrected Settlement (mm)	**6.9**
Total Settlement (mm) =	**17.5**

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CHAPTER – 61

"Minor Bridge No. 342",

Location – Existing Km. - 303/12-14

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61.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 2x3x2

61.2 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 ≥20.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.50	Clayey Silt with Sand	Loose
	1.50 to 4.50	Clayey Silt with Sand	Medium Dense
	4.50 to 10.50	Silty Sand	Medium Dense
	10.50 to 12.00	Silty Sand	Dense

61.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.80	0.007	0.0018	NIL	0.0009	0.041
	9.00	8.60	0.010	0.0017	NIL	0.0011	0.021

61.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	10.00
	6.00	NIL

61.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m^2)
BH-1	1.50	06.50
	3.00	10.00
	4.50	16.00
	6.00	17.00

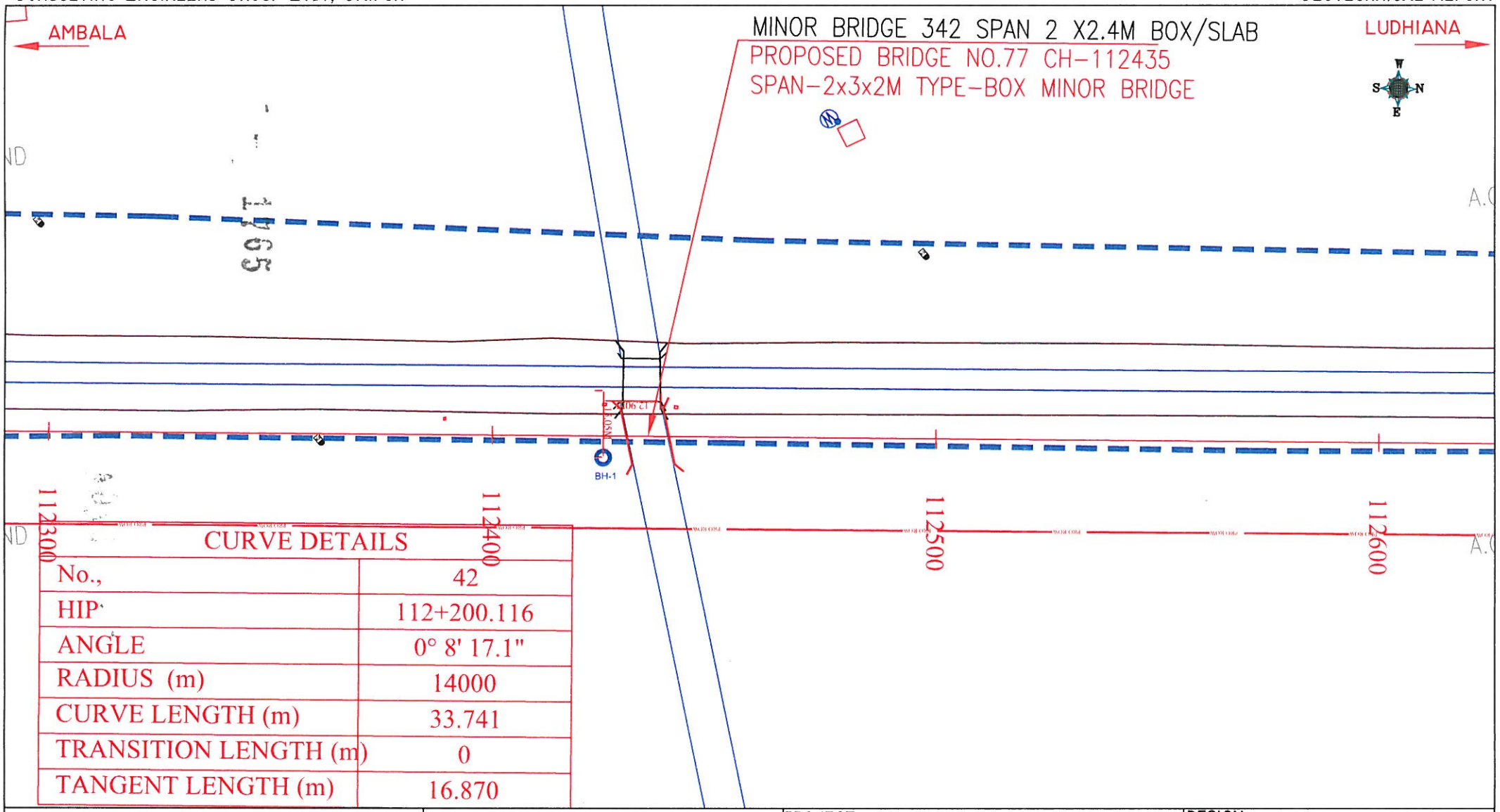
61.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

61.7 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 4.50 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.



CURVE DETAILS	
No.,	42
HIP	112+200.116
ANGLE	0° 8' 17.1"
RADIUS (m)	14000
CURVE LENGTH (m)	33.741
TRANSITION LENGTH (m)	0
TANGENT LENGTH (m)	16.870

ALL DIMENSIONS IN METER

FIG.:-I
LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 303/12-14

RL OF BH-I = 263.99

PROJECT :-
LUDHIANA-AMBALA (DFCCIL)

DESIGN :-
CONSULTING
ENGINEERS GROUP LTD.
E-12,Moji Colony,Malviya Nagar Jaipur-17
Tel: +91-141- 2520899, 2521899, 2520556
Fax: 2521348, E-Mail: ceg@cegindia.com

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 342 AT CHAINAGE 303/12-14

Project :	Chainage 303/12-14 Bridge No. 342			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				12.06.2009 to 12.06.2009	1	1(LHS)	below 20.00 m.	12.00mtr	263.990

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	17.52	66.88	10.25	3.25	1.45	0.65	0.00	33	18	15	-	-	-	-	-	-
1.50	10	1.51	15.10	Clayey Silt with Sand	20.58	63.44	10.12	2.56	1.73	1.57	0.00	35	18	17	-	-	-	-	-	
3.00	UDS	-	-	Clayey Silt with Sand	10.36	82.76	5.74	0.61	0.26	0.27	0.00	29	20	9	1.64	11.41	1.47	2.62	0.10	22.0
4.50	18	1.10	19.80	Silty Sand	2.21	9.65	86.00	1.84	0.11	0.19	0.00	25	NIL	NP	-	-	-	-	-	-
6.00	23	1.01	23.23	Silty Sand	2.10	8.13	83.74	5.31	0.39	0.33	0.00	24	NIL	NP	-		-	-	-	-
7.50	26	0.93	24.18	Silty Sand	2.35	9.99	77.60	9.14	0.78	0.14	0.00	26	NIL	NP	-	-	-	-	-	
9.00	UDS	-	-	Silty Sand	1.59	21.85	68.15	6.06	1.35	1.00	0.00	22	NIL	NP	1.65	6.83	1.54	2.62	0.00	26.00
10.50	45	0.82	36.90	Silty Sand	2.00	13.78	74.68	8.19	0.97	0.38	0.00	25	NIL	NP	-	-	-	-	-	-
12.00	53	0.77	40.81	Silty Sand	2.00	10.40	77.71	8.78	0.46	0.65	0.00	24	NIL	NP	-	-	-	-	-	-

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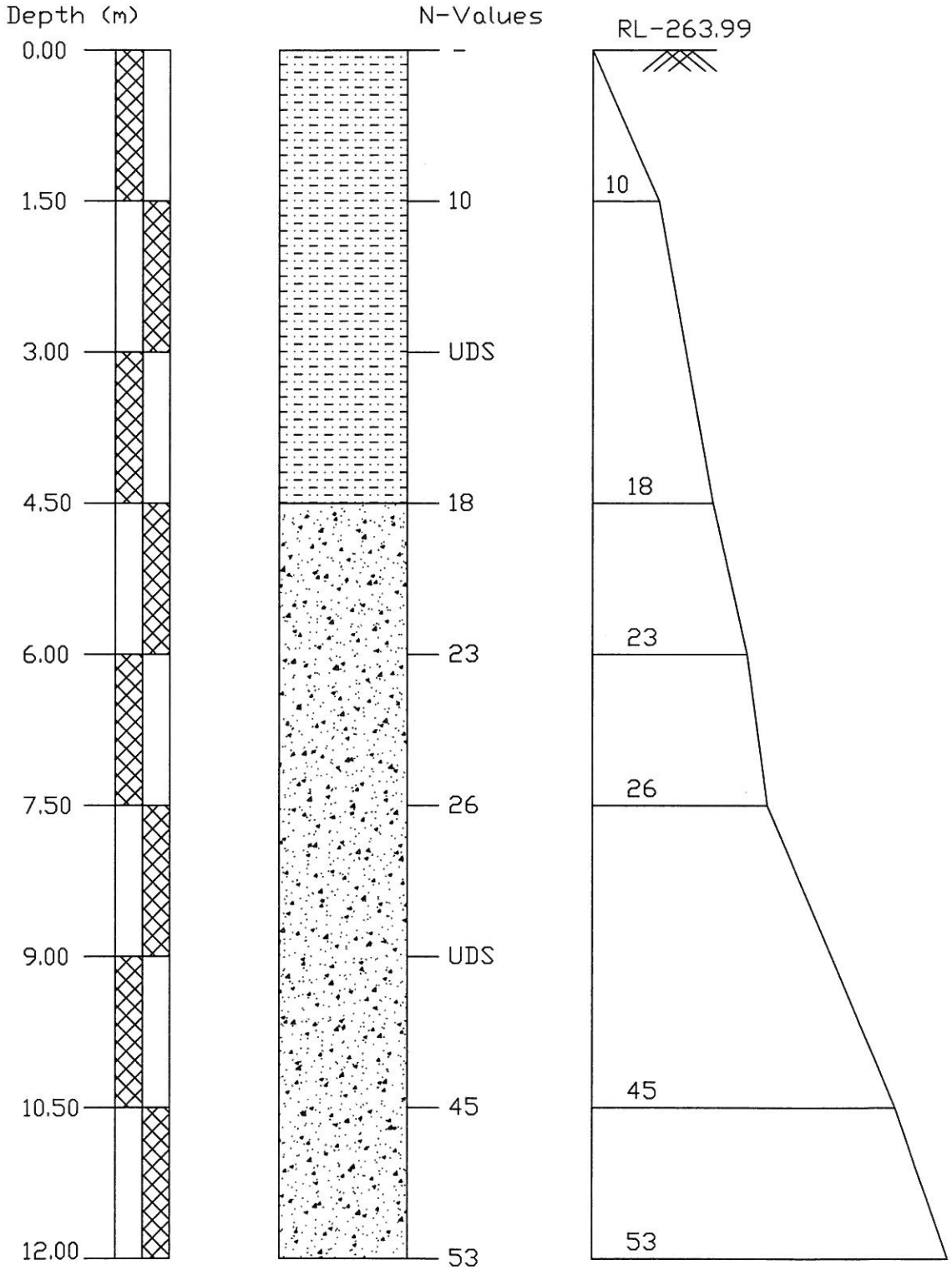
BORELOG OF BH–1(LHS) AT EXISTING KM–303/12–14 FOR MINOR BRIDGE NO.–342, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	SILTY SAND

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 303/12-14 BH-1

Type of footing

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

Angle of internal friction (ϕ°)	22.00
Cohesion (c in t/m2)	1.00
Void ratio (e)	0.78
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.64
Density of foundation soil (t/m^3)	1.64
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

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	22.00	ϕ'	15.15
N_c	17.19	N'_c	11.09
N_q	8.10	N'_q	4.01
N_γ	7.59	N'_γ	2.73

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	1.30	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	0.00	0.50
2	3.00	3.00	-0.50	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	16.64	6.92	6.92
2	3.00	3.00	8.00	25.40	10.63	10.63

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 303/12-14 BH-1

Type of footing

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

Angle of internal friction (ϕ °)	26.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.70
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.64
Density of foundation soil (t/m^3)	1.65
Depth of water table(m)	1.50
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 $\phi < 10^\circ$

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.00
N_c	22.60
N_q	12.21
N_γ	13.18

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

Shape factors :

S.no.	Width(m)	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	1.48	1.24	1.24
2	6.00	3.00	1.64	1.32	1.32

Inclination factors :

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

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	4.50	3.00	-1.00	0.50
2	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	4.50	3.00	8.00	30.24	11.65	16.29
2	6.00	3.00	8.00	32.19	12.40	17.35

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Minor Bridge Ch. 303/12-14**

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	=	4.8	t/m^2
Concentrated load *P*		=	6.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.238	
	ΔP	=	1.5	t/m^2
Compression Index	Cc	=	0.15	
Thickness of clay layer	H	=	3	m
Initial Void ratio	e_o	=	0.78	
	$\frac{Po + \Delta p}{Po}$	=	1.32229	

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

S_f = 0.03067 m

= 30.6726 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 = 0.91

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

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

S_{f2} = 19.0 mm

Footing Depth (m)	**1.50**
SBC (t/m2)	6.50
Average N value	22
Settlement for 10 t/m2 (mm)	13.00
Total Settlement (mm)	8.45
Depth Correction	0.91
Rigidity factor	0.8
Corrected Settlement (mm)	**6.2**
Total Settlement (mm) =	**25**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Minor Bridge Ch. 303/12-14**

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	=	6.03	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	=	0.247	
	ΔP	=	2.5	t/m^2
Compression Index	Cc	=	0.15	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.78	
	$\frac{Po + \Delta p}{Po}$	=	1.40962	

Settlement of clay layer

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

S_f = 0.01885 m

= 18.8471 mm

Correction for Depth and Rigidity of foundation on total settlement

Depth Factor Calculation

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

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

S_{f2} = 10.6 mm

Footing Depth (m)	**3.00**
SBC (t/m2)	10.00
Average N value	20
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	15.00
Depth Correction	0.83
Rigidity factor	0.8
Corrected Settlement (mm)	**9.96**
Total Settlement (mm)	**20.6**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Minor Bridge
Chainage	303/12-14
Bore Hole No.	1

Footing Depth (m)	**4.50**
SBC (t/m2)	16.00
Average N value	22
Settlement for 10 t/m2 (mm)	13.80
Total Settlement (mm)	22.08
Depth Correction	0.74
Rigidity factor	0.8
Corrected Settlement (mm)	**13.1**

Footing Depth (m)	**6.00**
SBC (t/m2)	17.00
Average N value	26
Settlement for 10 t/m2 (mm)	11.40
Total Settlement (mm)	19.38
Depth Correction	0.68
Rigidity factor	0.8
Corrected Settlement (mm)	**10.5**

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