8.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge No. 376A at Chainage 345/4-6

8.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table ≥16.00m 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 2.50	Clayey Silt with Sand	Medium Dense
	2.50 to 3.00	Sandy Silt	Medium Dense
	3.00 to 12.00	Silty Sand	Medium Dense

8.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.40	NIL	0.0014	NIL	0.0009	0.020

8.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

8.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	12.00
	3.00	14.50
	4.50	17.00
	6.00	19.00

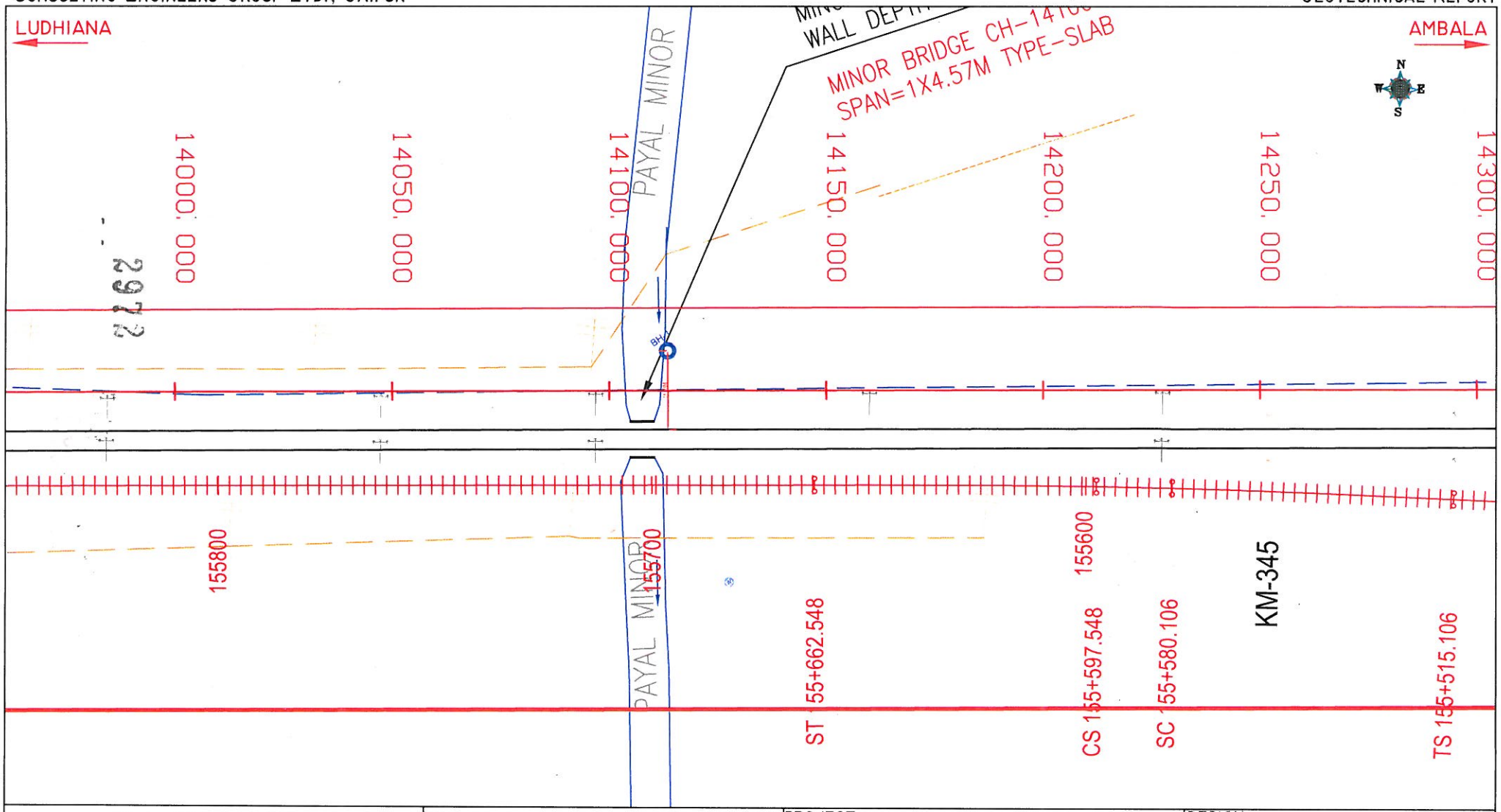
8.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

8.7 RECOMMENDATIONS

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

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



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 345/4-6	RL OF BH-I = 262.562	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

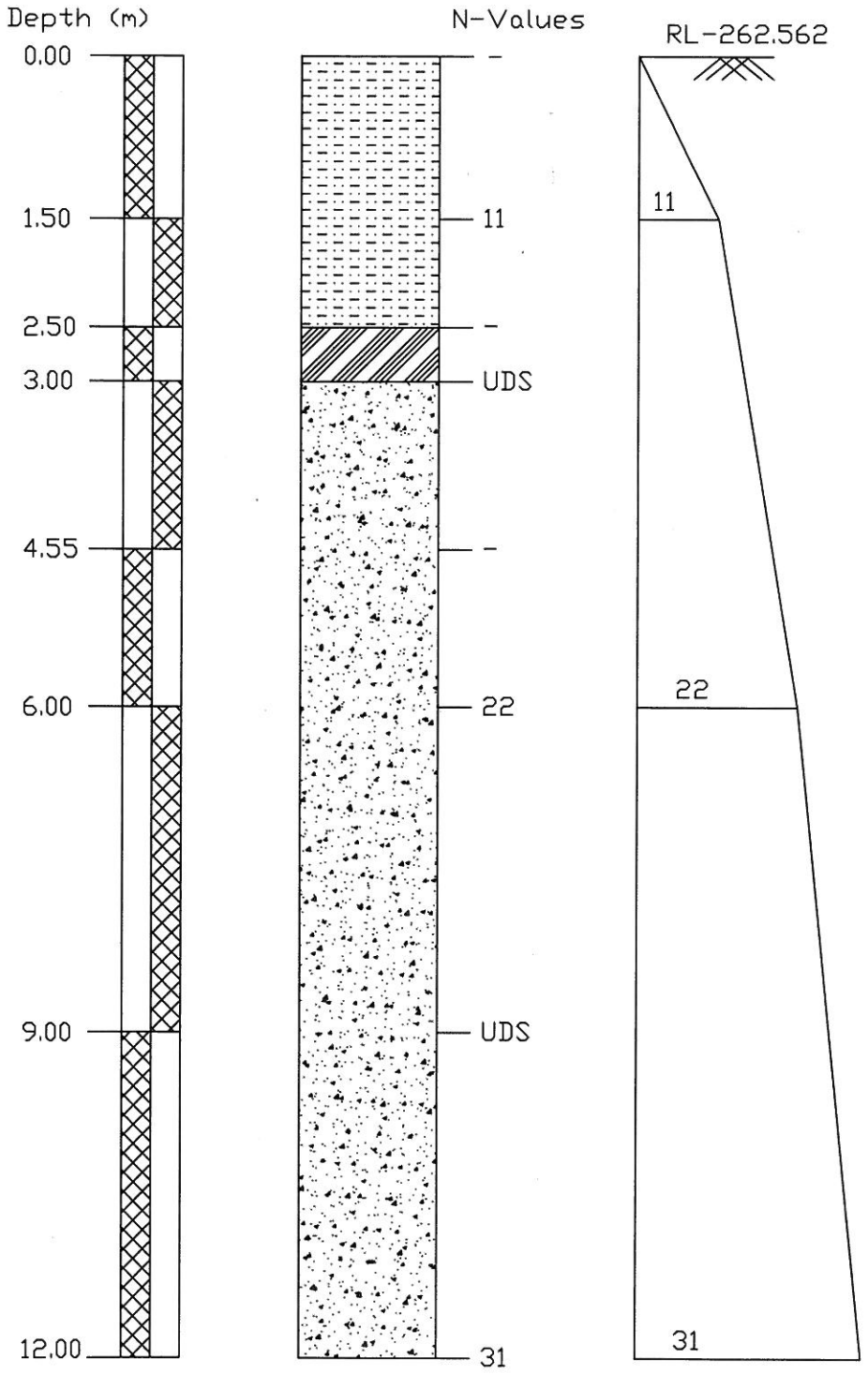
SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 FOR MINOR BRIDGE No. 376 AT CHAINAGE 345/4-6

Project :	Chainage 345/4-6 Bridge No. 376			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				31.05.2009 to 31.05.2009	1	1	below 16.00 m.	12.00mtr	262.562

Depth from GL (m)	Observed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel									c kg/cm^2	ϕ degree
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
0.00	-	-	-	Clayey Silt with Sand	12.34	65.66	18.36	2.33	0.34	0.97	0.00	26	16	10	-	-	-	-	-	-
1.50	11	1.46	16.06	Clayey Silt with Sand	14.95	56.49	28.22	0.34	0.00	0.00	0.00	26	14	12	-	-	-	-	-	-
2.50				Sandy Silt	2.67	66.73	16.39	10.95	3.26	0.00	0.00	22	NIL	NP						
3.00	UDS	-	-	Silty Sand	3.99	13.84	63.82	17.66	0.05	0.64	0.00	24	NIL	NP	1.69	3.98	1.63	2.60	0.00	27.50
4.55				Silty Sand	2.15	9.93	75.69	10.33	1.21	0.69	0.00	21	NIL	NP						
6.00	22	1.00	22.00	Silty Sand	3.67	6.14	71.03	13.92	1.75	3.49	0.00	23	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand	2.99	23.84	65.66	6.22	1.29	0.00	0.00	21	NIL	NP	1.76	4.66	1.68	2.63	0.00	28.50
12.00	31	0.76	23.56	Silty Sand	1.21	5.28	87.53	5.98	0.00	0.00	0.00	28	NIL	NP	-	-	-	-	-	-

BORELOG OF BH–1(LHS) AT EXISTING KM–345/4–6 FOR MINOR BRIDGE NO.–376,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	SANDY SILT
	SILTY SAND

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 345/4-6 BH-1

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Continuous Strip | **1**

Angle of internal friction (ϕ °)	21.00
Cohesion (c in t/m2)	1.00
Void ratio (e)	0.59
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.69
Density of foundation soil (t/m^3)	1.69
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)
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	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)	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	1.36	1.18	1.18

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 shea	Local shear	Actual
1	1.50	1.20	13.57	5.95	12.04

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 345/4-6 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)	0.59
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.69
Density of foundation soil (t/m^3)	1.69
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)
1	3.00	1.20
2	4.50	1.20
3	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 $\phi < 10°$

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)*SQRT(N_\phi)$ 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	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
2	1.20	1.00	1.00	1.00
3	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
2	4.50	1.20	2.24	1.62	1.62
3	6.00	1.20	2.65	1.82	1.82

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
2	4.50	1.20	-2.50	0.50
3	6.00	1.20	-3.75	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shea	Local shear	Actual
1	3.00	1.20	16.89	5.98	14.70
2	4.50	1.20	19.35	6.85	16.85
3	6.00	1.20	21.81	7.72	18.99

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ANNEXURE - IV

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

BH No. (A1)			**Minor bridge at Ch. 345 (4-6)**	
Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	1.2	m
Initial effective stress at mid of layer	Po	=	6	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	=	0.22	
	ΔP	=	2.6	t/m^2
Compression Index	Cc	=	0.1	
Thickness of clay layer	H	=	1	m
Initial Void ratio	e_o	=	0.6	
	$\frac{Po + \Delta p}{Po}$	=	1.44	

Settlement of clay layer

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

S_f = 0.0099 m

= 9.89766 mm

Correction for Depth and Rigidity of foundation on total settlement

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 6.67

Depth Factor = 0.78

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

= 0.80

Pore Pressure correction = 0.85

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

S_{f2} = **5.2** **mm**

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

Footing Depth (m)	**1.50**
SBC (t/m2)	2.52
Average N value	18.00
Settlement for 10 t/m2 (mm)	13.00
Total Settlement (mm)	3.28
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**1.8**

Total settlement (mm) - - 7.0 2973

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Minor Bridge No. 376A
Chainage	345/4-6
Bore Hole No.	1

Footing Depth (m)	3.00
SBC (t/m2)	14.50
Average N value	21.00
Settlement for 10 t/m2 (mm)	14.00
Total Settlement (mm)	20.30
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	13.5

Footing Depth (m)	4.50
SBC (t/m2)	17.00
Average N value	22.00
Settlement for 10 t/m2 (mm)	13.00
Total Settlement (mm)	22.10
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	13.1

Footing Depth (m)	6.00
SBC (t/m2)	19.00
Average N value	23.00
Settlement for 10 t/m2 (mm)	12.00
Total Settlement (mm)	22.80
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	12.4

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CHAPTER – 09

"Minor Bridge No. 374",

Location – Existing Km. - 341/03-05

2981

9.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge No. 374 at Chainage 341/3-5

9.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table ≥16.00m 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	Medium Dense
	3.00 to 12.00	Silty Sand	Medium Dense

9.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.10	NIL	0.0016	NIL	0.0011	0.022

9.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

9.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	11.00
	3.00	12.50
	4.50	18.00
	6.00	20.50

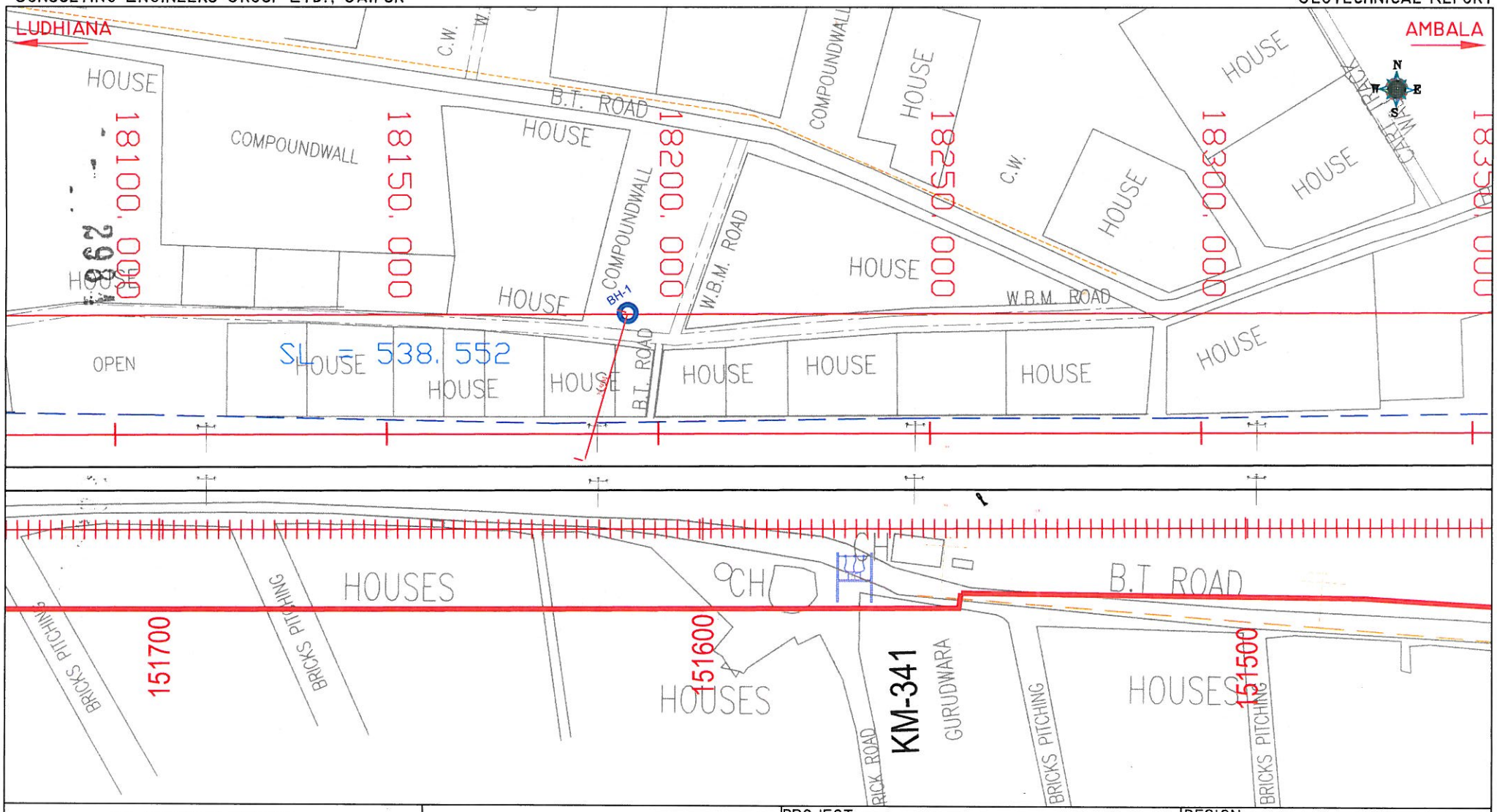
9.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

9.7 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 4.50m 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. 341/3-5	RL OF BH-I = 262.190	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. 374 AT CHAINAGE 341/3-5

Project :	Chainage 341/3-5 Bridge No. 374			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				01.06.2009 to 01.06.2009	1	1(LHS)	below 16.00 m.	12.00mtr	262.190

Depth from GL (m)	Observed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel										c kg/cm^2	ϕ degree
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
0.00	-	-	-	Sandy Silt with Clay	9.36	72.67	10.36	2.29	1.11	4.21	0.00	30	23	7	-	-	-	-	-	-
1.50	9	1.45	13.05	Sandy Silt	4.62	51.44	33.38	2.75	3.52	4.29	0.00	28	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt	2.23	77.94	13.26	2.36	1.00	3.21	0.00	27	NIL	NP	1.74	5.69	1.65	2.64	0.00	26.50
3.60	-			Silty Sand	3.50	12.43	70.23	10.25	3.01	0.58	0.00	25	NIL	NP						
6.00	19	0.99	18.81	Silty Sand	3.21	9.87	81.45	4.12	1.11	0.24	0.00	26	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand	2.98	12.64	76.39	5.21	2.10	0.68	0.00	25	NIL	NP	1.79	6.69	1.68	2.67	0.00	28.00
12.00	28	0.75	21.00	Silty Sand	2.29	16.60	73.99	6.27	0.85	0.00	0.00	24	NIL	NP	-	-	-	-	-	-

DFCCIL *KESARI TO SANEHWAL*

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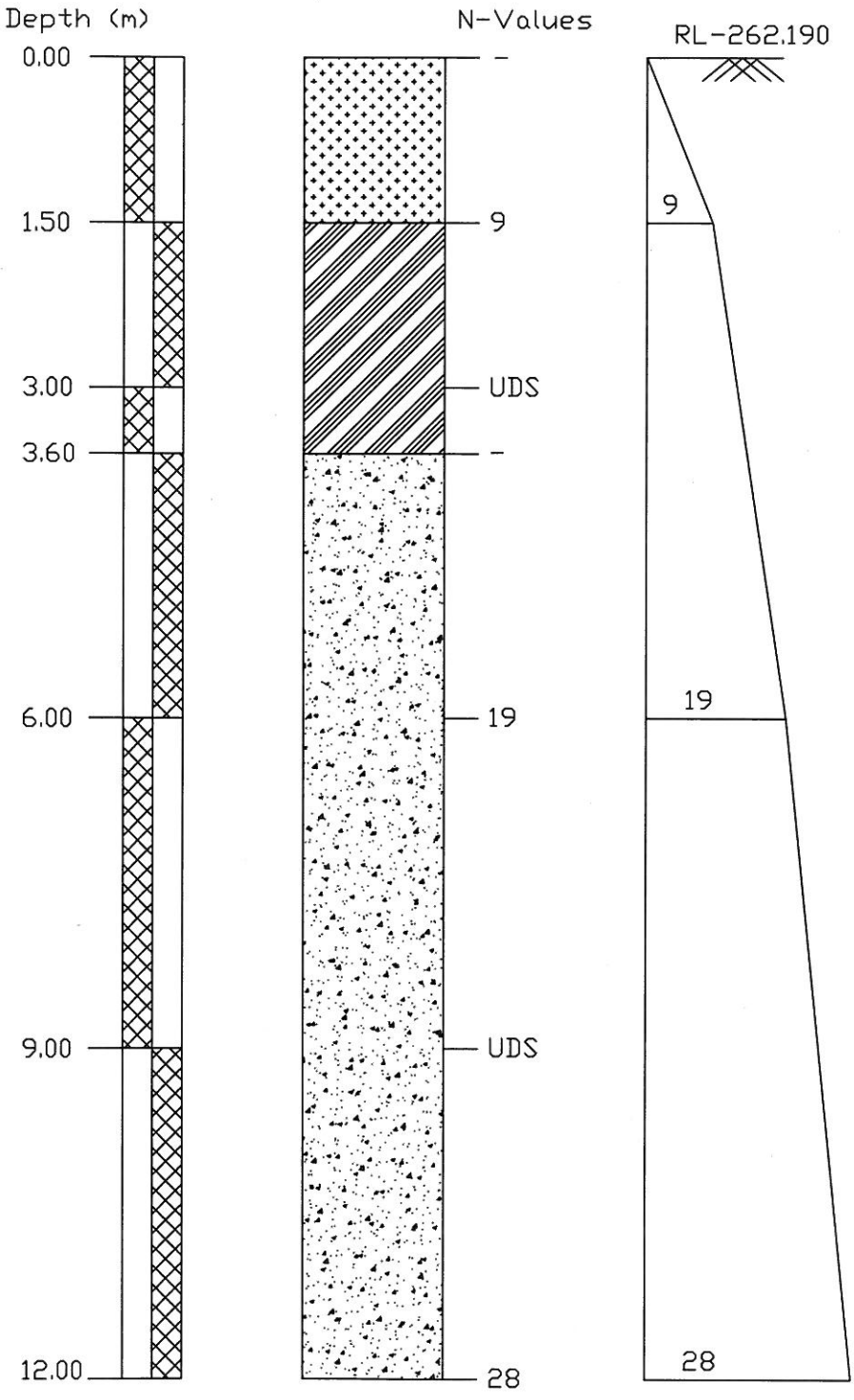
BORELOG OF BH–1(LHS) AT EXISTING KM–341/3–5 FOR MINOR BRIDGE NO.–374,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT WITH CLAY
	SANDY SILT
	SILTY SAND

2986

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 341/3-5 BH-1

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Continuous Strip | **1**

Angle of internal friction (ϕ°)	26.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.60
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.74
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.50
N_c	23.55
N_q	12.98
N_γ	14.34

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	1.20	1.40	1.20	1.20
2	3.00	1.20	1.81	1.40	1.40

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shea	Local shear	Actual
1	1.50	1.20	12.79	4.75	10.78
2	3.00	1.20	14.94	5.55	12.59

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 341/3-5 BH-1

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Continuous Strip | 1

Angle of internal friction (ϕ°)	28.00
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)	1.70
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)
1	4.50	1.20
2	6.00	1.20

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	28.00
N_c	26.37
N_q	15.30
N_γ	17.79

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

Shape factors :

S.no.	Width(m)	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	2.25	1.62	1.62
2	6.00	1.20	2.66	1.83	1.83

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shea	Local shear	Actual
1	4.50	1.20	20.97	7.26	18.23
2	6.00	1.20	23.66	8.18	20.56

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2990

ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Minor Bridge No. 374
Chainage	341/3-5

Footing Depth (m)	1.50
SBC (t/m2)	11.00
Average N value	15.00
Settlement for 10 t/m2 (mm)	20.00
Total Settlement (mm)	22.00
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	16.0

Footing Depth (m)	3.00
SBC (t/m2)	12.50
Average N value	17.50
Settlement for 10 t/m2 (mm)	17.00
Total Settlement (mm)	21.25
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	14.1

Footing Depth (m)	4.50
SBC (t/m2)	18.00
Average N value	18.74
Settlement for 10 t/m2 (mm)	16.00
Total Settlement (mm)	28.80
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	17.0

Footing Depth (m)	6.00
SBC (t/m2)	20.50
Average N value	19.63
Settlement for 10 t/m2 (mm)	15.50
Total Settlement (mm)	31.78
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	17.3

2991

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CHAPTER – 10

"Minor Bridge No. 372",

Location – Existing Km. - 340/07-09

10.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 1x3.05

10.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

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

Subsurface profile at the site

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

10.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.70	0.005	0.0014	NIL	0.0011	0.026
	9.00	8.60	0.002	0.0021	NIL	0.0012	0.037

10.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

105 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	12.50
	3.00	17.00
	4.50	19.00
	6.00	20.50

10.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

10.7 RECOMMENDATIONS

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

2993

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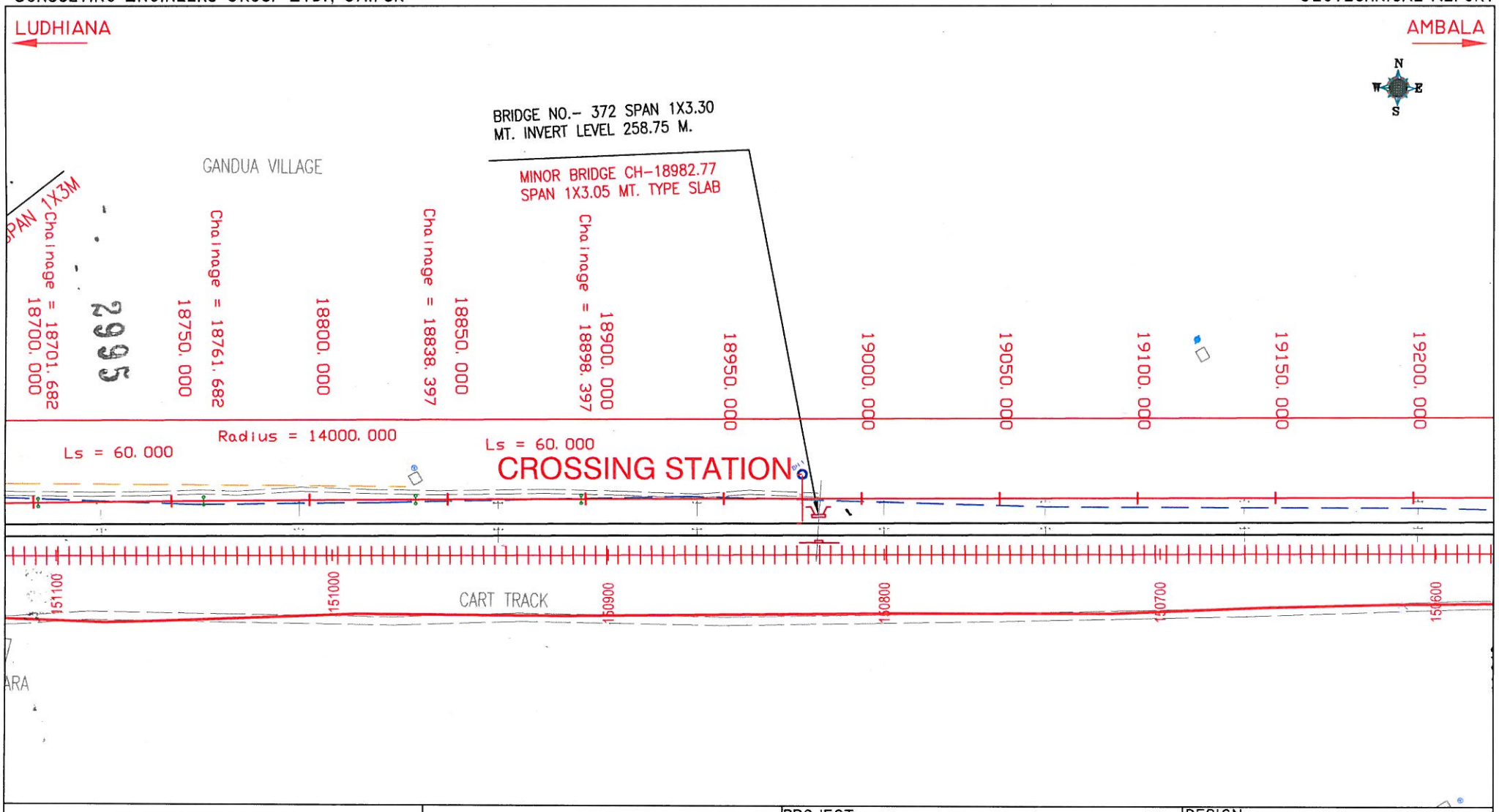
Note- The above recommendations are based on the field and laboratory tests conducted on the soil, and our experience in this regard. If the actual subsoil conditions during excavation for the foundation differ from the observations reported here, the design experts/consultants should be referred for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



ALL DIMENSIONS IN METER			
FIG.:-I LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 340/7-9	RL OF BH-I = 258.862	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. 372 AT CHAINAGE 340/7-9

Project :	Chainage 340/7-9 Bridge No. 372			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				01.06.2009 to 01.06.2009	1	1(LHS)	below 18.00 m.	12.00mtr	258.862

Depth from	Observed	Correction Factor	Corrected	Soil Description	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel									c kg/cm^2	ϕ
							Fine	Medium	Coarse	Fine	Coarse									
GL (m)	N	C_n	N_n	(Soil Group)								L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Sandy Silt with clay	10.29	59.03	19.68	8.66	1.39	0.95	0.00	29	21	8	-	-	-	-	-	-
1.50	8	1.45	11.60	Silty Sand	3.35	17.64	78.40	0.61	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	0.00	6.97	90.37	2.60	0.06	0.00	0.00	27	NIL	NP	1.72	4.85	1.64	2.66	0.00	27.50
6.00	17	0.99	16.83	Silty Sand	2.10	5.54	88.88	3.33	0.15	0.00	0.00	28	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand	1.59	5.10	91.52	1.79	0.00	0.00	0.00	28	NIL	NP	1.78	5.36	1.69	2.67	0.00	28.50
12.00	30	0.75	22.50	Silty Sand	1.68	5.26	89.82	3.24	0.00	0.00	0.00	28	NIL	NP	-	-	-	-	-	-

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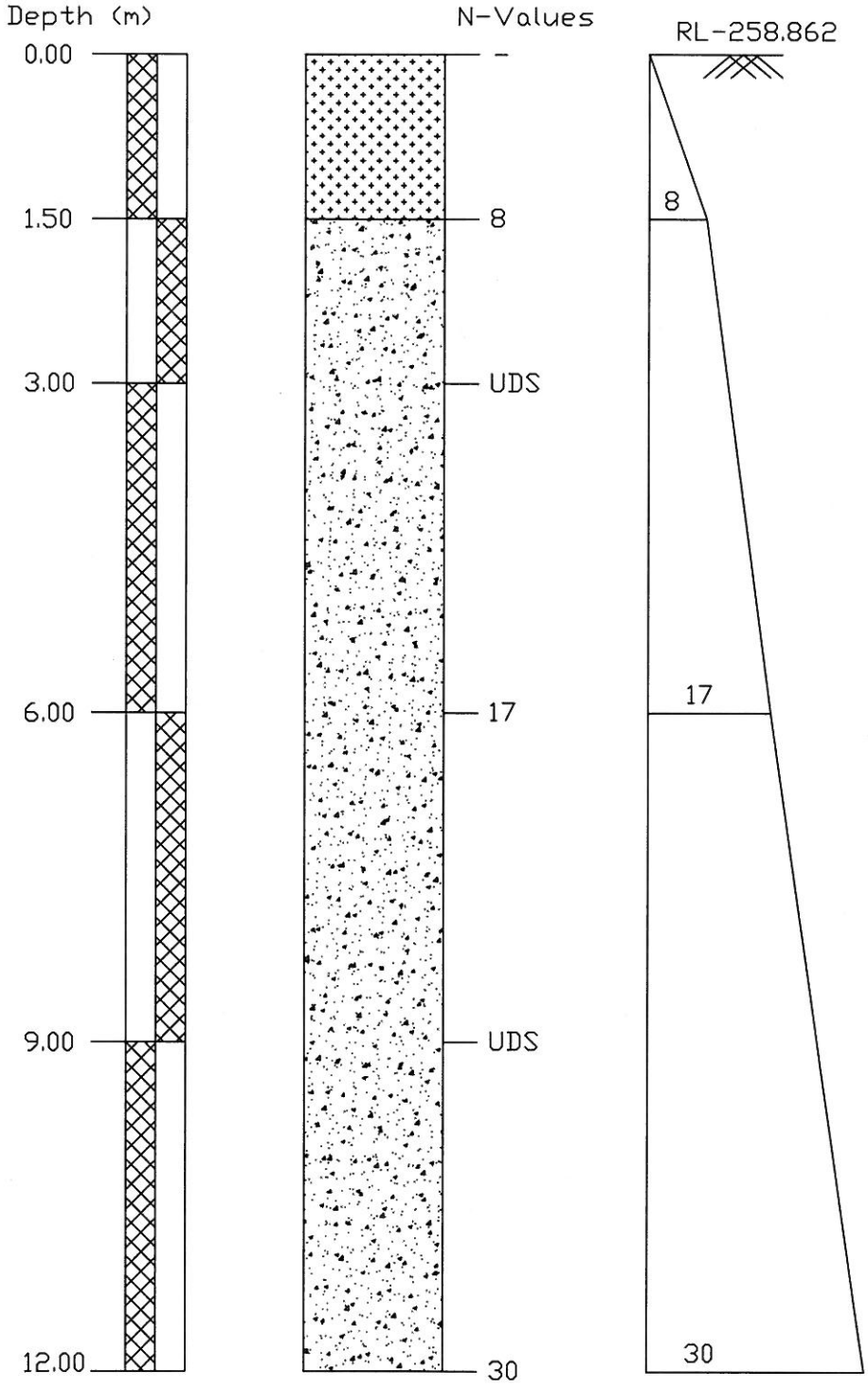
BORELOG OF BH–1(LHS) AT EXISTING KM–340/7–9 FOR MINOR BRIDGE NO.–372,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT WITH CLAY
	SILTY SAND

2997

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 340/7-9 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)	0.62
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.72
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Actual Depth	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	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
3	3.00	8.00	1.08	1.08	0.85
4	3.00	8.00	1.08	1.08	0.85

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.16	1.08	1.08
2	3.00	3.00	1.33	1.16	1.16
3	4.50	3.00	1.49	1.25	1.25
4	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	1.50	3.00	0.00	0.50
2	3.00	3.00	-0.50	0.50
3	4.50	3.00	-1.00	0.50
4	6.00	3.00	-1.50	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	19.96	6.93	15.40
2	3.00	3.00	8.00	35.88	12.80	27.81
3	4.50	3.00	8.00	38.42	13.71	29.77
4	6.00	3.00	8.00	40.96	14.61	31.74

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2999

ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Minor Bridge No. 372
Chainage	340/7-9
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	12.50
Average N value	13.30
Settlement for 10 t/m2 (mm)	22.00
Total Settlement (mm)	27.50
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	20.0

Footing Depth (m)	3.00
SBC (t/m2)	17.00
Average N value	15.87
Settlement for 10 t/m2 (mm)	20.00
Total Settlement (mm)	34.00
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	22.6

Footing Depth (m)	4.50
SBC (t/m2)	19.00
Average N value	17.46
Settlement for 10 t/m2 (mm)	18.00
Total Settlement (mm)	34.20
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	20.2

Footing Depth (m)	6.00
SBC (t/m2)	20.50
Average N value	18.96
Settlement for 10 t/m2 (mm)	16.00
Total Settlement (mm)	32.80
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	17.8

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CHAPTER – 11

"Minor Bridge No. 371",

Location – Existing Km. - 338/03-05

11.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 1x3.05

11.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table ≥17.00m below EGL.

Subsurface profile at the site

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

11.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.60	0.002	0.0021	NIL	0.0013	0.040

11.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

11.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	13.00
	3.00	20.00
	4.50	23.00
	6.00	25.00

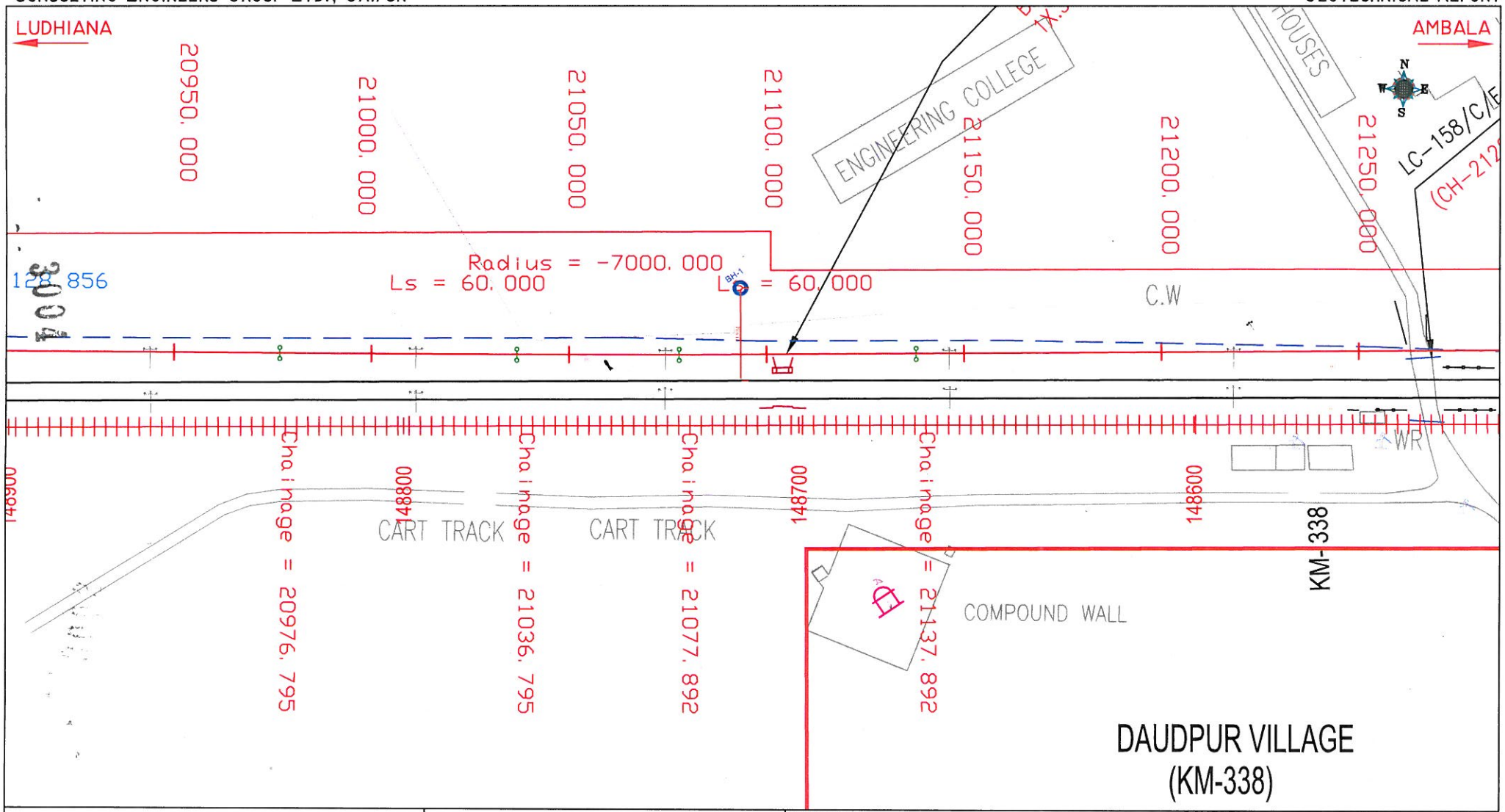
11.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

11.7 RECOMMENDATIONS

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

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



ALL DIMENSIONS IN METER

FIG.:-I
LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 338/3-5

RL OF BH-I = 260.302

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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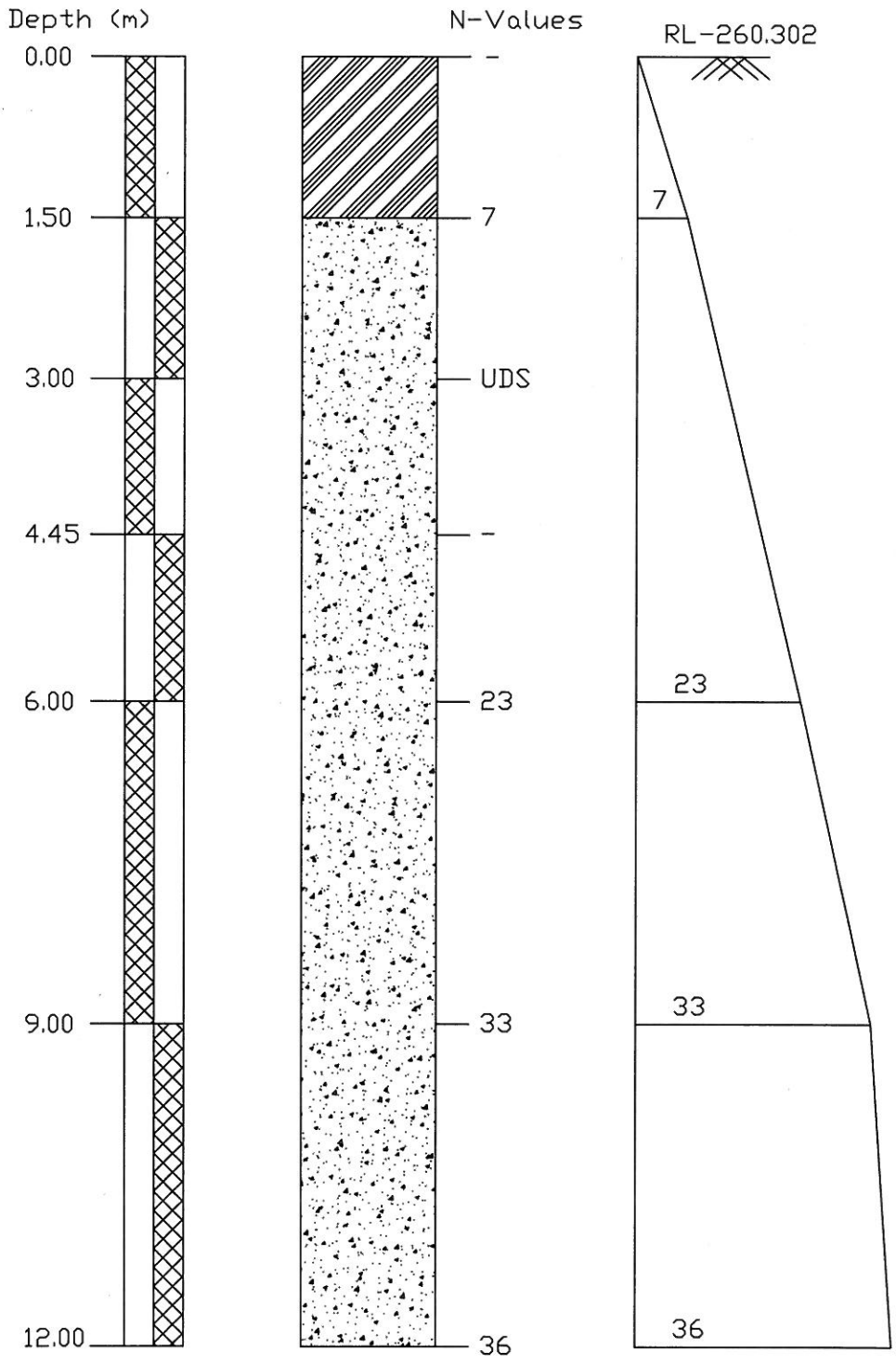
SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 371 AT CHAINAGE 338/3-5

Project :	Chainage 338/3-5 Bridge No. 371			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				02.06.2009 to 02.06.2009	1	1(LHS)	below 17.00 m.	12.00mtr	260.302

Depth from GL (m)	Observed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel										c kg/cm^2	ϕ degree
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
0.00	-	-	-	Sandy Silt	3.22	54.83	26.39	13.25	1.21	1.10	0.00	22	NIL	NP	-	-	-	-	-	-
1.50	7	1.46	10.22	Silty Sand	2.69	17.67	76.80	1.66	0.45	0.73	0.00	23	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	2.29	7.42	85.42	2.62	0.29	1.96	0.00	25	NIL	NP	1.68	4.09	1.61	2.67	0.00	27.00
4.45	-	-	-	Silty Sand	2.10	8.60	80.33	5.67	1.95	1.35	0.00	24	NIL	NP						
6.00	23	1.00	23.00	Silty Sand	2.12	7.53	87.73	2.53	0.09	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
9.00	33	0.86	28.38	Silty Sand	2.10	5.96	82.11	8.11	0.85	0.87	0.00	25	NIL	NP					-	-
12.00	36	0.77	27.72	Silty Sand	3.57	5.21	86.17	3.93	0.39	0.73	0.00	26	NIL	NP	-	-	-	-	-	-

BORELOG OF BH–1(LHS) AT EXISTING KM–338/3–5 FOR MINOR BRIDGE NO.–371,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT
	SILTY SAND

3006

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 338/3-5 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)	0.66
Direction of load with vertical (^{o})	0.00
Density of surcharge (t/m^3)	1.68
Density of foundation soil (t/m^3)	1.68
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	27.00
N_c	24.49
N_q	13.76
N_γ	15.49

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

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	18.44	6.56	11.90
2	3.00	3.00	8.00	33.23	12.13	21.62
3	4.50	3.00	8.00	35.56	12.98	23.14
4	6.00	3.00	8.00	37.89	13.83	24.66

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Minor Bridge No. 371
Chainage	338/3-5
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	12.00
Average N value	14.48
Settlement for 10 t/m2 (mm)	21.00
Total Settlement (mm)	25.20
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	18.3

Footing Depth (m)	3.00
SBC (t/m2)	20.00
Average N value	18.74
Settlement for 10 t/m2 (mm)	16.00
Total Settlement (mm)	32.00
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	21.2

Footing Depth (m)	4.50
SBC (t/m2)	23.00
Average N value	22.47
Settlement for 10 t/m2 (mm)	14.00
Total Settlement (mm)	32.20
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	19.1

Footing Depth (m)	6.00
SBC (t/m2)	25.00
Average N value	25.69
Settlement for 10 t/m2 (mm)	11.50
Total Settlement (mm)	28.75
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	15.6

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CHAPTER – 12

"Minor Bridge No. 370",

Location – Existing Km. - 336/20-22

12.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 1x3.05

12.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table 2.10m below EGL.

Subsurface profile at the site

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

12.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	9.00	0.017	0.0018	NIL	0.0011	0.025

12.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

12.5 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	85	95	163	796	0.4	3.0	989	632
Permissible limit as per IS 456/ Morth	Not less then 6.0	2000 for CC and 500 for RCC	400	200	3000	5 ml of 0.02 normal NaoH	25 ml of 0.02 normal H_2SO_4	-	-

3011

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12.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	7.50
	3.00	16.00
	4.50	19.00
	6.00	21.00

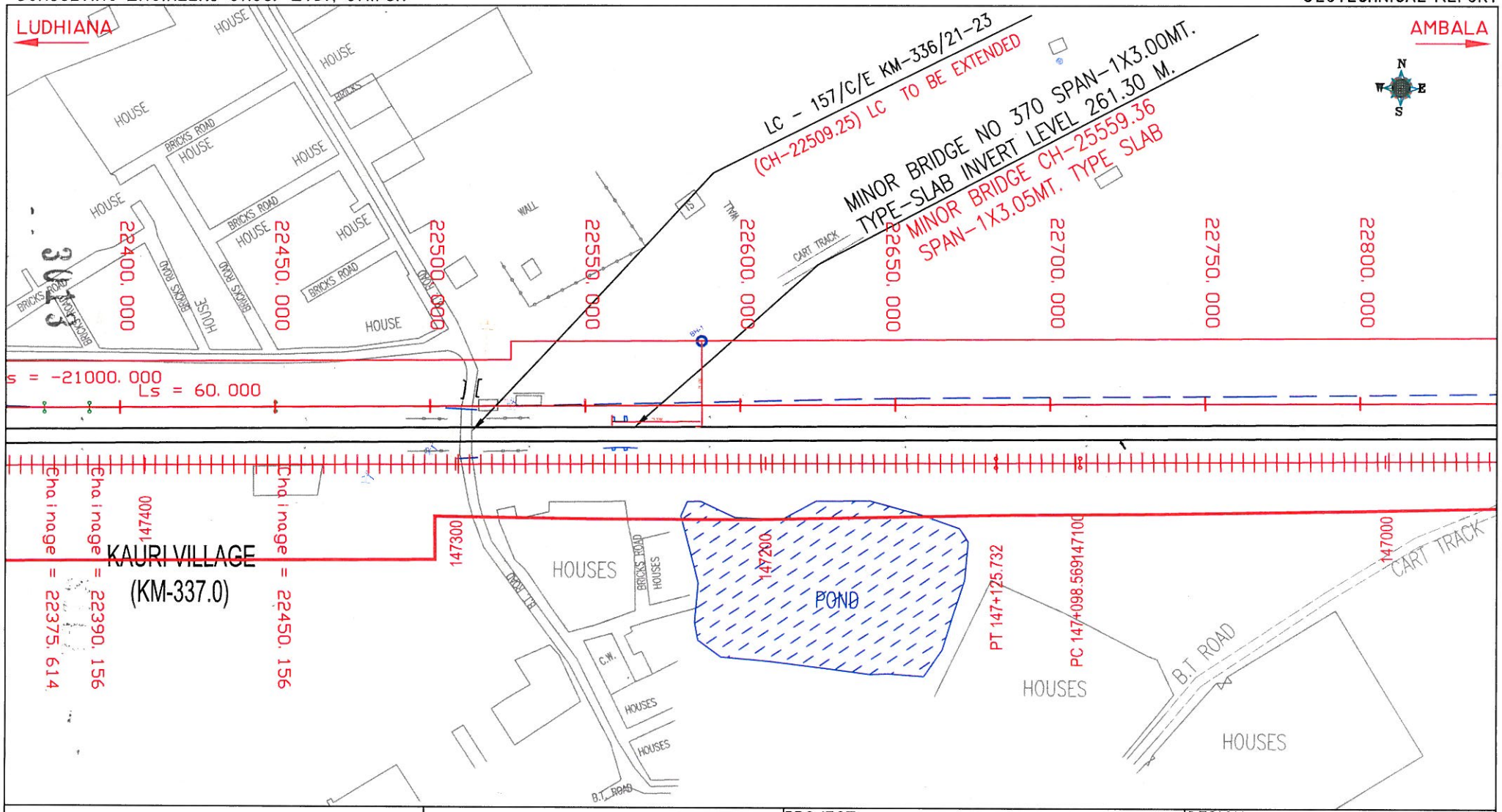
12.7 CONCLUSIONS

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

12.8 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 3.00 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. 336/20-22	RL OF BH-I = 262.054	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. 370 AT CHAINAGE 336/20-22

Project :	Chainage 336/20-22 Bridge No. 370			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				02.06.2009 to 02.06.2009	1	1(LHS)	below 2.00 m.	12.00mtr	262.054

Depth from GL (m)	Observed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel										c kg/cm^2	ϕ degree
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
0.00	-	-	-	Sandy Silt	4.59	52.49	30.51	10.22	1.68	0.51	0.00	22	NIL	NP	-	-	-	-	-	-
1.50	4	1.45	5.80	Silty Sand	3.10	16.53	74.68	4.91	0.37	0.41	0.00	22	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand with Gravels	2.20	35.60	45.66	5.15	1.50	5.86	4.03	25	NIL	NP	1.74	5.44	1.65	2.65	0.00	27.50
6.00	19	0.99	16.91	Silty Sand	1.95	5.78	80.36	11.06	0.22	0.63	0.00	25	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand	2.42	8.40	86.87	2.31	0.00	0.00	0.00	26	NIL	NP	1.95	12.72	1.73	2.64	0.00	28.50
12.00	42	0.74	23.04	Silty Sand	2.28	5.30	86.56	5.72	0.14	0.00	0.00	25	NIL	NP	-	-	-	-	-	-

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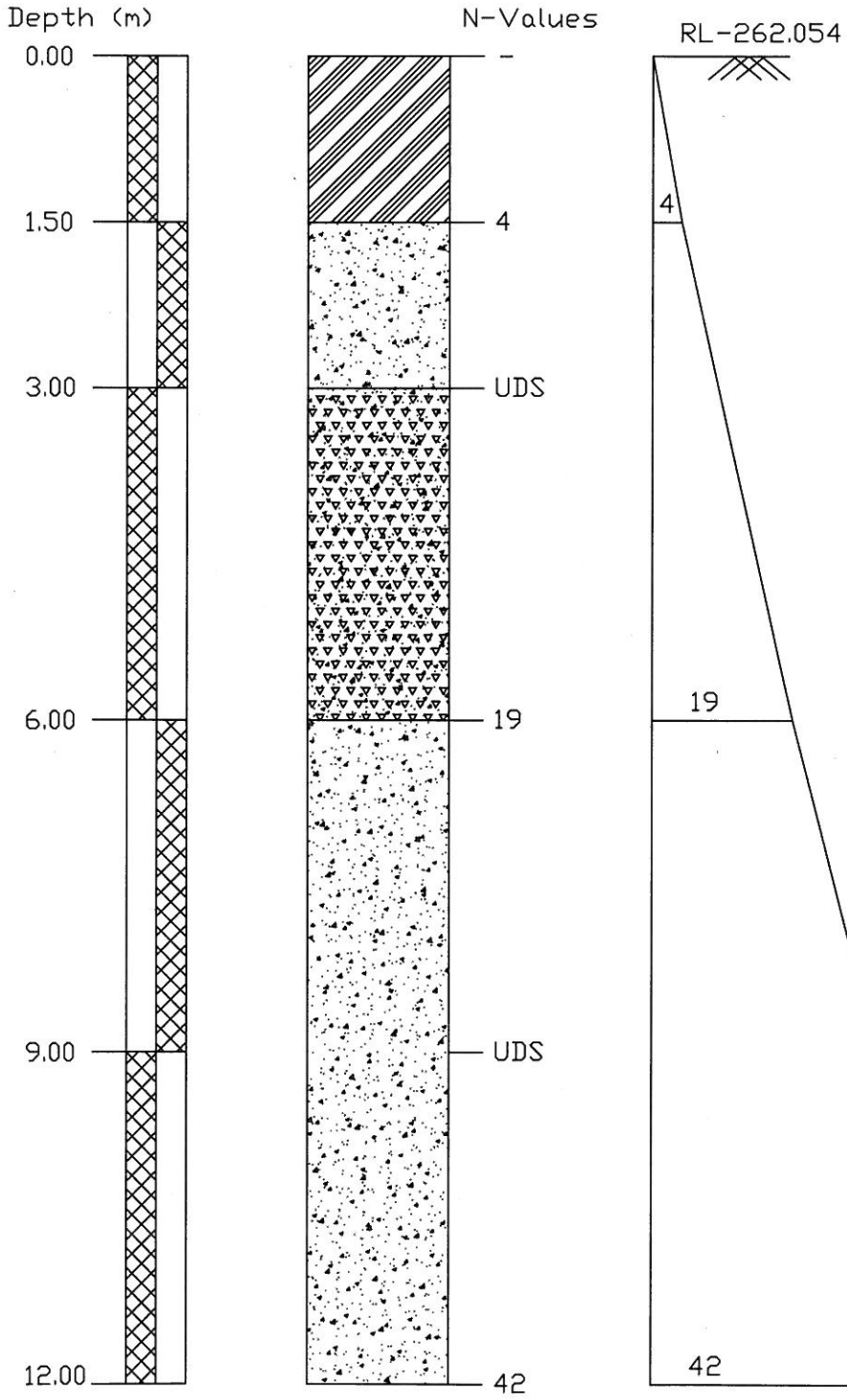
BORELOG OF BH–1(LHS) AT EXISTING KM–336/20–22 FOR MINOR BRIDGE NO.–370, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT
	SILTY SAND
	SILTY SAND WITH GRAVELS

3015

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 336/20 BH-1

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Rectangular **2**

Angle of internal friction (ϕ °)	27.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.60
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.74
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.

3016

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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
3	3.00	8.00	1.08	1.08	0.85
4	3.00	8.00	1.08	1.08	0.85

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.16	1.08	1.08
2	3.00	3.00	1.33	1.16	1.16
3	4.50	3.00	1.49	1.25	1.25
4	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	1.50	3.00	0.00	0.50
2	3.00	3.00	-0.50	0.50
3	4.50	3.00	-1.00	0.50
4	6.00	3.00	-1.50	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	20.04	6.95	16.77
2	3.00	3.00	8.00	35.97	12.83	30.18
3	4.50	3.00	8.00	38.51	13.73	32.32
4	6.00	3.00	8.00	41.06	14.64	34.45

3017

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Minor Bridge No. 370
Chainage	336/20-22
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	7.50
Average N value	9.55
Settlement for 10 t/m2 (mm)	37.00
Total Settlement (mm)	27.75
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	20.2

Footing Depth (m)	3.00
SBC (t/m2)	16.00
Average N value	14.51
Settlement for 10 t/m2 (mm)	21.00
Total Settlement (mm)	33.60
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	22.3

Footing Depth (m)	4.50
SBC (t/m2)	19.00
Average N value	17.10
Settlement for 10 t/m2 (mm)	18.00
Total Settlement (mm)	34.20
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	20.2

Footing Depth (m)	6.00
SBC (t/m2)	21.00
Average N value	19.20
Settlement for 10 t/m2 (mm)	16.00
Total Settlement (mm)	33.60
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	18.3

3018

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CHAPTER – 13

"Minor Bridge No. 369A",

Location – Existing Km. - 335/23-25

13.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge of Span 1x 6.10

13.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

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

Subsurface profile at the site

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

13.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.60	0.007	0.0014	NIL	0.0010	0.022
	9.00	8.30	NIL	0.0011	NIL	0.0009	0.012

13.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

13.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	10.00
	3.00	27.00
	4.50	28.00
	6.00	30.00

13.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

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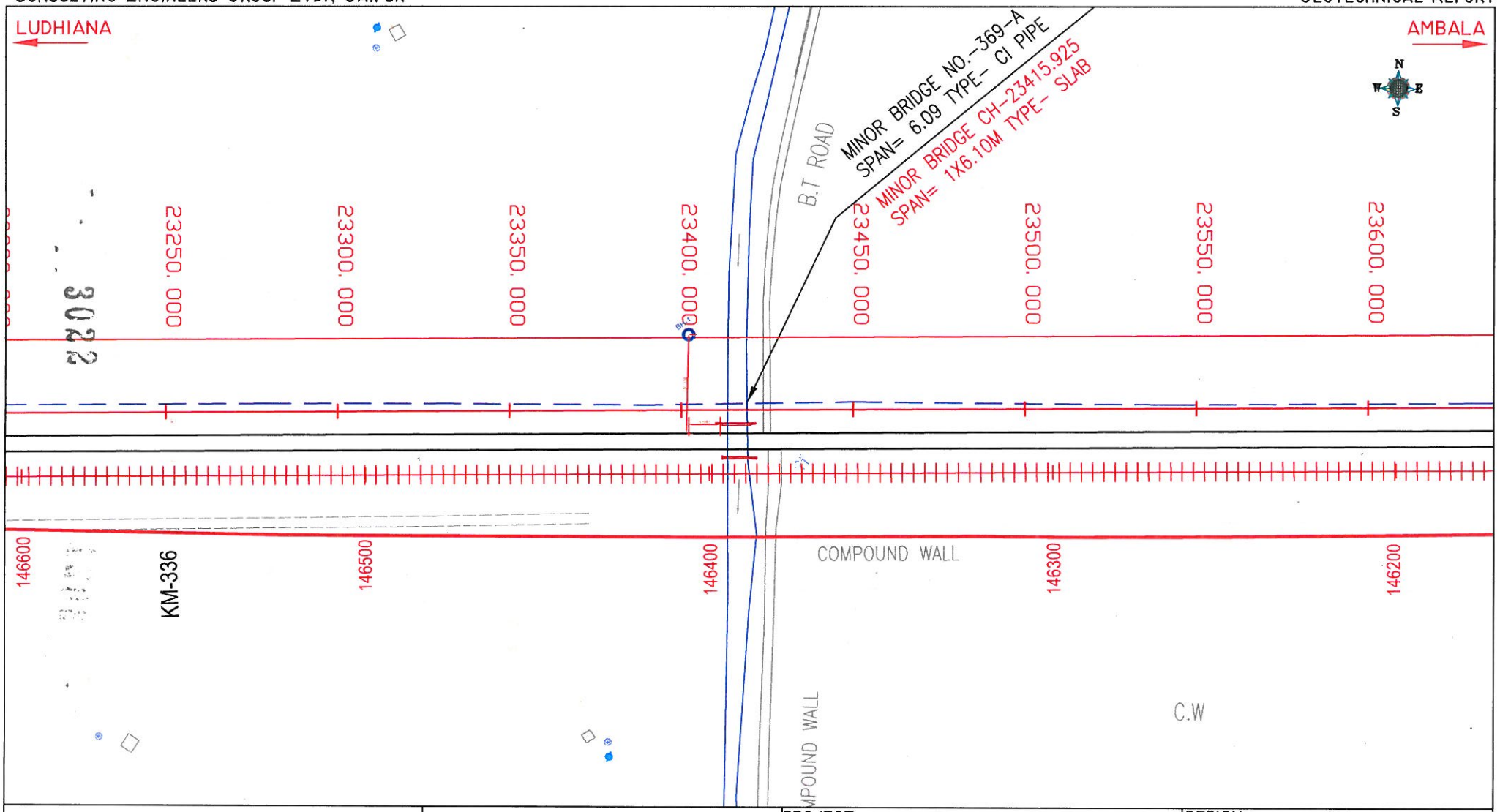
13.7 RECOMMENDATIONS

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

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



ALL DIMENSIONS IN METER

FIG.:-I
LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 335/23-25

RL OF BH-I = 262.366

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. 369-A AT CHAINAGE 335/23-25

Project :	Chainage 335/23-25 Bridge No. 369-A			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				02.06.2009 to 02.06.2009	1	1(LHS)	below 18.00 m.	12.00mtr	262.366

Depth from	Observed	Correction Factor	Corrected	Soil Description	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel									c kg/cm^2	ϕ
							Fine	Medium	Coarse	Fine	Coarse									
GL (m)	N	C_n	N_n	(Soil Group)								L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Sandy Silt with Clay	10.38	64.57	14.26	6.32	2.11	2.36	0.00	23	16	7	-	-	-	-	-	-
1.50	9	1.45	13.05	Sandy Silt with Clay & Gravels	9.22	39.80	20.50	4.00	5.06	21.42	0.00	22	15	7	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	4.21	13.47	81.16	0.83	0.08	0.25	0.00	27	NIL	NP	1.75	4.35	1.68	2.66	0.00	26.00
6.00	37	0.99	36.63	Silty Sand	3.21	14.16	80.85	1.59	0.19	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand with Gravels	3.29	14.49	68.20	2.13	2.70	9.19	0.00	24	NIL	NP	1.84	9.76	1.68	2.67	0.00	28.50
12.00	42	0.75	31.50	Silty Sand	2.21	11.42	81.96	2.95	0.58	0.88	0.00	23	NIL	NP	-	-	-	-	-	-

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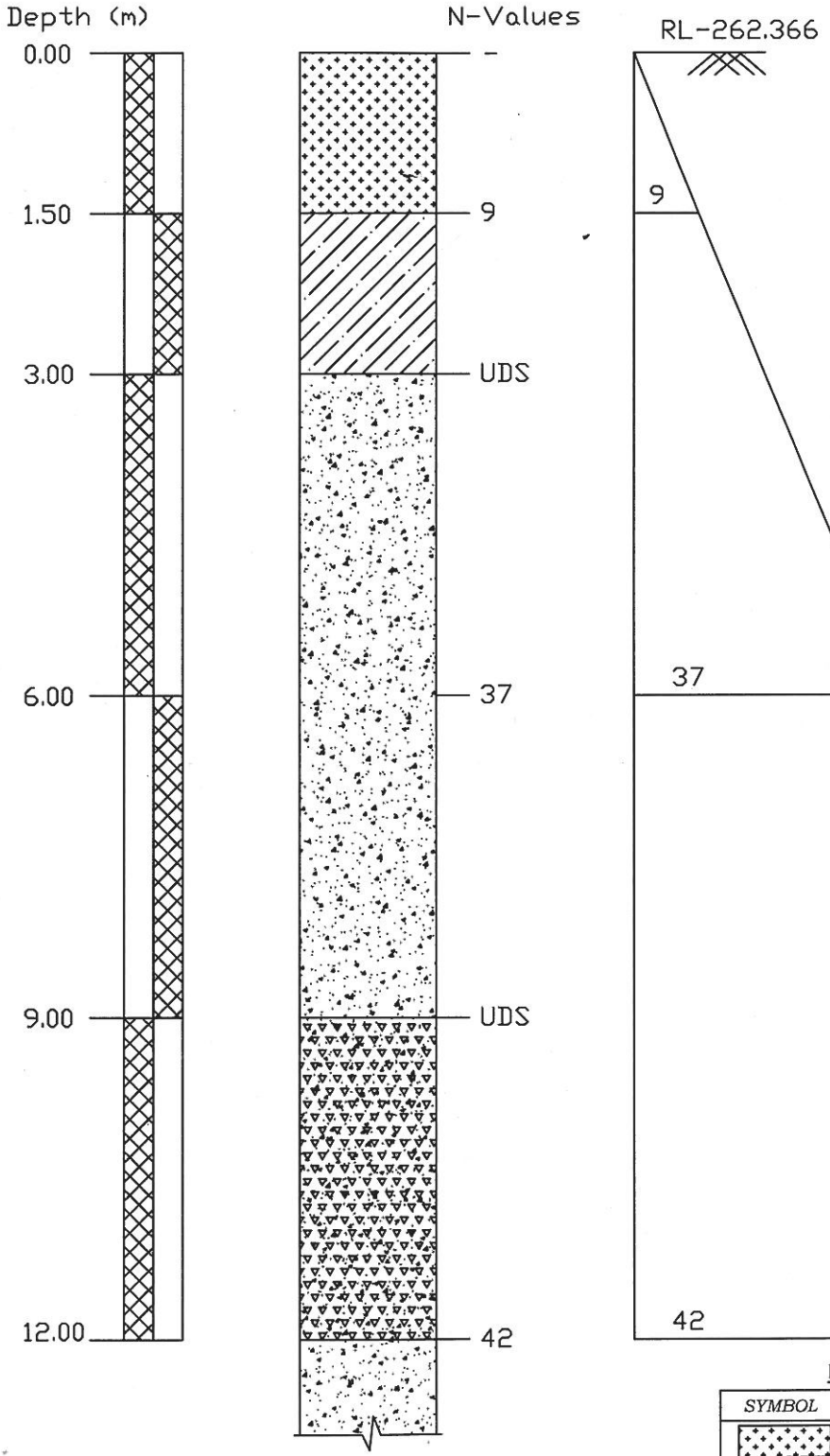
BORELOG OF BH–1(LHS) AT EXISTING KM–335/23–25 FOR MINOR BRIDGE NO.–369A,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

3024

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 335/23-25 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)	0.80
Void ratio (e)	0.67
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

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
N_c	17.19
N_q	8.10
N_γ	7.59

ϕ'	15.15
N'_c	11.09
N'_q	4.01
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

Depth factors :

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

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	15.66	6.48	10.15

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 335/23-25 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)	0.58
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	3.00	3.00	8.00
2	4.50	3.00	8.00
3	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

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

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

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

Where,

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

$d_q = d_\gamma = 1$ for $\phi < 10°$

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.00
N_c	22.60
N_q	12.21
N_γ	13.18

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	3.00	3.00	1.32	1.16	1.16
2	4.50	3.00	1.48	1.24	1.24
3	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	3.00	3.00	-0.50	0.50
2	4.50	3.00	-1.00	0.50
3	6.00	3.00	-1.50	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	3.00	3.00	8.00	29.45	11.34	26.73
2	4.50	3.00	8.00	31.48	12.12	28.58
3	6.00	3.00	8.00	33.51	12.90	30.42

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Minor Bridge No. 369A
Chainage	335/23-25
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	10.00
Average N value	16.98
Settlement for 10 t/m2 (mm)	18.00
Total Settlement (mm)	18.00
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	13.1

Footing Depth (m)	3.00
SBC (t/m2)	27.00
Average N value	24.84
Settlement for 10 t/m2 (mm)	13.20
Total Settlement (mm)	35.64
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	23.7

Footing Depth (m)	4.50
SBC (t/m2)	28.00
Average N value	31.12
Settlement for 10 t/m2 (mm)	8.70
Total Settlement (mm)	24.36
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	14.4

Footing Depth (m)	6.00
SBC (t/m2)	30.00
Average N value	34.07
Settlement for 10 t/m2 (mm)	7.80
Total Settlement (mm)	23.40
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	12.7

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CHAPTER – 14

"Minor Bridge No. 369A1",

Location – Existing Km. - 334/16-18

14.1 LOCATION OF STRUCTURE:

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

14.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table ≥19.00m 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 9.00	Silty Sand	Medium Dense
	9.00 to 12.00	Silty Sand with Gravels	Medium Dense
	Below 12.00	Silty Sand	Medium Dense

14.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.70	0.010	0.0014	NIL	0.0010	0.026

14.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

14.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	8.50
	3.00	20.00
	4.50	23.00
	6.00	25.50

14.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

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14.7 RECOMMENDATIONS

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

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

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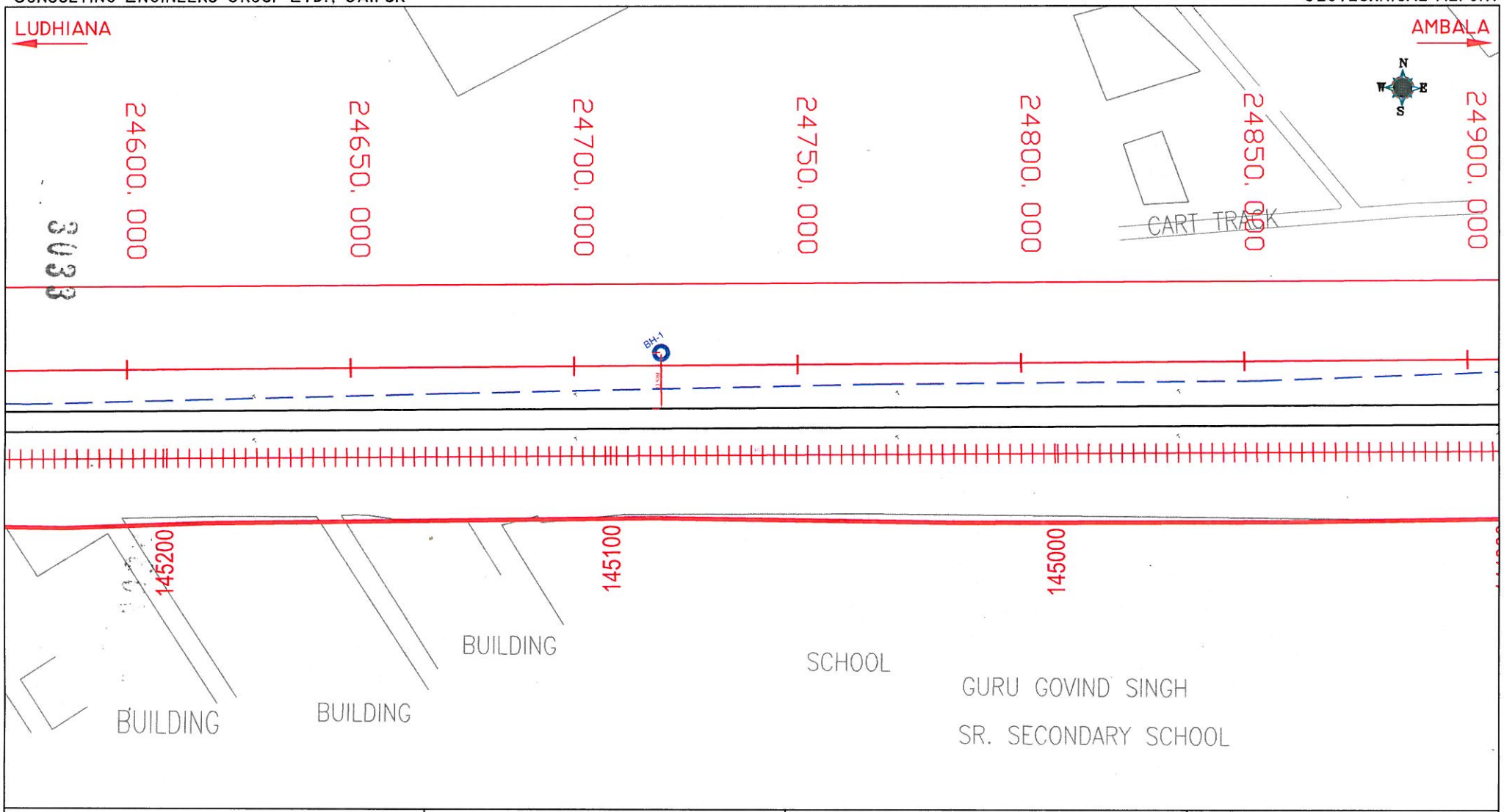

ALL DIMENSIONS IN METER

FIG.:-I

LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 334/16-18

RL OF BH-I = 262.910

PROJECT :-

LUDHIANA-AMBALA (DFCCIL)

DESIGN :-

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ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 369-A AT CHAINAGE 334/16-18

Project :	Chainage 334/16-18 Bridge No. 369-A			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				03.06.2009 to 03.06.2009	1	1(LHS)	below 19.00 m.	12.00mtr	262.910

Depth from GL (m)	Observed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel										c kg/cm^2	ϕ degree
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
0.00	-	-	-	Clayey Silt with Sand	12.39	42.79	30.26	11.36	1.10	2.10	0.00	28	18	10	-	-	-	-	-	-
1.50	11	1.39	15.29	Clayey Silt with Sand	13.29	71.46	9.47	0.76	0.43	4.59	0.00	28	17	11	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	1.21	45.01	43.29	7.57	0.64	2.28	0.00	22	NIL	NP	2.07	11.70	1.85	2.61	0.00	28.50
6.00	24	0.93	22.32	Silty Sand	2.21	14.85	79.44	1.89	0.40	1.21	0.00	24	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand with Gravels	2.33	31.32	49.62	2.03	2.13	12.57	0.00	23	NIL	NP	2.09	12.10	1.86	2.63	0.00	30.00
12.00	39	0.70	27.30	Silty Sand	3.54	9.36	83.40	3.32	0.38	0.00	0.00	25	NIL	NP	-	-	-	-	-	-

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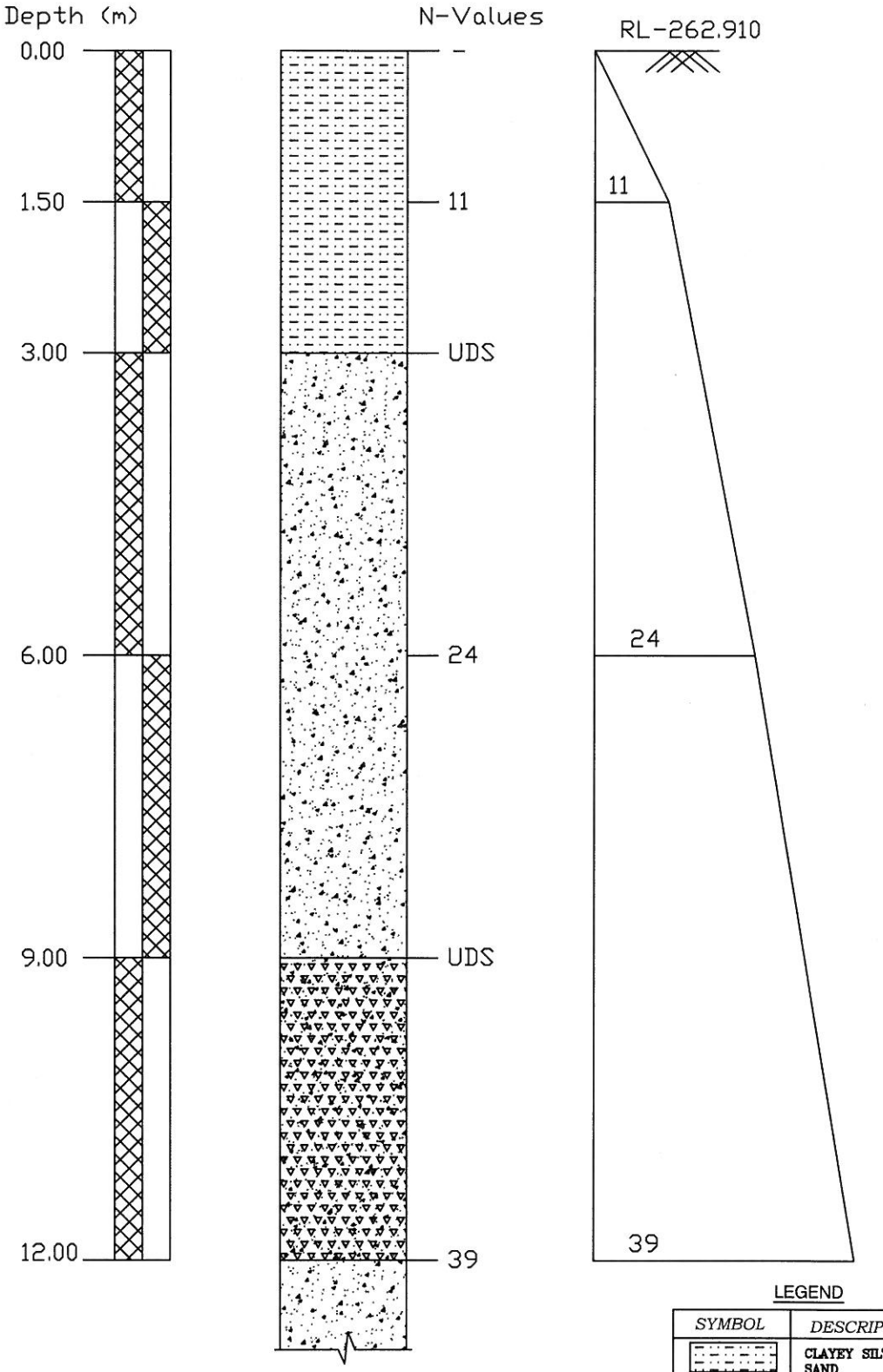
BORELOG OF BH–1(LHS) AT EXISTING KM–334/16–18 FOR MINOR BRIDGE NO.–369 A,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	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 334/16-18 BH-1

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Continuous Strip | 1

Angle of internal friction (ϕ °)	22.00
Cohesion (c in t/m2)	0.13
Void ratio (e)	0.55
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	2.07
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	22.00
N_c	17.19
N_q	8.10
N_γ	7.59

ϕ'	15.15
N'_c	11.09
N'_q	4.01
N'_γ	2.73

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	1.37	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 shea	Local shear	Actual
1	1.50	1.20	8.61	3.54	8.61

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 334/16-18 BH-1

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Continuous Strip | **1**

Angle of internal friction (ϕ°)	28.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.41
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	2.07
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	28.50
N_c	27.31
N_q	16.08
N_γ	18.94

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

Shape factors :

S.no.	Width(m)	S_c	S_q	S_γ
1	1.20	1.00	1.00	1.00
2	1.20	1.00	1.00	1.00
3	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	1.84	1.42	1.42
2	4.50	1.20	2.26	1.63	1.63
3	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	3.00	1.20	-1.25	0.50
2	4.50	1.20	-2.50	0.50
3	6.00	1.20	-3.75	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shea	Local shear	Actual
1	3.00	1.20	20.13	6.79	20.13
2	4.50	1.20	23.11	7.80	23.11
3	6.00	1.20	26.09	8.80	26.09

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

BH No. (A1) — **Minor Bridge at Ch. 334 (16-18)**

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	=	7.5	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	=	0.22	
	ΔP	=	1.9	t/m^2
Compression Index	Cc	=	0.04	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.41	
	$\frac{Po + \Delta p}{Po}$	=	1.2493333	

Settlement of clay layer

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

S_f = 0.004114 m

= 4.1139714 mm

Correction for Depth and Rigidity of foundation on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.31 $(LB)^{\wedge 0.5}/D$ = 3.27

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.80

Pore Pressure correction = 0.85

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

S_{f2} = **2.5** **mm**

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

Footing Depth (m)	**1.50**
SBC (t/m2)	8.50
Average N value	17.00
Settlement for 10 t/m2 (mm)	18.00
Total Settlement (mm)	15.30
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**11.1**

Total settlement (mm) **13.7**

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Minor Bridge No. 369A
Chainage	334/16-18
Bore Hole No.	1

Footing Depth (m)	3.00
SBC (t/m2)	20.00
Average N value	20.00
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	30.00
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**19.9**

Footing Depth (m)	4.50
SBC (t/m2)	23.00
Average N value	21.95
Settlement for 10 t/m2 (mm)	13.80
Total Settlement (mm)	31.74
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**18.8**

Footing Depth (m)	6.00
SBC (t/m2)	25.50
Average N value	23.56
Settlement for 10 t/m2 (mm)	13.00
Total Settlement (mm)	33.15
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**18.0**

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CHAPTER – 15

"Minor Bridge No. 369",

Location – Existing Km. - 333/15-17

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15.1 LOCATION OF STRUCTURE:

Proposed Minor Bridge No. 369 at Chainage 333/15-17

15.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table ≥21.00m 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 2.10	Clayey Silt with Sand	Medium Dense
	2.10 to 6.00	Sandy Silt	Medium Dense
	6.00 to 12.00	Silty Sand	Medium Dense
	Below 12.00	Silty Sand with Gravels	Medium Dense

15.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate	Salinity %
BH-1	3.00	8.60	0.0015	0.0014	NIL	0.0021	0.023

15.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

15.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	7.50
	3.00	16.00
	4.50	18.50
	6.00	21.00

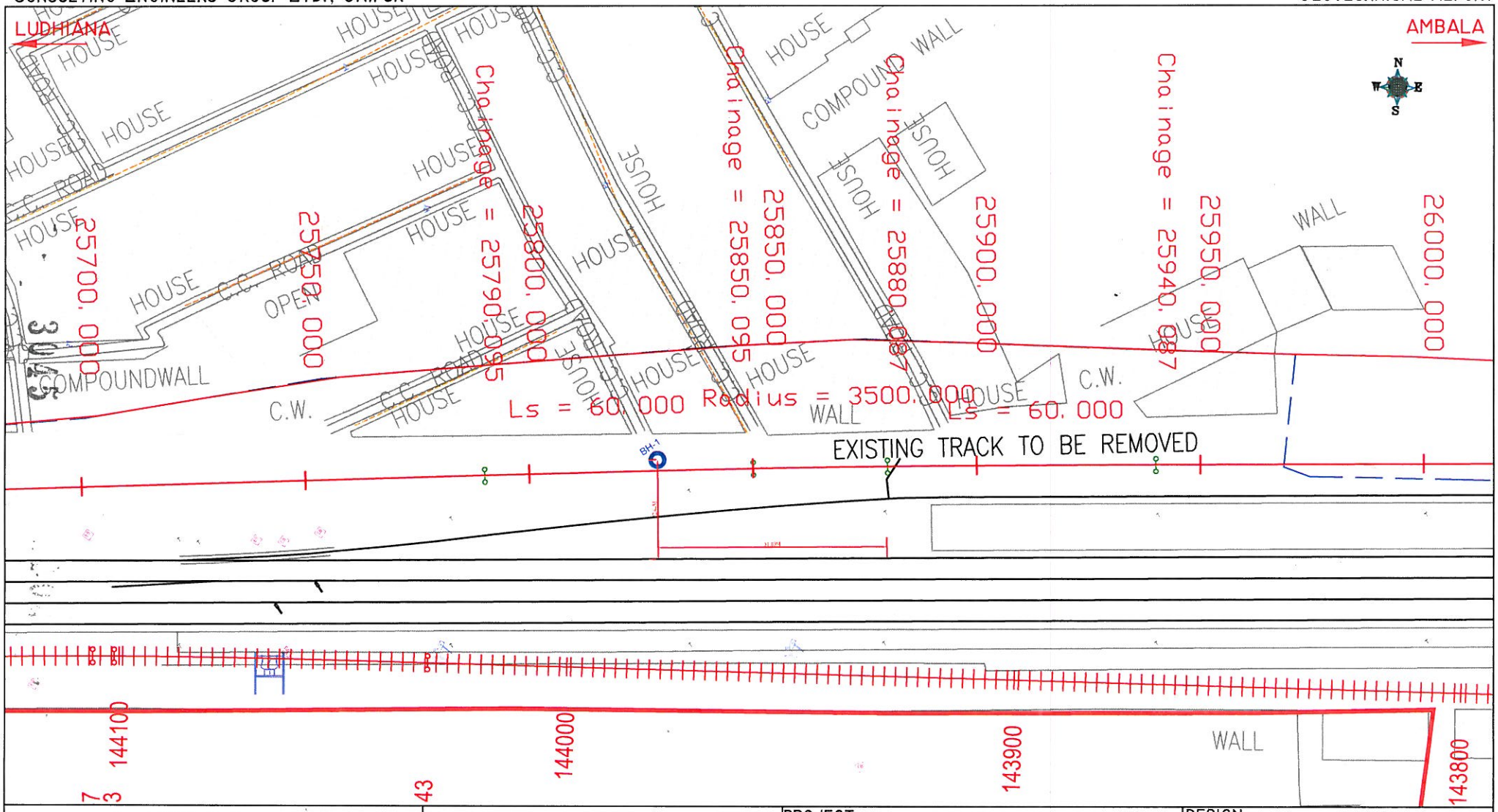
15.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

15.7 RECOMMENDATIONS

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

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



ALL DIMENSIONS IN METER

FIG.:-I

LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 333/15-17

RL OF BH-I = 262.853

PROJECT :-

LUDHIANA-AMBALA (DFCCIL)

DESIGN :-

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ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 369 AT CHAINAGE 333/15-17

Project :	Chainage 333/15-17 Bridge No. 369			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				03.06.2009 to 03.06.2009	1	1(LHS)	below 21.00 m.	12.00mtr	262.853

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	ċ 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	15.23	70.40	10.36	2.36	0.65	1.00	0.00	35	23	12	-	-	-	-	-	-
1.50	13	1.42	18.46	Clayey Silt with Sand	13.22	78.57	6.32	1.23	0.66	0.00	0.00	34	24	10	-	-	-	-	-	-
2.10				Sandy Silt	3.21	67.73	20.39	7.65	1.02	0.00	0.00	26	NIL	NP						
3.00	UDS	-	-	Sandy Silt	2.13	51.18	44.34	0.98	0.35	1.02	0.00	23	NIL	NP	1.89	5.79	1.79	2.65	0.00	27.00
6.00	24	0.96	23.04	Silty Sand	2.59	12.94	79.90	3.86	0.38	0.33	0.00	24	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand	3.25	5.44	87.61	3.42	0.28	0.00	0.00	29	NIL	NP	1.94	6.33	1.82	2.67	0.00	29.00
12.00	28	0.72	20.16	Silty Sand with Gravels	1.68	5.46	81.97	4.11	0.80	5.98	0.00	27	NIL	NP	-	-	-	-	-	-

DFCCIL *KESARI TO SANEHWAL*

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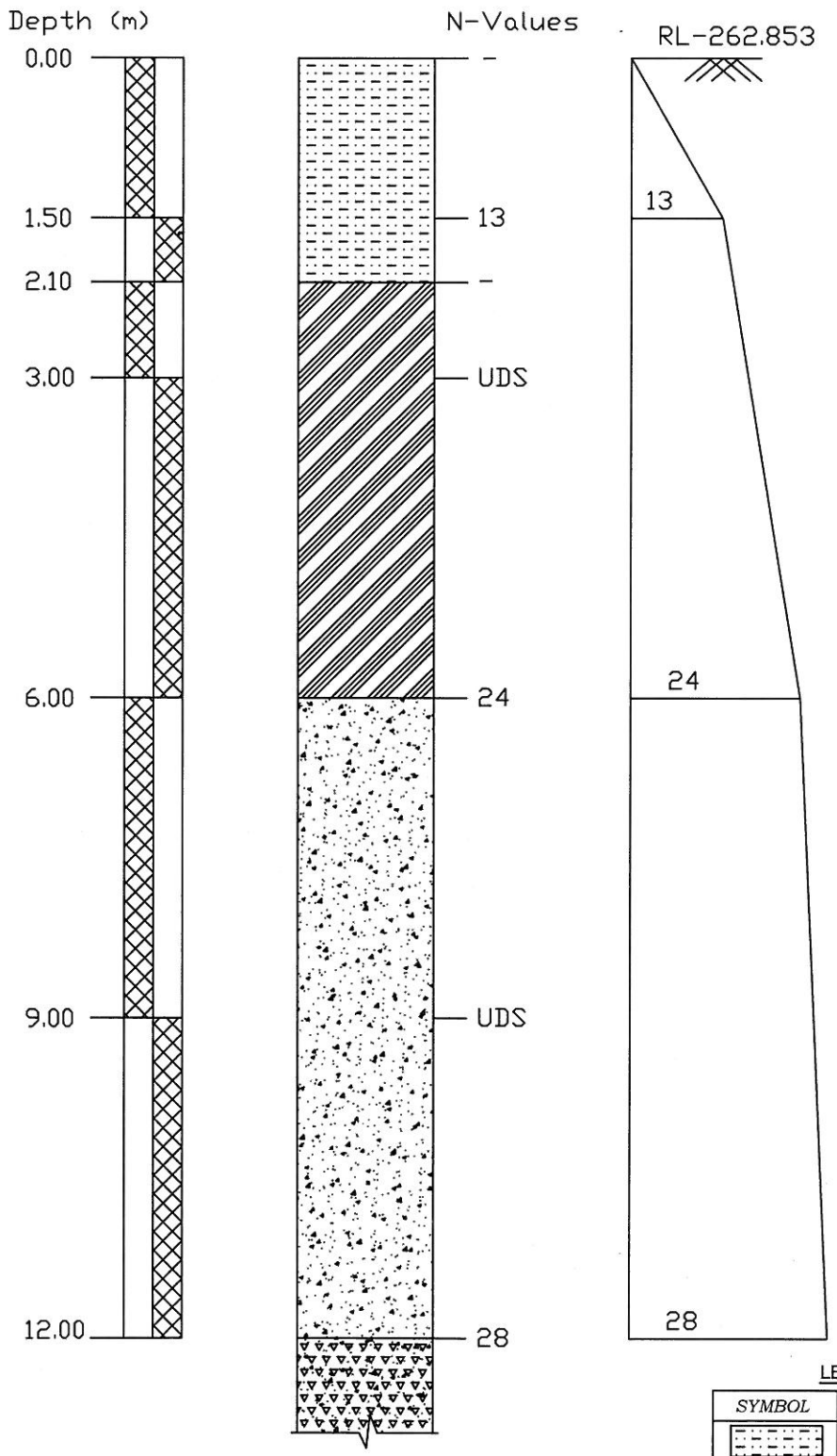
BORELOG OF BH–1(LHS) AT EXISTING KM–333/15–17 FOR MINOR BRIDGE NO.–369, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 333/15-17 BH-1

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Continuous Strip | 1

Angle of internal friction (ϕ°)	21.00
Cohesion (c in t/m2)	0.13
Void ratio (e)	0.55
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.89
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.

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)	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	1.36	1.18	1.18

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 shea	Local shear	Actual
1	1.50	1.20	7.42	3.20	7.42

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ANNEXURE - III

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

INPUT DATA

Minor Bridge No 333/15-17 BH-1

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Continuous Strip | 1

Angle of internal friction (ϕ °)	27.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.48
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.89
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)
1	3.00	1.20
2	4.50	1.20
3	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 $\phi < 10°$

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)*SQRT(N_\phi)$ 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	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)	S_c	S_q	S_γ
1	1.20	1.00	1.00	1.00
2	1.20	1.00	1.00	1.00
3	1.20	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	3.00	1.20	1.82	1.41	1.41
2	4.50	1.20	2.22	1.61	1.61
3	6.00	1.20	2.63	1.82	1.82

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
2	4.50	1.20	-2.50	0.50
3	6.00	1.20	-3.75	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shea	Local shear	Actual
1	3.00	1.20	16.33	5.89	16.33
2	4.50	1.20	18.70	6.75	18.70
3	6.00	1.20	21.07	7.60	21.07

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Minor Bridge No. 369
Chainage	333/15-17
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	7.50
Average N value	19.00
Settlement for 10 t/m2 (mm)	17.00
Total Settlement (mm)	12.75
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	9.3

Footing Depth (m)	3.00
SBC (t/m2)	16.00
Average N value	20.79
Settlement for 10 t/m2 (mm)	14.00
Total Settlement (mm)	22.40
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	14.9

Footing Depth (m)	4.50
SBC (t/m2)	18.50
Average N value	21.33
Settlement for 10 t/m2 (mm)	14.50
Total Settlement (mm)	26.83
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	15.9

Footing Depth (m)	6.00
SBC (t/m2)	21.00
Average N value	22.09
Settlement for 10 t/m2 (mm)	13.80
Total Settlement (mm)	28.98
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	15.8

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CHAPTER – 16

"Minor Bridge No. 368",

Location – Existing Km. - 332/15-17

16.1 LOCATION OF STRUCTURE:

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

16.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table ≥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	Filled up Strata	Loose
	1.50 to 3.00	Gravelly Silt with Sand	Loose
	3.00 to 6.00	Gravelly Silt with Sand	Medium Dense
	6.00 to 9.00	Silty Sand	Medium Dense
	9.00 to 12.00	Silty Sand	Dense

16.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	5.00	8.70	0.007	0.0018	NIL	0.0010	0.039

16.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	5.00	NIL

16.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	20.00
	3.00	23.00
	4.50	26.00
	6.00	28.00

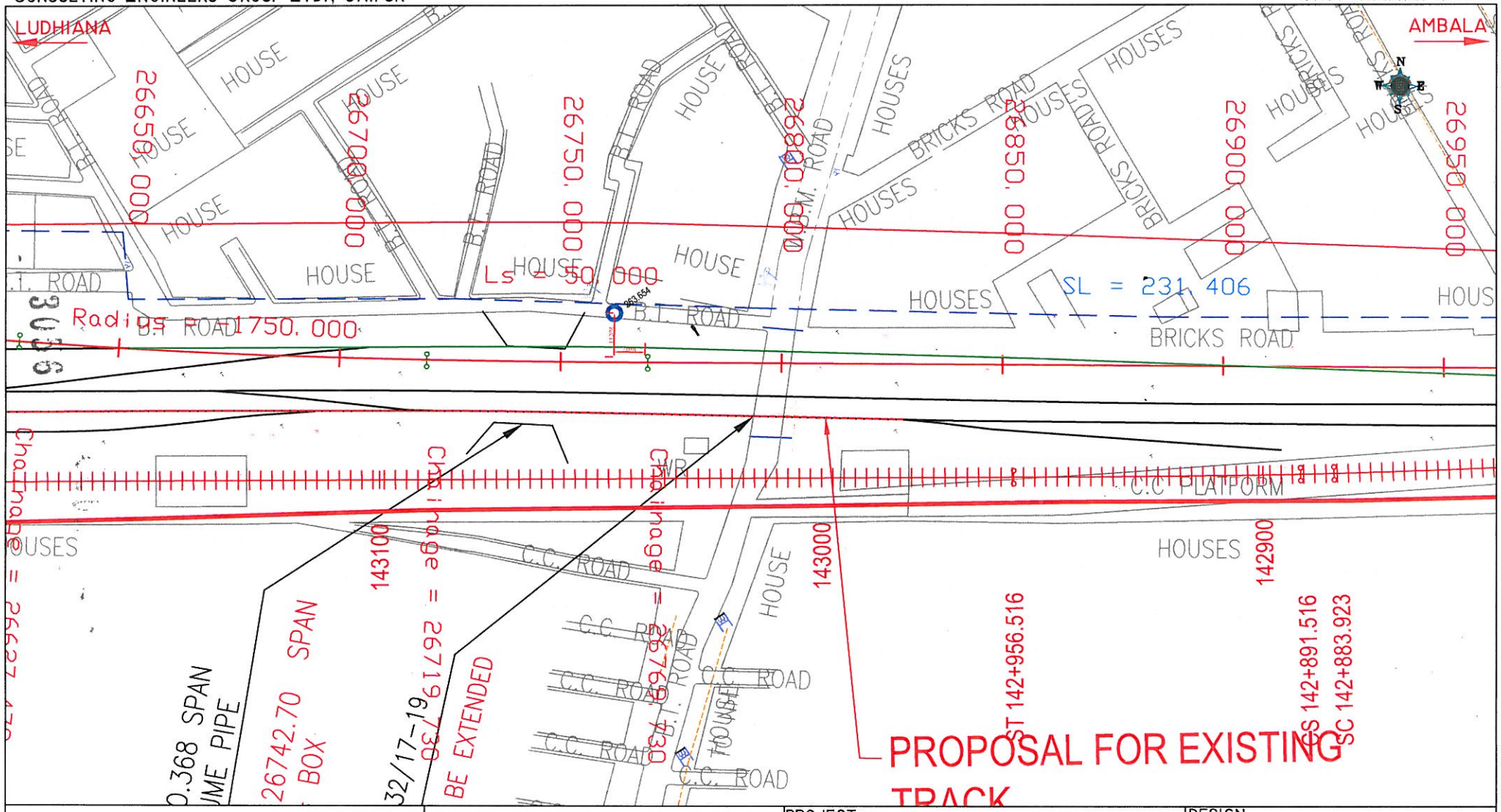
16.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

16.8 RECOMMENDATIONS

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

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



ALL DIMENSIONS IN METER

FIG.:-I

LOCATION PLAN OF PROPOSED MINOR BRIDGE AT CH. 332/15-17

RL OF BH-I = 263.654

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

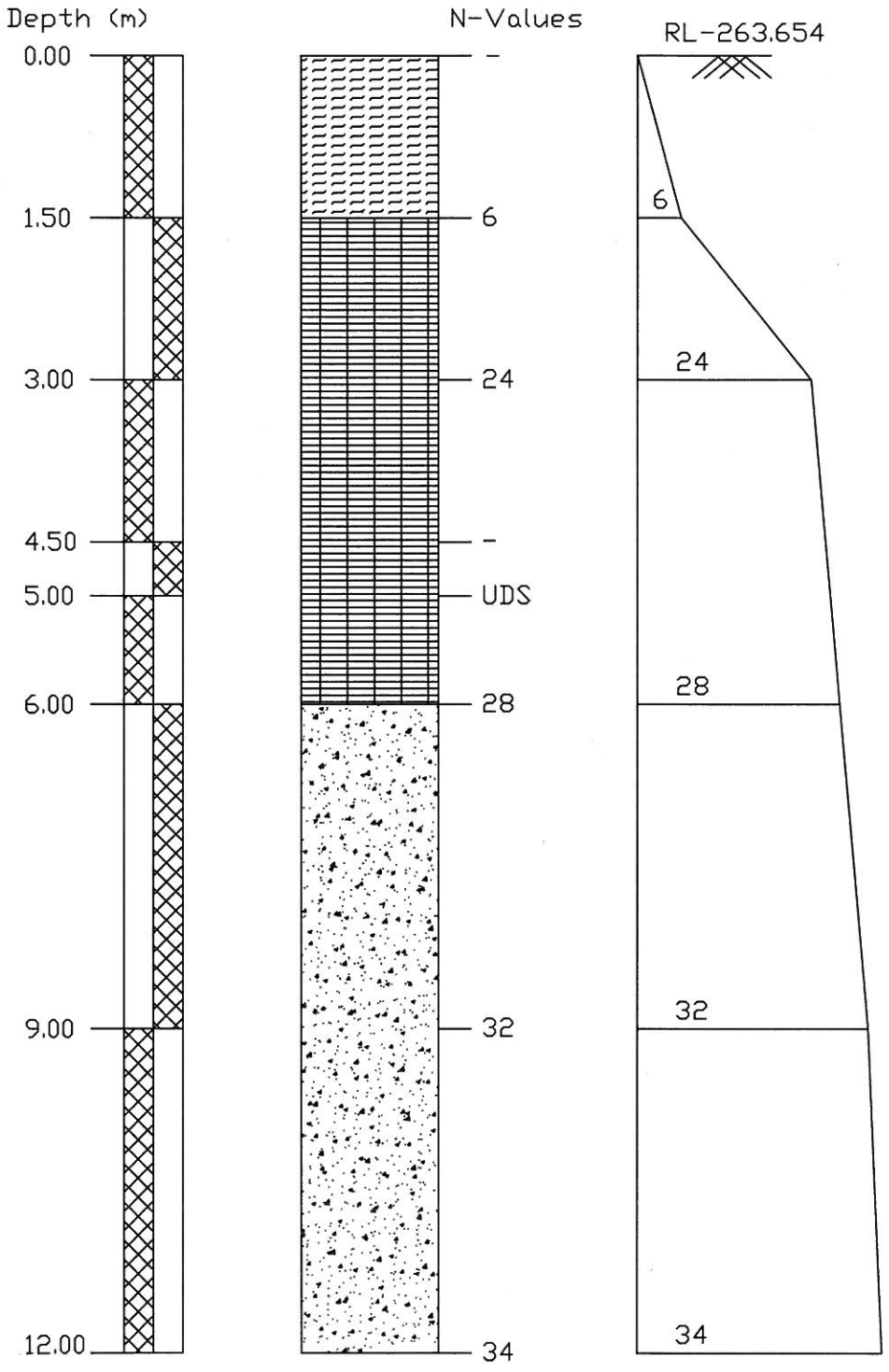
SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(LHS) FOR MINOR BRIDGE No. 368 AT CHAINAGE 332/15-17

Project :	Chainage 332/15-17 Bridge No. 368			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				03.06.2009 to 03.06.2009	1	1(LHS)	below 21.00 m.	12.00mtr	263.654

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	1.41	8.46	Gravelly Silt with Sand	3.68	46.27	13.56	1.58	1.86	33.05	0.00	23	NIL	NP	-	-	-	-	-	-
3.00	24	1.18	28.32	Gravelly Silt with Sand	2.21	50.49	11.50	1.73	1.50	32.57	0.00	24	NIL	NP	-	-	-	-	-	-
4.50				Gravelly Silt with Sand	2.59	63.68	11.23	6.21	0.68	12.33	3.28	23	NIL	NP						
5.00	UDS	-	-	Gravelly Silt with Sand	2.32	54.27	17.02	2.44	2.89	21.06	0.00	24	NIL	NP	1.98	6.51	1.86	2.63	0.00	30.00
6.00	28	0.94	26.32	Silty Sand	1.89	9.85	79.39	3.69	1.69	2.39	1.10	23	NIL	NP		-	-	-	-	-
9.00	32	0.81	25.92	Silty Sand	2.10	6.73	87.67	3.50	0.00	0.00	0.00	27	NIL	NP		-	-	-	-	-
12.00	34	0.71	24.14	Silty Sand	3.89	5.92	86.53	3.66	0.00	0.00	0.00	28	NIL	NP	-	-	-	-	-	-

BORELOG OF BH–1(LHS) AT EXISTING KM–332/15–17 FOR MINOR BRIDGE NO.–368,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	FILLEDUP STRATA
	GRAVELLY 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 332/15-17 BH-1

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Continuous Strip 1

Angle of internal friction (ϕ °)	30.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.41
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.98
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

$d_q = d_\gamma = 1$ for $\phi < 10°$

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

CONSULTING Engineers Group Ltd.