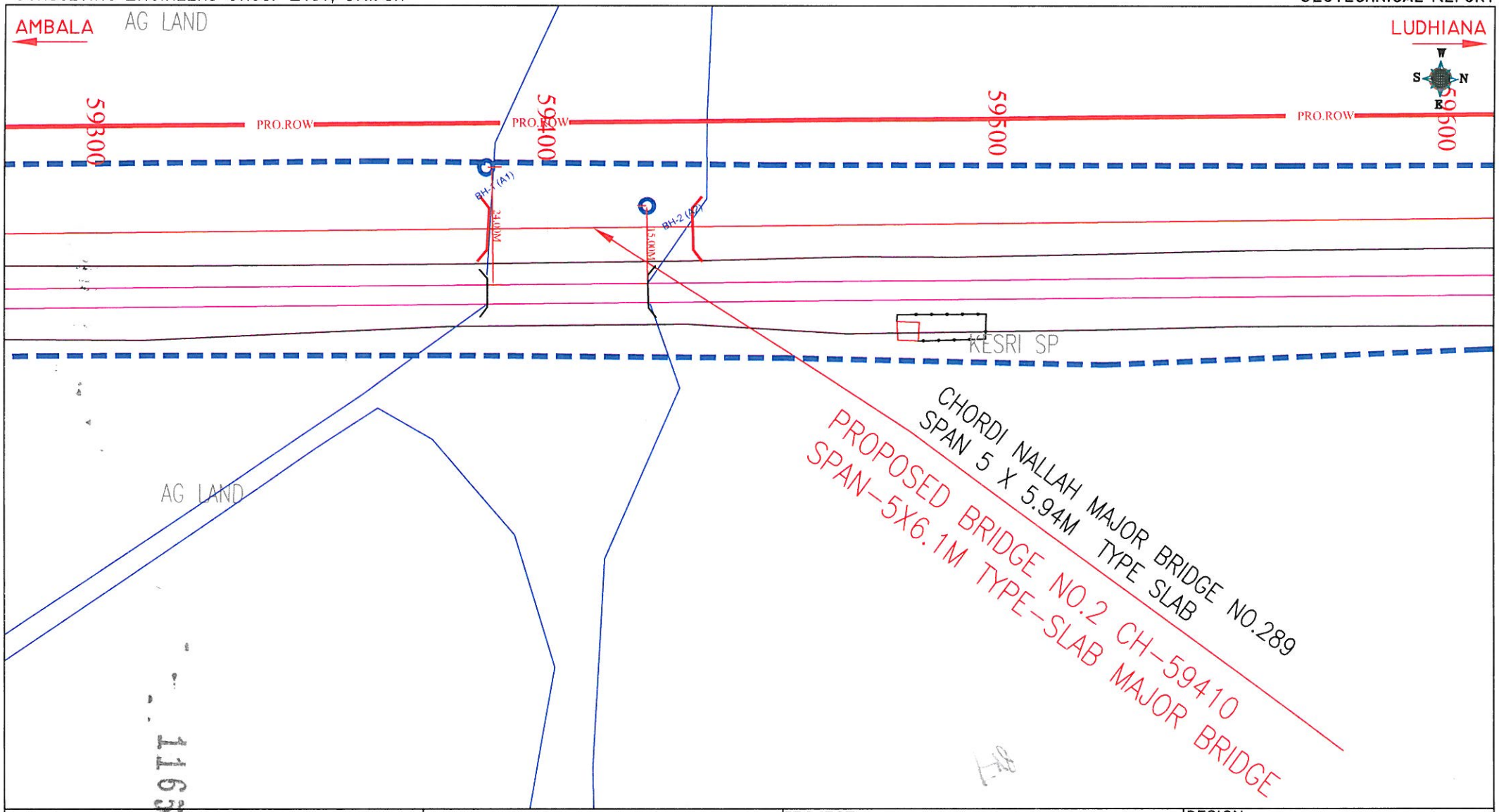

ALL DIMENSIONS IN METER

FIG.:-I

LOCATION PLAN OF PROPOSED MAJOR BRIDGE AT CH. 251/5-7

RL OF BH (AI) = 267.373

RL OF BH (A2) = 267.294

PROJECT :-

LUDHIANA-AMBALA (DFCCIL)

DESIGN :-

CONSULTING ENGINEERS GROUP LTD.
E-12,Moji Colony,Malviya Nagar Jaipur-17
Tel: +91-141- 2520899, 2521899, 2520556
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SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (A1) OF MAJOR BRIDGE No. 289 AT CHAINAGE 251/5-7

Project :	Chainage 251/5-7 Bridge No. 289			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				16.12.2009 to 16.12.2009	A1	1	08.00 m.	30.00mtr	267.373

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	11.12	62.45	16.94	4.58	3.65	1.26	0.00	30	20	10	-	-	-	-	-	-
1.50	6	1.46	8.76	Sandy Silt with Clay	12.11	66.17	15.68	3.85	1.26	0.93	0.00	30	19	11	-	-	-	-	-	-
3.00	UDS	-	-	Clayey Silt with Sand	16.42	75.83	7.25	0.50	0.00	0.00	0.00	36	22	14	1.68	9.64	1.55	2.72	0.19	16.0
4.50	9	1.10	9.90	Clayey Silt with Sand	21.79	69.73	8.12	0.36	0.00	0.00	0.00	41	22	19	-	-	-	-	-	-
7.50	13	0.92	11.96	Clayey Silt with Sand	12.98	76.67	10.13	0.22	0.00	0.00	0.00	29	17	12	-	-	-	-	-	-
10.50	14	0.81	11.34	Silty Sand	3.47	9.38	86.40	0.68	0.07	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
12.00	UDS	-	-	Clayey Silt with Sand	21.42	66.44	11.09	0.51	0.54	0.00	0.00	40	21	19	2.00	19.93	1.67	2.67	0.22	15.0
13.50	17	0.71	12.07	Clayey Silt	23.68	73.52	2.80	0.00	0.00	0.00	0.00	43	22	21	-	-	-	-	-	-
16.50	19	0.64	12.16	Clayey Silt	19.14	78.87	1.86	0.05	0.08	0.00	0.00	38	21	17	-	-	-	-	-	-
18.00	UDS	-	-	Clayey Silt	26.24	69.97	3.66	0.10	0.03	0.00	0.00	46	22	23	2.01	20.12	1.74	2.66	0.25	13.0
19.50	15	0.58	8.70	Clayey Silt	22.12	74.63	2.65	0.25	0.35	0.00	0.00	40	20	20	-	-	-	-	-	-
21.00	UDS	-	-	Clayey Silt	18.93	76.97	3.15	0.53	0.42	0.00	0.00	38	21	17	2.08	20.36	1.73	2.67	0.20	18.0
22.50	18	0.52	9.36	Clayey Silt	18.54	76.51	4.16	0.43	0.36	0.00	0.00	36	20	16	-	-	-	-	-	-
25.50	20	0.48	9.60	Clayey Silt	20.46	75.96	2.52	0.65	0.41	0.00	0.00	39	21	18	-	-	-	-	-	-
28.50	22	0.44	9.68	Clayey Silt	16.98	78.84	3.75	0.18	0.25	0.00	0.00	36	21	15	-	-	-	-	-	-
30.00	29	0.42	12.18	Clayey Silt	23.14	71.61	4.00	0.73	0.52	0.00	0.00	42	21	21	-	-	-	-	-	-

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SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (A2) OF MAJOR BRIDGE No. 289 AT CHAINAGE 251/5-7

Project :	Chainage 251/5-7 Bridge No. 289			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				10.12.2009 to 10.12.2009	A2	2	07.00 m.	30.00mtr	267.294

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	13.84	74.76	10.36	0.68	0.36	0.00	0.00	32	20	12	-	-	-	-	-	-
1.50	5	1.46	7.30	Clayey Silt with Sand	16.35	74.18	8.90	0.14	0.43	0.00	0.00	34	20	14	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt with Clay	15.94	62.34	21.22	0.50	0.00	0.00	0.00	31	17	14	1.67	10.67	1.51	2.68	0.18	17.0
4.50	8	1.10	8.80	Silty Sand	4.12	15.96	79.89	0.03	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
7.50	12	0.93	11.16	Silty Sand	3.65	21.85	74.26	0.24	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
10.50	14	0.81	11.34	Silty Sand	3.26	22.74	73.65	0.35	0.00	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
12.00	UDS	-	-	Clayey Silt with Sand	11.25	77.29	10.56	0.65	0.25	0.00	0.00	30	20	10	1.93	19.36	1.62	2.65	0.11	19.0
13.50	17	0.72	12.24	Clayey Silt with Sand	13.94	76.87	8.59	0.25	0.35	0.00	0.00	33	21	12	-	-	-	-	-	-
16.50	20	0.64	12.80	Clayey Silt with Sand	16.10	77.48	6.24	0.18	0.00	0.00	0.00	36	21	14	-	-	-	-	-	-
19.50	17	0.58	9.86	Clayey Silt	13.86	82.71	2.65	0.36	0.42	0.00	0.00	32	20	12	-	-	-	-	-	-
22.50	19	0.53	10.07	Clayey Silt	18.66	76.15	4.12	0.82	0.25	0.00	0.00	37	21	16	-	-	-	-	-	-
24.00	UDS	-	-	Clayey Silt	19.65	75.72	3.25	0.76	0.62	0.00	0.00	38	21	17	2.10	20.35	1.66	2.67	0.20	16.0
25.50	23	0.48	11.04	Clayey Silt	17.56	79.08	2.68	0.26	0.42	0.00	0.00	36	21	15	-	-	-	-	-	-
28.50	28	0.44	12.32	Clayey Silt	19.93	75.66	3.52	0.52	0.37	0.00	0.00	39	21	18	-	-	-	-	-	-
30.00	32	0.42	13.44	Clayey Silt	18.46	71.04	2.54	0.36	7.60	0.00	0.00	38	22	16	-	-	-	-	-	-

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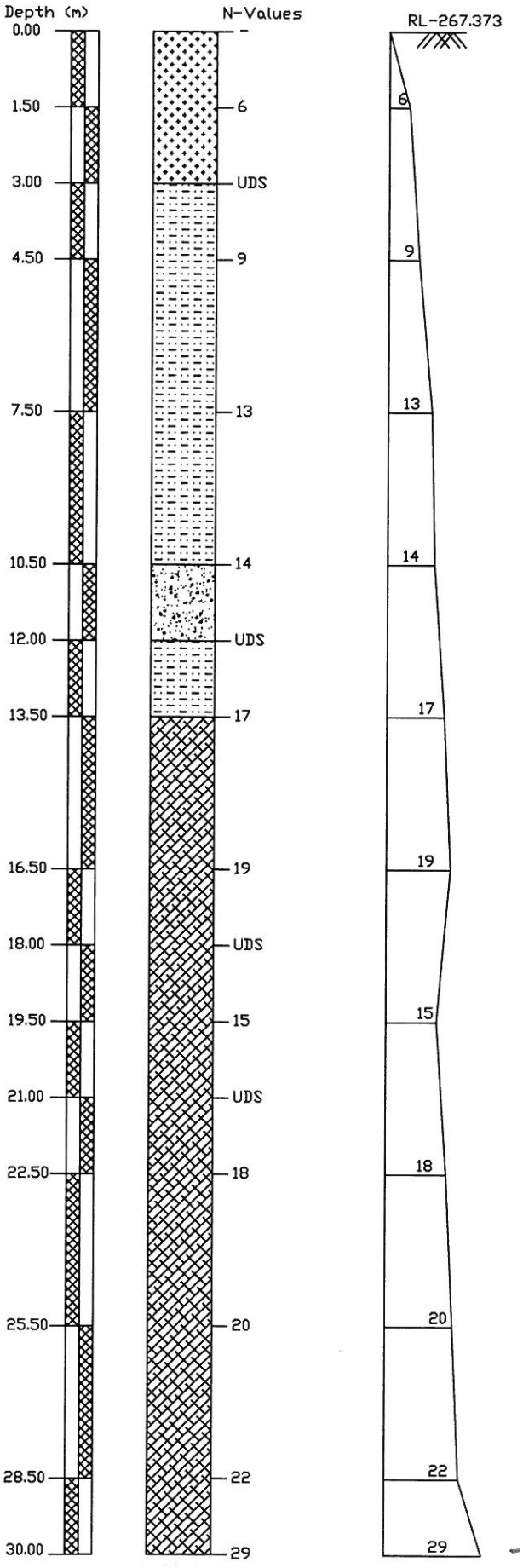
1167

BORELOG OF BH–1(A1) AT EXISTING KM–251/5–7 FOR MAJOR BRIDGE NO.–289,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

1168

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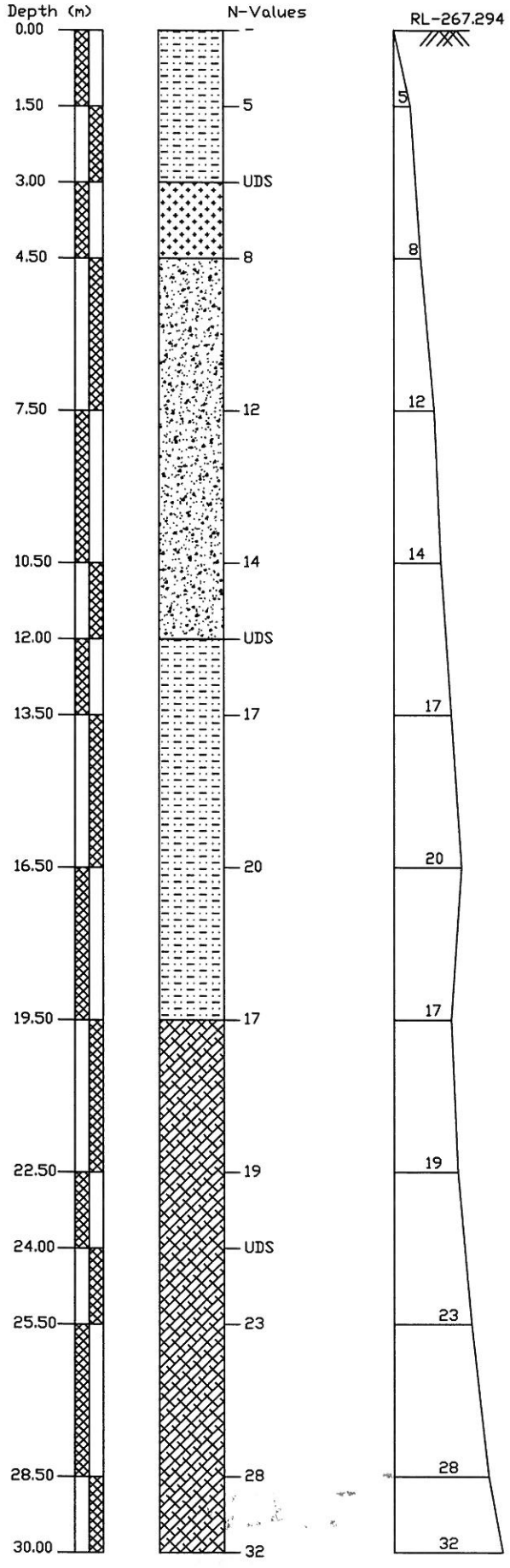
BORELOG OF BH–2(A2) AT EXISTING KM–251/5–7 FOR MAJOR BRIDGE NO.–289,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

ANNEXURE - III

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

INPUT DATA **Ch. 251 5-7** **BH-A1**

Type of footing

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

Angle of internal friction (ϕ °)	16.00
Cohesion (c in t/m2)	1.90
Void ratio (e)	0.75
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.68
Density of foundation soil (t/m^3)	1.68
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

$d_q = d_\gamma = 1$ for $\phi < 10°$

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

1170

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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	16.89	8.42	8.42
2	3.00	3.00	8.00	18.44	9.19	9.19
3	4.50	3.00	8.00	19.99	9.96	9.96
4	6.00	3.00	8.00	21.53	10.73	10.73

ANNEXURE - III

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

INPUT DATA **Ch. 251 5-7** **BH-A2**

Type of footing

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

Angle of internal friction (ϕ °)	17.00
Cohesion (c in t/m2)	1.80
Void ratio (e)	0.75
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.67
Density of foundation soil (t/m^3)	1.67
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

1172

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ANNEXURE - III

Bearing capacity factors :

ϕ	17.00
N_c	12.52
N_q	4.92
N_γ	3.75

ϕ'	11.58
N'_c	9.18
N'_q	2.93
N'_γ	1.67

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.14	1.07	1.07
2	3.00	3.00	1.27	1.14	1.14

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	18.11	8.82	8.82
2	3.00	3.00	8.00	19.76	9.63	9.63

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1173

ANNEXURE - III

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

INPUT DATA **Ch. 251 5-7** **BH-A2**

Type of footing

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

Angle of internal friction (ϕ °)	27.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.75
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.67
Density of foundation soil (t/m^3)	1.67
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

$d_c = 1 + 0.2\,(D_f/B)$*SQRT(N_ϕ)

$d_q = d_\gamma = 1$ for $\phi < 10°$

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

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

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

OUTPUT

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

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1174

ANNEXURE - III

Bearing capacity factors :

ϕ	27.00
N_c	24.49
N_q	13.76
N_γ	15.49

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

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	4.50	3.00	8.00	35.35	12.90	12.90
2	6.00	3.00	8.00	37.66	13.75	13.75

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.251/ 5-7**

BH No. (A1)

Depth of foundation		=	1.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	6.8	t/m^2
Concentrated load *P*		=	8.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.7	t/m^2
Compression Index	Cc	=	0.099	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.6	
	$\frac{Po + \Delta p}{Po}$	=	1.24889	

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

S_f = 0.02688 m

= 26.8758 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} = **19.6 mm**

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1176

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.251/ 5-7**

BH No. (A1)

Depth of foundation		=	3.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	9.45	t/m^2
Concentrated load *P*		=	9.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.9	t/m^2
Compression Index	Cc	=	0.099	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.6	
	$\frac{Po + \Delta p}{Po}$	=	1.2	

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

S_f = 0.02205 m

= 22.047 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} = **14.6 mm**

1177

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.251/ 5-7**

BH No. (A1)

Depth of foundation		=	4.5	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	12.15	t/m^2
Concentrated load *P*		=	10.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.1	t/m^2
Compression Index	Cc	=	0.144	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.6	
	$\frac{Po + \Delta p}{Po}$	=	1.17284	

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

S_f = 0.02804 m

= 28.0416 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.74

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

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = **16.6 mm**

1178

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Major Bridge at Ch.251/ 5-7**

BH No. (A1)

Depth of foundation		=	6.0	m
Length of footing (L)		=	8.0	m
Width of footing (B)		=	3.0	m
Initial effective stress at mid of layer	Po	=	14.85	t/m^2
Concentrated load *P*		=	10.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.2	t/m^2
Compression Index	Cc	=	0.099	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.6	
	$\frac{Po + \Delta p}{Po}$	=	1.14848	

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

S_f = 0.01674 m

= 16.7411 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} = **9.1** **mm**

1179

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) for coh. Soil **Major Bridge at Ch.251/ 5-7**

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	=	5.4	t/m^2
Concentrated load *P*		=	8.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	1.8	t/m^2
Compression Index	Cc	=	0.12	
Thickness of clay layer	H	=	3	m
Initial Void ratio	e_o	=	0.67	
	$\frac{Po + \Delta p}{Po}$	=	1.32873	

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

S_f = 0.02661 m

= 26.6091 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore Pr. Correction = 0.85

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

S_{f2} = **16.5 mm**

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

Footing Depth (m)	**1.50**
Effective Pressure (t/m2)	1.70
Average N value	8
Settlement for 10 t/m2 (mm)	56.00
Settlement (mm) for SBC	9.52
Depth Correction	0.91
Regidity Factor	0.80
Corrected Settlement (mm)	**6.9**

Total corrected Settlement	23.4	**mm**

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1180

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) for coh. Soil **Major Bridge at Ch.251/ 5-7**

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	=	9.5025	t/m^2
Concentrated load *P*		=	9.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.21	
	ΔP	=	2.0	t/m^2
Compression Index	Cc	=	0.12	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.6	
	$\frac{Po + \Delta p}{Po}$	=	1.20994	

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

S_f = 0.00931 m

= 9.31112 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 = $\frac{\text{Total Settlement of Rigid foundation}}{\text{otal Settlement at the centre of Flexible foundatio}}$

= 0.8

Pore Pr. Correction = 0.85

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

S_{f2} = **5.3** **mm**

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

Footing Depth (m)	**3.00**
Effective Pressure (t/m2)	2.19
Average N value	10
Settlement for 10 t/m2 (mm)	36.00
Settlement (mm) for SBC	7.87
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	**5.2**

Total corrected Settlement	10.5	**mm**

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1181

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Major Bridge
Chainage	251/5-7
Bore Hole No.	A2

Footing Depth (m)	4.50
Effective Pressure (t/m2)	10.50
Average N value	10
Settlement for 10 t/m2 (mm)	36.00
Settlement (mm) for SBC	37.80
Depth Correction	0.74
Regidity Factor	0.80
Corrected Settlement (mm)	22.4

Footing Depth (m)	6.00
Effective Pressure (t/m2)	11.50
Average N value	11
Settlement for 10 t/m2 (mm)	32.00
Settlement (mm) for SBC	36.80
Depth Correction	0.74
Regidity Factor	0.80
Corrected Settlement (mm)	21.8

1182

CHAPTER – 135

"Alignment",

Location – Existing Km. – 265/19-21

135.1 LOCATION OF STRUCTURE:

Alignment at existing km 265/19-21

135.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table 08.00m below EGL

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.50	Filled up Strata	Loose
	1.50 to 10.50	Sandy Silt with Clay	Loose
	10.50 to 12.00	Sandy Silt with Clay	Medium Dense

135.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.50	NIL	0.0028	NIL	0.0013	0.097
	6.00	8.40	0.005	0.0035	NIL	0.0015	0.112

135.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	11.00
	6.00	08.00

135.5 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	127	90	155	841	0.2	2.3	983	632
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	-	-

135.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	06.00
	3.00	10.00
	4.50	11.00
	6.00	12.00

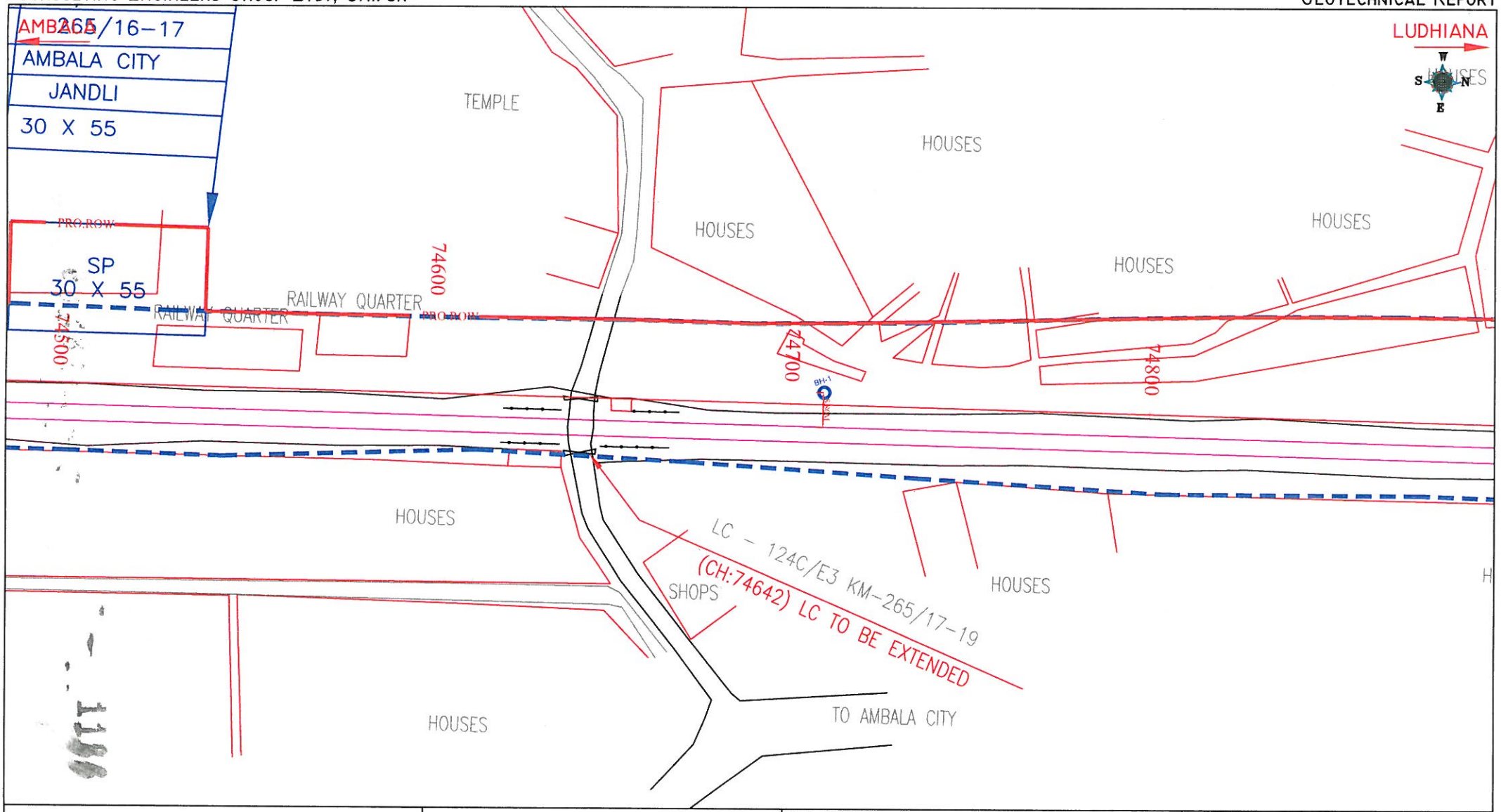
135.7 CONCLUSIONS

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

135.8 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		PROJECT :-	DESIGN :-
FIG.:-I LOCATION PLAN OF PROPOSED ALIGNMENT CH. 265/19-21	RL OF BH-I = 269.269	LUDHIANA-AMBALA (DFCCIL)	CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 OF ALIGNMENT AT CHAINAGE 265/19-21

Project :	Chainage 265/19-21			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				09.12.2009 to 09.12.2009	1	1	08.00 m.	12.00mtr	269.269

Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Filled up Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.50	4	1.46	5.84	Sandy Silt with Clay	11.14	54.89	32.52	1.10	0.35	0.00	0.00	28	18	10	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt with Clay	9.21	61.18	28.54	0.85	0.22	0.00	0.00	27	18	9	1.69	9.68	1.54	2.69	0.11	21.0
4.50	5	1.09	5.45	Sandy Silt with Clay	10.34	61.47	27.21	0.61	0.10	0.27	0.00	27	17	10	-	-	-	-	-	-
6.00	UDS	-	-	Sandy Silt with Clay	5.38	57.78	36.16	0.49	0.19	0.00	0.00	21	15	6	1.72	15.36	1.66	2.66	0.08	22.0
7.50	9	0.92	8.28	Sandy Silt with Clay	11.29	47.61	40.21	0.68	0.21	0.00	0.00	29	19	10	-	-	-	-	-	-
10.50	11	0.81	8.91	Sandy Silt with Clay	8.56	52.16	38.52	0.58	0.18	0.00	0.00	27	19	8	-	-	-	-	-	-
12.00	14	0.76	10.64	Sandy Silt with Clay	10.10	51.47	37.33	0.75	0.35	0.00	0.00	28	19	9	-	-	-	-	-	-

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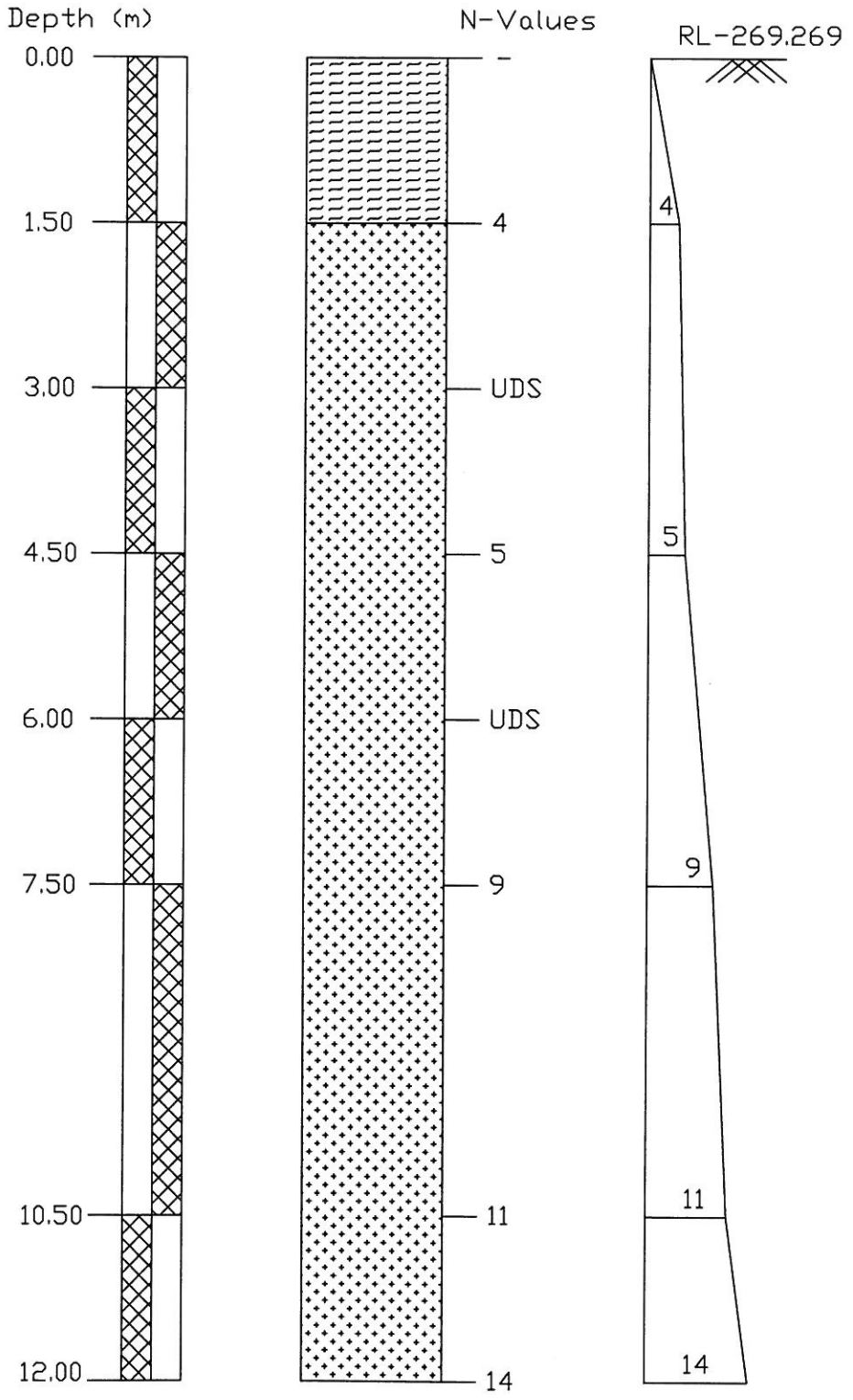
1187

BORELOG OF BH–1 AT EXISTING KM–265/19–21 FOR ALIGNMENT,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	FILLED UP STRATA
	SANDY SILT WITH CLAY

ANNEXURE - III

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

INPUT DATA

Ch 265 19-21 **BH-1**

Type of footing

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

Angle of internal friction (ϕ °)	21.00
Cohesion (c in t/m2)	1.10
Void ratio (e)	0.75
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.83
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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1189

ANNEXURE - III

Bearing capacity factors :

ϕ	21.00
N_c	16.01
N_q	7.25
N_γ	6.49

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

Shape factors :

S.no.	Width(m)	Length (m)	S_c	S_q	S_γ
1	3.00	8.00	1.08	1.08	0.85
2	3.00	8.00	1.08	1.08	0.85
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	1.15	1.07	1.07
2	3.00	3.00	1.29	1.15	1.15
3	4.50	3.00	1.44	1.22	1.22
4	6.00	3.00	1.58	1.29	1.29

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	16.06	6.97	6.97
2	3.00	3.00	8.00	24.12	10.53	10.53
3	4.50	3.00	8.00	26.06	11.38	11.38
4	6.00	3.00	8.00	27.99	12.22	12.22

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 265/19-21**

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 = 0.02793 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.

S_{f2} = **20.3 mm**

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 265/19-21**

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*		=	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	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.2328	

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

S_f = 0.03272 m

= 32.7219 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore pr. Correction = N.A.

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

S_{f2} = **21.7 mm**

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1192

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 265/19-21**

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*		=	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	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.19918	

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

S_f = 0.0284 m

= 28.398 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} = **21.0 mm**

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 265/19-21**

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	=	15.2625	t/m^2
Concentrated load *P*		=	12.00	t/m^2
Incerase in pressure at mid of laye	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	2.6	t/m^2
Compression Index	Cc	=	0.14	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.75	
	$\frac{Po + \Delta p}{Po}$	=	1.172973	

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

S_f = 0.0249437 m

= 24.943682 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} = **13.6 mm**

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1194

CHAPTER – 136

"Alignment",

Location – Existing Km. – 262/800

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136.1 LOCATION OF STRUCTURE:

Alignment at existing km 262/800

136.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table 07.00m below EGL

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 3.00	Sandy Silt	Loose
	3.00 to 4.50	Sandy Silt with Clay	Loose
	4.50 to 6.00	Sandy Silt with Clay	Medium Dense
	6.00 to 12.00	Clayey Silt with Sand	Medium Dense

136.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.00	NIL	0.0015	NIL	0.0017	0.098
	6.00	8.40	NIL	0.0014	NIL	0.0015	0.128

136.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

136.5 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	105	100	160	823	0.2	2.1	998	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	-	-

136.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	07.00
	3.00	13.00
	4.50	14.00
	6.00	15.00

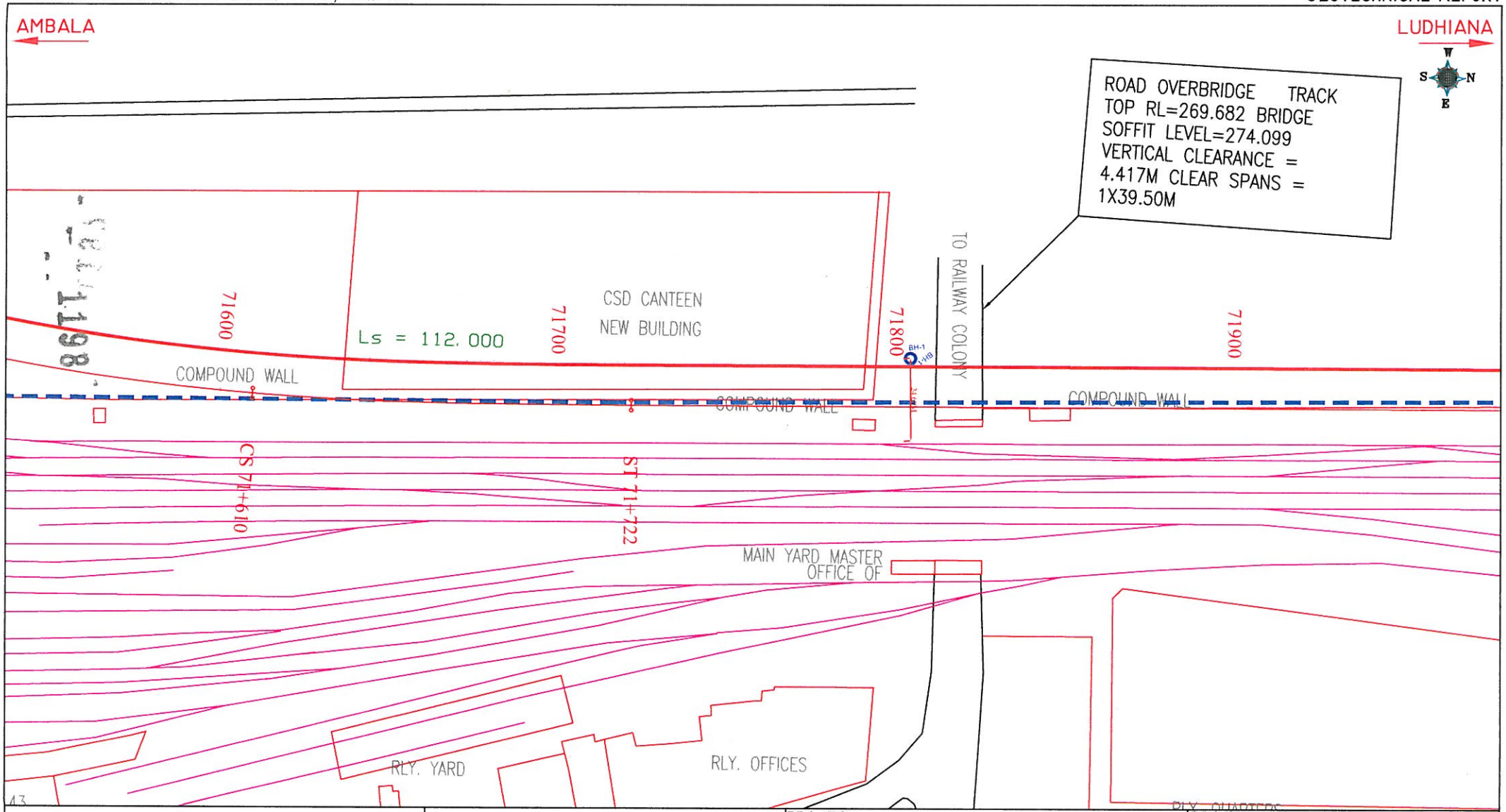
136.7 CONCLUSIONS

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

136.8 RECOMMENDATIONS

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

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



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALIGNMENT CH. 262/800	RL OF BH-I = 270.378	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 OF ALIGNMENT AT CHAINAGE 262.800

Project :	Chainage 262.800			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				10.12.2009 to 10.12.2009	1	1	07.00 m.	12.00mtr	270.378

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	3.25	78.90	16.37	0.73	0.53	0.22	0.00	24	NIL	NP	-	-	-	-	-	-
1.50	8	1.45	11.60	Sandy Silt	4.25	79.16	15.07	0.87	0.30	0.35	0.00	26	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt with Clay	8.35	74.03	15.69	1.38	0.55	0.00	0.00	27	19	8	1.72	10.30	1.55	2.65	0.10	21.0
4.50	11	1.09	11.99	Sandy Silt with Clay	7.11	72.72	17.74	1.35	0.63	0.45	0.00	25	19	6	-	-	-	-	-	-
6.00	UDS	-	-	Clayey Silt with Sand	9.14	81.53	7.36	1.39	0.58	0.00	0.00	27	19	8	1.79	13.68	1.57	2.63	0.10	21.0
7.50	14	0.91	12.74	Clayey Silt with Sand	11.26	78.90	8.63	0.85	0.36	0.00	0.00	30	20	10	-	-	-	-	-	-
10.50	16	0.80	12.80	Clayey Silt with Sand	14.63	74.17	10.33	0.45	0.42	0.00	0.00	32	20	12	-	-	-	-	-	-
12.00	20	0.75	15.00	Clayey Silt with Sand	12.59	77.05	9.41	0.58	0.37	0.00	0.00	32	21	11	-	-	-	-	-	-

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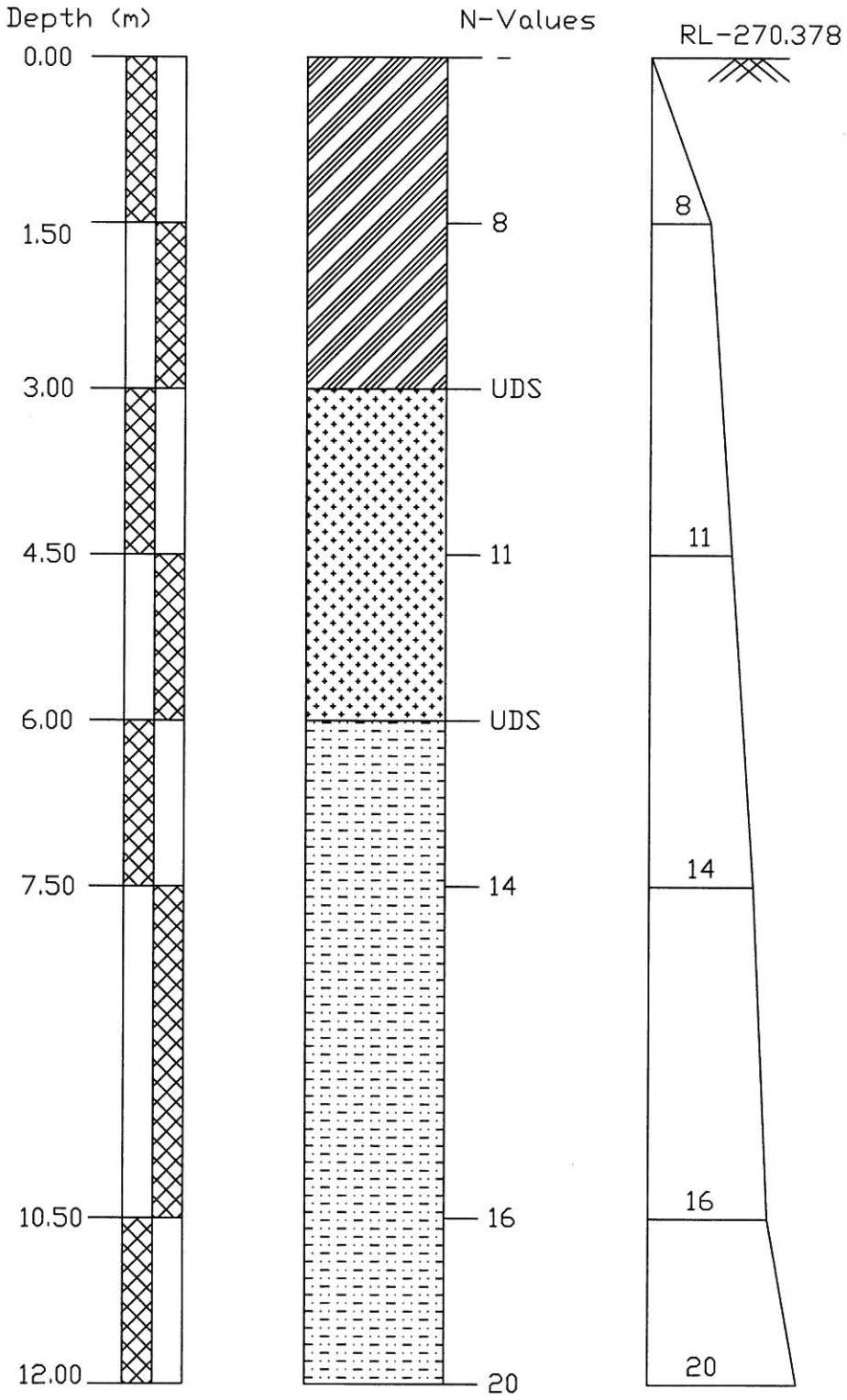
BORELOG OF BH–1 AT EXISTING KM–262/800 FOR ALIGNMENT,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

1200

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ANNEXURE - III

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

INPUT DATA

	Ch 262-800	**BH-1**	
Type of footing			
1	Continuous Strip		
2	Rectangular	***Rectangular***	**2**
3	Square		
4	Circular		

Angle of internal friction (ϕ °)	27.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.70
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

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.

1201

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ANNEXURE - III

Bearing capacity factors :

ϕ	27.00
N_c	24.49
N_q	13.76
N_γ	15.49

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

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	18.66	6.64	9.64

ANNEXURE - III

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

INPUT DATA

	Ch 262-800	BH-1
Type of footing		
1 Continuous Strip		
2 Rectangular	***Rectangular***	**2**
3 Square		
4 Circular		

Angle of internal friction (ϕ °)	21.00
Cohesion (c in t/m2)	1.00
Void ratio (e)	0.70
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.70
Depth of water table(m)	0.00
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

$d_q = d_\gamma = 1$ for $\phi < 10°$

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

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

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

OUTPUT

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

ANNEXURE - III

Bearing capacity factors :

ϕ	21.00
N_c	16.01
N_q	7.25
N_γ	6.49

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	3.00	3.00	1.29	1.15	1.15
2	4.50	3.00	1.44	1.22	1.22
3	6.00	3.00	1.58	1.29	1.29

Inclination factors :

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

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	3.00	3.00	-1.00	0.50
2	4.50	3.00	-1.50	0.50
3	6.00	3.00	-2.00	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	3.00	3.00	8.00	23.18	10.12	13.39
2	4.50	3.00	8.00	25.01	10.93	14.45
3	6.00	3.00	8.00	26.85	11.73	15.51

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) for cohesionless soil **Alignment at 262/ 800**

BH No.1

Footing Depth (m)	**1.50**
SBC (t/m2)	7.00
Average N value	12
Settlement for 10 t/m2 (mm)	30.00
Settlement (mm) for SBC	21.00
Depth Correction	0.91
Regidity Factor	0.80
Corrected Settlement (mm)	15.3

Settlement Calculation As per IS 8009 (Part 1) for cohesionless soil **Alignment at 262/ 800**

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 = 8.28 t/m^2

Concentrated load *P* = 7.00 t/m^2

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

I_B = 0.22

ΔP = 1.5 t/m^2

Compression Index Cc = 0.1

Thickness of clay layer H = 3 m

Initial Void ratio e_o = 0.7

$\frac{Po + \Delta p}{Po}$ = 1.18599

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

S_f = 0.01307 m

= 13.0731 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = 9.5 **mm**

1205

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ANNEXURE - IV

Total Corrected Settlement =	25 mm

1206

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 262/ 800**

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	=	9.66	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	=	0.1	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.7	
	$\frac{Po + \Delta p}{Po}$	=	1.29607	

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

S_f = 0.02981 m

= 29.8131 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

pore pr. Correction = N.A.

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

S_{f2} = **19.8 mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 262/800**

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	=	12.42	t/m^2
Concentrated load *P*		=	14.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	3.1	t/m^2
Compression Index	Cc	=	0.1	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.7	
	$\frac{Po + \Delta p}{Po}$	=	1.24799	

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

S_f = 0.02547 m

= 25.4674 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} = **15.1 mm**

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 262/ 800**

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	=	15.2625	t/m^2
Concentrated load *P*		=	15.00	t/m^2
Incerase in pressure at mid of laye	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	3.3	t/m^2
Compression Index	Cc	=	0.1	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.7	
	$\frac{Po + \Delta p}{Po}$	=	1.2162162	

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

S_f = 0.0225029 m

= 22.502856 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = **12.2 mm**

1209

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CHAPTER – 137

"Alignment",

Location – Existing Km. – 259/11-13

137.1 LOCATION OF STRUCTURE:

Alignment at existing km 259/11-13

137.2 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 06.00m 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	Silty Sand	Loose
	4.50 to 10.50	Clayey Silt with Sand	Loose
	10.50 to 12.00	Clayey Silt with Sand	Medium Dense

137.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.20	NIL	0.0015	NIL	0.0011	0.067
	6.00	8.40	NIL	0.0017	NIL	0.0011	0.049

137.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	NIL
	6.00	16.00

137.5 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	112	121	167	835	0.1	2.6	1006	665
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	-	-

137.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	05.00
	3.00	05.00
	4.50	11.00
	6.00	11.50

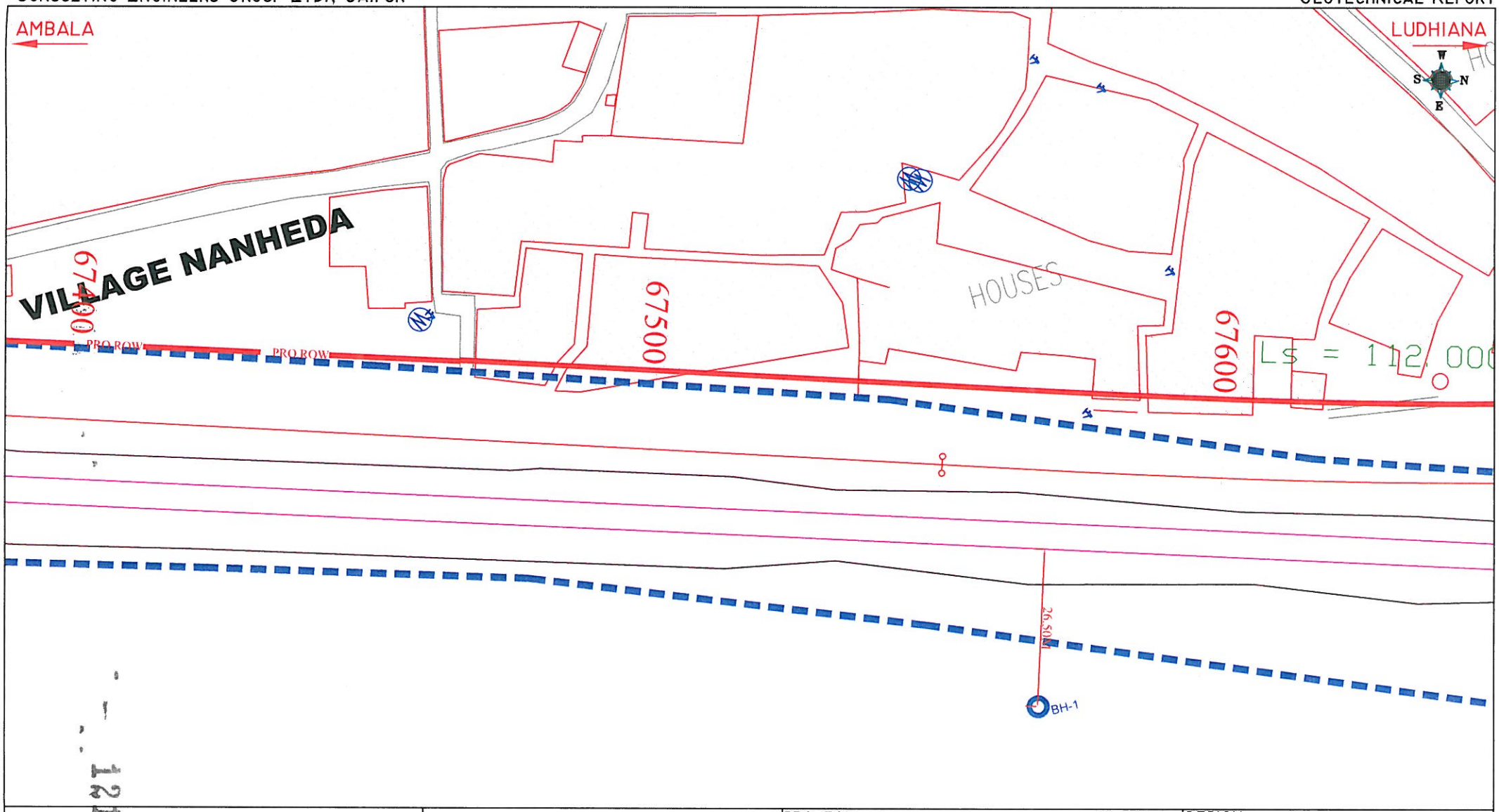
137.7 CONCLUSIONS

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

137.8 RECOMMENDATIONS

(i)	*Type of foundation*	Open and raft 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 ALIGNMENT
CH. 259/11-13

RL OF BH-1 = 269.431

PROJECT :-

LUDHIANA-AMBALA (DFCCIL)

DESIGN :-

CONSULTING
ENGINEERS GROUP LTD.
E-12,Moji Colony,Malviya Nagar Jaipur-17
Tel: +91-141- 2520899, 2521899, 2520556
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SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 OF ALIGNMENT AT CHAINAGE 259/11-13

Project :	Chainage 259/11-13			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	269.431

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	2.25	16.94	80.35	0.46	0.00	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
1.50	4	1.45	5.80	Silty Sand	3.15	17.98	78.48	0.39	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	2.00	21.01	76.60	0.39	0.00	0.00	0.00	22	NIL	NP	1.73	12.35	1.54	2.67	0.00	27.5
4.50	6	1.09	6.54	Clayey Silt with Sand	14.28	79.11	5.48	1.13	0.00	0.00	0.00	35	22	13	-	-	-	-	-	-
6.00	UDS	-	-	Clayey Silt with Sand	15.86	75.52	4.71	1.91	2.00	0.00	0.00	35	21	14	1.82	18.26	1.54	2.68	0.18	17.0
7.50	9	0.91	8.19	Clayey Silt with Sand	13.67	78.83	5.36	2.14	0.00	0.00	0.00	33	21	12	-	-	-	-	-	-
10.50	13	0.79	10.27	Clayey Silt with Sand	17.54	75.20	5.41	1.85	0.00	0.00	0.00	35	20	15	-	-	-	-	-	-
12.00	18	0.75	13.50	Clayey Silt with Sand	12.53	78.48	6.79	2.20	0.00	0.00	0.00	31	20	11	-	-	-	-	-	-

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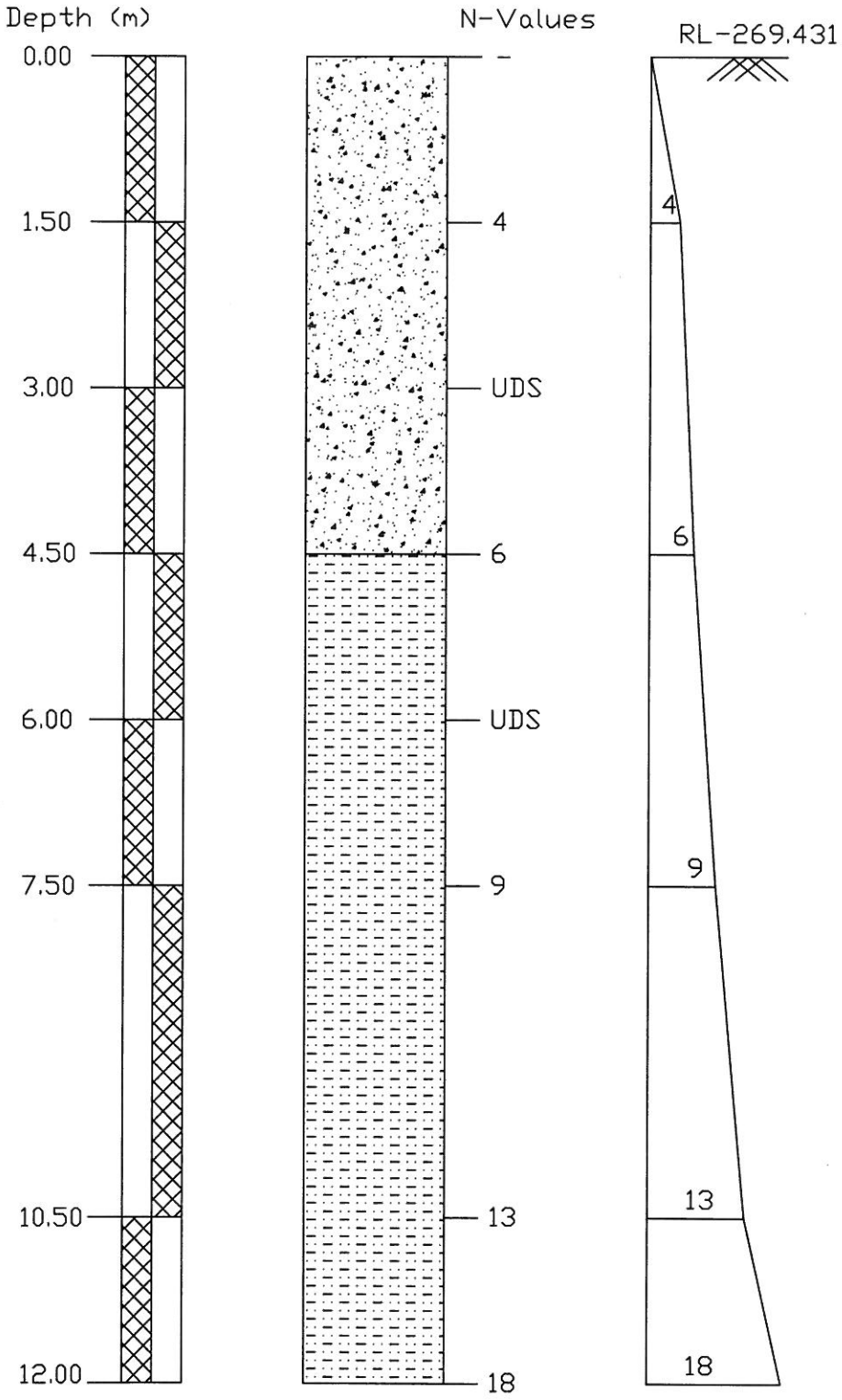
BORELOG OF BH–1 AT EXISTING KM–259/11–13 FOR ALIGNMENT,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SILTY SAND
	CLAYEY SILT WITH SAND

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ANNEXURE - III

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

INPUT DATA

		Ch 259 11-13	BH-1
Type of footing			
1	Continuous Strip		
2	Rectangular	***Rectangular***	**2**
3	Square		
4	Circular		

Angle of internal friction (ϕ°)	27.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.73
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.83
Depth of water table(m)	0.00
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

1222

ANNEXURE - III

Bearing capacity factors :

ϕ	27.50	ϕ'	19.23
N_c	25.43	N'_c	14.24
N_q	14.53	N'_q	6.02
N_γ	16.64	N'_γ	4.97

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.16	1.08	1.08
2	3.00	3.00	1.33	1.16	1.16

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	20.39	7.06	8.39
2	3.00	3.00	8.00	36.34	12.94	15.28

ANNEXURE - III

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

INPUT DATA

Ch 259 11-13 **BH-1**

Type of footing

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

Angle of internal friction (ϕ °)	17.00
Cohesion (c in t/m2)	1.80
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)	1.80
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

1224

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ANNEXURE - III

Bearing capacity factors :

ϕ	17.00	ϕ'	11.58
N_c	12.52	N'_c	9.18
N_q	4.92	N'_q	2.93
N_γ	3.75	N'_γ	1.67

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	4.50	3.00	1.41	1.20	1.20
2	6.00	3.00	1.54	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	4.50	3.00	-1.00	0.50
2	6.00	3.00	-1.50	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	4.50	3.00	8.00	21.70	10.57	11.12
2	6.00	3.00	8.00	23.37	11.38	11.98

1225

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) for cohesionless soil **Alignment at 259/ 11-13**

BH No.1

Footing Depth (m)	**1.50**
SBC (t/m2)	5.00
Average N value	7
Settlement for 10 t/m2 (mm)	100.00
Settlement (mm) for SBC	50.00
Depth Correction	0.91
Rigidity Factor	0.80
Corrected Settlement (mm)	36.4

Settlement Calculation As per IS 8009 (Part 1) for cohessive soil **Alignment at 259/ 11-13**

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 = 9.45 t/m^2

Concentrated load *P* = 5.00 t/m^2

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

I_B = 0.22

ΔP = 1.1 t/m^2

Compression Index Cc = 0.13

Thickness of clay layer H = 1.5 m

Initial Void ratio e_o = 0.73

$\frac{Po + \Delta p}{Po}$ = 1.1164

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

S_f = 0.00539 m

= 5.39019 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore Pr. Coprrection = N.A.

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

S_{f2} = 3.9 **mm**

Total Settlement = 40 **mm**

1226

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) for cohesionless soil **Alignment at 259/ 11-13**

BH No.1

Footing Depth (m)	**3.00**
SBC (t/m2)	5.00
Average N value	7
Settlement for 10 t/m2 (mm)	100.00
Settlement (mm) for SBC	50.00
Depth Correction	0.83
Rigidity Factor	0.80
Corrected Settlement (mm)	33.2

Settlement Calculation As per IS 8009 (Part 1) for cohessive soil **Alignment at 259/ 11-13**

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 = 11.1 t/m^2

Concentrated load *P* = 5.00 t/m^2

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

I_B = 0.22

ΔP = 1.1 t/m^2

Compression Index Cc = 0.13

Thickness of clay layer H = 3 m

Initial Void ratio e_o = 0.73

$\frac{Po + \Delta p}{Po}$ = 1.0991

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

S_f = 0.00925 m

= 9.25108 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. Coprrection = N.A.

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

S_{f2} = 6.1 **mm**

Total Settlement = 39.3 **mm**

1227

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 259/ 11-13**

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*		=	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	=	0.73	
	$\frac{Po + \Delta p}{Po}$	=	1.19918	

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

S_f = 0.02667 m

= 26.6744 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} = **15.8 mm**

1228

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 259/ 11-13**

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	=	15.26	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	=	0.13		
Thickness of clay layer H	=	4.5	m	
Initial Void ratio e_o	=	0.73		
$\frac{Po + \Delta p}{Po}$	=	1.17		

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

S_f	=	0.023	m
	=	22.52	mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B	=	2.67	
Depth Factor	=	0.68	

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

= 0.8

Pore Pr. Correction = N.A.

Corrected Total Settlement	=	S_f x D.F.x R.F.	
S_{f2}	=	**12.3**	**mm**

1229

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CHAPTER – 138

"Alignment",

Location – Existing Km. – 258/15-17

138.1 LOCATION OF STRUCTURE:

Alignment at existing km 258/15-17

138.2 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 06.00m below EGL

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 3.00	Silty Sand	Loose
	3.00 to 4.50	Clayey Silt with Sand	Loose
	4.50 to 6.00	Clayey Silt with Sand	Medium Dense
	6.00 to 7.50	Silty Sand	Medium Dense
	7.50 to 12.00	Clayey Silt with Sand	Medium Dense

138.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.60	NIL	0.0015	NIL	0.0011	0.088
	6.00	8.50	0.002	0.0014	NIL	0.0012	0.042

138.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	17.00
	6.00	NIL

138.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BORE HOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (µS/cm)
Test Result	7.3	126	152	179	810	0.1	2.4	990	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	-	-

138.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	06.00
	3.00	09.50
	4.50	10.00
	6.00	10.00

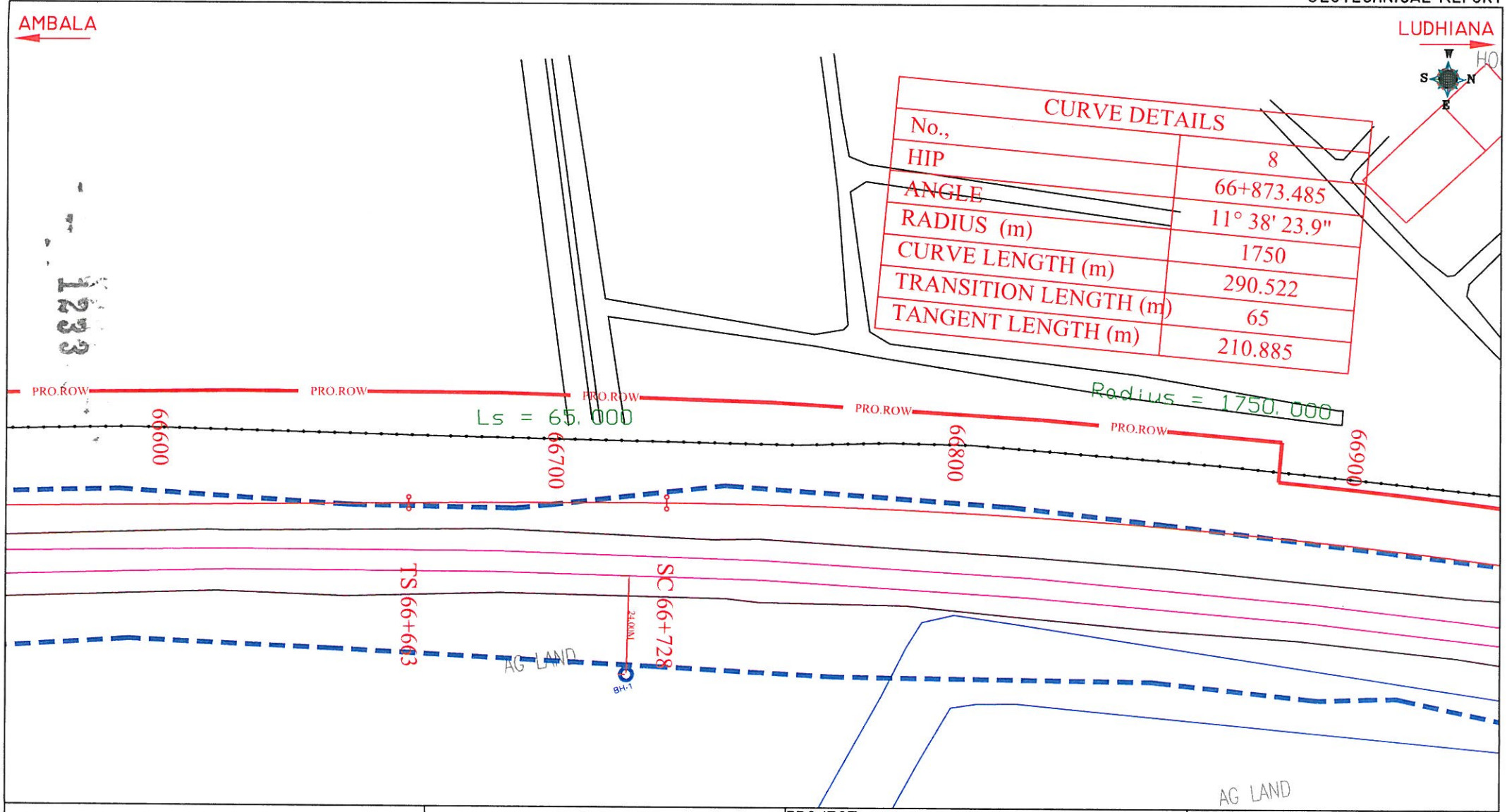
138.7 CONCLUSIONS

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

138.8 RECOMMENDATIONS

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

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



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALIGNMENT CH. 258/15-17	RL OF BH-I = 269.721	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 OF ALIGNMENT AT CHAINAGE 258/15-17

Project :	Chainage 258/15-17			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	269.721

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	2.51	26.57	70.56	0.36	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
1.50	7	1.42	9.94	Silty Sand	3.68	27.73	68.50	0.09	0.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Clayey Silt with Sand	16.22	75.49	5.52	1.08	0.90	0.79	0.00	33	19	14	1.80	13.31	1.58	2.69	0.16	15.0
4.50	10	1.06	10.60	Clayey Silt with Sand	7.32	85.51	6.14	0.44	0.36	0.23	0.00	28	21	7	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	4.12	44.06	50.87	0.83	0.12	0.00	0.00	26	NIL	NP	1.90	20.69	1.57	2.64	0.00	27.0
7.50	13	0.88	11.44	Clayey Silt with Sand	7.42	85.63	5.35	1.25	0.35	0.00	0.00	27	20	7	-	-	-	-	-	-
10.50	17	0.77	13.09	Clayey Silt with Sand	10.24	81.40	7.26	0.85	0.25	0.00	0.00	30	21	9	-	-	-	-	-	-
12.00	22	0.73	15.53	Clayey Silt with Sand	8.56	82.84	6.63	1.36	0.61	0.00	0.00	29	21	8	-	-	-	-	-	-

1234

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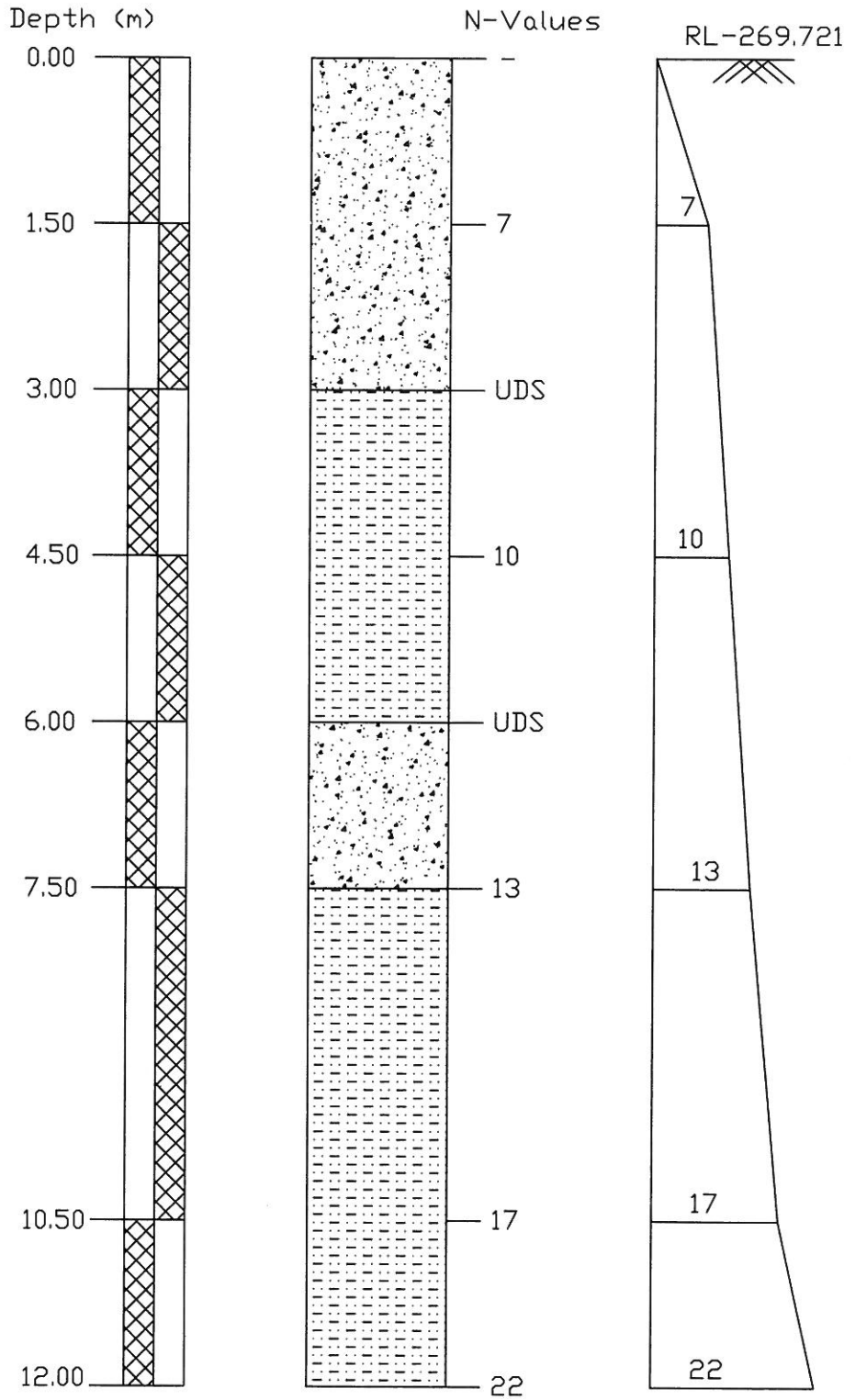
BORELOG OF BH–1 AT EXISTING KM–258/15–17 FOR ALIGNMENT,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SILTY SAND
	CLAYEY SILT WITH SAND

1235

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ANNEXURE - III

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

INPUT DATA

Ch 258 15-17 **BH-1**

Type of footing

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

Angle of internal friction (ϕ°)	27.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.70
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.80
Depth of water table(m)	0.00
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

ANNEXURE - III

Bearing capacity factors :

ϕ	27.00
N_c	24.49
N_q	13.76
N_γ	15.49

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

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

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

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	19.01	6.75	9.81

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1237

ANNEXURE - III

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

INPUT DATA

	Ch 258 15-17	BH-1
Type of footing		
1 Continuous Strip		
2 Rectangular	***Rectangular***	2
3 Square		
4 Circular		

Angle of internal friction (ϕ °)	15.00
Cohesion (c in t/m2)	1.60
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)	1.80
Depth of water table(m)	0.00
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

1238

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ANNEXURE - III

Bearing capacity factors :

ϕ	15.00
N_c	10.98
N_q	3.94
N_γ	2.65

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	3.00	3.00	1.26	1.13	1.13
2	4.50	3.00	1.39	1.20	1.20

Inclination factors :

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

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	3.00	3.00	-1.00	0.50
2	4.50	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	3.00	3.00	8.00	15.15	7.76	9.61
2	4.50	3.00	8.00	16.39	8.40	10.39

ANNEXURE - III

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

INPUT DATA

Ch 258 15-17 **BH-1**

Type of footing

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

Angle of internal friction (ϕ °)	27.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.68
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.90
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)	Length (m)
1	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.

1240

ANNEXURE - III

Bearing capacity factors :

ϕ	27.00
N_c	24.49
N_q	13.76
N_γ	15.49

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

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	6.00	3.00	-1.50	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	6.00	3.00	8.00	39.21	14.27	23.00

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) for cohesionless soil **Alignment at 258/ 15-17**

BH No.1

Footing Depth (m)	**1.50**
SBC (t/m2)	6.00
Average N value	10
Settlement for 10 t/m2 (mm)	36.00
Settlement (mm) for SBC	21.60
Depth Correction	0.91
Rigidity Factor	0.80
Corrected Settlement (mm)	**15.72**

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 258/ 15-17**

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 = 8.1 t/m^2

Concentrated load *P* = 6.00 t/m^2

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

I_B = 0.22

ΔP = 1.3 t/m^2

Compression Index Cc = 0.12

Thickness of clay layer H = 3 m

Initial Void ratio e_o = 0.68

$\frac{Po + \Delta p}{Po}$ = 1.16296

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

S_f = 0.01405 m

= 14.0498 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 = 0.85

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

S_{f2} = **8.7 mm**

Total Settlement = 24.4 mm

1242

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 258/15-17**

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	=	8.325	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	=	0.12	
Thickness of clay layer	H	=	3	m
Initial Void ratio	e_o	=	0.68	
	$\frac{Po + \Delta p}{Po}$	=	1.25105	

Settlement of clay layer

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

S_f = 0.02084 m

= 20.8446 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore Pr. Correction = 0.85

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

S_{f2} = **11.8 mm**

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

Footing Depth (m)	**3.00**
Effective Pressure (t/m2)	1.90
Average N value	10
Settlement for 10 t/m2 (mm)	36.00
Settlement (mm) for SBC	6.84
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	**4.5**

Total corrected Settlement	**16.3**	**mm**

1243

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 258/15-17**

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*		=	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	=	0.114	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.68	
	$\frac{Po + \Delta p}{Po}$	=	1.18107	

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

S_f = 0.02207 m

= 22.0699 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} = **13.1 mm**

1241

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 258/15-17**

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	=	12.49	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	=	0.114	
Thickness of clay layer	H	=	3	m
Initial Void ratio	e_o	=	0.65	
	$\frac{Po + \Delta p}{Po}$	=	1.18	

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

S_f = 0.015 m

= 14.61 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} = **7.9 mm**

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

Footing Depth (m)	**3.00**
Effective Pressure (t/m2)	10.00
Average N value	12
Settlement for 10 t/m2 (mm)	25.00
Settlement (mm) for SBC	25.00
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	**16.6**

Total corrected Settlement	25	**mm**

1245

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CHAPTER – 139

"Alignment",

Location – Existing Km. – 255/05-07

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139.1 LOCATION OF STRUCTURE:

Alignment at existing km 255/05-07

139.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table 07.00m below EGL

Subsurface profile at the site

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

139.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.70	0.005	0.0031	NIL	0.0014	0.114
	12.00	8.60	0.002	0.0033	NIL	0.0013	0.124

139.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	22.00
	6.00	15.00

139.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BORE HOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (µS/cm)
Test Result	7.2	136	132	181	835	0.2	2.6	1025	662
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	-	-

139.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m^2)
BH-1	1.50	08.00
	3.00	11.00
	4.50	12.00
	6.00	13.00

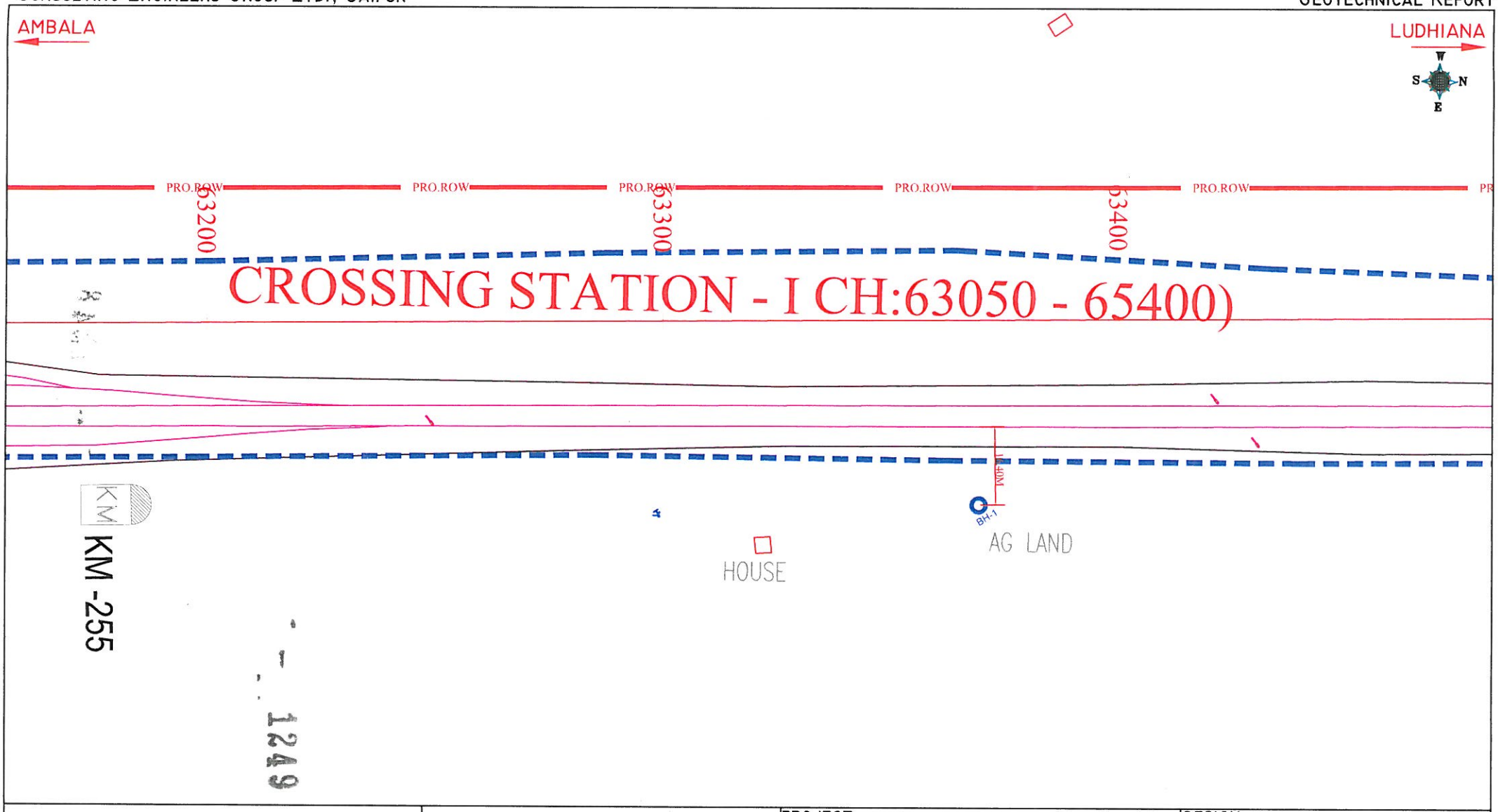
139.7 CONCLUSIONS

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

139.8 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 4.50 m from EGL

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



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALINGMENT CH. 255/5-7	RL OF BH-I = 270.927	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 OF ALIGNMENT AT CHAINAGE 255/5-7

Project :	Chainage 255/5-7			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				16.12.2009 to 16.12.2009	1	1	07.00 m.	12.00mtr	270.927

Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Clayey Silt with Sand	17.22	74.88	6.25	1.65	0.00	0.00	0.00	35	20	15	-	-	-	-	-	-
1.50	7	1.42	9.94	Clayey Silt with Sand	20.14	74.10	4.03	1.73	0.00	0.00	0.00	40	22	18	-	-	-	-	-	-
3.00	UDS	-	-	Clayey Silt with Sand	20.89	67.19	5.24	2.09	2.27	2.32	0.00	38	19	19	1.83	13.58	1.61	2.68	0.21	13.0
4.50	14	1.05	14.70	Clayey Silt with Sand	28.83	63.49	4.90	0.43	0.50	1.85	0.00	51	25	26	-	-	-	-	-	-
6.00	UDS	-	-	Clayey Silt with Sand	14.52	75.00	7.71	1.76	0.81	0.20	0.00	31	18	13	1.88	14.25	1.64	2.69	0.13	18.0
7.50	21	0.88	16.74	Clayey Silt with Sand	10.28	72.63	8.37	2.36	1.45	4.91	0.00	29	20	9	-	-	-	-	-	-
10.50	24	0.76	16.62	Silty Sand	3.29	38.68	56.73	0.60	0.17	0.53	0.00	24	NIL	NP	-	-	-	-	-	-
12.00	31	0.72	18.66	Clayey Silt with Sand	21.93	69.24	5.18	1.40	1.39	0.86	0.00	40	21	19	-	-	-	-	-	-

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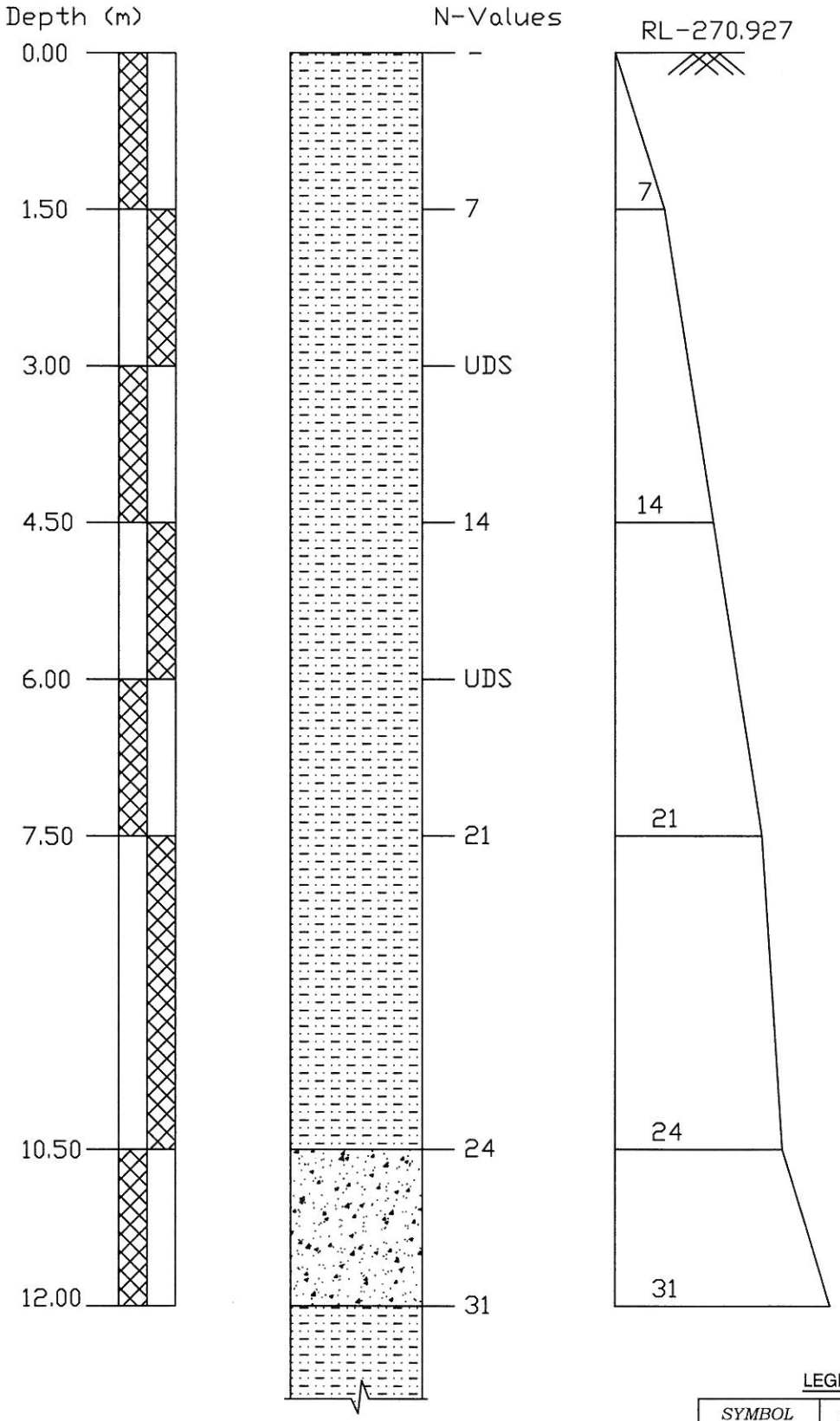
BORELOG OF BH–1 AT EXISTING KM–255/5–7 FOR ALIGNMENT,

ON KESARI TO SANEHWAL, LUDHIANA



1251

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ANNEXURE - III

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

INPUT DATA

		Ch 255 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)	1.80
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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1252

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	11.54	6.10	8.55
2	3.00	3.00	8.00	15.08	7.98	11.18
3	4.50	3.00	8.00	16.34	8.65	12.11
4	6.00	3.00	8.00	17.60	9.32	13.04

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 255/ 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	=	7.13	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	=	0.12	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.66	
	$\frac{Po + \Delta p}{Po}$	=	1.24702	

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

S_f = 0.03119 m

= 31.1875 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = 22.7 mm

1254

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 255/ 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	=	9.98	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	
	$\frac{Po + \Delta p}{Po}$	=	1.24261	

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

S_f = 0.03069 m

= 30.6868 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**

1255

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 255/ 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	=	12.825	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	
	$\frac{Po + \Delta p}{Po}$	=	1.20585	

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

S_f = 0.02644 m

= 26.4446 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**

1256

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 255/ 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 layer	Po	=	15.68	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	=	0.12	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.66	
	$\frac{Po + \Delta p}{Po}$	=	1.18	

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

S_f = 0.02368 m

= 23.68 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = **12.9 mm**

1257

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139.1 LOCATION OF STRUCTURE:

Alignment at existing km 255/05-07

139.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table 07.00m below EGL

Subsurface profile at the site

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

139.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.70	0.005	0.0031	NIL	0.0014	0.114
	12.00	8.60	0.002	0.0033	NIL	0.0013	0.124

139.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	22.00
	6.00	15.00

139.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BORE HOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (µS/cm)
Test Result	7.2	136	132	181	835	0.2	2.6	1025	662
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	-	-

139.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	08.00
	3.00	11.00
	4.50	12.00
	6.00	13.00

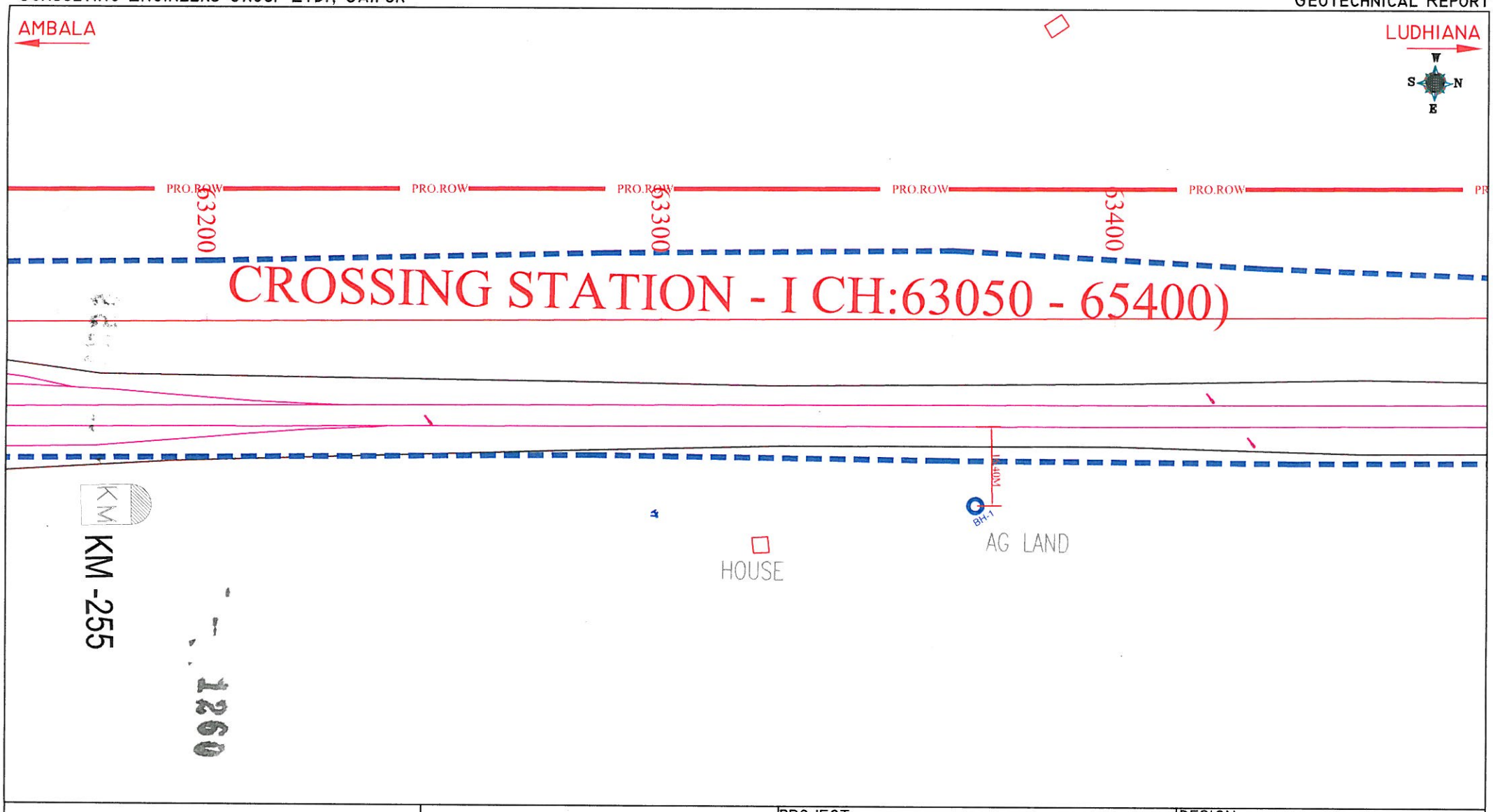
139.7 CONCLUSIONS

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

139.8 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 4.50 m from EGL

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



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALINGMENT CH. 255/5-7	RL OF BH-I = 270.927	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 OF ALIGNMENT AT CHAINAGE 255/5-7

Project :	Chainage 255/5-7			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				16.12.2009 to 16.12.2009	1	1	07.00 m.	12.00mtr	270.927

Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Clayey Silt with Sand	17.22	74.88	6.25	1.65	0.00	0.00	0.00	35	20	15	-	-	-	-	-	-
1.50	7	1.42	9.94	Clayey Silt with Sand	20.14	74.10	4.03	1.73	0.00	0.00	0.00	40	22	18	-	-	-	-	-	-
3.00	UDS	-	-	Clayey Silt with Sand	20.89	67.19	5.24	2.09	2.27	2.32	0.00	38	19	19	1.83	13.58	1.61	2.68	0.21	13.0
4.50	14	1.05	14.70	Clayey Silt with Sand	28.83	63.49	4.90	0.43	0.50	1.85	0.00	51	25	26	-	-	-	-	-	-
6.00	UDS	-	-	Clayey Silt with Sand	14.52	75.00	7.71	1.76	0.81	0.20	0.00	31	18	13	1.88	14.25	1.64	2.69	0.13	18.0
7.50	21	0.88	16.74	Clayey Silt with Sand	10.28	72.63	8.37	2.36	1.45	4.91	0.00	29	20	9	-	-	-	-	-	-
10.50	24	0.76	16.62	Silty Sand	3.29	38.68	56.73	0.60	0.17	0.53	0.00	24	NIL	NP	-	-	-	-	-	-
12.00	31	0.72	18.66	Clayey Silt with Sand	21.93	69.24	5.18	1.40	1.39	0.86	0.00	40	21	19	-	-	-	-	-	-

1261

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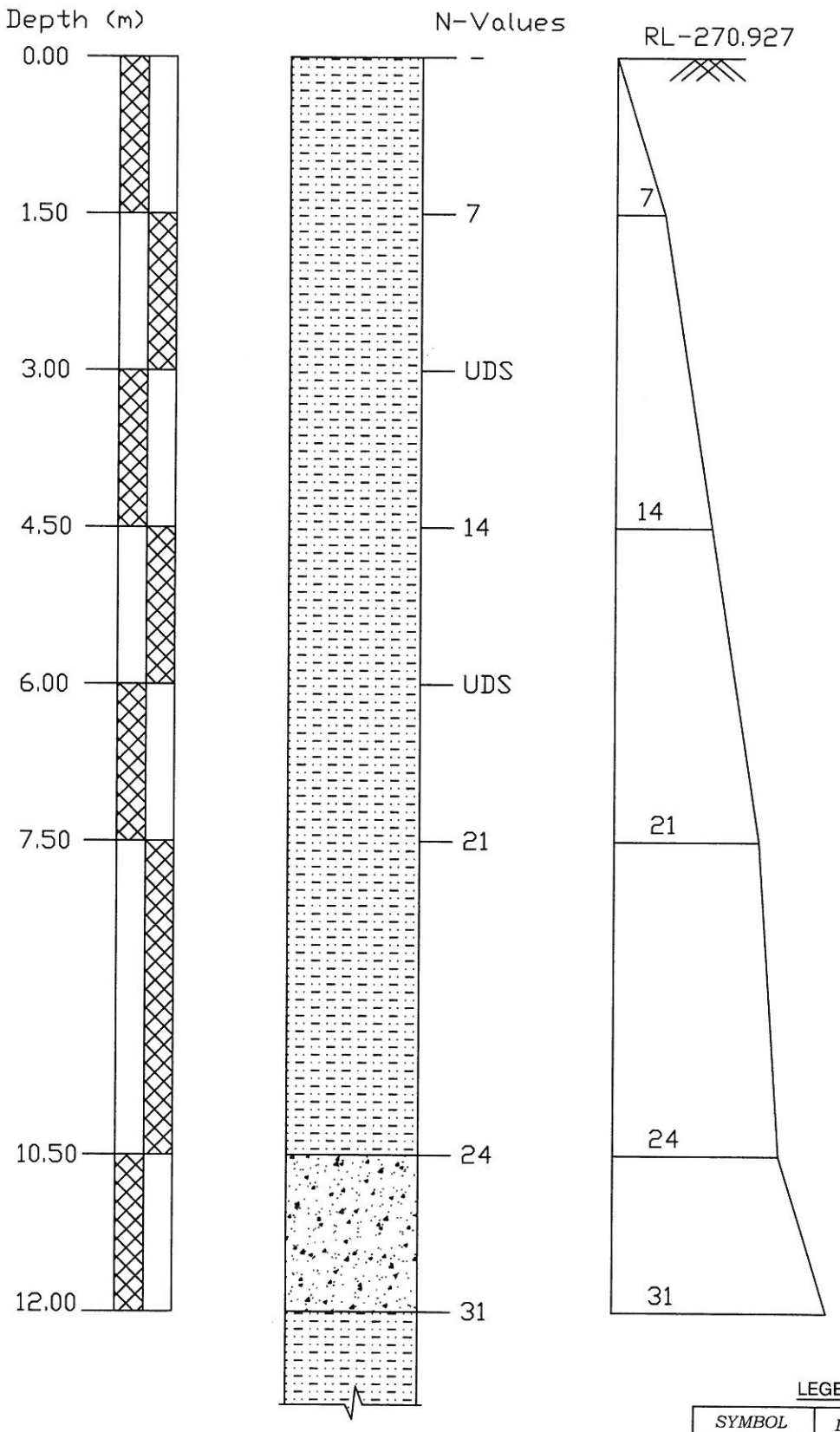
BORELOG OF BH–1 AT EXISTING KM–255/5–7 FOR ALIGNMENT,

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	SILTY SAND

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ANNEXURE - III

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

INPUT DATA

Ch 255 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 (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.80
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

ANNEXURE - III

Bearing capacity factors :

ϕ	13.00	ϕ'	8.79
N_c	9.93	N'_c	7.90
N_q	3.35	N'_q	2.25
N_γ	2.08	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	11.54	6.10	8.55
2	3.00	3.00	8.00	15.08	7.98	11.18
3	4.50	3.00	8.00	16.34	8.65	12.11
4	6.00	3.00	8.00	17.60	9.32	13.04

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 255/ 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	=	7.13	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	=	0.12	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.66	
	$\frac{Po + \Delta p}{Po}$	=	1.24702	

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

S_f = 0.03119 m

= 31.1875 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.91

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

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = **22.7 mm**

1265

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 255/ 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	=	9.98	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	
	$\frac{Po + \Delta p}{Po}$	=	1.24261	

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

S_f = 0.03069 m

= 30.6868 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**

1266

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 255/ 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	=	12.825	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	
	$\frac{Po + \Delta p}{Po}$	=	1.20585	

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

S_f = 0.02644 m

= 26.4446 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**

1267

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1) **Alignment at 255/ 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 layer	Po	=	15.68	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	=	0.12	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.66	
	$\frac{Po + \Delta p}{Po}$	=	1.18	

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

S_f = 0.02368 m

= 23.68 mm

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

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.68

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

= 0.8

Pore Pr. Correction = N.A.

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

S_{f2} = **12.9 mm**

1268

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