CHAPTER - 140

"Alignment",

Location - Existing Km. - 252/5-7

140.1 LOCATION OF STRUCTURE:

Alignment at existing km 252/5-7.

140.2 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 >12.00m 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	Loose
	1.50 to 3.00	Clayey Silt	Medium Dense
	3.00 to 7.50	Clayey Silt with Sand	Medium Dense
	7.50 to 10.50	Clayey Silt	Medium Dense
	10.50 to 12.00	Sandy Silt	Medium Dense
	Below 12.00	Clayey Silt with Sand	Medium Dense

140.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.30	NIL	0.0014	NIL	0.0010	0.027
	12.00	8.50	0.002	0.0021	NIL	0.0012	0.043

140.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	10.00
BH-1	12.00	20.00

141.5 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	10.00
	4.50	12.00
	6.00	13.00

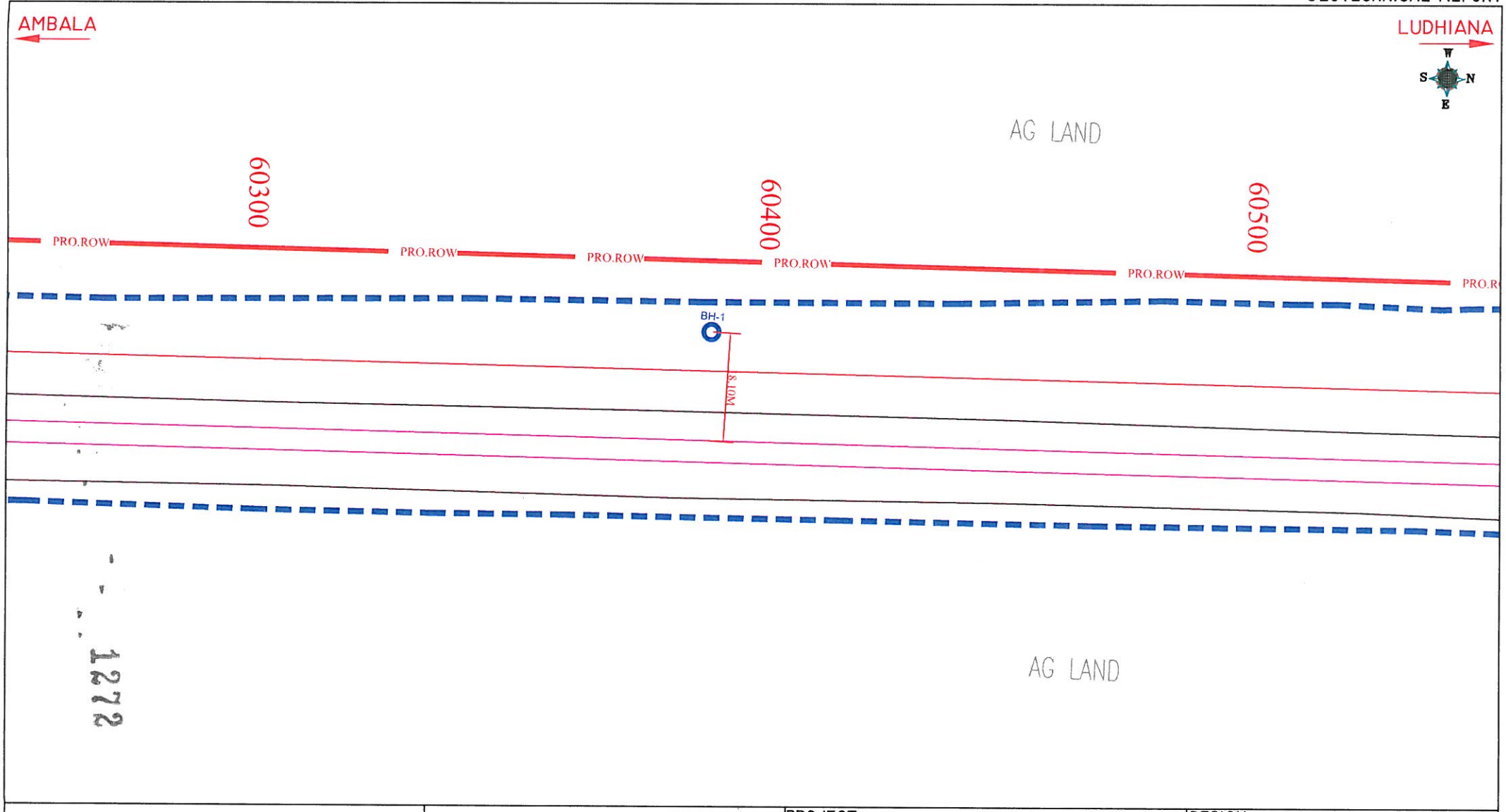
140.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

140.7 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		PROJECT :-	DESIGN :-
FIG.:-I LOCATION PLAN OF PROPOSED ALINGMENTAT CH. 252/5-7	RL OF BH-I = 268.897	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

ANNEXURE - I

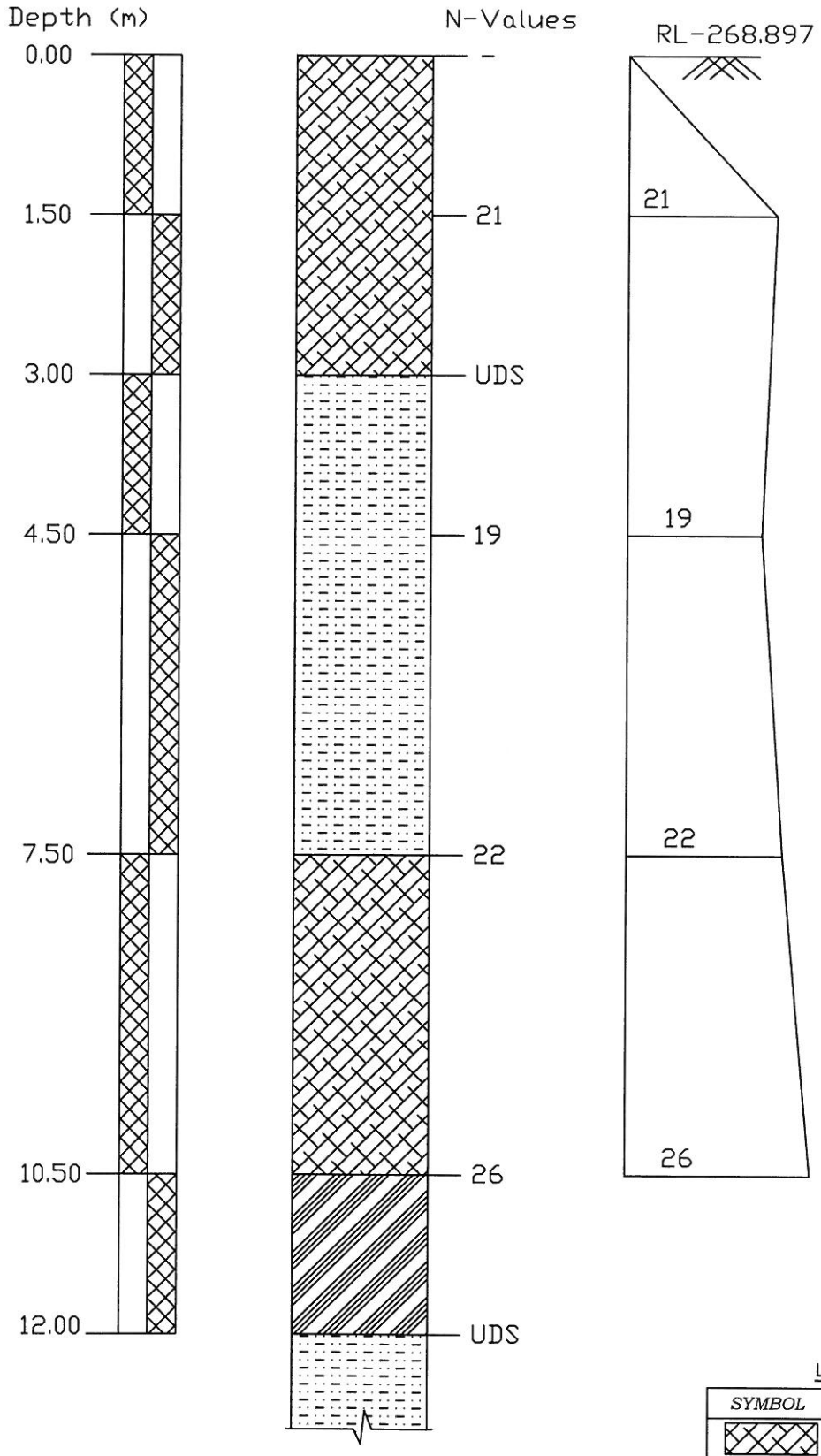
SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (RHS) OF ALIGNMENT AT CHAINAGE 252/5-7

Project :	Chainage 252/5-7			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				24.07.2009 to 24.07.2009	1	1(RHS)	13.30 m.	12.00mtr	268.897	

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	22.69	69.89	1.26	0.95	1.33	3.88	0.00	40	20	20	-	-	-	-	-	-
1.50	21	1.46	30.66	Clayey silt	25.10	68.05	0.98	1.29	1.33	3.25	0.00	42	20	22	-	-	-	-	-	-
3.00	UDS	-	-	Clayey silt with sand	11.21	61.90	26.43	0.36	0.10	0.00	0.00	27	19	8	1.78	9.59	1.62	2.7	0.08	22.0
4.50	19	1.10	20.90	Clayey silt with sand	20.15	66.25	2.27	7.17	3.35	0.81	0.00	36	18	18	-	-	-	-	-	-
7.50	22	0.92	20.24	Clayey silt	26.97	69.77	2.66	0.50	0.10	0.00	0.00	48	23	25	-	-	-	-	-	-
10.50	26	0.81	21.06	Sandy silt	2.68	61.58	34.83	0.51	0.40	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
12.00	UDS	-	-	Clayey silt with sand	17.89	53.56	20.78	2.45	3.73	1.59	0.00	30	15	15	1.86	12.59	1.65	2.68	0.16	17.0

CONSULTING
Engineers Group Ltd.

BORELOG OF BH–1(RHS) AT EXISTING KM–252/5–7 FOR ALIGNMENT ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT
	CLAYEY SILT WITH SAND
	SANDY SILT

1274

CONSULTING Engineers Group Ltd.

ANNEXURE - III

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

INPUT DATA

		Ch 252 5-7	BH-1
Type of footing			
1	Continuous Strip		
2	Rectangular	***Rectangular***	2
3	Square		
4	Circular		

Angle of internal friction (ϕ°)	13.00
Cohesion (c in t/m2)	2.10
Void ratio (e)	0.66
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.70
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

ANNEXURE - III

Bearing capacity factors :

ϕ	13.00
N_c	9.93
N_q	3.35
N_γ	2.08

ϕ'	8.79
N'_c	7.90
N'_q	2.25
N'_γ	1.03

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.13	1.06	1.06
2	3.00	3.00	1.25	1.13	1.13
3	4.50	3.00	1.38	1.19	1.19
4	6.00	3.00	1.50	1.25	1.25

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	11.49	6.08	8.51
2	3.00	3.00	8.00	15.03	7.96	11.14
3	4.50	3.00	8.00	16.29	8.62	12.07
4	6.00	3.00	8.00	17.55	9.29	13.00

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 252/ 5-7**

BH No. 1

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	6.68	t/m^2
Concentrated load *P*		=	7.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	1.5	t/m^2
Compression Index	Cc	=	0.12	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.66	
	$\frac{Po + \Delta p}{Po}$	=	1.23071	

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

S_f = 0.02933 m

= 29.328 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore pr. Correction = N.A.

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

S_{f2} = **21.4 mm**

1277

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 252/ 5-7**

BH No. 1

Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	8.82	t/m^2
Concentrated load *P*		=	11.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.4	t/m^2
Compression Index	Cc	=	0.12	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.66	
	$\frac{Po + \Delta p}{Po}$	=	1.27438	

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

S_f = 0.03425 m

= 34.2535 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = **22.7 mm**

1278

CONSULTING
Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 252/ 5-7**

BH No. 1

Depth of foundation		=	4.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	11.34	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	=	0.12	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.66	
	$\frac{Po + \Delta p}{Po}$	=	1.2328	

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

S_f = 0.02957 m

= 29.568 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.74

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

0.8

Pore Pr. Correction N.A.

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

S_{f2} = **17.5 mm**

1279

CONSULTING
Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 252/ 5-7**

BH No. 1

Depth of foundation		=	6.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of lay	Po	=	14.03	t/m^2
Concentrated load *P*		=	13.00	t/m^2
Incerase in pressure at mid of laye	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.9	t/m^2
Compression Index	Cc	=	0.12	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.66	
	$\frac{Po + \Delta p}{Po}$	=	1.20	

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

S_f = 0.02622 m

= 26.22 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

0.8

Pore Pr. Correction N.A.

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

S_{f2} = **14.3 mm**

1280

CONSULTING Engineers Group Ltd.

CHAPTER – 141

"Alignment",

Location – Existing Km. – 250/7-9

141.1 LOCATION OF STRUCTURE:

Alignment at existing km 250/7-9.

141.2 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 >12.00m 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 12.00	Clayey Silt with Sand	Medium Dense

141.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.60	0.002	0.0014	NIL	0.0010	0.026

141.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

141.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	07.00
	3.00	10.00
	4.50	13.00
	6.00	14.00

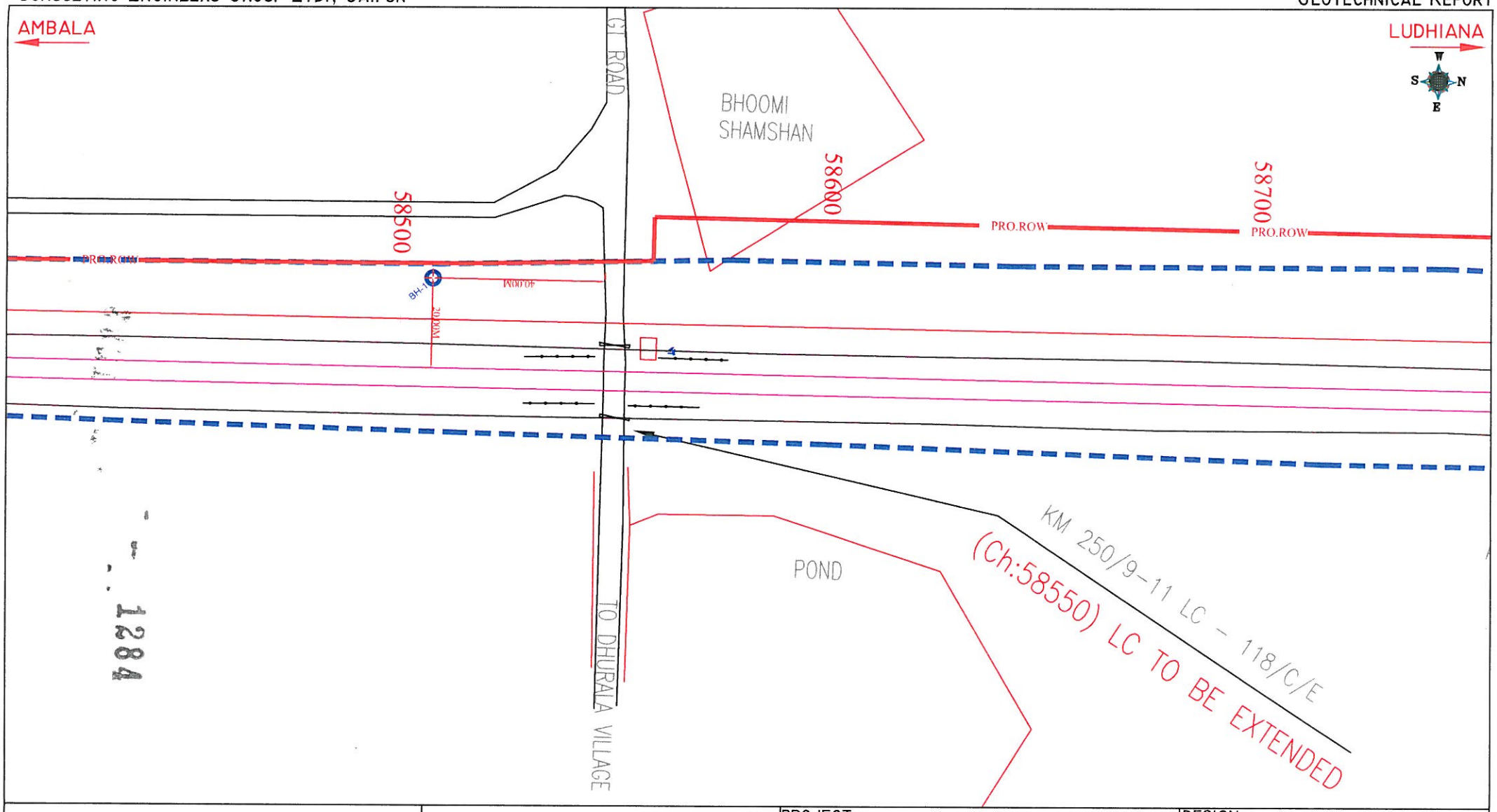
141.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

141.7 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 ALIGNMENT AT CH. 250/7-9	RL OF BH 1 = 269.045	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

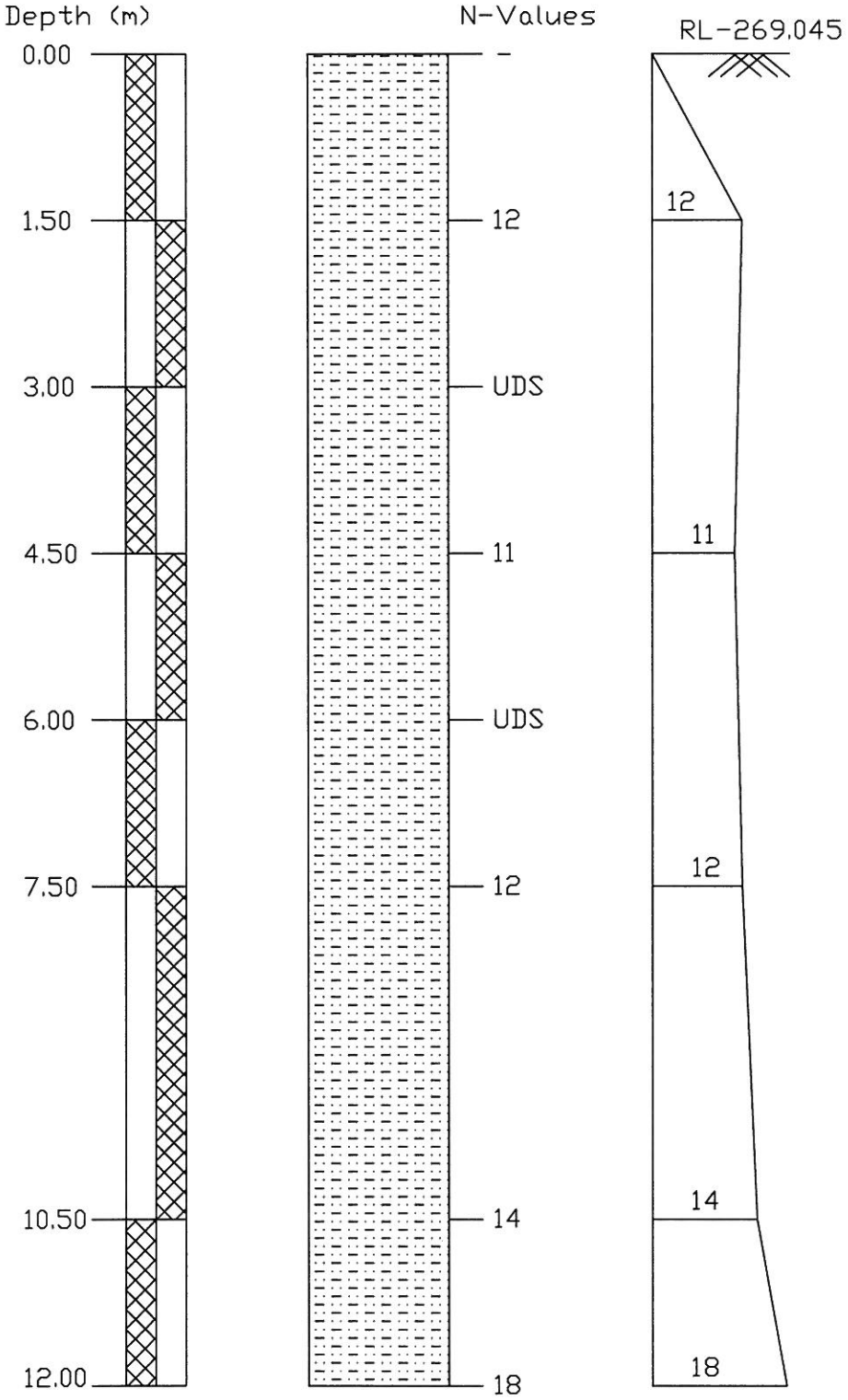
SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (RHS) OF ALIGNMENT AT CHAINAGE 250/7-9

Project :	Chainage 250/7-9			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				21.07.2009 to 21.07.2009	1	1(RHS)	13.60 m.	12.00mtr	269.045	

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	12.86	64.41	20.56	1.26	0.52	0.39	0	27	17	10	-	-	-	-	-	-
1.50	12	1.42	17.04	Clayey silt with sand	13.25	63.79	22.00	0.51	0.10	0.35	0.00	27	16	11	-	-	-	-	-	-
3.00	UDS	-	-	Clayey silt with sand	12.59	45.08	41.29	0.99	0.05	0.00	0.00	25	15	10	1.66	9.52	1.52	2.64	0.10	21.0
4.50	11	1.04	11.44	Clayey silt with sand	30.25	65.98	1.08	1.23	0.75	0.71	0.00	50	21	29	-	-	-	-	-	-
6.00	UDS	-	-	Clayey silt with sand	20.15	53.57	7.38	6.47	7.29	5.14	0.00	35	18	17	1.77	11.21	1.59	2.67	0.19	16.0
7.50	12	0.86	10.32	Clayey silt with sand	18.95	67.94	9.06	1.82	1.02	1.21	0.00	33	17	16	-	-	-	-	-	-
10.50	14	0.74	10.36	Clayey silt with sand	21.21	67.08	7.85	1.59	0.69	1.58	0.00	36	18	18	-	-	-	-	-	-
12.00	18	0.70	12.60	Clayey silt with sand	20.85	67.35	9.88	1.35	0.27	0.30	0.00	34	16	18	-	-	-	-	-	-

CONSULTING
Engineers Group Ltd.

BORELOG OF BH–1(RHS) AT EXISTING KM–250/7–9 FOR ALIGNMENT ON KESARI TO SANEHWAL, LUDHIANA



1286

LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND

CONSULTING Engineers Group Ltd.

ANNEXURE - III

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

INPUT DATA

Ch 250 7-9 **BH-1**

Type of footing

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

Angle of internal friction (ϕ °)	16.00
Cohesion (c in t/m2)	1.90
Void ratio (e)	0.68
Direction of load with vertical (°)	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
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.

1287

CONSULTING Engineers Group Ltd.

ANNEXURE - III

Bearing capacity factors :

ϕ	16.00
N_c	11.75
N_q	4.43
N_γ	3.20

ϕ'	10.88
N'_c	8.81
N'_q	2.73
N'_γ	1.47

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.13	1.07	1.07
2	3.00	3.00	1.27	1.13	1.13
3	4.50	3.00	1.40	1.20	1.20
4	6.00	3.00	1.53	1.27	1.27

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	13.69	6.80	9.21
2	3.00	3.00	8.00	18.59	9.26	12.53
3	4.50	3.00	8.00	20.15	10.04	13.58
4	6.00	3.00	8.00	21.70	10.82	14.63

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 250/ 7-9**

BH No. 1

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	6.23	t/m^2
Concentrated load *P*		=	7.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	1.5	t/m^2
Compression Index	Cc	=	0.141	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.74	
	$\frac{Po + \Delta p}{Po}$	=	1.24739	

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

S_f = 0.03501 m

= 35.0077 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore Pr. Correction = N.A.

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

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

1289

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 250/7-9**

BH No. 1

Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	8.72	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	=	0.22	
	ΔP	=	2.2	t/m^2
Compression Index	Cc	=	0.141	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.74	
	$\frac{Po + \Delta p}{Po}$	=	1.25244	

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

S_f = 0.03565 m

= 35.6474 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

0.8

Pore Pr. Correction = N.A.

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

S_{f2} = **23.7 mm**

1290

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 250/7-9**

BH No. 1

Depth of foundation		=	4.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	11.205	t/m^2
Concentrated load *P*		=	13.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.9	t/m^2
Compression Index	Cc	=	0.123	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.68	
	$\frac{Po + \Delta p}{Po}$	=	1.25524	

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

S_f = 0.03253 m

= 32.5273 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.74

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

0.8

Pore Pr. Correction N.A.

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

S_{f2} = **19.3 mm**

1291

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 250/ 7-9**

BH No. 1

Depth of foundation	=	6.0	m	
Length of footing (L)	=	8.0	m	
Width of footing (B)	=	3.0	m	
Initial effective stress at mid of lay Po	=	14.03	t/m^2	
Concentrated load *P*	=	14.00	t/m^2	
Incerase in pressure at mid of laye ΔP	=	$P \times I_B$		
I_B	=	0.22		
ΔP	=	3.1	t/m^2	
Compression Index Cc	=	0.123		
Thickness of clay layer H	=	4.5	m	
Initial Void ratio e_o	=	0.68		
$\frac{Po + \Delta p}{Po}$	=	1.22		

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

S_f	=	0.02841	m
	=	28.41	mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B	=	2.67	
Depth Factor	=	0.68	

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

0.8

Pore Pr. Correction= N.A.

Corrected Total Settlement	=	S_f x D.F.x R.F.	
S_{f2}	=	**15.5**	**mm**

1292

CONSULTING Engineers Group Ltd.

CHAPTER - 142

"Minor Bridge" of Detour Section

Location - Proposed Chainage - 14800

142.1 LOCATION OF STRUCTURE:

Minor Bridge at Proposed Chainage 14800

142.2 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 6.50m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 7.50	Clayey Silt with Sand	Loose
	7.50 to 10.50	Silty Sand	Medium Dense
	10.50 to 12.00	Clayey Silt with Sand	Medium Dense

142.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.30	NIL	0.0028	NIL	0.0011	0.088
	12.00	8.20	NIL	0.0031	NIL	0.0012	0.091

142.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	16.00
	12.00	19.00

142.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BORE HOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (µS/cm)
Test Result	7.0	89	142	136	821	0.1	2.3	980	633
Requirement as per IS:456 / Mosrth's	Not less then 6.0	2000 for CC and 500 for RCC	400	200	3000	5 ml of 0.02 normal NaoH	25 ml of 0.02 normal H_2SO_4	-	-

142.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	07.00
	3.00	10.00
	4.50	10.50
	6.00	11.50

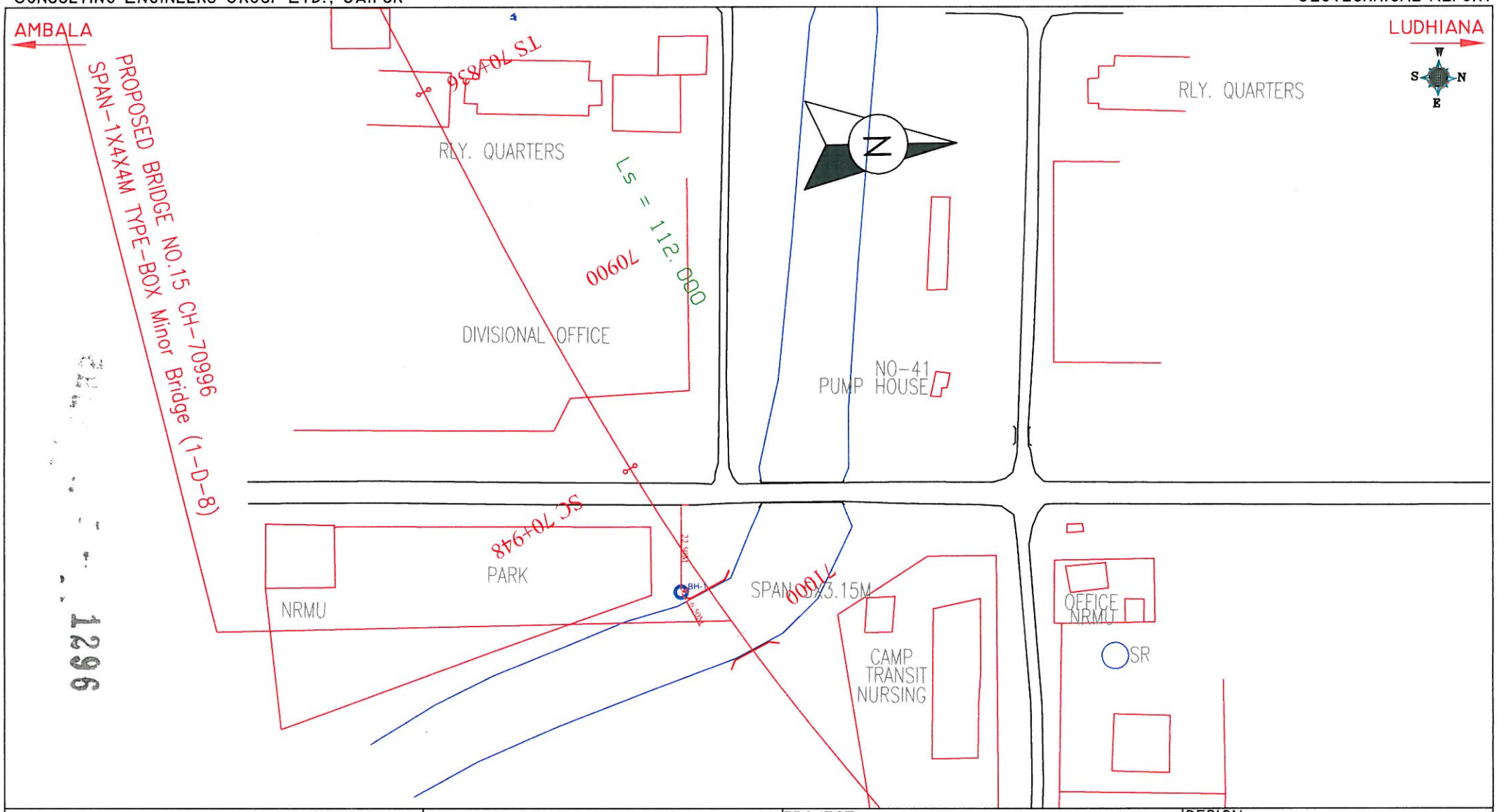
142.7 CONCLUSIONS

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

142.8 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 DETOUR SECTION CH. 14800

RL OF BH-I = 268.221

PROJECT :-

LUDHIANA-AMBALA (DFCCIL)

DESIGN :-

CONSULTING ENGINEERS GROUP LTD.

E-12,Moji Colony,Malviya Nagar Jaipur-17

Tel: +91-141- 2520899, 2521899, 2520556

Fax: 2521348, E-Mail: ceg@cegindia.com

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 FOR AT CHAINAGE 14800

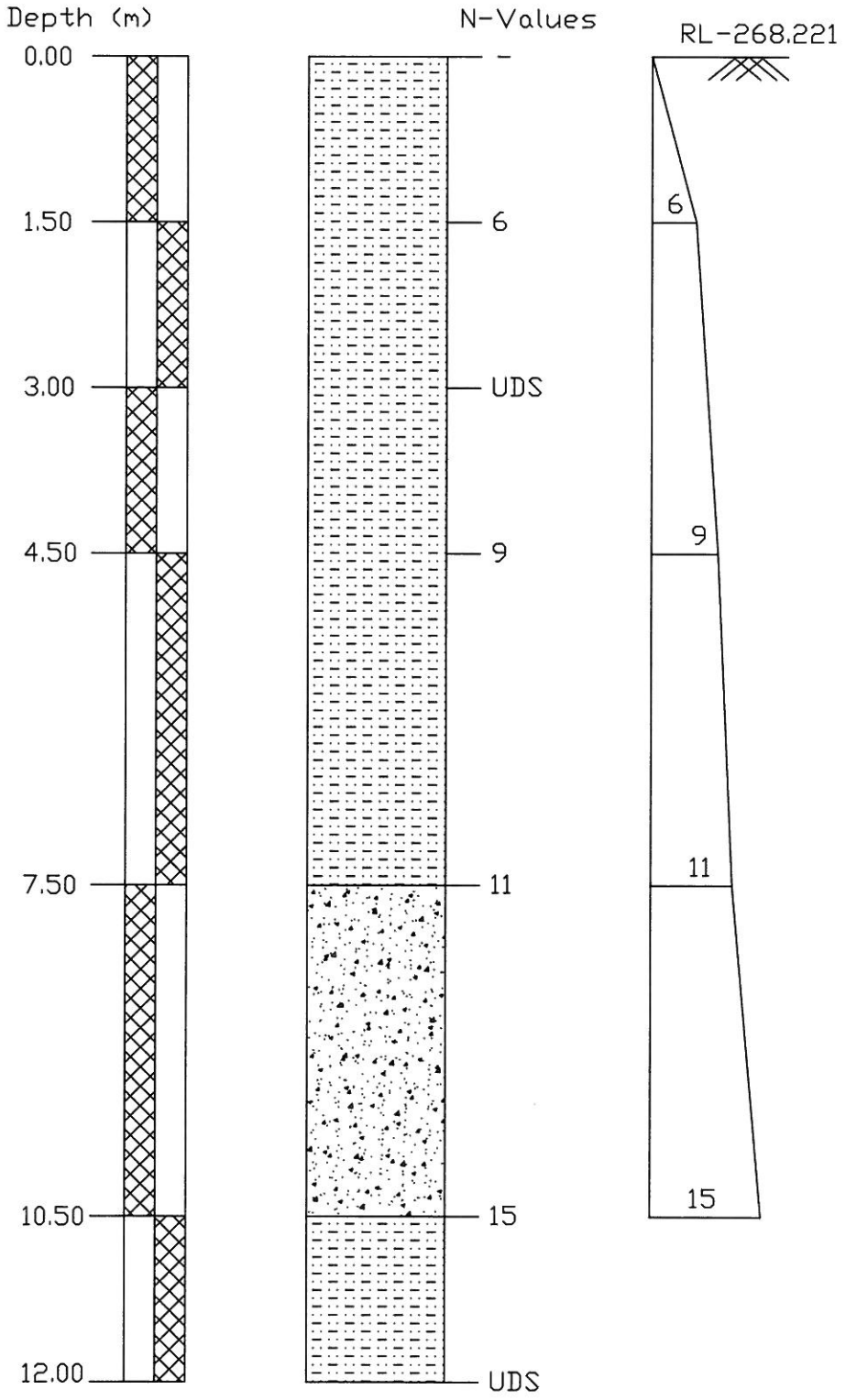
Project :	Chainage 14800 Bridge No. 000			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				11.12.2009 to 11.12.2009	1	1	06.50 m.	12.00mtr	268.221

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	16.89	62.64	9.45	5.35	2.37	3.30	0.00	35	20	15	-	-	-	-	-	-
1.50	6	1.45	8.70	Clayey Silt with Sand	20.94	62.74	8.45	3.07	1.41	3.39	0.00	37	18	19	-	-	-	-	-	-
3.00	UDS	-	-	Clayey Silt with Sand	15.63	77.78	4.27	0.90	0.36	1.06	0.00	32	18	14	1.77	15.60	1.53	2.68	0.16	18.0
4.50	9	1.08	9.72	Clayey Silt with Sand	15.10	66.93	12.95	1.42	1.09	2.51	0.00	30	17	13	-	-	-	-	-	-
7.50	11	0.91	10.01	Silty Sand	3.52	11.71	81.61	0.59	0.23	2.34	0.00	26	NIL	NP	-	-	-	-	-	-
10.50	15	0.79	11.85	Clayey Silt with Sand	9.64	83.56	4.70	1.18	0.29	0.63	0.00	25	16	9	-	-	-	-	-	-
12.00	UDS	-	-	Clayey Silt with Sand	18.79	76.11	4.00	1.10	0.00	0.00	0.00	38	22	16	1.89	22.74	1.54	2.72	0.19	15.0

CONSULTING
Engineers Group Ltd.

BORELOG OF BH–1 AT PROPOSED KM–14800 FOR MINOR BRIDGE,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	SILTY SAND

1298

ANNEXURE - III

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

INPUT DATA

Ch 14800 **BH-1**

Type of footing

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

Angle of internal friction (ϕ°)	18.00
Cohesion (c in t/m2)	1.60
Void ratio (e)	0.75
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
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.

1299

CONSULTING Engineers Group Ltd.

ANNEXURE - III

Bearing capacity factors :

ϕ	18.00	ϕ'	12.28
N_c	13.29	N'_c	9.55
N_q	5.42	N'_q	3.14
N_γ	4.29	N'_γ	1.87

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.14	1.07	1.07
2	3.00	3.00	1.28	1.14	1.14
3	4.50	3.00	1.41	1.21	1.21
4	6.00	3.00	1.55	1.28	1.28

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	14.71	7.00	7.00
2	3.00	3.00	8.00	20.74	9.91	9.91
3	4.50	3.00	8.00	22.45	10.73	10.73
4	6.00	3.00	8.00	24.17	11.55	11.55

1300

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Sction on 14800**

BH No. 1

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	7.125	t/m^2
Concentrated load *P*		=	7.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	1.5	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.21614	

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

S_f = 0.03059 m

= 30.5941 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = 22.3 mm

1301

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Sction on 14800**

BH No. 1

Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	9.975	t/m^2
Concentrated load *P*		=	10.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.2	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	3.0	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.22055	

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

S_f = 0.02077 m

= 20.7735 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = **13.8 mm**

1302

CONSULTING
Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Sction on 14800**

BH No. 1

Depth of foundation		=	4.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	11.4	t/m^2
Concentrated load *P*		=	10.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.3	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	3	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.20263	

Settlement of clay layer

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

S_f = 0.01923 m

= 19.2318 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.74

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

= 0.8

Pore Pr. Correction = 0.85

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

S_{f2} = 9.7 mm

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

Footing Depth (m)	**4.50**
Effective Pressure (t/m2)	2.10
Average N value	10
Settlement for 10 t/m2 (mm)	36.00
Settlement (mm) for SBC	7.56
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	**5.0**

Total corrected Settlement	**14.7**	**mm**

CONSULTING Engineers Group Ltd.

1303

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Sction on 14800**

BH No. 1

Depth of foundation		=	6.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	12.825	t/m^2
Concentrated load *P*		=	11.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.5	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.197271	

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

S_f = 0.0093831 m

= 9.3830936 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

= 0.8

Pore Pr. Correction = 0.85

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

S_{f2} = **4.3** **mm**

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

Footing Depth (m)	**6.00**
Effective Pressure (t/m2)	2.65
Average N value	10
Settlement for 10 t/m2 (mm)	36.00
Settlement (mm) for SBC	9.52
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	**6.3**

Total corrected Settlement	10.7	mr

1304

CONSULTING Engineers Group Ltd.

CHAPTER - 143

"Alignment" of Detour Section

Location - Proposed Chainage - 13750

143.1 LOCATION OF STRUCTURE:

Minor Bridge at Proposed Chainage 13750

143.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table 8.00m below EGL.

Subsurface profile at the site

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

143.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.10	NIL	0.0026	NIL	0.0013	0.087
	9.00	8.50	NIL	0.0028	NIL	0.0015	0.121

143.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	27.00
	9.00	20.00

143.5 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	7.7	96	142	183	745	0.2	2.2	977	652
Requirement as per IS: 456 / Mosrth's	Not less then 6.0	2000 for CC and 500 for RCC	400	200	3000	5 ml of 0.02 normal NaoH	25 ml of 0.02 normal H_2SO_4	-	-

143.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	08.50
	3.00	10.50
	4.50	11.50
	6.00	12.50

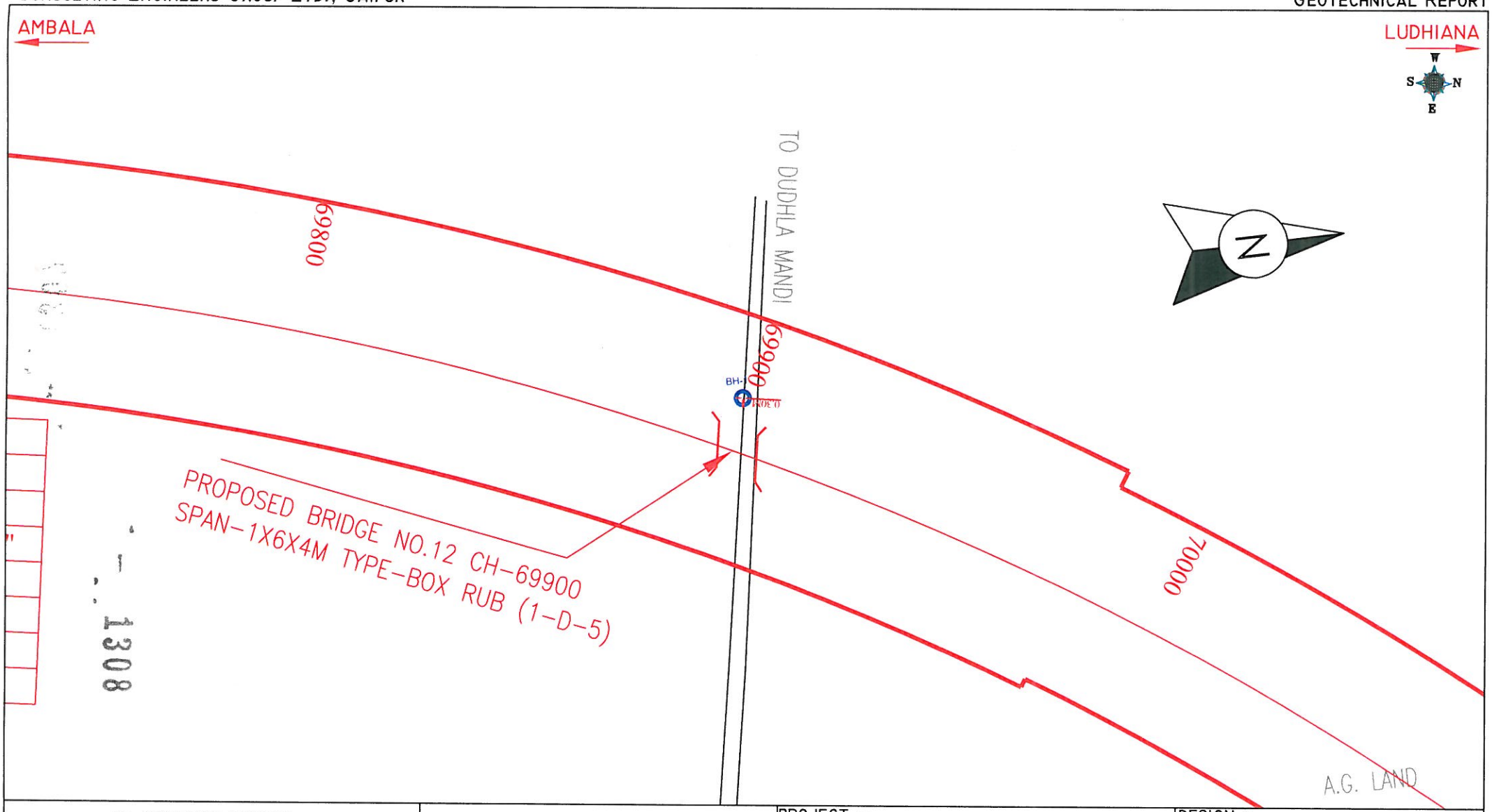
143.7 CONCLUSIONS

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

143.8 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 DETOUR SECTION CH. 13750

RL OF BH-I = 267.501

PROJECT :-

LUDHIANA-AMBALA (DFCCIL)

DESIGN :-

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

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 FOR AT CHAINAGE 13750

Project :	Chainage 13750			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				11.12.2009 to 11.12.2009	1	1	08.00 m.	12.00mtr	267.501

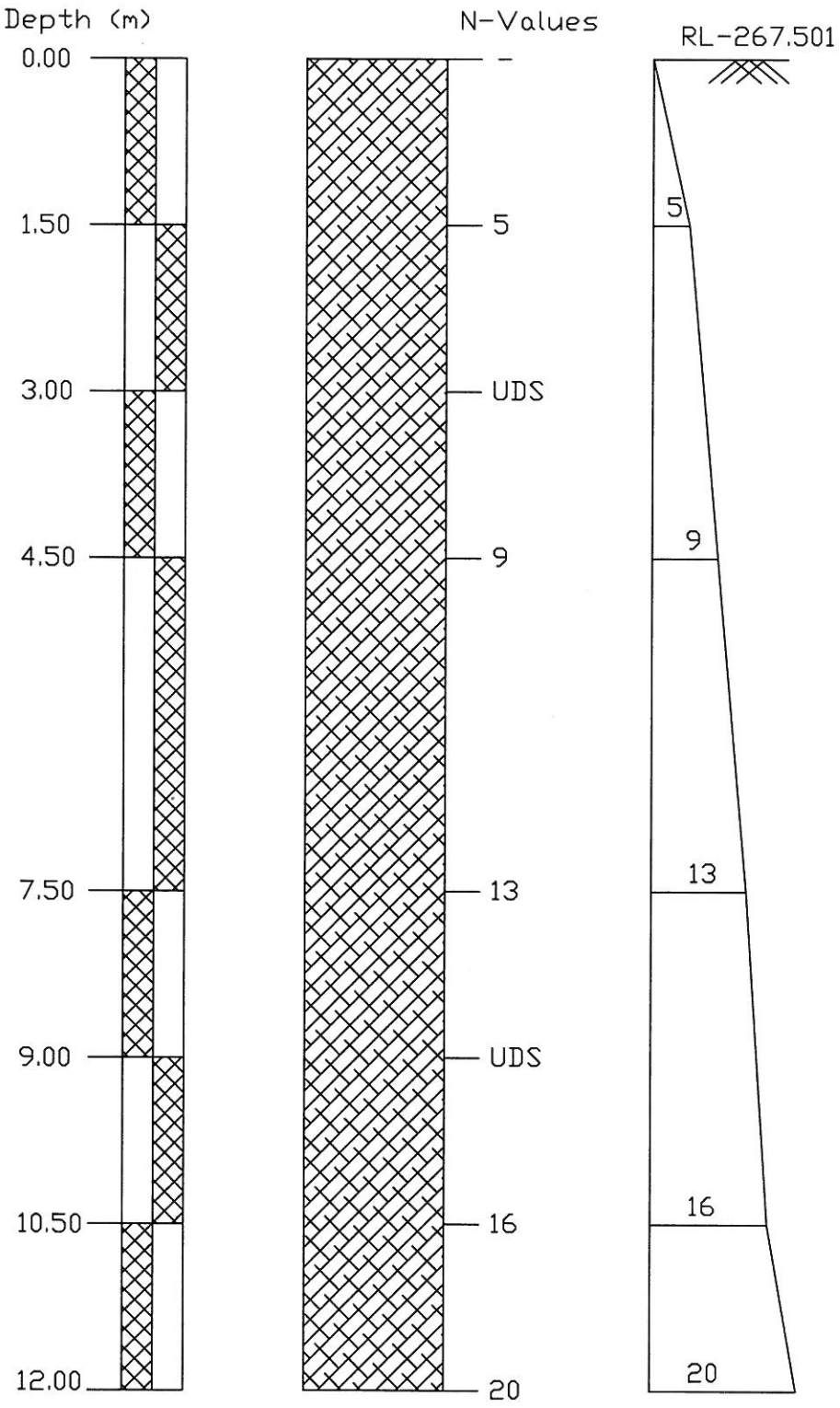
Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Clayey Silt	19.35	74.70	4.36	0.76	0.41	0.42	0.00	38	21	17	-	-	-	-	-	-
1.50	5	1.44	7.20	Clayey Silt	22.82	72.62	3.08	0.87	0.28	0.33	0.00	44	24	20	-	-	-	-	-	-
3.00	UDS	-	-	Clayey Silt	26.57	69.88	2.75	0.60	0.20	0.00	0.00	48	24	24	1.79	16.40	1.54	2.65	0.30	12.0
4.50	9	1.07	9.63	Clayey Silt	24.63	72.30	2.50	0.30	0.04	0.23	0.00	41	19	22	-	-	-	-	-	-
7.50	13	0.90	11.70	Clayey Silt	21.86	74.86	2.41	0.45	0.14	0.28	0.00	40	20	20	-	-	-	-	-	-
9.00	UDS	-	-	Clayey Silt	19.64	75.52	3.42	0.63	0.38	0.41	0.00	38	20	18	1.90	20.38	1.67	2.68	0.22	14.0
10.50	16	0.78	12.48	Clayey Silt	19.52	78.07	1.26	0.28	0.52	0.35	0.00	38	21	17	-	-	-	-	-	-
12.00	20	0.74	14.80	Clayey Silt	22.30	74.20	2.65	0.46	0.39	0.00	0.00	41	21	20	-	-	-	-	-	-

CONSULTING
Engineers Group Ltd.

1309

BORELOG OF BH–1 AT PROPOSED KM–13750 FOR ALIGNMENT,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT

1310

CONSULTING Engineers Group Ltd.

ANNEXURE - III

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

INPUT DATA

		Ch 13750	BH-1
Type of footing			
1	Continuous Strip		
2	Rectangular	***Rectangular***	2
3	Square		
4	Circular		

Angle of internal friction (ϕ°)	12.00
Cohesion (c in t/m2)	3.00
Void ratio (e)	0.72
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.96
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.

1311

CONSULTING Engineers Group Ltd.

ANNEXURE - III

Bearing capacity factors :

ϕ	12.00
N_c	9.40
N_q	3.06
N_γ	1.79

ϕ'	8.11
N'_c	7.65
N'_q	2.13
N'_γ	0.93

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.12	1.06	1.06
2	3.00	3.00	1.25	1.12	1.12
3	4.50	3.00	1.37	1.19	1.19
4	6.00	3.00	1.49	1.25	1.25

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	14.14	7.66	8.63
2	3.00	3.00	8.00	17.67	9.58	10.80
3	4.50	3.00	8.00	19.19	10.41	11.73
4	6.00	3.00	8.00	20.72	11.24	12.66

1312

CONSULTING
Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Sction on 13750**

BH No. 1

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	7.125	t/m^2
Concentrated load *P*		=	8.50	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	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.72	
	$\frac{Po + \Delta p}{Po}$	=	1.26246	

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

S_f = 0.03443 m

= 34.4253 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore Pr. Correction = N.A.

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

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

1313

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Sction on 13750**

BH No. 1

Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	9.975	t/m^2
Concentrated load *P*		=	10.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.3	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.72	
	$\frac{Po + \Delta p}{Po}$	=	1.23158	

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

S_f = 0.03077 m

= 30.7677 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = **20.4 mm**

1314

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Sction on 13750**

BH No. 1

Depth of foundation		=	4.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	12.825	t/m^2
Concentrated load *P*		=	11.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.5	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.72	
	$\frac{Po + \Delta p}{Po}$	=	1.19727	

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

S_f = 0.02659 m

= 26.5945 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.74

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

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = **15.7 mm**

1315

CONSULTING
Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Sction on 13750**

BH No. 1

Depth of foundation		=	6.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of lay	Po	=	15.675	t/m^2
Concentrated load *P*		=	12.50	t/m^2
Incerase in pressure at mid of laye	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.8	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.72	
	$\frac{Po + \Delta p}{Po}$	=	1.1754386	

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

S_f = 0.0238761 m

= 23.876145 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

= 0.8

Pore Pr. Correction= N.A.

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

S_{f2} = **13.0 mm**

1316

CONSULTING Engineers Group Ltd.

CHAPTER – 144

"RFO (ROR)" of Detour Section

Location – Proposed Chainage – 12650

CONSULTING
Engineers Group Ltd.

144.1 LOCATION OF STRUCTURE:
RFO (ROR) at Proposed Chainage 12650

144.2 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 12.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1 (A1)	0.00 to 4.50	Clayey Silt	Loose
	4.50 to 9.00	Clayey Silt with Sand	Medium Dense
	9.00 to 10.50	Silty Sand with Clay	Medium Dense
	10.50 to 16.50	Clayey Silt with Sand	Medium Dense
	16.50 to 19.50	Clayey Silt	Dense
	19.50 to 30.00	Clayey Silt with Sand	Dense
BH-2 (A2)	0.00 to 3.00	Silty Sand with Clay	Loose
	3.00 to 4.50	Clayey Silt with Sand	Loose
	4.50 to 7.50	Clayey Silt with Sand	Medium Dense
	7.50 to 16.50	Silty Sand	Medium Dense
	16.50 to 19.50	Clayey Silt with Sand	Medium Dense
	19.50 to 22.50	Silty Sand	Medium Dense
	22.50 to 24.00	Silty Sand	Dense
	24.00 to 25.50	Clayey Silt	Dense
	25.50 to 30.00	Clayey Silt with Sand	Dense

144.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.10	NIL	0.0031	NIL	0.0011	0.192
	9.00	8.80	0.005	0.0030	NIL	0.0013	0.220
	18.00	8.10	0.009	0.0040	NIL	0.0012	0.111
	24.00	8.30	NIL	0.0039	NIL	0.0015	0.158
BH-2 (A2)	3.00	8.10	NIL	0.0038	NIL	0.0014	0.346
	12.00	8.80	0.012	0.0021	NIL	0.0012	0.052
	18.00	8.20	NIL	0.0040	NIL	0.0013	0.088
	24.00	8.10	NIL	0.0029	NIL	0.0011	0.125

144.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1 (A1)	3.00	26.00
	9.00	10.00
	18.00	13.00
	24.00	23.00
BH-2 (A2)	3.00	26.00
	12.00	NIL
	18.00	15.00
	24.00	24.00

144.5 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	7.1	99	108	169	825	0.1	1.5	1012	639
Requirement as per IS:456 / Morth's	Not less then 6.0	2000 for CC and 500 for RCC	400	200	3000	5 ml of 0.02 normal NaoH	25 ml of 0.02 normal H_2SO_4	-	-

144.6 PILE LOAD CARRYING CAPACITY

144.6.1 Normal Bored Cast in- situ Pile Foundations:

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

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

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

Safe bearing capacity in t/m²

BH -NO.	DEPTH (mtr)	Net Allowable Bearing Pressure (t/m²)
BH-1 (A1)	1.50m	07.50
	3.00m	10.00
	4.50m	10.50
	6.00m	11.50

BH-3 (A2)	1.50m	08.00
	3.00m	11.00
	4.50m	11.50
	6.00m	12.50

Pile load carrying capacity in t

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE
		Pile Diameter= 1.0 m
BH-1 (A1)	17.00	105.00
	20.00	140.00
	23.00	175.00
BH-2 (A2)	17.00	150.00
	20.00	170.00
	23.00	195.00

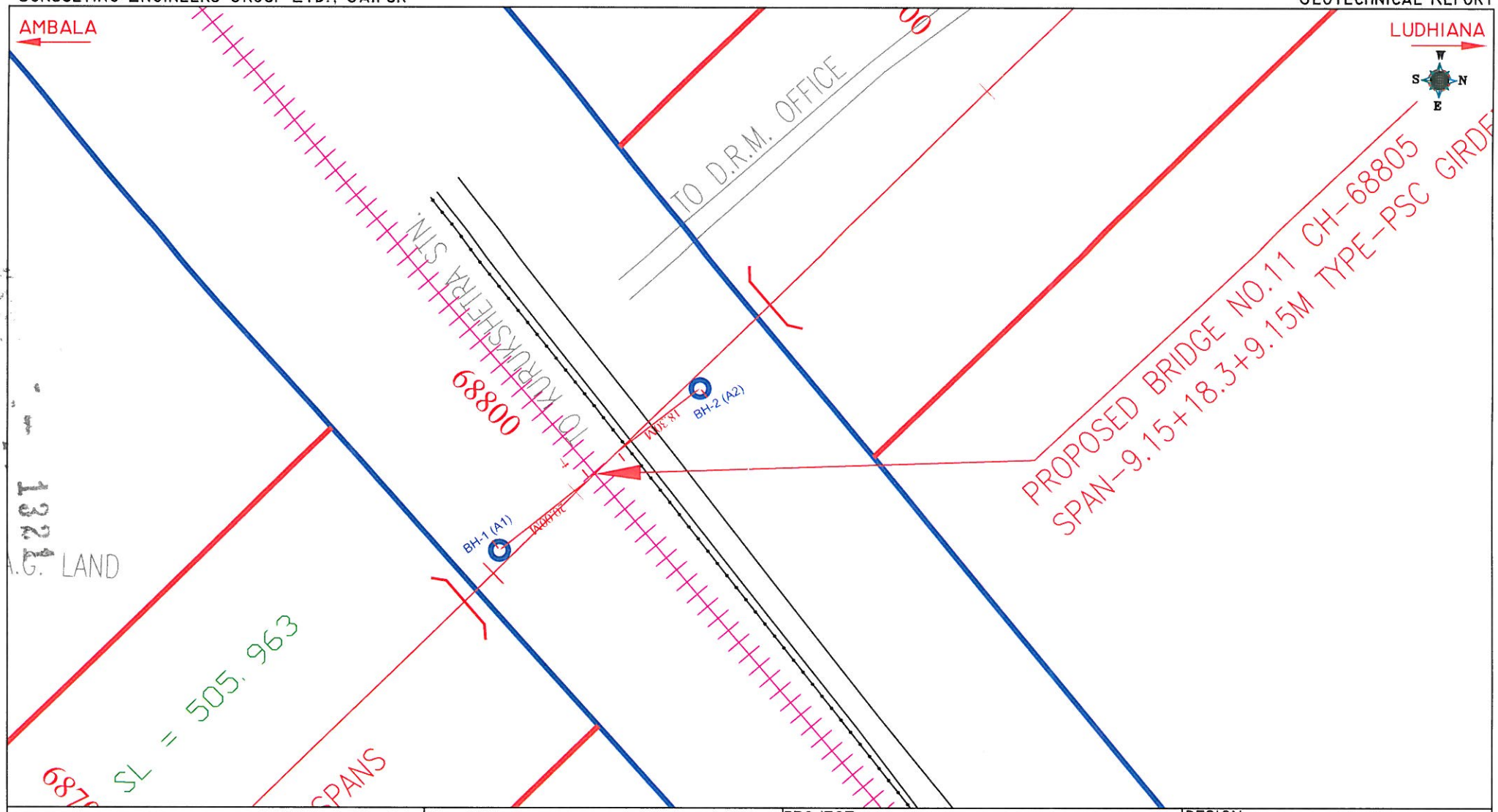
144.7 CONCLUSIONS

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

144.8 RECOMMENDATIONS

(i)	*Type of foundation*	Pile foundation

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



ALL DIMENSIONS IN METER

FIG.:-I

LOCATION PLAN OF PROPOSED DETOUR
SECTION CH. 12650

RL OF BH-AI = 268.072
RL OF BH-A2 = 268.673

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 AT CHAINAGE 12650

Project :	Chainage 12650			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				12.12.2009 to 12.12.2009	A1	1	12.00 m.	30.00mtr	268.072

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	22.14	73.00	4.15	0.52	0.19	0.00	0.00	40	20	20	-	-	-	-	-	-
1.50	7	1.45	10.15	Clayey Silt	25.23	70.59	3.58	0.40	0.20	0.00	0.00	43	21	22	-	-	-	-	-	-
3.00	UDS	-	-	Clayey Silt	26.88	69.01	3.49	0.49	0.13	0.00	0.00	50	26	24	1.72	10.50	1.56	2.71	0.28	13.0
4.50	10	1.09	10.90	Clayey Silt with Sand	23.21	71.76	4.42	0.47	0.14	0.00	0.00	42	22	20	-	-	-	-	-	-
7.50	13	0.92	11.96	Clayey Silt with Sand	24.93	67.12	6.81	0.70	0.29	0.15	0.00	45	22	23	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand with Clay	10.15	37.92	51.82	0.11	0.00	0.00	0.00	28	19	9	1.91	19.83	1.59	2.67	0.12	20.0
10.50	18	0.79	14.22	Clayey Silt with Sand	14.43	71.46	8.98	2.64	1.16	1.33	0.00	32	20	12	-	-	-	-	-	-
13.50	23	0.70	15.55	Clayey Silt with Sand	16.58	77.39	3.65	1.18	1.20	0.00	0.00	35	21	14	-	-	-	-	-	-
16.50	28	0.63	16.32	Clayey Silt	13.74	83.03	2.14	0.58	0.51	0.00	0.00	33	21	12	-	-	-	-	-	-
18.00	UDS	-	-	Clayey Silt	11.26	86.93	1.49	0.20	0.12	0.00	0.00	34	24	10	2.00	20.12	1.66	2.66	0.10	20.0
19.50	31	0.58	16.49	Clayey Silt with Sand	21.85	72.66	4.40	0.63	0.30	0.16	0.00	39	20	19	-	-	-	-	-	-
22.50	34	0.53	16.51	Clayey Silt with Sand	20.14	74.31	4.10	0.75	0.50	0.20	0.00	40	22	18	-	-	-	-	-	-
24.00	UDS	-	-	Clayey Silt with Sand	22.43	71.47	4.89	0.84	0.37	0.00	0.00	42	23	19	2.01	20.00	1.67	2.67	0.21	16.0
25.50	40	0.48	17.10	Clayey Silt with Sand	22.00	73.11	4.05	0.68	0.16	0.00	0.00	42	24	18	-	-	-	-	-	-
28.50	43	0.44	16.96	Clayey Silt with Sand	17.25	71.71	8.85	1.02	0.48	0.69	0.00	38	23	15	-	-	-	-	-	-
30.00	48	0.43	17.82	Clayey Silt with Sand	18.62	68.29	11.49	1.01	0.43	0.16	0.00	39	23	16	-	-	-	-	-	-

CONSULTING
Engineers Group Ltd.

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 FOR AT CHAINAGE 12650

Project :	Chainage 12650 Bridge No. 000			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				13.12.2009 to 13.12.2009	A2	2	12.00 m.	30.00mtr	268.673

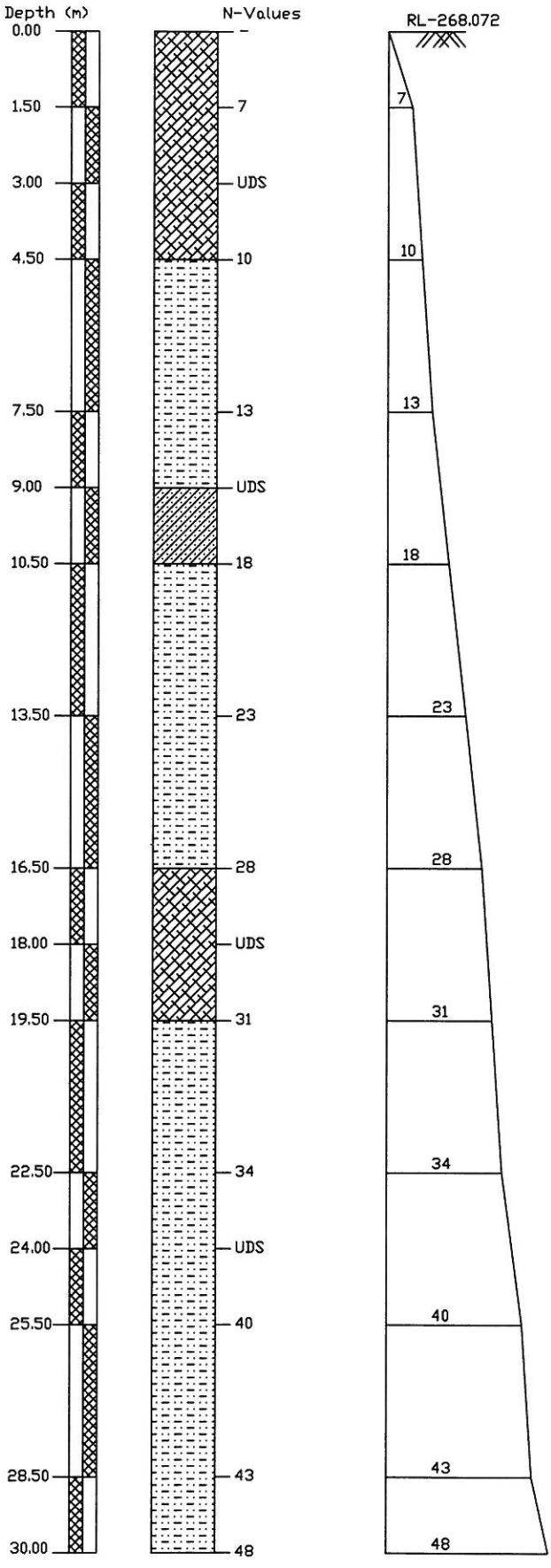
Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Silty Sand with Clay	11.14	17.52	70.52	0.66	0.16	0.00	0.00	28	18	10	-	-	-	-	-	-
1.50	8	1.43	11.44	Silty Sand with Clay	8.14	15.01	76.19	0.56	0.10	0.00	0.00	25	17	8	-	-	-	-	-	-
3.00	UDS	-	-	Clayey Silt with Sand	25.58	67.87	6.06	0.35	0.14	0.00	0.00	46	23	23	1.87	13.37	1.65	2.59	0.23	14.0
4.50	10	1.06	10.60	Clayey Silt with Sand	22.38	69.05	6.77	1.50	0.18	0.12	0.00	42	22	20	-	-	-	-	-	-
7.50	12	0.89	10.68	Silty Sand	4.15	30.67	65.06	0.12	0.00	0.00	0.00	32	NIL	NP	-	-	-	-	-	-
10.50	16	0.78	12.48	Silty Sand	3.15	24.79	71.45	0.41	0.20	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
12.00	UDS	-	-	Silty Sand	2.85	24.27	71.42	0.67	0.60	0.19	0.00	24	NIL	NP	1.89	20.65	1.57	2.68	0.00	28.0
13.50	22	0.69	15.09	Silty Sand	2.16	23.79	73.60	0.45	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
16.50	26	0.62	15.56	Clayey Silt with Sand	15.86	72.63	11.15	0.36	0.00	0.00	0.00	32	18	14	-	-	-	-	-	-
18.00	UDS	-	-	Clayey Silt with Sand	13.52	72.66	13.41	0.41	0.00	0.00	0.00	30	18	12	2.00	21.12	1.65	2.67	0.12	19.0
19.50	29	0.56	15.62	Silty Sand	3.65	6.34	89.71	0.30	0.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
22.50	33	0.51	15.92	Silty Sand	4.00	52.62	43.19	0.19	0.00	0.00	0.00	29	NIL	NP	-	-	-	-	-	-
24.00	UDS	-	-	Clayey Silt	22.65	66.72	10.41	0.22	0.00	0.00	0.00	40	20	20	2.00	20.91	1.65	2.67	0.26	13.0
25.50	34	0.47	15.49	Clayey Silt with Sand	23.14	71.45	5.27	0.14	0.00	0.00	0.00	43	22	21	-	-	-	-	-	-
28.50	41	0.43	16.32	Clayey Silt with Sand	16.85	68.76	12.86	1.03	0.50	0.00	0.00	34	19	15	-	-	-	-	-	-
30.00	45	0.41	16.73	Clayey Silt with Sand	25.59	70.62	3.50	0.19	0.10	0.00	0.00	46	23	23	-	-	-	-	-	-

CONSULTING Engineers Group Ltd.

1323

BORELOG OF BH–1(A1) AT PROPOSED KM–12650 FOR ROR,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

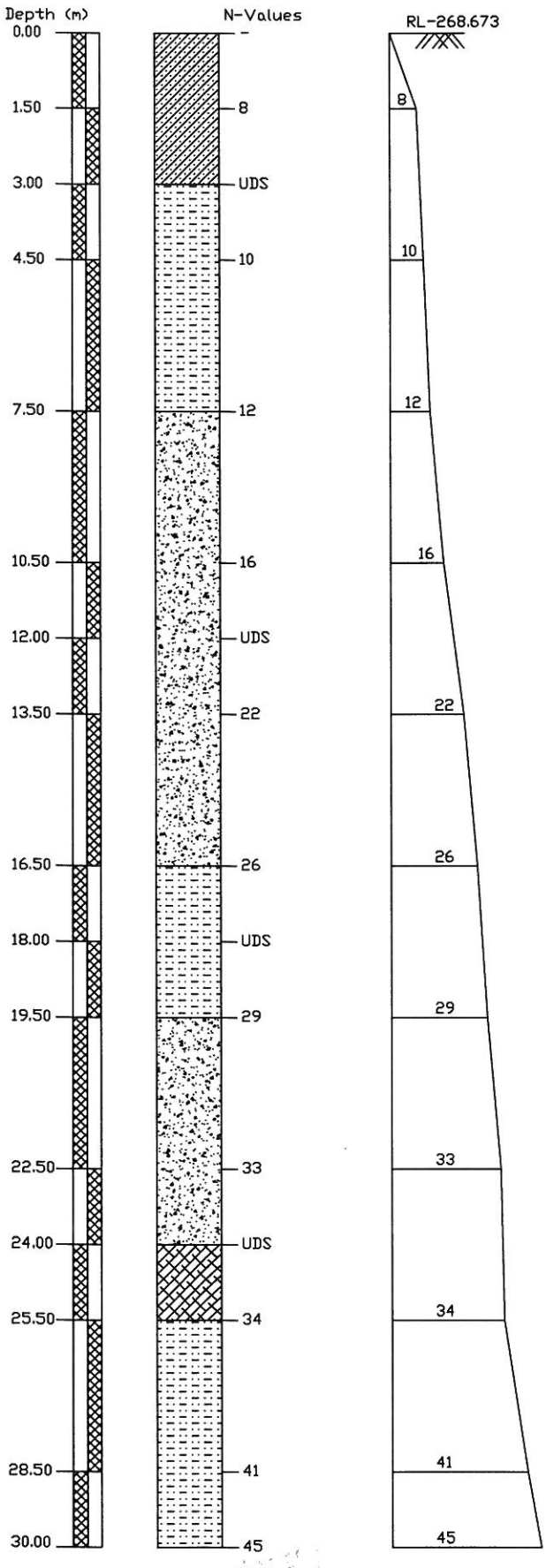
SYMBOL	DESCRIPTION
	CLAYEY SILT
	CLAYEY SILT WITH SAND
	SILTY SAND WITH CLAY

1324

CONSULTING Engineers Group Ltd.

BORELOG OF BH–2(A2) AT PROPOSED KM–12650 FOR ROR,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

1325

CONSULTING Engineers Group Ltd.

ANNEXURE - III

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

INPUT DATA

Ch 12650 **BH-1**

Type of footing

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

Angle of internal friction (ϕ °)	13.00
Cohesion (c in t/m2)	2.80
Void ratio (e)	0.74
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.70
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

$d_c = 1 + 0.2\,(D_f/B)$*SQRT(N_ϕ)

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

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

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

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

OUTPUT

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

CONSULTING Engineers Group Ltd.

1326

ANNEXURE - III

Bearing capacity factors :

ϕ	13.00
N_c	9.93
N_q	3.35
N_γ	2.08

ϕ'	8.79
N'_c	7.90
N'_q	2.25
N'_γ	1.03

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.13	1.06	1.06
2	3.00	3.00	1.25	1.13	1.13
3	4.50	3.00	1.38	1.19	1.19
4	6.00	3.00	1.50	1.25	1.25

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	14.30	7.56	7.90
2	3.00	3.00	8.00	18.15	9.61	10.04
3	4.50	3.00	8.00	19.72	10.44	10.91
4	6.00	3.00	8.00	21.29	11.27	11.78

CONSULTING
Engineers Group Ltd.

ANNEXURE - III

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

INPUT DATA

Ch 12650 **BH-A2**

Type of footing

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

Angle of internal friction (ϕ°)	14.00
Cohesion (c in t/m2)	2.30
Void ratio (e)	0.70
Direction of load with vertical ($^{\circ}$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.70
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

$d_c = 1 + 0.2\,(D_f/B)$*SQRT(N_ϕ)

$d_q = d_\gamma = 1$ 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.

1328

CONSULTING Engineers Group Ltd.

ANNEXURE - III

Bearing capacity factors :

ϕ	14.00
N_c	10.45
N_q	3.65
N_γ	2.36

ϕ'	9.48
N'_c	8.16
N'_q	2.38
N'_γ	1.14

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.13	1.06	1.06
2	3.00	3.00	1.26	1.13	1.13
3	4.50	3.00	1.38	1.19	1.19
4	6.00	3.00	1.51	1.26	1.26

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	13.20	6.83	8.42
2	3.00	3.00	8.00	17.24	8.93	11.01
3	4.50	3.00	8.00	18.71	9.69	11.95
4	6.00	3.00	8.00	20.17	10.46	12.88

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Sction on 12650**

BH No. -A1

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	7.125	t/m^2
Concentrated load *P*		=	7.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	1.7	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.74	
	$\frac{Po + \Delta p}{Po}$	=	1.23158	

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

S_f = 0.03275 m

= 32.7536 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore Pr. Cc = N.A.

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

S_{f2} = **23.8 mm**

1330

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Sction on 12650**

BH No. -A1

Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	9.975	t/m^2
Concentrated load *P*		=	10.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.2	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.74	
	$\frac{Po + \Delta p}{Po}$	=	1.22055	

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

S_f = 0.03134 m

= 31.3393 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore Pr. Cc = N.A.

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

S_{f2} = **20.8 mm**

CONSULTING Engineers Group Ltd.

1331

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Sction on 12650**

BH No. -A1

Depth of foundation		=	4.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	12.825	t/m^2
Concentrated load *P*		=	10.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.3	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.74	
	$\frac{Po + \Delta p}{Po}$	=	1.18012	

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

S_f = 0.02604 m

= 26.0418 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.74

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

= 0.8

Pore Pr. Cc = N.A.

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

S_{f2} = **15.4 mm**

1332

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Sction on 12650**

BH No. -A1

Depth of foundation	=	6.0	m	
Length of footing (L)	=	8.0	m	
Width of footing (B)	=	3.0	m	
Initial effective stress at mid of lay Po	=	15.675	t/m^2	
Concentrated load *P*	=	11.50	t/m^2	
Incerase in pressure at mid of laye ΔP	=	$P \times I_B$		
	I_B =	0.22		
	ΔP =	2.5	t/m^2	
Compression Index	Cc =	0.14		
Thickness of clay layer	H =	4.5	m	
Initial Void ratio	e_o =	0.74		
	$\frac{Po + \Delta p}{Po}$ =	1.1614035		

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

S_f = 0.02353 m

= 23.53 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = **12.8** **mm**

1333

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Sction on 12650**

BH No. A2

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	6.75	t/m^2
Concentrated load *P*		=	8.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	1.8	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.7	
	$\frac{Po + \Delta p}{Po}$	=	1.26074	

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

S_f = 0.03463 m

= 34.6271 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.80

Pore Pr. Correction = N.A

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

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

1334

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Sction on 12650**

BH No. A2

Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	9.45	t/m^2
Concentrated load *P*		=	11.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.4	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.7	
	$\frac{Po + \Delta p}{Po}$	=	1.25608	

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

S_f = 0.03407 m

= 34.0742 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore Pr. Correction = N.A

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

S_{f2} = **22.6** **mm**

1335

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) for cohesive soil **Detour Sction on 12650**

BH No. A2

Depth of foundation		=	4.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	10.8	t/m^2
Concentrated load *P*		=	11.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.5	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	3	m
Initial Void ratio	e_o	=	0.7	
	$\frac{Po + \Delta p}{Po}$	=	1.23426	

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

S_f = 0.02097 m

= 20.9697 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.74

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

= 0.8

Pore Pr. Correction = 0.85

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

S_{f2} = **10.6 mm**

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

Footing Depth (m)	**4.50**
Effective Pressure (t/m2)	2.30
Average N value	12
Settlement for 10 t/m2 (mm)	23.00
Settlement (mm) for SBC	5.29
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	**3.5**

Total corrected Settlement	**14.1**	**mm**

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) for cohesive soil **Detour Sction on 12650**

BH No. A2

Depth of foundation		=	6.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	17.1	t/m^2
Concentrated load *P*		=	12.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.8	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.7	
	$\frac{Po + \Delta p}{Po}$	=	1.1608187	

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

S_f = 0.00743 m

= 7.43 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

= 0.8

Pore Pr. Correction = 0.85

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

S_{f2} = **3.4** **mm**

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

Footing Depth (m)	**6.00**
Effective Pressure (t/m2)	2.88
Average N value	12
Settlement for 10 t/m2 (mm)	23.00
Settlement (mm) for SBC	6.61
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	**4.4**

Total corrected Settlement	**7.8**	**mm**

CONSULTING Engineers Group Ltd.

1337

CHAPTER – 145

"RUB" of Detour Section

Location – Proposed Chainage – 12450

CBE CONSULTING Engineers Group Ltd.

145.1 LOCATION OF STRUCTURE:
RUB at Proposed Chainage 12450

145.2 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 12.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1 (A1)	0.00 to 1.50	Filled up Strata	Loose
	1.50 to 4.50	Sandy Silt with Clay	Loose
	4.50 to 18.00	Clayey Silt with Sand	Medium Dense
	18.00 to 25.50	Clayey Silt	Medium Dense
	25.50 to 30.00	Clayey Silt with Sand	Dense
BH-2 (A2)	0.00 to 1.50	Silty Sand	Loose
	1.50 to 3.00	Silty Sand with Clay	Loose
	3.00 to 7.50	Clayey Silt with Sand	Loose
	7.50 to 12.00	Clayey Silt with Sand	Medium Dense
	12.00 to 13.50	Silty Sand	Medium Dense
	13.50 to 22.50	Clayey Silt with Sand	Medium Dense
	22.50 to 30.00	Clayey Silt with Sand	Dense

145.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.30	NIL	0.0035	NIL	0.0014	0.227
	9.00	8.20	NIL	0.0021	NIL	0.0013	0.068
	18.00	8.80	NIL	0.0028	NIL	0.0011	0.162
	24.00	9.10	NIL	0.0022	NIL	0.0013	0.152
BH-2 (A2)	3.00	8.10	NIL	0.0032	NIL	0.0015	0.091
	12.00	8.80	0.007	0.0017	NIL	0.0011	0.041
	21.00	8.20	0.005	0.0021	NIL	0.0022	0.098
	27.00	9.20	NIL	0.0032	NIL	0.0015	0.132

145.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1 (A1)	3.00	07.00
	9.00	15.00
	18.00	12.00
	24.00	13.00

BH-2 (A2)	3.00	27.00
	12.00	NIL
	21.00	17.00
	27.00	23.00

145.5 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	7.15	79	98	188	785	0.2	2.0	1011	662
Requirement as per IS:456 / Morth's	Not less then 6.0	2000 for CC and 500 for RCC	400	200	3000	5 ml of 0.02 normal NaoH	25 ml of 0.02 normal H_2SO_4	-	-

145.6 PILE LOAD CARRYING CAPACITY

145.6.1 Normal Bored Cast in- situ Pile Foundations:

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

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

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

Safe bearing capacity in t/m²

BH -NO.	DEPTH (mtr)	Net Allowable Bearing Pressure (t/m²)
BH-1 (A1)	1.50m	08.00
	3.00m	12.00
	4.50m	13.00
	6.00m	13.50
BH-3 (A2)	1.50m	07.50
	3.00m	09.00
	4.50m	09.50
	6.00m	10.50

Pile load carrying capacity in t

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE	
		Pile Diameter= 1.0 m	Pile Diameter= 1.2 m
BH-1 (A1)	17.00	80.00	100.00
	20.00	105.00	130.00
	23.00	130.00	160.00
BH-2 (A2)	17.00	95.00	115.00
	20.00	125.00	150.00
	23.00	140.00	170.00

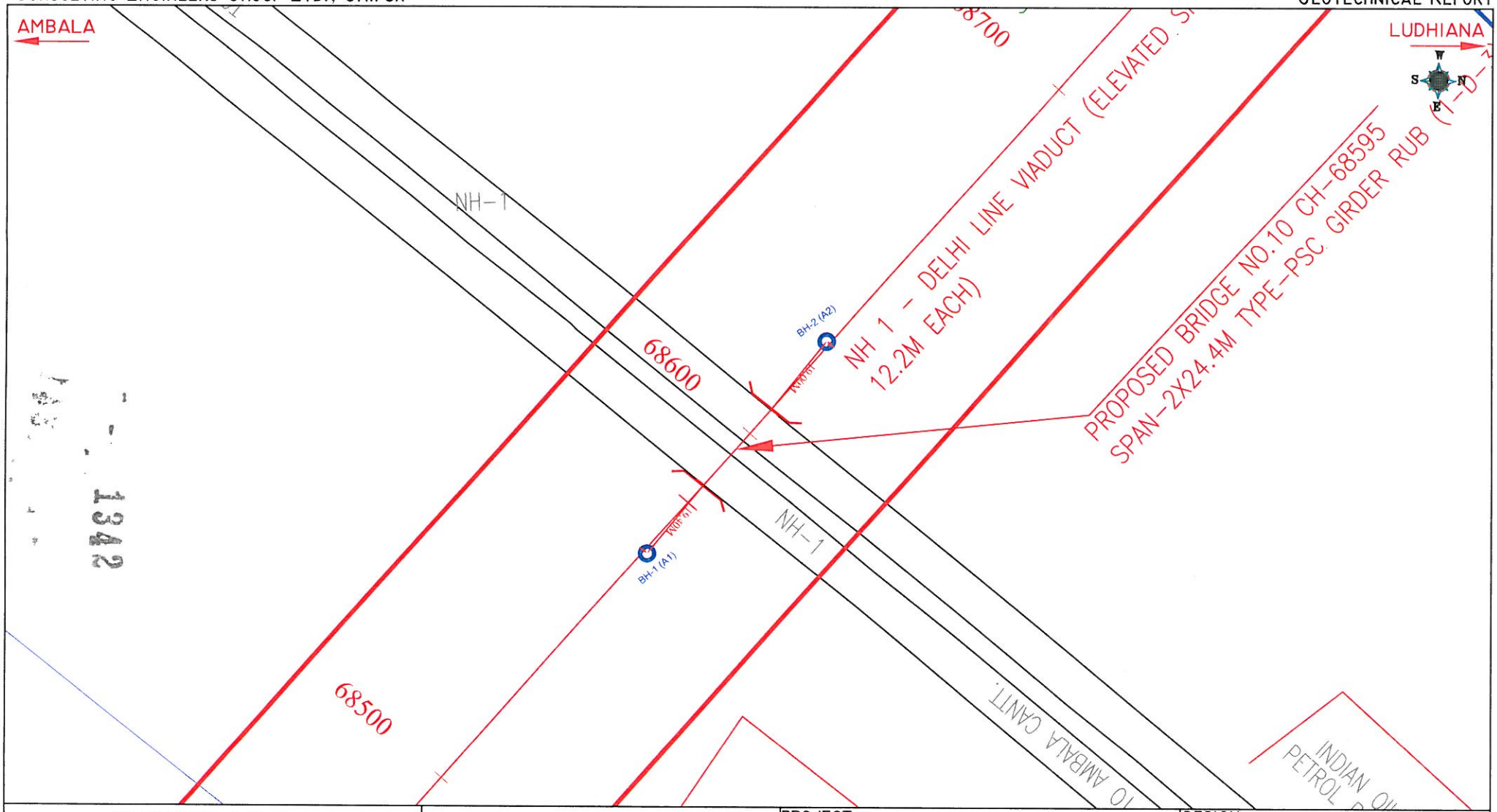
145.7 CONCLUSIONS

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

145.8 RECOMMENDATIONS

(i)	*Type of foundation*	Pile foundation

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



ALL DIMENSIONS IN METER

FIG.:-I

LOCATION PLAN OF PROPOSED DETOUR
SECTION CH. 12450

RL OF BH-A1 = 269.580
RL OF BH-A2 = 268.323

PROJECT :-

LUDHIANA-AMBALA (DFCCIL)

DESIGN :-

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

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 FOR AT CHAINAGE 12450

Project :	Chainage 12450			Date of Testing	Location at		B.H. No.		Depth of Water Table			Termination Depth			Surface Elevation					
				14.12.2009 to 14.12.2009	A1		1		12.00 m.			30.00mtr			269.580					
Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Filled up Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.50	5	1.44	7.20	Sandy Silt with Clay	16.48	50.15	32.63	0.56	0.18	0.00	0.00	33	19	14	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt with Clay	6.41	73.26	17.30	2.55	0.48	0.00	0.00	23	17	6	1.78	12.36	1.58	2.70	0.09	22.0
4.50	10	1.08	10.80	Clayey Silt with Sand	16.89	65.66	12.30	4.00	0.85	0.30	0.00	33	18	15	-	-	-	-	-	-
7.50	12	0.91	10.92	Clayey Silt with Sand	12.47	79.51	7.12	0.69	0.21	0.00	0.00	31	20	11	-	-	-	-	-	-
9.00	UDS	-	-	Clayey Silt with Sand	13.86	77.10	6.50	1.69	0.85	0.00	0.00	31	19	12	1.82	13.69	1.63	2.70	0.12	19.0
10.50	14	0.79	11.06	Clayey Silt with Sand	17.22	71.83	8.45	1.72	0.78	0.00	0.00	35	20	15	-	-	-	-	-	-
13.50	18	0.71	12.78	Clayey Silt with Sand	19.68	67.73	9.93	1.60	0.70	0.36	0.00	37	19	18	-	-	-	-	-	-
16.50	22	0.64	14.08	Clayey Silt with Sand	19.94	69.12	8.27	2.13	0.54	0.00	0.00	38	20	18	-	-	-	-	-	-
18.00	UDS	-	-	Clayey Silt	12.12	85.96	1.76	0.16	0.00	0.00	0.00	34	24	10	1.95	20.14	1.62	2.67	0.11	19.0
19.50	25	0.58	14.50	Clayey Silt	20.41	77.80	1.71	0.08	0.00	0.00	0.00	38	20	18	-	-	-	-	-	-
22.50	26	0.52	13.52	Clayey Silt	25.11	71.24	3.36	0.29	0.00	0.00	0.00	45	22	23	-	-	-	-	-	-
24.00	UDS	-	-	Clayey Silt	11.32	87.96	0.62	0.10	0.00	0.00	0.00	29	19	10	1.99	21.56	1.64	2.67	0.12	20.0
25.50	33	0.48	15.42	Clayey Silt with Sand	16.14	66.91	16.10	0.85	0.00	0.00	0.00	32	18	14	-	-	-	-	-	-
28.50	38	0.44	15.86	Clayey Silt with Sand	26.12	64.79	7.45	1.22	0.42	0.00	0.00	47	24	23	-	-	-	-	-	-
30.00	42	0.42	16.32	Clayey Silt with Sand	9.85	75.94	13.56	0.49	0.16	0.00	0.00	26	17	9	-	-	-	-	-	-

CONSULTING
Engineers Group Ltd.

1343

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 FOR AT CHAINAGE 12450

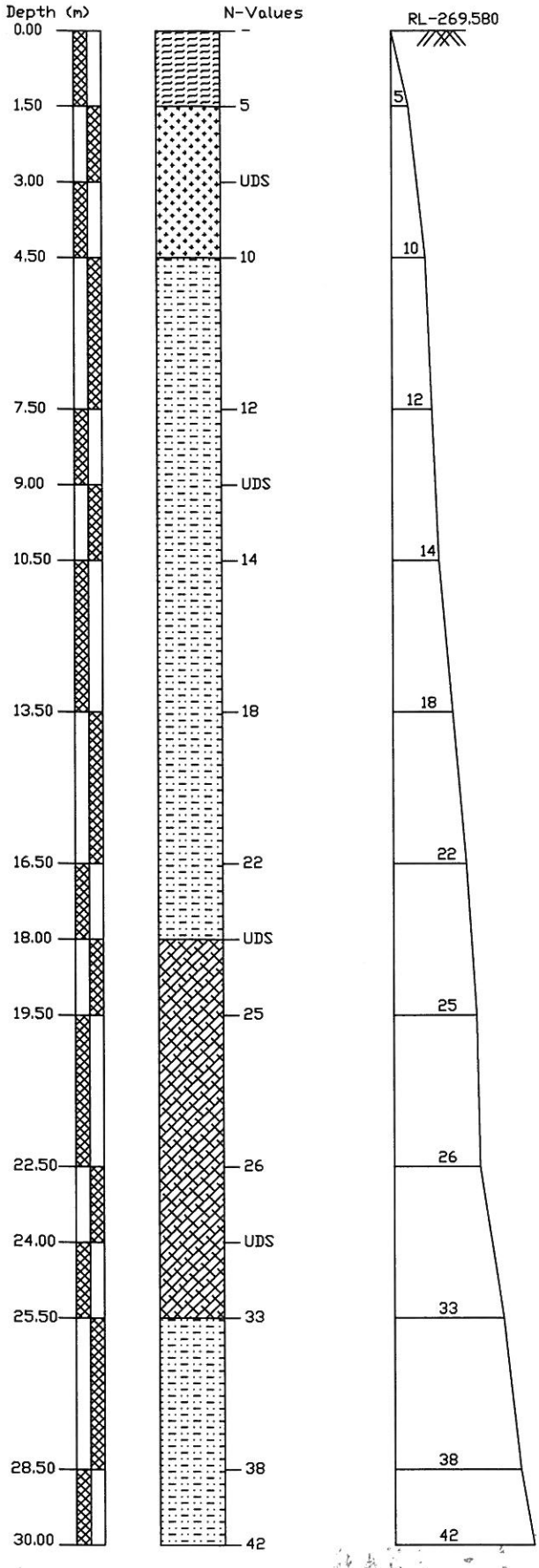
Project :	Chainage 12450			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				15.12.2009 to 15.12.2009	A2	2	12.00 m.	30.00mtr	268.323

Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Silty Sand	2.54	30.69	65.34	0.95	0.48	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
1.50	5	1.45	7.25	Silty Sand with clay	13.39	23.03	62.37	0.87	0.34	0.00	0.00	32	20	12	-	-	-	-	-	-
3.00	UDS	-	-	Clayey Silt with Sand	26.25	67.42	6.01	0.23	0.09	0.00	0.00	46	23	23	1.75	14.06	1.53	2.70	0.28	12.0
4.50	7	1.08	7.56	Clayey Silt with Sand	20.15	60.33	17.85	1.19	0.48	0.00	0.00	42	24	18	-	-	-	-	-	-
7.50	12	0.91	10.92	Clayey Silt with Sand	22.38	71.36	5.21	0.72	0.33	0.00	0.00	41	21	20	-	-	-	-	-	-
10.50	15	0.80	12.00	Clayey Silt with Sand	21.41	54.66	20.20	1.65	0.96	1.12	0.00	40	21	19	-	-	-	-	-	-
12.00	UDS	-	-	Silty Sand	3.67	44.47	51.78	0.08	0.00	0.00	0.00	27	NIL	NP	1.91	19.24	1.60	2.69	0.00	27.5
13.50	19	0.71	13.49	Clayey Silt with Sand	17.54	64.61	15.24	1.35	0.00	1.26	0.00	35	20	15	-	-	-	-	-	-
16.50	22	0.63	13.86	Clayey Silt with Sand	18.24	67.41	12.52	1.15	0.68	0.00	0.00	37	21	16	-	-	-	-	-	-
19.50	29	0.57	15.77	Clayey Silt with Sand	20.24	63.32	14.36	0.85	0.98	0.25	0.00	38	20	18	-	-	-	-	-	-
21.00	UDS	-	-	Clayey Silt with Sand	16.35	71.51	10.26	0.73	1.15	0.00	0.00	34	20	14	1.95	20.46	1.62	2.65	0.15	16.0
22.50	33	0.52	16.08	Clayey Silt with Sand	18.16	66.19	13.65	1.14	0.86	0.00	0.00	38	22	16	-	-	-	-	-	-
25.50	37	0.48	16.38	Clayey Silt with Sand	17.22	64.60	14.25	2.15	1.32	0.46	0.00	35	20	15	-	-	-	-	-	-
27.00	UDS	-	-	Clayey Silt with Sand	22.51	57.97	17.25	1.12	1.15	0.00	0.00	41	21	20	2.01	20.26	1.67	2.66	0.21	14.0
28.50	43	0.44	16.96	Clayey Silt with Sand	15.35	71.39	11.62	0.76	0.88	0.00	0.00	34	21	13	-	-	-	-	-	-
30.00	46	0.41	16.93	Clayey Silt with Sand	11.62	76.75	9.65	0.83	0.76	0.39	0.00	29	19	10	-	-	-	-	-	-

CONSULTING
Engineers Group Ltd.

BORELOG OF BH–1(A1) AT PROPOSED KM–12450 FOR RUB,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

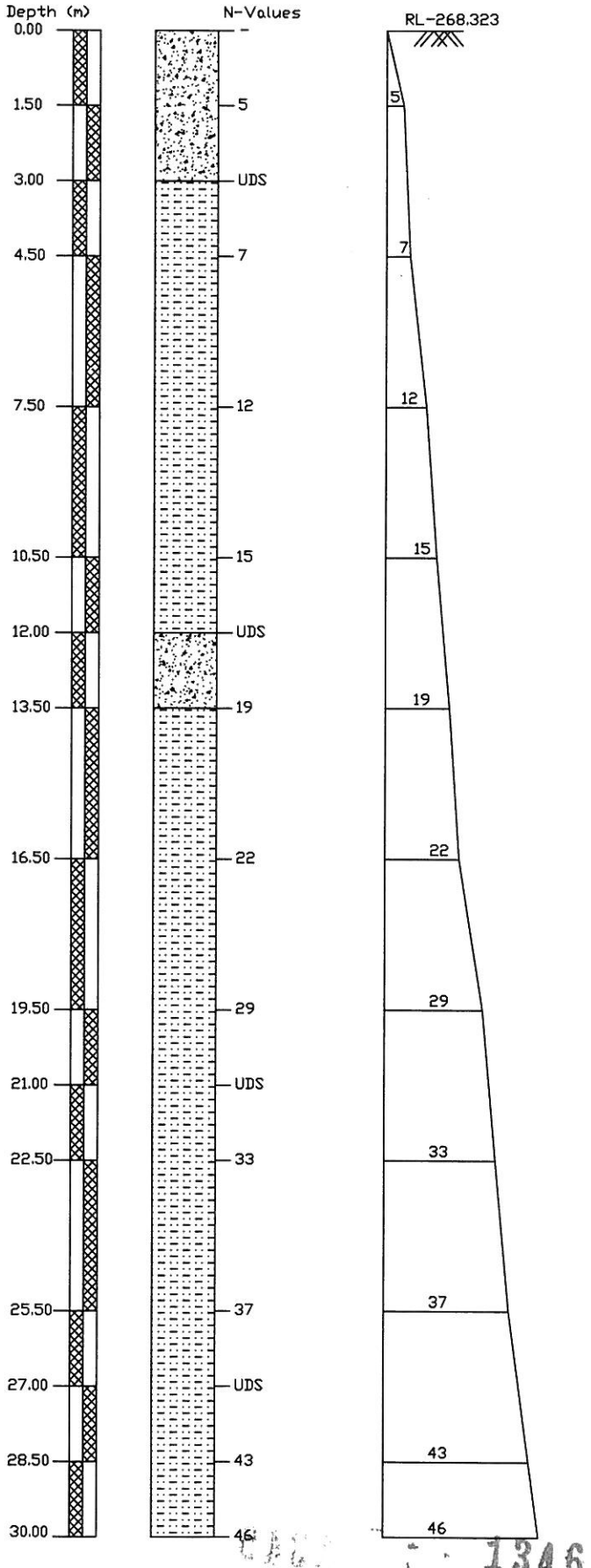
SYMBOL	DESCRIPTION
	FILLED UP STRATA
	SANDY SILT WITH CLAY
	CLAYEY SILT WITH SAND
	CLAYEY SILT

1345

CONSULTING Engineers Group Ltd.

BORELOG OF BH–2(A2) AT PROPOSED KM–12450 FOR RUB,

ON KESARI TO SANEHWAL, LUDHIANA



1346

LEGEND

SYMBOL	DESCRIPTION
	SILTY SAND
	CLAYEY SILT WITH SAND

CONSULTING Engineers Group Ltd.

ANNEXURE - III

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

INPUT DATA

	Ch 12450	BH-A1	
Type of footing			
1 Continuous Strip			
2 Rectangular		***Rectangular***	**2**
3 Square			
4 Circular			

Angle of internal friction (ϕ °)	19.00
Cohesion (c in t/m2)	1.20
Void ratio (e)	0.70
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.70
Depth of water table(m)	1.50
Factor of safety	3.00

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

1347

CONSULTING Engineers Group Ltd.

ANNEXURE - III

Bearing capacity factors :

ϕ	19.00
N_c	14.06
N_q	5.91
N_γ	4.84

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.14	1.07	1.07
2	3.00	3.00	1.28	1.14	1.14
3	4.50	3.00	1.42	1.21	1.21
4	6.00	3.00	1.56	1.28	1.28

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	13.56	6.34	8.15
2	3.00	3.00	8.00	19.96	9.39	12.03
3	4.50	3.00	8.00	21.56	10.14	13.00
4	6.00	3.00	8.00	23.16	10.90	13.96

CONSULTING Engineers Group Ltd.

ANNEXURE - III

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

INPUT DATA

	Ch 12450	BH-A2	
Type of footing			
1 Continuous Strip			
2 Rectangular		***Rectangular***	**2**
3 Square			
4 Circular			

Angle of internal friction (ϕ°)	12.00
Cohesion (c in t/m2)	2.80
Void ratio (e)	0.75
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.70
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)	Length (m)
1	1.50	3.00	8.00
1	3.00	3.00	8.00
2	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.

1349

CONSULTING Engineers Group Ltd.

ANNEXURE - III

Bearing capacity factors :

ϕ	12.00
N_c	9.40
N_q	3.06
N_γ	1.79

ϕ'	8.11
N'_c	7.65
N'_q	2.13
N'_γ	0.93

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
1	3.00	8.00	1.08	1.08	0.85
2	3.00	8.00	1.08	1.08	0.85
4	3.00	8.00	1.08	1.08	0.85

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.12	1.06	1.06
1	3.00	3.00	1.25	1.12	1.12
2	4.50	3.00	1.37	1.19	1.19
4	6.00	3.00	1.49	1.25	1.25

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	13.28	7.20	7.20
1	3.00	3.00	8.00	16.72	9.07	9.07
2	4.50	3.00	8.00	18.15	9.85	9.85
4	6.00	3.00	8.00	19.59	10.63	10.63

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) for cohesive soil **Detour Sction on 12450**

BH No. -A1

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	6.75	t/m^2
Concentrated load *P*		=	8.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	1.8	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.7	
	$\frac{Po + \Delta p}{Po}$	=	1.26074	

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

S_f = 0.0346 m

= 34.6271 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore Pr. Correction = N.A

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

S_{f2} = **25 mm**

1351

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) for cohesive soil **Detour Sction on 12450**

BH No. -A1

Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	9.45	t/m^2
Concentrated load *P*		=	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	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.7	
	$\frac{Po + \Delta p}{Po}$	=	1.27937	

Settlement of clay layer

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

S_f = 0.03682 m

= 36.8187 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore Pr. Correction = N.A

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

S_{f2} = **24.4** **mm**

1352

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) for cohessive soil **Detour Sction on 12450**

BH No. -A1

Depth of foundation		=	4.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	12.15	t/m^2
Concentrated load *P*		=	13.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.9	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.7	
	$\frac{Po + \Delta p}{Po}$	=	1.23539	

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

S_f = 0.03159 m

= 31.5915 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.74

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

= 0.8

Pore Pr. Correction = N.A

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

S_{f2} = **18.7 mm**

1353

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) for cohessive soil **Detour Sction on 12450**

BH No. -A1

Depth of foundation		=	6.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	15.26	t/m^2
Concentrated load *P*		=	13.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
		I_B =	0.22	
	ΔP	=	3.0	t/m^2
Compression Index	Cc	=	0.13	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.7	
	$\frac{Po + \Delta p}{Po}$	=	1.194595	

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

S_f = 0.02657 m

= 26.57 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

= 0.8

Pore Pr. Correction = N.A

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

S_{f2} = **14.5** **mm**

1354

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Section on 12450**

BH No. -A2

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	7.125	t/m^2
Concentrated load *P*		=	7.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	1.5	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.21614	

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

S_f = 0.0306 m

= 30.5941 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore Pr. Correction = N.A

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

S_{f2} = **22.3 mm**

1355

CONSULTING
Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Section on 12450**

BH No. -A2

Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	9.975	t/m^2
Concentrated load *P*		=	9.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.0	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.1985	

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

S_f = 0.02831 m

= 28.3092 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore Pr. Correction = N.A

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

S_{f2} = **18.8 mm**

1356

CONSULTING
Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Section on 12450**

BH No. -A2

Depth of foundation		=	4.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	12.825	t/m^2
Concentrated load *P*		=	9.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.1	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.16296	

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

S_f = 0.0236 m

= 23.6037 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.74

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

= 0.8

Pore Pr. Correction = N.A

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

S_{f2} = **14.0 mm**

1357

CONSULTING
Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Section on 12450**

BH No. -A2

Depth of foundation		=	6.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	15.68	t/m^2
Concentrated load *P*		=	10.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.3	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.1473684	

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

S_f = 0.02149 m

= 21.49 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

= 0.8

Pore Pr. Correction = N.A

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

S_{f2} = **11.7 mm**

1358

CONSULTING Engineers Group Ltd.

CHAPTER – 146

"Minor Bridge" of Detour Section

Location – Proposed Chainage – 11800

146.1 LOCATION OF STRUCTURE:

Minor Bridge at Proposed Chainage 11800

146.2 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 6.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 4.50	Sandy Silt with Clay	Loose
	4.50 to 7.50	Clayey Silt with Sand	Medium Dense
	7.50 to 12.00	Silty Sand	Medium Dense

146.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.50	NIL	0.0035	NIL	0.0014	0.120
	6.00	8.80	0.007	0.0035	NIL	0.0013	0.128

146.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	NIL
	6.00	23.00

146.5 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	6.9	132	99	184	779	0.1	2.1	972	613
Requirement as per IS: 456 / Mosrth's	Not less then 6.0	2000 for CC and 500 for RCC	400	200	3000	5 ml of 0.02 normal NaoH	25 ml of 0.02 normal H_2SO_4	-	-

146.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	06.00
	3.00	08.00
	4.50	09.00
	6.00	10.00

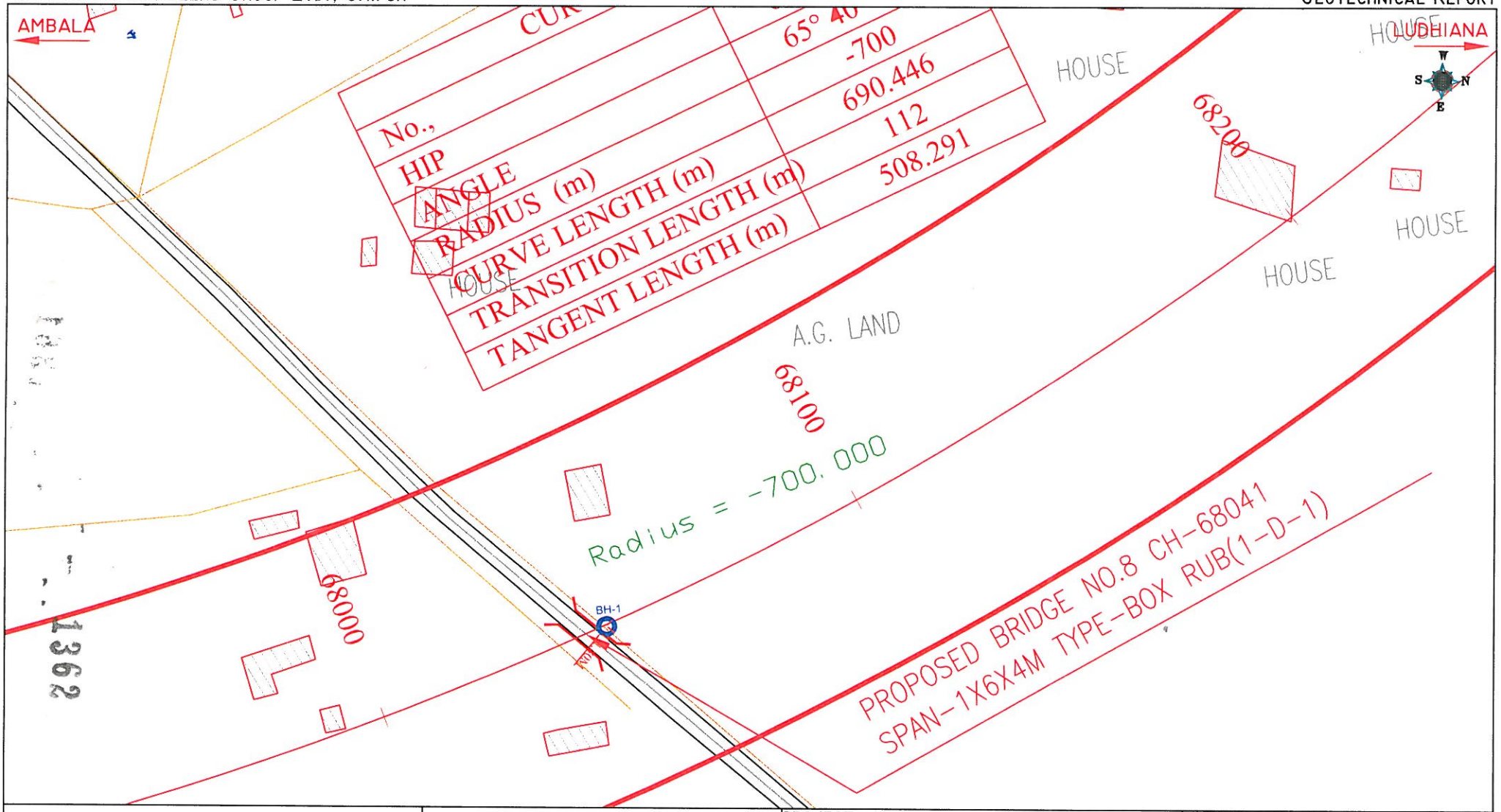
146.7 CONCLUSIONS

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

146.8 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 DETOUR SECTION CH. 11800

RL OF BH-I = 269.373

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 AT CHAINAGE 11800

Project :	Chainage 11800 Bridge No. 000			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				12.12.2009 to 12.12.2009	1	1	06.00 m.	12.00mtr	269.373

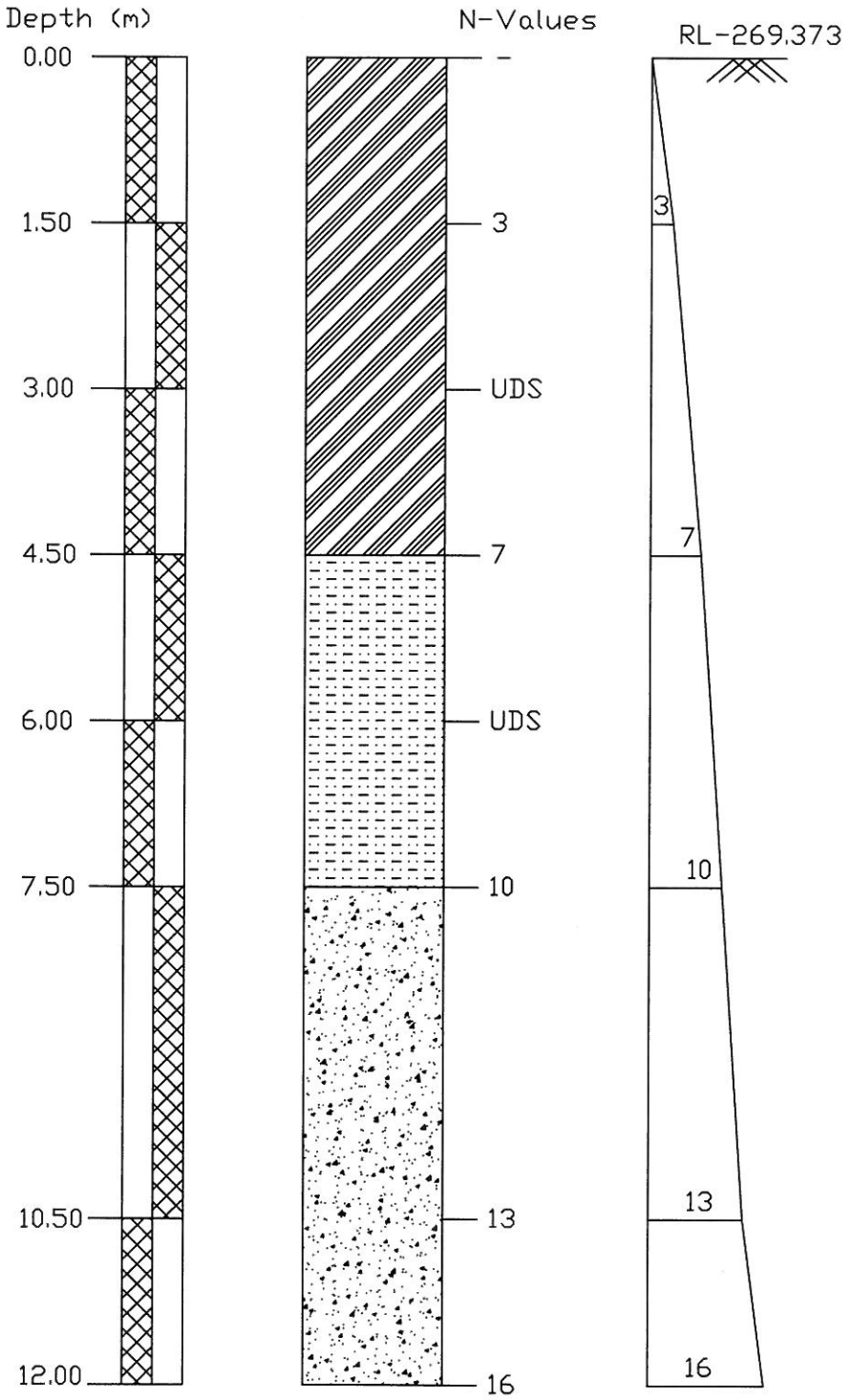
Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Sandy Silt with clay	8.54	74.37	15.26	1.23	0.35	0.25	0.00	29	21	8	-	-	-	-	-	-
1.50	3	1.43	4.29	Sandy Silt with clay	7.65	78.69	12.52	0.85	0.16	0.13	0.00	26	20	6	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt with clay	3.55	47.11	47.04	1.00	0.45	0.85	0.00	30	21	9	1.70	13.36	1.50	2.67	0.10	20
4.50	7	1.06	7.42	Clayey Silt with Sand	19.52	72.44	3.15	2.13	1.31	1.45	0.00	37	20	17	-	-	-	-	-	-
6.00	UDS	-	-	Clayey Silt with Sand	21.46	70.44	2.93	2.98	1.35	0.84	0.00	40	21	19	1.96	21.65	1.61	2.64	0.21	14.0
7.50	10	0.88	8.80	Silty Sand	3.68	10.63	85.46	0.17	0.06	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
10.50	13	0.77	10.01	Silty Sand	4.12	14.29	79.42	1.22	0.42	0.53	0.00	26	NIL	NP	-	-	-	-	-	-
12.00	16	0.72	11.52	Silty Sand	4.56	17.38	77.95	0.03	0.08	0.00	0.00	28	NIL	NP	-	-	-	-	-	-

CONSULTING Engineers Group Ltd.

1363

BORELOG OF BH–1 AT PROPOSED KM–11800 FOR MINOR BRIDGE,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT
	CLAYEY SILT WITH SAND
	SILTY SAND

1364

CONSULTING Engineers Group Ltd.

ANNEXURE - III

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

INPUT DATA

		Ch 11800	BH-1
Type of footing			
1	Continuous Strip		
2	Rectangular	***Rectangular***	**2**
3	Square		
4	Circular		

Angle of internal friction (ϕ °)	14.00
Cohesion (c in t/m2)	2.10
Void ratio (e)	0.78
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.96
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

$d_q = d_\gamma = 1$ for $\phi < 10°$

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

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

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

OUTPUT

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

CONSULTING Engineers Group Ltd.

ANNEXURE - III

Bearing capacity factors :

ϕ	14.00
N_c	10.45
N_q	3.65
N_γ	2.36

ϕ'	9.48
N'_c	8.16
N'_q	2.38
N'_γ	1.14

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.13	1.06	1.06
2	3.00	3.00	1.26	1.13	1.13
3	4.50	3.00	1.38	1.19	1.19
4	6.00	3.00	1.51	1.26	1.26

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	12.49	6.46	6.46
2	3.00	3.00	8.00	16.45	8.51	8.51
3	4.50	3.00	8.00	17.82	9.23	9.23
4	6.00	3.00	8.00	19.20	9.95	9.95

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Section on 11800**

BH No. -1

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	6.75	t/m^2
Concentrated load *P*		=	6.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	1.3	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.19556	

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

S_f = 0.0279 m

= 27.9251 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore Pr. Correction = N.A.

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

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

1367

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Section on 11800**

BH No. -1

Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	9.45	t/m^2
Concentrated load *P*		=	8.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	1.8	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.18624	

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

S_f = 0.0267 m

= 26.7026 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = **22.2 mm**

CONSULTING Engineers Group Ltd.

1368

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Detour Section on 11800**

BH No. -1

Depth of foundation		=	4.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	12.15	t/m^2
Concentrated load *P*		=	9.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.0	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	3	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.16296	

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

S_f = 0.01574 m

= 15.7358 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.74

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

= 0.8

Pore Pr. Correction = = 0.85

Corrected Total Settlement = S_f x D.F.x R.F.xP.C.x pore pr. Correction

S_{f2} = **9.9 mm**

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

Footing Depth (m)	**4.50**
Effective Pressure (t/m2)	1.80
Average N value	10
Settlement for 10 t/m2 (mm)	36.00
Settlement (mm) for SBC	6.48
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	**4.3**

Total corrected Settlement	**14.2**	mm

CONSULTIN
Engineers Group Lt

1369

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) — **Detour Section on 11800**

BH No. -1

Depth of foundation		=	6.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	15.68	t/m^2
Concentrated load *P*		=	10.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.2	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.1403509	

Settlement of clay layer

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

S_f = 0.00684 m

= 6.84 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

= 0.8

Pore Pr. Correction = = 0.85

Corrected Total Settlement = S_f x D.F.x R.F.xP.C.x pore pr. Correction

S_{f2} = **4.0 mm**

Total settlement = 23.1 mm

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

Footing Depth (m)	6.00
Effective Pressure (t/m2)	2.30
Average N value	10
Settlement for 10 t/m2 (mm)	36.00
Settlement (mm) for SBC	8.28
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	5.5

Total corrected Settlement	9.5	mm