28.1 LOCATION OF STRUCTURE:

Alignment at existing km 358/1.

28.2 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 ≥16.00m below EGL.

Subsurface profile at the site

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

28.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.50	0.008	0.0016	NIL	0.0009	0.031

28.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

28.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	13.00
	3.00	18.00
	4.50	18.50
	6.00	19.50

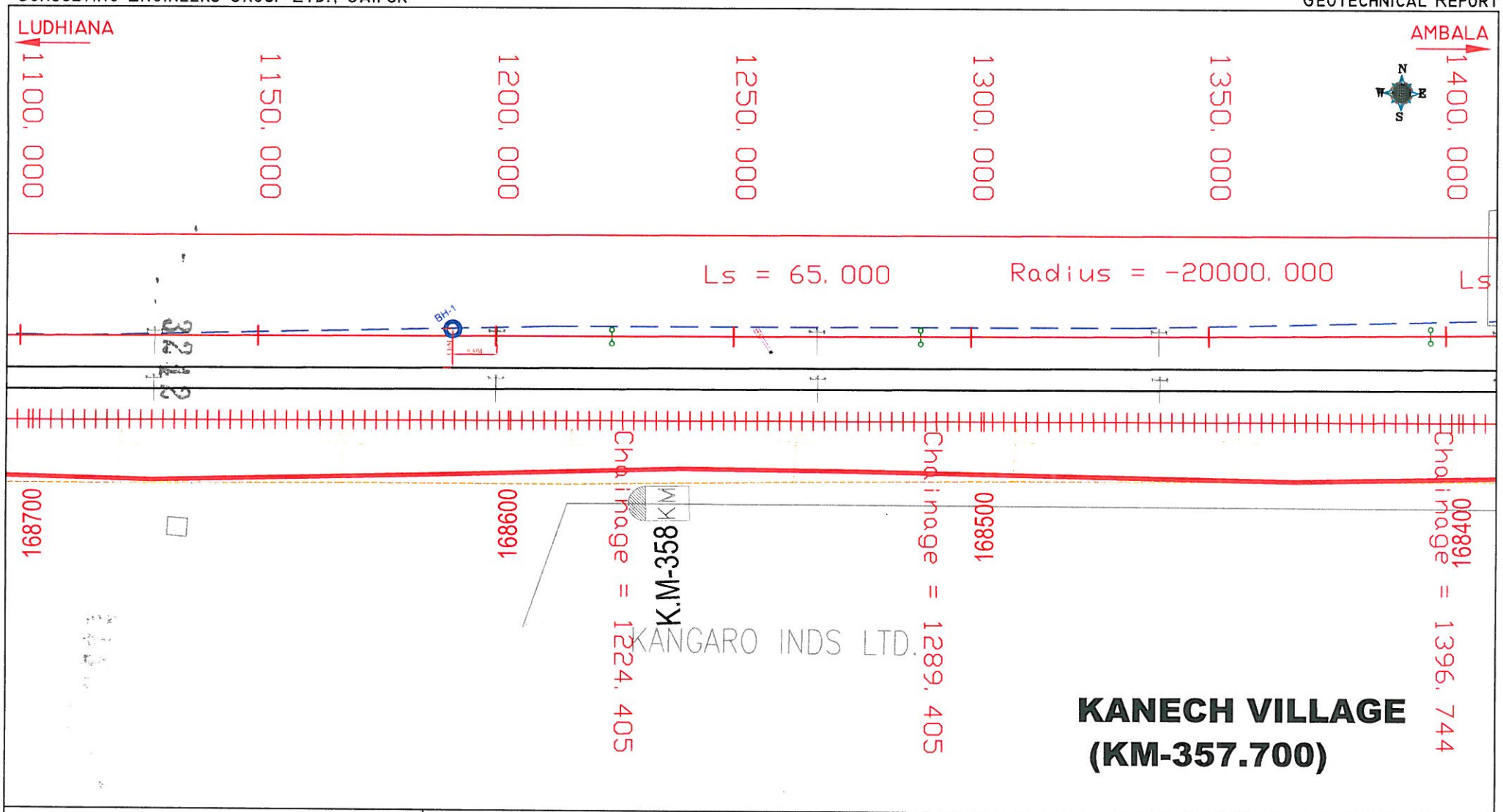
28.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

28.7 RECOMMENDATIONS

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

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



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 358/1	RL OF BH-1 = 256.013	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (LHS) OF ALIGNMENT AT CHAINAGE 358/1

Project :	Chainage 358/1			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				24.05.2009 to 24.05.2009	1	1 (LHS)	below 16.00 m.	12.00mtr	256.013

Depth from GL (m)	Observed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel										c kg/cm^2	ϕ degree
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
0.00	-	-	-	Sandy Silt	2.57	65.72	13.26	14.29	2.37	1.15	0.64	22	NP	NIL	-	-	-	-	-	-
1.50	12	1.45	17.40	Sandy Silt	3.18	50.13	46.45	0.24	0.00	0.00	0.00	21	NP	NIL	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	1.75	7.39	85.02	3.27	1.90	0.67	0.00	28	NP	NIL	1.73	3.06	1.68	2.67	0.00	26.00
6.00	17	0.99	16.83	Silty Sand	3.38	12.06	83.41	1.10	0.05	0.00	0.00	29	NP	NIL	-	-	-	-	-	-
9.00	21	0.85	17.85	Silty Sand	2.64	8.37	87.42	1.42	0.15	0.00	0.00	29	NP	NIL	-	-	-	-	-	-
12.00	29	0.76	22.04	Silty Sand	3.25	7.83	87.56	0.99	0.37	0.00	0.00	30	NP	NIL	-	-	-	-	-	-

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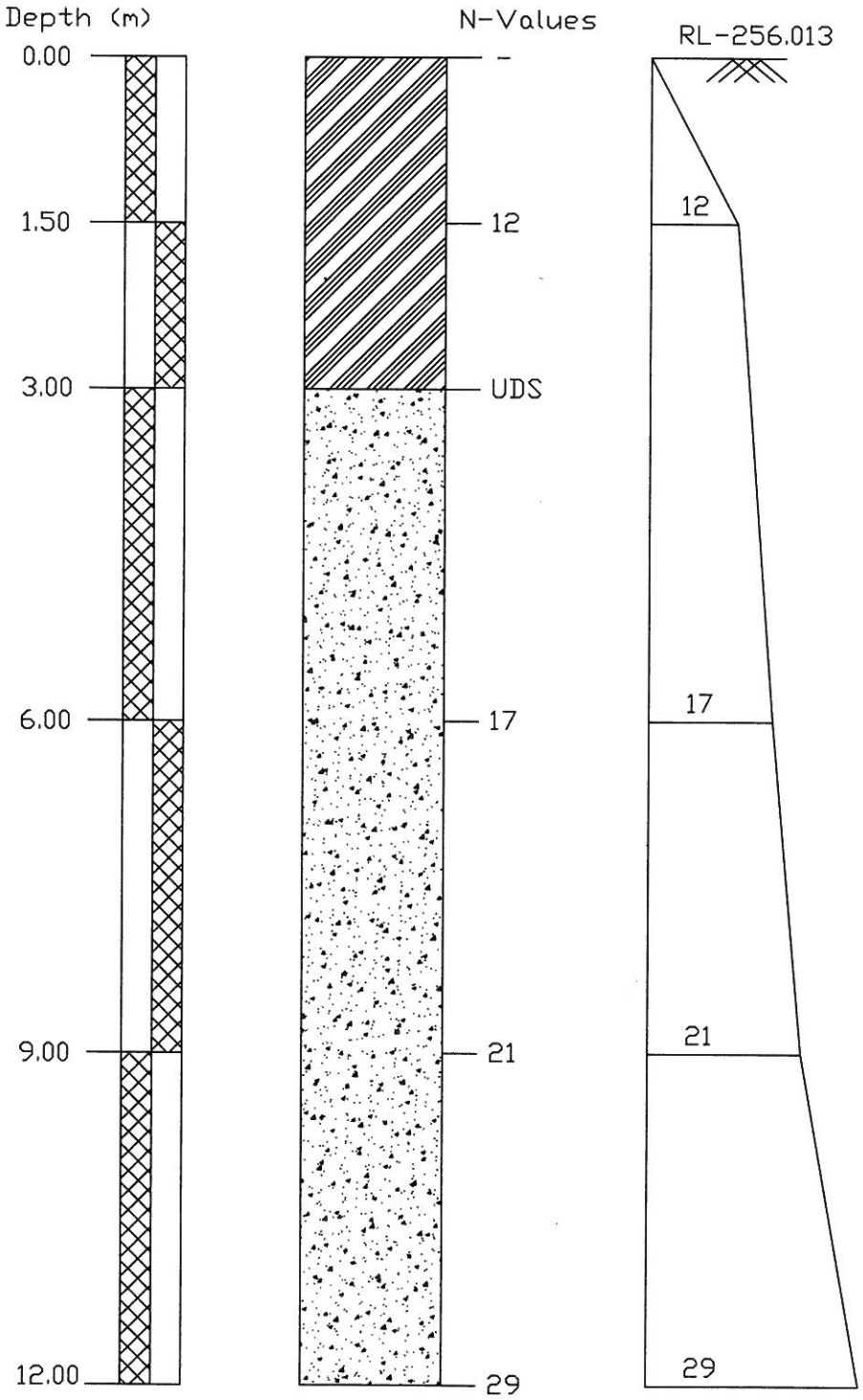
BORELOG OF BH–1(LHS) AT EXISTING KM–358/1 FOR ALIGNMENT ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT
	SILTY SAND

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ANNEXURE - III

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

INPUT DATA

Alignment at Ch 358/1 — BH-1

Type of footing

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

Angle of internal friction (ϕ°)	26.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.59
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.73
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.00
N_c	22.60
N_q	12.21
N_γ	13.18

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.16	1.08	1.08
2	3.00	3.00	1.32	1.16	1.16
3	4.50	3.00	1.48	1.24	1.24
4	6.00	3.00	1.64	1.32	1.32

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	16.30	6.13	14.26
2	3.00	3.00	8.00	29.38	11.32	25.77
3	4.50	3.00	8.00	31.41	12.10	27.55
4	6.00	3.00	8.00	33.44	12.88	29.32

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	358/1
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	13.00
Average N value	17
Settlement for 10 t/m2 (mm)	18.00
Total Settlement (mm)	23.40
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	17.0

Footing Depth (m)	3.00
SBC (t/m2)	18.00
Average N value	17
Settlement for 10 t/m2 (mm)	18.00
Total Settlement (mm)	32.40
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	21.5

Footing Depth (m)	4.50
SBC (t/m2)	18.50
Average N value	17
Settlement for 10 t/m2 (mm)	18.00
Total Settlement (mm)	33.30
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	19.7

Footing Depth (m)	6.00
SBC (t/m2)	19.50
Average N value	17
Settlement for 10 t/m2 (mm)	18.00
Total Settlement (mm)	35.10
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	19.1

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CHAPTER – 29

"Alignment",

Location – Existing Km. – 357/1

29.1 LOCATION OF STRUCTURE:

Alignment at existing km 357/1.

29.2 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 ≥17.00m below EGL.

Subsurface profile at the site

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

29.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.30	0.002	0.0013	NIL	0.0008	0.019

29.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

29.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	13.00
	3.00	19.00
	4.50	20.00
	6.00	20.50

29.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

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29.7 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 2.00m from EGL

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

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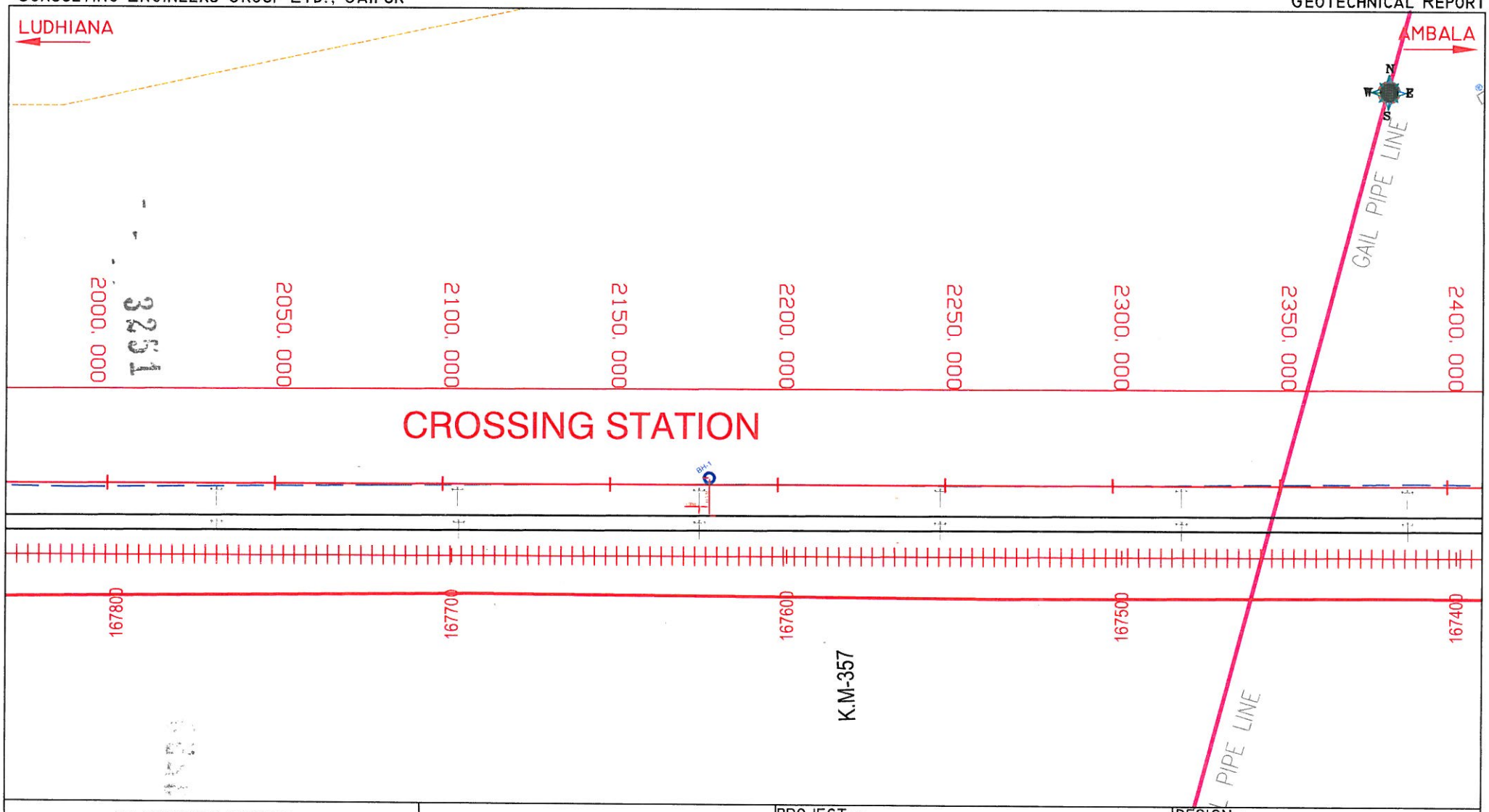

ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 357/1	RL OF BH-I = 254.983	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (LHS) OF ALIGNMENT AT CHAINAGE 357/1

Project :	Chainage 357/1			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				24.05.2009 to 24.05.2009	1	1 (LHS)	below 17.00 m.	12.00mtr	254.983

Depth from GL (m)	Observed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel										c kg/cm^2	ϕ degree
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
0.00	-	-	-	Sandy Silt	3.16	69.02	10.36	15.26	1.26	0.94	0.00	25	NP	NIL	-	-	-	-	-	-
1.50	11	1.46	16.06	Silty Sand	3.18	9.34	83.88	3.60	0.00	0.00	0.00	29	NP	NIL	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	1.65	11.61	74.23	10.36	2.15	0.00	0.00	25	NP	NIL	1.68	4.69	1.60	2.66	0.00	27.00
6.00	18	1.00	18.00	Silty Sand	2.47	5.79	88.46	3.28	0.00	0.00	0.00	28	NP	NIL	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand with Gravels	3.67	14.35	71.21	1.23	1.12	8.42	0.00	26	NP	NIL	2.00	3.62	1.93	2.67	0.00	30.00
12.00	28	0.74	20.72	Silty Sand	2.97	11.27	82.98	2.65	0.13	0.00	0.00	27	NP	NIL	-	-	-		-	-

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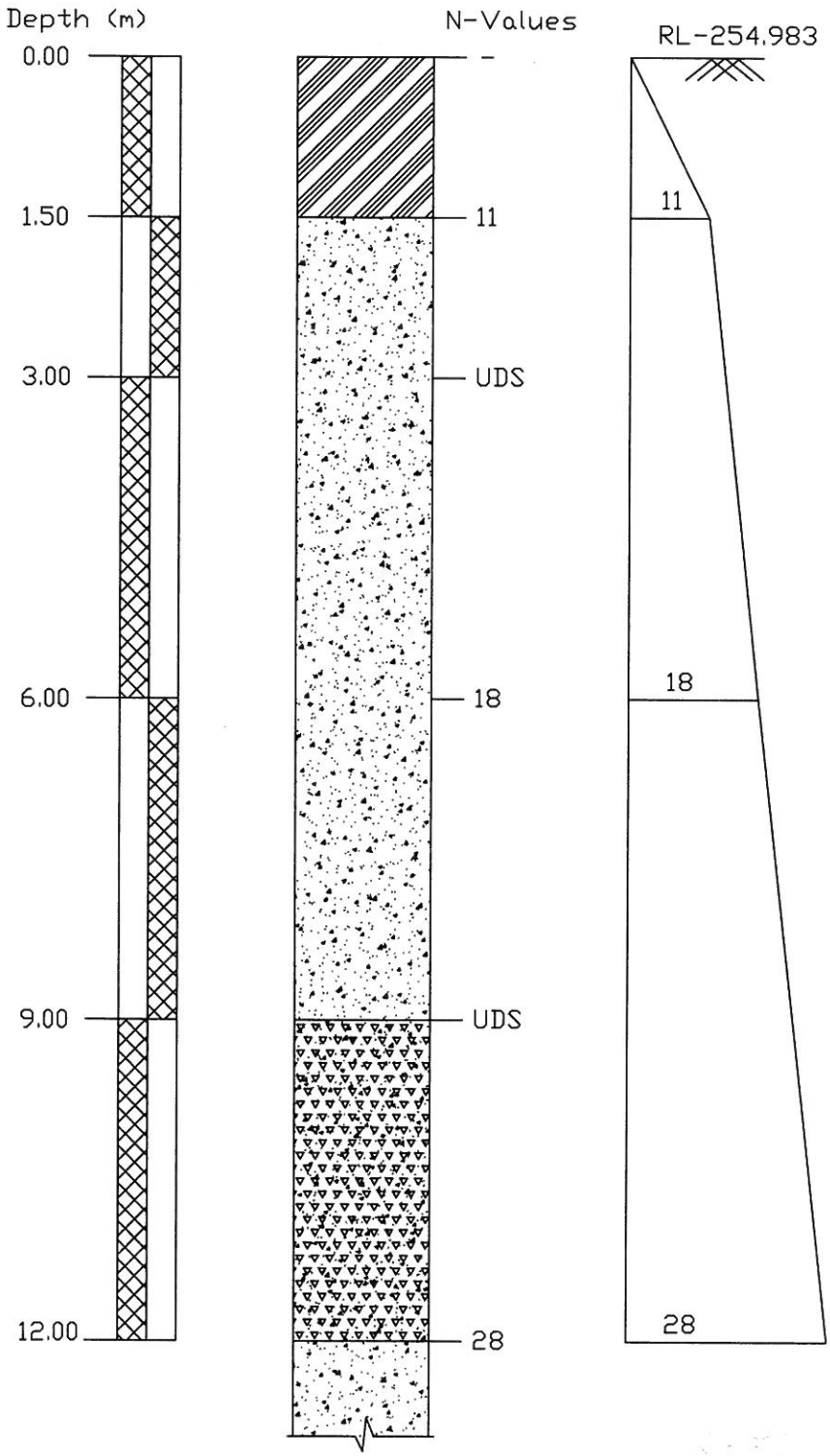
BORELOG OF BH–1(LHS) AT EXISTING KM–357/1 FOR ALIGNMENT ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT
	SILTY SAND
	SILTY SAND WITH GRAVELS

3253

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ANNEXURE - III

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

INPUT DATA

Alignment at Ch 357/1 BH-1

Type of footing

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

Angle of internal friction (ϕ °)	27.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.66
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.68
Density of foundation soil (t/m^3)	1.68
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	27.00
N_c	24.49
N_q	13.76
N_γ	15.49

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

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	18.44	6.56	11.90
2	3.00	3.00	8.00	33.23	12.13	21.62
3	4.50	3.00	8.00	35.56	12.98	23.14
4	6.00	3.00	8.00	37.89	25.41	31.03

3255

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	357/1
Bore Hole No.	1

Footing Depth (m)	**1.50**
SBC (t/m2)	13.00
Average N value	16
Settlement for 10 t/m2 (mm)	19.00
Total Settlement (mm)	24.70
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**18.0**

Footing Depth (m)	**3.00**
SBC (t/m2)	19.00
Average N value	17
Settlement for 10 t/m2 (mm)	18.00
Total Settlement (mm)	34.20
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**22.7**

Footing Depth (m)	**4.50**
SBC (t/m2)	20.00
Average N value	17
Settlement for 10 t/m2 (mm)	18.00
Total Settlement (mm)	36.00
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**21.3**

Footing Depth (m)	**6.00**
SBC (t/m2)	20.50
Average N value	18
Settlement for 10 t/m2 (mm)	17.00
Total Settlement (mm)	34.85
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**19.0**

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CHAPTER – 30

"Alignment",

Location – Existing Km. – 356/1

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30.1 LOCATION OF STRUCTURE:

Alignment at existing km 356/1

30.2 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 ≥16.00m below EGL.

Subsurface profile at the site

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

30.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.20	NIL	0.0011	NIL	0.0010	0.014

30.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

30.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	9.00
	3.00	15.00
	4.50	16.00
	6.00	20.00

30.7 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

30.8 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.

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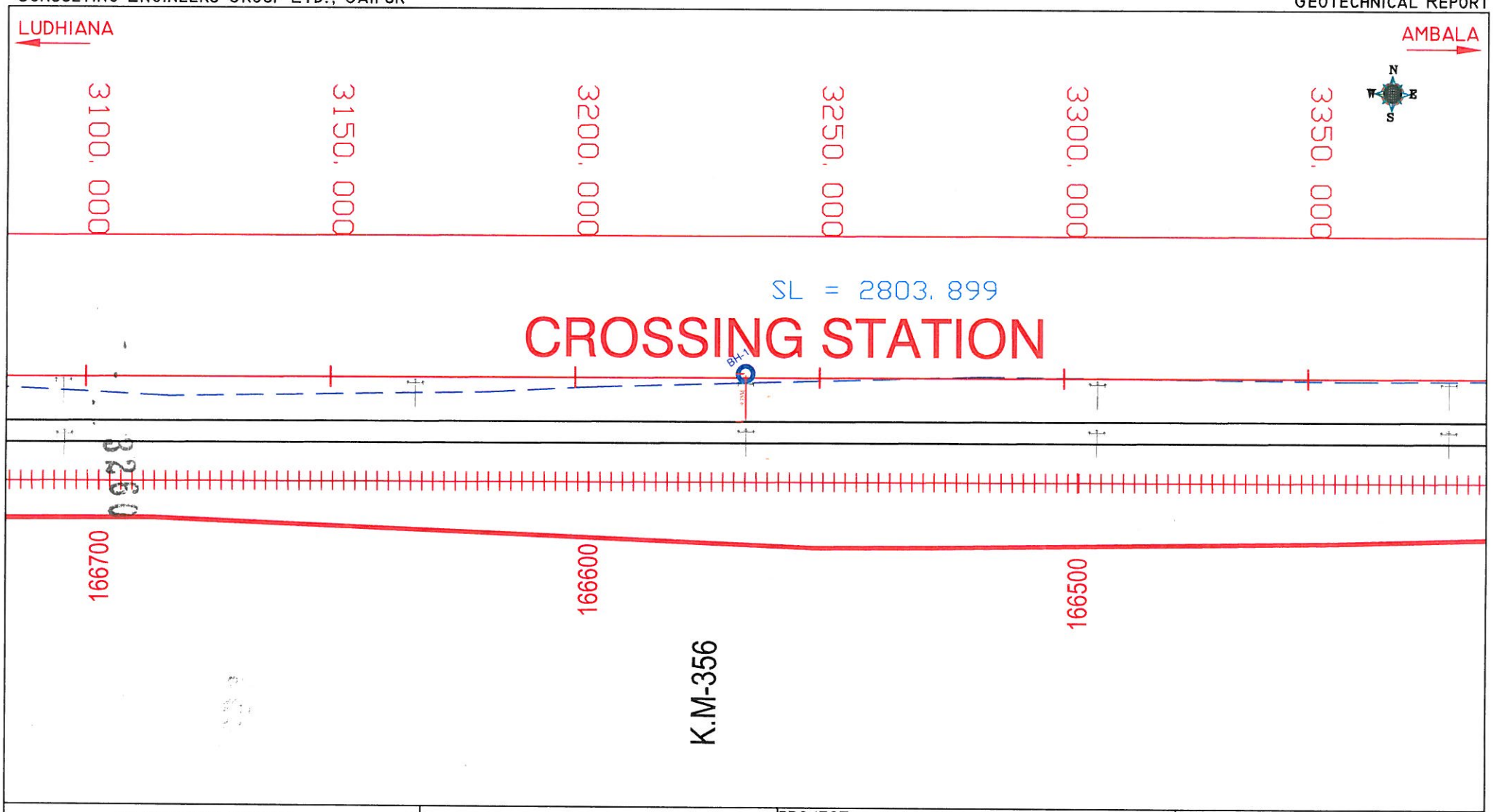

ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 356/1	RL OF BH-I = 255.322	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (LHS) OF ALIGNMENT AT CHAINAGE 356/1

Project :	Chainage 356/1			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				25.05.2009 to 25.05.2009	1	1 (LHS)	below 16.00 m.	12.00mtr	255.322	

Depth from GL (m)	Observ-ed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel										c kg/cm^2	ϕ degree
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
0.00	-	-	-	Sandy Silt	3.16	68.30	10.36	15.23	2.36	0.59	0.00	25	NIL	NP	-	-	-	-	-	-
1.50	7	1.43	10.01	Silty Sand	2.97	6.17	86.64	4.22	0.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	1.64	5.03	84.94	8.27	0.12	0.00	0.00	26	NIL	NP	1.86	6.25	1.75	2.67	0.00	28.50
6.00	14	0.97	13.58	Silty Sand	2.67	15.59	78.68	2.48	0.09	0.49	0.00	28	NIL	NP	-	-	-	-	-	-
9.00	29	0.83	24.07	Silty Sand with Gravels	3.28	7.46	79.74	2.60	0.29	6.63	0.00	27	NIL	NP		-	-	-	-	-
12.00	31	0.73	22.63	Silty Sand	2.14	5.67	89.90	2.29	0.00	0.00	0.00	29	NIL	NP	-	-	-	-	-	-

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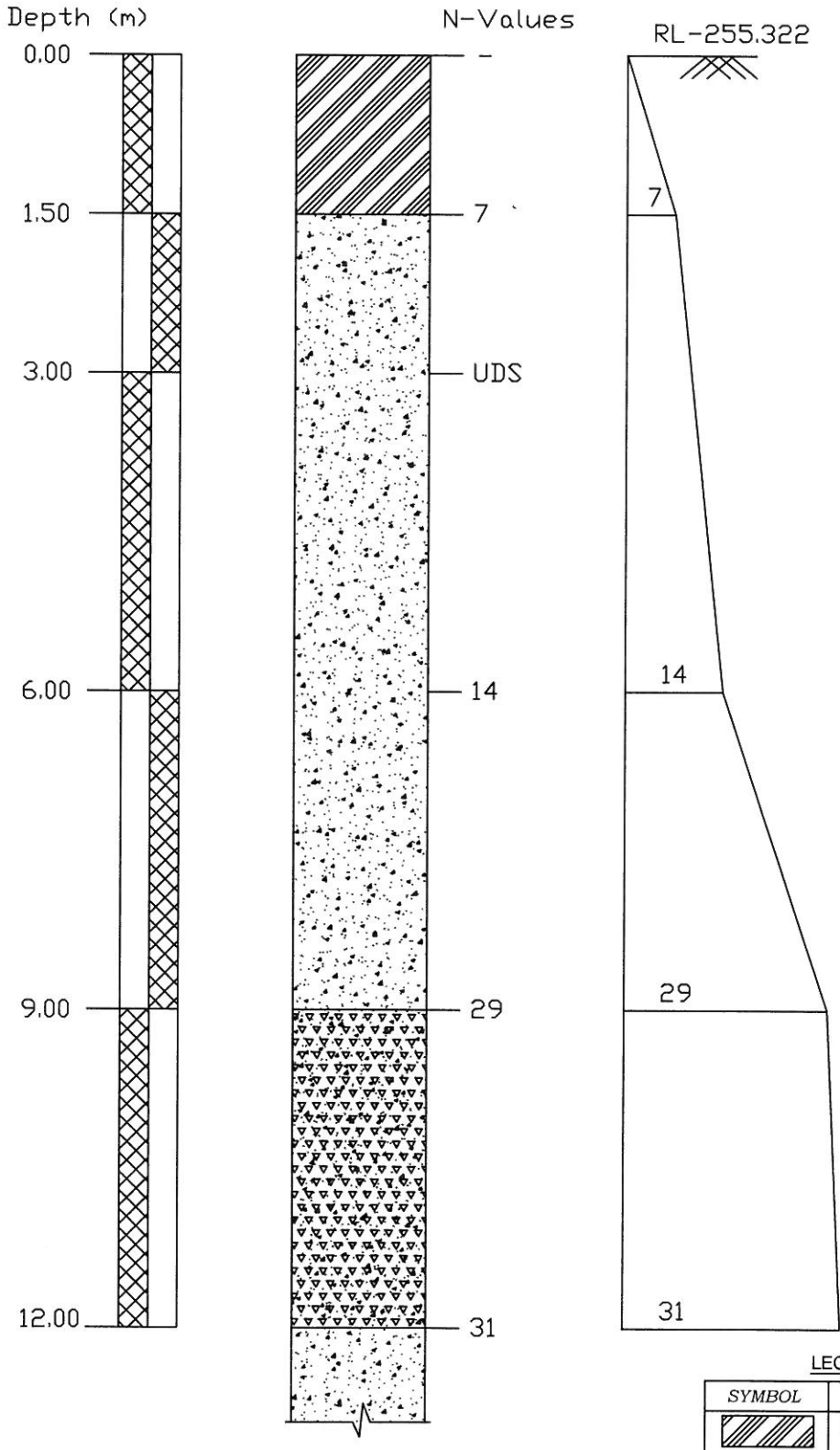
BORELOG OF BH–1(LHS) AT EXISTING KM–356/1 FOR ALIGNMENT ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT
	SILTY SAND
	SILTY SAND WITH GRAVELS

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ANNEXURE - III

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

INPUT DATA

Alignment at Ch 356/1 BH-1

Type of footing

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

Angle of internal friction (ϕ °)	28.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.53
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.86
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	28.50
N_c	27.31
N_q	16.08
N_γ	18.94

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

Shape factors :

S.no.	Width(m)	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	1.17	1.08	1.08
2	3.00	3.00	1.34	1.17	1.17
3	4.50	3.00	1.50	1.25	1.25
4	6.00	3.00	1.67	1.34	1.34

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	23.05	7.65	23.05
2	3.00	3.00	8.00	40.93	14.00	40.93
3	4.50	3.00	8.00	43.88	15.01	43.88
4	6.00	3.00	8.00	46.82	29.19	46.82

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	356/1
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	9.00
Average N value	10
Settlement for 10 t/m2 (mm)	37.00
Total Settlement (mm)	33.30
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	24.2

Footing Depth (m)	3.00
SBC (t/m2)	15.00
Average N value	13
Settlement for 10 t/m2 (mm)	25.00
Total Settlement (mm)	37.50
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	24.9

Footing Depth (m)	4.50
SBC (t/m2)	16.00
Average N value	13
Settlement for 10 t/m2 (mm)	26.00
Total Settlement (mm)	41.60
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	24.6

Footing Depth (m)	6.00
SBC (t/m2)	20.00
Average N value	14
Settlement for 10 t/m2 (mm)	23.00
Total Settlement (mm)	46.00
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	25.0

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CHAPTER – 31

"Alignment",

Location – Existing Km. – 355/0-1

31.1 LOCATION OF STRUCTURE:

Alignment at Span existing km 355/0-1

31.2 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 ≥17.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.50	Sandy Silt	Loose
	1.50 to 3.00	Sandy Silt	Medium Dense
	3.00 to 4.50	Sandy Silt with Gravels	Medium Dense
	4.50 to 12.00	Silty Sand	Medium Dense
	Below 12.00	Silty Sand with Clay	Dense

31.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate %	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.70	0.005	0.0021	NIL	0.0010	0.042

31.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

31.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	20.00
	3.00	26.00
	4.50	26.50
	6.00	27.00

31.7 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

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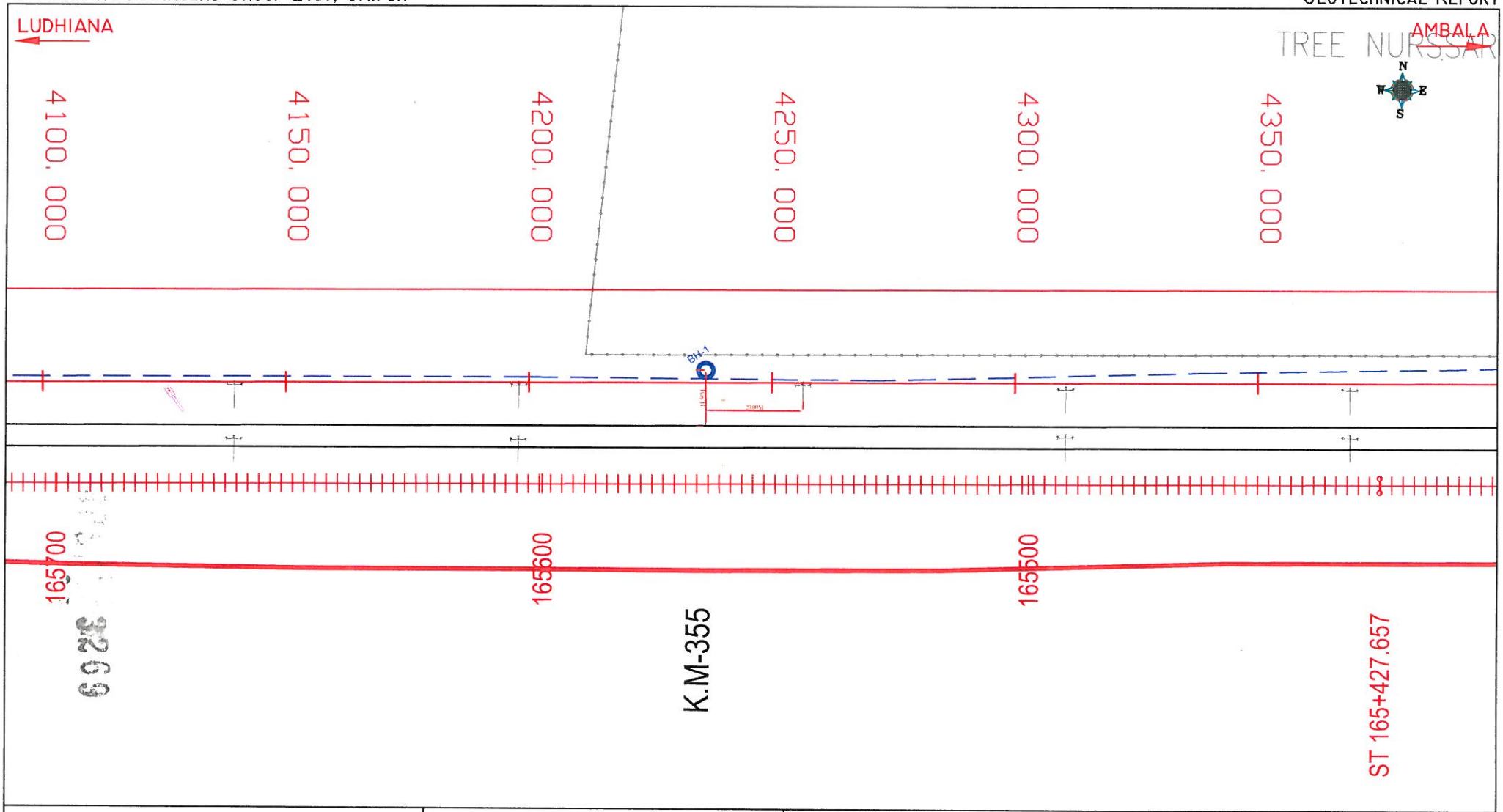
31.8 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 2.00m 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 AT CH. 355/0-I	RL OF BH-I = 255.751	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (LHS) OF ALIGNMENT AT CHAINAGE 355/0-1

Project :	Chainage 355/0-1			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				25.05.2009 to 25.05.2009	1	1 (LHS)	below 17.00 m.	12.00mtr	255.751	

Depth from	Observ-ed	Correction Factor	Corrected	Soil Description	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel									c kg/cm^2	ϕ
							Fine	Medium	Coarse	Fine	Coarse									
GL (m)	N	C_n	N_n	(Soil Group)								L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Sandy Silt	2.67	61.19	20.67	11.26	2.34	1.2	0.67	24	NIL	NP	-	-	-	-	-	-
1.50	23	1.43	32.89	Sandy Silt	2.21	63.84	32.99	0.96	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt with Gravels	3.67	62.60	18.71	1.38	1.79	11.85	0.00	26	NIL	NP	1.87	4.71	1.79	2.64	0.00	28.00
4.50				Silty Sand	1.06	25.55	60.34	10.23	2.15	0.67	0.00	24	NIL	NP	-	-	-	-	-	-
6.00	26	0.96	24.96	Silty Sand	1.97	6.43	90.06	1.41	0.13	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
9.00	30	0.83	24.90	Silty Sand	2.10	36.72	51.06	3.85	2.65	3.62	0.00	20	NIL	NP	-	-	-	-	-	-
12.00	33	0.73	24.09	Silty Sand with Clay	10.10	32.30	48.20	3.45	2.16	3.79	0.00	21	14	7	-	-	-	-	-	-

DFCCIL *KESARI TO SANEHWAL*

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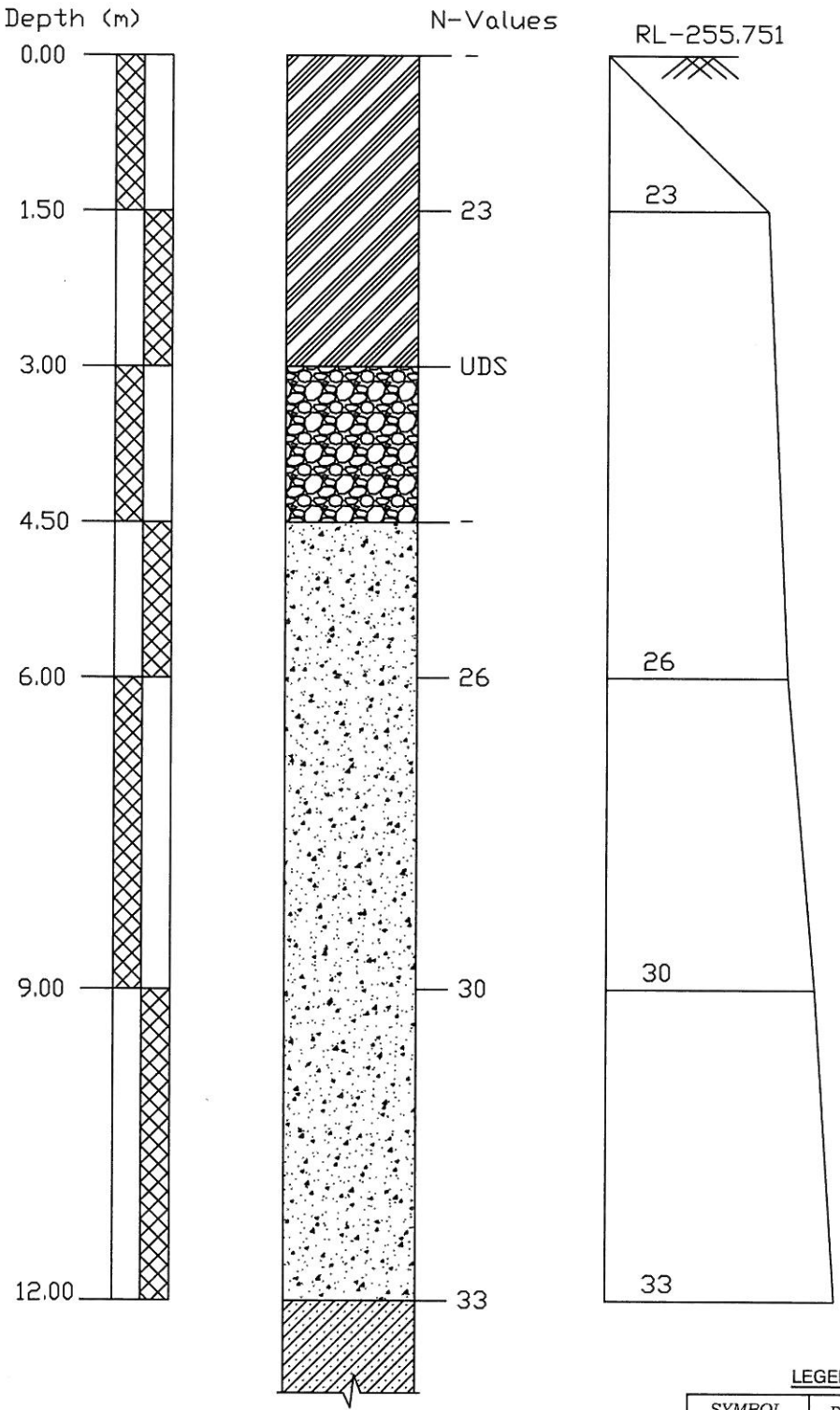
BORELOG OF BH–1(LHS) AT EXISTING KM–355/0–1 FOR ALIGNMENT ON KESARI TO SANEHWAL, LUDHIANA



ANNEXURE - III

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

INPUT DATA

	Alignment at Ch 355/1	BH-1
Type of footing		
1 Continuous Strip		
2 Rectangular	***Rectangular***	**2**
3 Square		
4 Circular		

Angle of internal friction (ϕ°)	28.00
Cohesion (c in t/m2)	.0.00
Void ratio (e)	0.47
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.87
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	28.00
N_c	26.37
N_q	15.30
N_γ	17.79

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

Shape factors :

S.no.	Width(m)	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	1.17	1.08	1.08
2	3.00	3.00	1.33	1.17	1.17
3	4.50	3.00	1.50	1.25	1.25
4	6.00	3.00	1.67	1.33	1.33

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	21.82	7.38	21.82
2	3.00	3.00	8.00	38.74	13.50	38.74
3	4.50	3.00	8.00	41.50	14.46	41.50
4	6.00	3.00	8.00	44.27	15.42	44.27

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	355/0-1
Bore Hole No.	1

Footing Depth (m)	**1.50**
SBC (t/m2)	20.00
Average N value	28
Settlement for 10 t/m2 (mm)	10.00
Total Settlement (mm)	20.00
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**14.6**

Footing Depth (m)	**3.00**
SBC (t/m2)	26.00
Average N value	25
Settlement for 10 t/m2 (mm)	12.00
Total Settlement (mm)	31.20
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**20.7**

Footing Depth (m)	**4.50**
SBC (t/m2)	26.50
Average N value	25
Settlement for 10 t/m2 (mm)	12.00
Total Settlement (mm)	31.80
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**18.8**

Footing Depth (m)	**6.00**
SBC (t/m2)	27.00
Average N value	25
Settlement for 10 t/m2 (mm)	12.00
Total Settlement (mm)	32.40
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**17.6**

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CHAPTER – 32

"Alignment",

Location – Existing Km. – 347/1

32.1 LOCATION OF STRUCTURE:

Alignment at existing km 347/1

32.2 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 ≥14.00m 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 12.00	Silty Sand	Medium Dense
	Below 12.00	Silty Sand	Medium Dense

32.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate %	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.40	NIL	0.0011	NIL	0.0010	0.017

32.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

32.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	9.00
	3.00	16.00
	4.50	17.00
	6.00	18.00

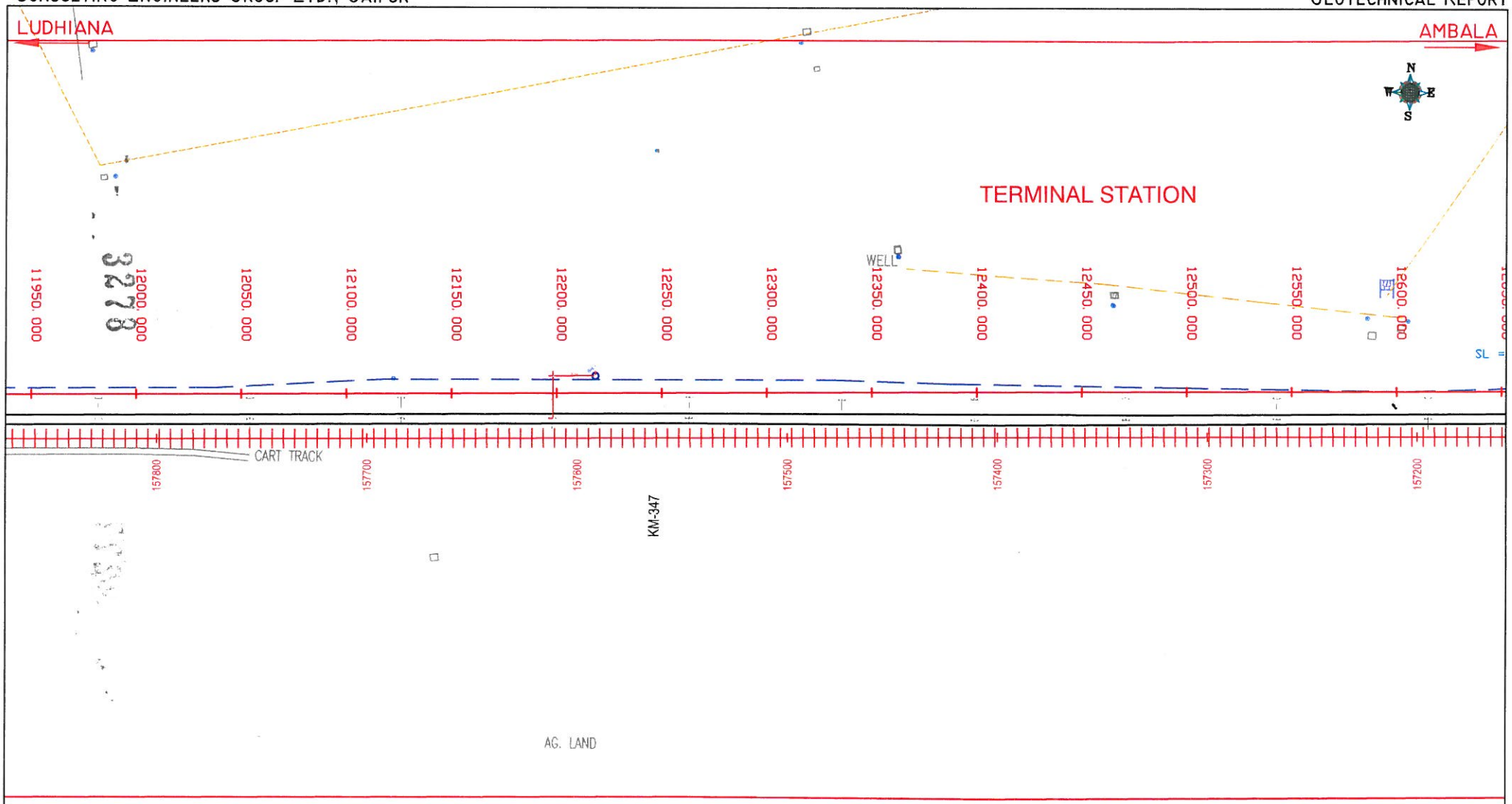
32.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

32.6 RECOMMENDATIONS

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

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



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 347/1	RL OF BH-I = 257.916	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel. +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (LHS) OF ALIGNMENT AT CHAINAGE 347/1

Project :	Chainage 347/1			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				30.05.2009 to 30.05.2009	1	1 (LHS)	below 14.00 m.	12.00mtr	257.916	

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	3.17	34.37	50.36	10.65	1.45	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
1.50	5	1.51	7.55	Silty Sand	2.67	39.35	56.59	1.39	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
2.40				Silty Sand	2.56	16.69	65.29	14.23	1.23	0.00	0.00	24	NIL	NP						
3.00	UDS	-	-	Silty Sand	2.16	6.21	88.52	3.01	0.10	0.00	0.00	27	NIL	NP	1.62	3.54	1.56	2.64	0.00	26.00
6.00	20	1.01	20.20	Silty Sand	1.85	8.41	87.68	2.06	0.00	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand	2.67	10.22	84.21	2.45	0.45	0.00	0.00	27	NIL	NP	1.71	5.36	1.62	2.66	0.00	27.50
12.00	32	0.77	24.64	Silty Sand	3.11	7.28	87.20	2.41	0.00	0.00	0.00	24	NIL	NP	-	-	-	-	-	-

DFCCIL *KESARI TO SANEHWAL*

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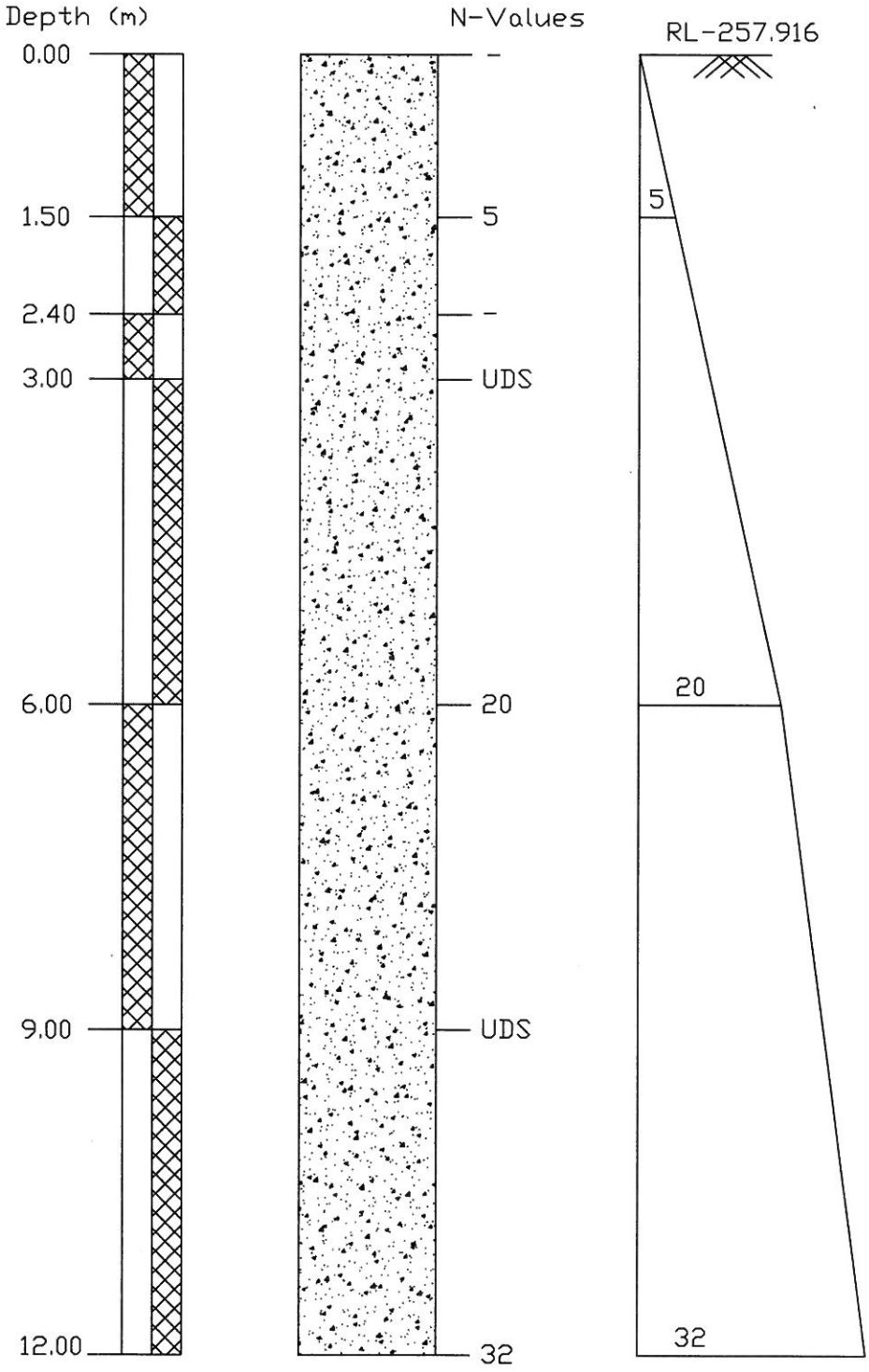
BORELOG OF BH–1(LHS) AT EXISTING KM–347/1 FOR ALIGNMENT

ON KESARI TO SANEHWAL, LUDHIANA



3280

LEGEND

SYMBOL	DESCRIPTION
	SILTY SAND

CONSULTING Engineers Group Ltd.

ANNEXURE - III

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

INPUT DATA

Alignment at Ch 347/1 BH-1

Type of footing

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

Angle of internal friction (ϕ °)	26.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.69
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.62
Density of foundation soil (t/m^3)	1.62
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)	Length (m)
1	1.50	3.00	8.00
2	3.00	3.00	8.00
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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CONSULTING Engineers Group Ltd.

ANNEXURE - III

Bearing capacity factors :

ϕ	26.00
N_c	22.60
N_q	12.21
N_γ	13.18

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.16	1.08	1.08
2	3.00	3.00	1.32	1.16	1.16
3	4.50	3.00	1.48	1.24	1.24
4	6.00	3.00	1.64	1.32	1.32

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	15.44	5.81	8.70
2	3.00	3.00	8.00	27.91	10.75	15.90
3	4.50	3.00	8.00	29.83	11.49	17.00
4	6.00	3.00	8.00	31.76	12.24	18.09

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	347/1
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	9.00
Average N value	12
Settlement for 10 t/m2 (mm)	29.00
Total Settlement (mm)	26.10
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	19.0

Footing Depth (m)	3.00
SBC (t/m2)	16.00
Average N value	15
Settlement for 10 t/m2 (mm)	21.00
Total Settlement (mm)	33.60
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	22.3

Footing Depth (m)	4.50
SBC (t/m2)	17.00
Average N value	16
Settlement for 10 t/m2 (mm)	19.00
Total Settlement (mm)	32.30
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	19.1

Footing Depth (m)	6.00
SBC (t/m2)	18.00
Average N value	20
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	27.00
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	14.7

3283

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CHAPTER – 33

"Alignment",

Location – Existing Km. – 347/25-27

33.1 LOCATION OF STRUCTURE:

Alignment at existing km 347/25-27

33.2 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 ≥14.00m below EGL.

Subsurface profile at the site

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

33.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate %	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	6.00	8.70	0.012	0.0014	NIL	0.0009	0.019

33.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

33.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	9.50
	3.00	17.00
	4.50	18.00
	6.00	20.00

33.6 CONCLUSIONS

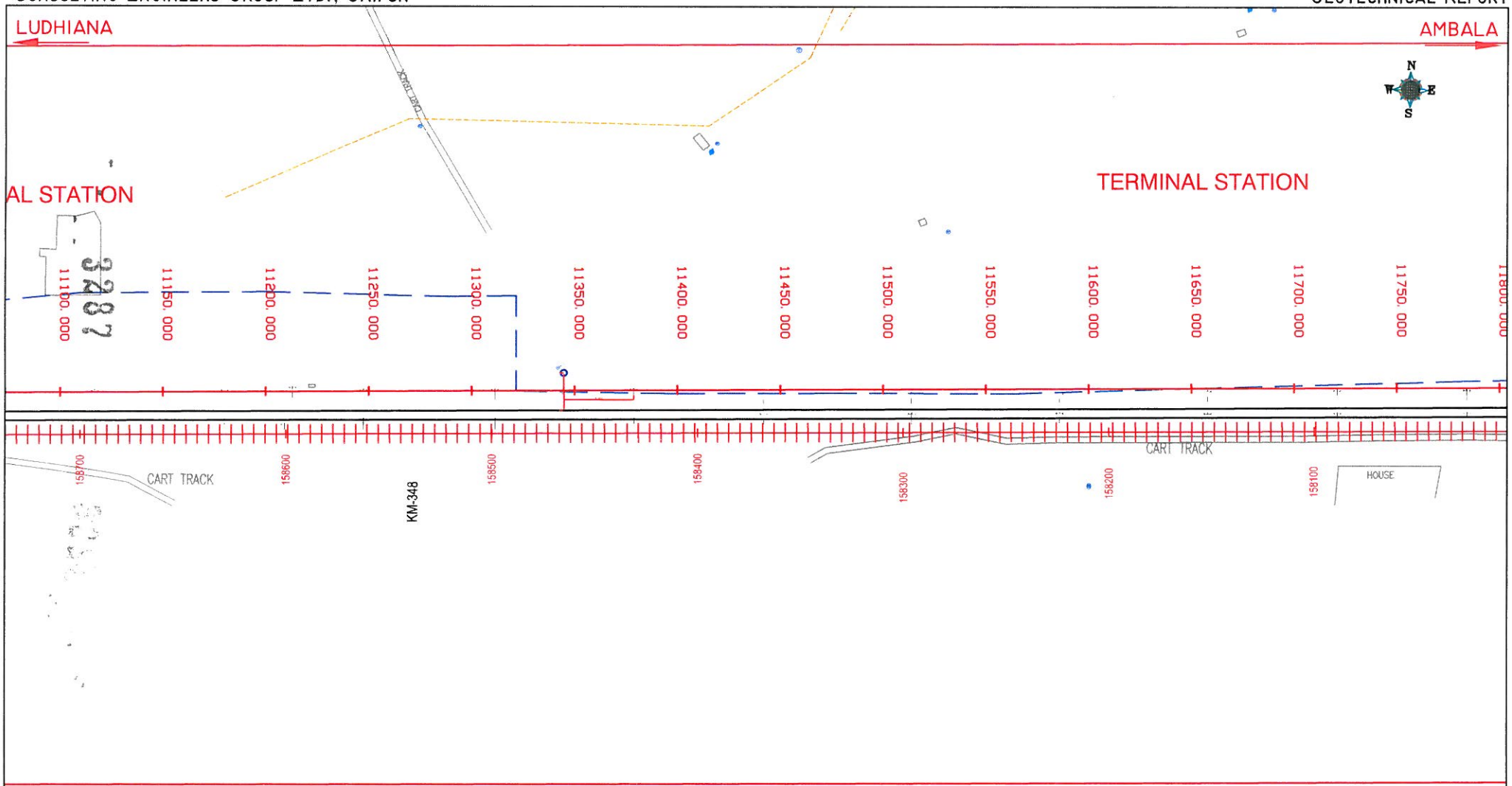
- Subsurface Profiles indicates suitable Soil formation for foundations.

3285

33.7 RECOMMENDATIONS

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

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



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 347/25-27	RL OF BH-I = 259.574	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel. +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (LHS) OF ALIGNMENT AT CHAINAGE 347/25-27

Project :	Chainage 347/25-27			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				30.05.2009 to 30.05.2009	1	1 (LHS)	below 14.00 m.	12.00mtr	259.574	

Depth from GL (m)	Observed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel										c kg/cm^2	ϕ degree
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
0.00	-	-	-	Sandy Silt	3.26	76.68	11.38	5.26	1.23	2.19	0.00	24	NIL	NIL	-	-	-	-	-	-
1.50	11	1.52	16.72	Sandy Silt	2.97	83.22	8.02	1.04	1.88	2.87	0.00	25	NIL	NIL	-	-	-	-	-	-
3.00	17	1.25	21.25	Sandy Silt	3.18	89.71	6.25	0.55	0.10	0.21	0.00	33	NIL	NIL	-	-	-	-	-	-
6.00	UDS	-	-	Sandy Silt with Gravels	4.10	37.22	30.33	3.94	2.08	22.33	0.00	29	NIL	NIL	1.60	3.29	1.55	2.59	0.00	26.00
9.00	19	0.88	16.72	Silty Sand	2.13	30.57	50.22	4.67	8.29	4.12	0.00	22	NIL	NIL	-	-	-	-		-
12.00	27	0.78	18.03	Silty Sand	2.33	10.27	84.25	3.15	0.00	0.00	0.00	23	NIL	NIL	-	-	-	-	-	-

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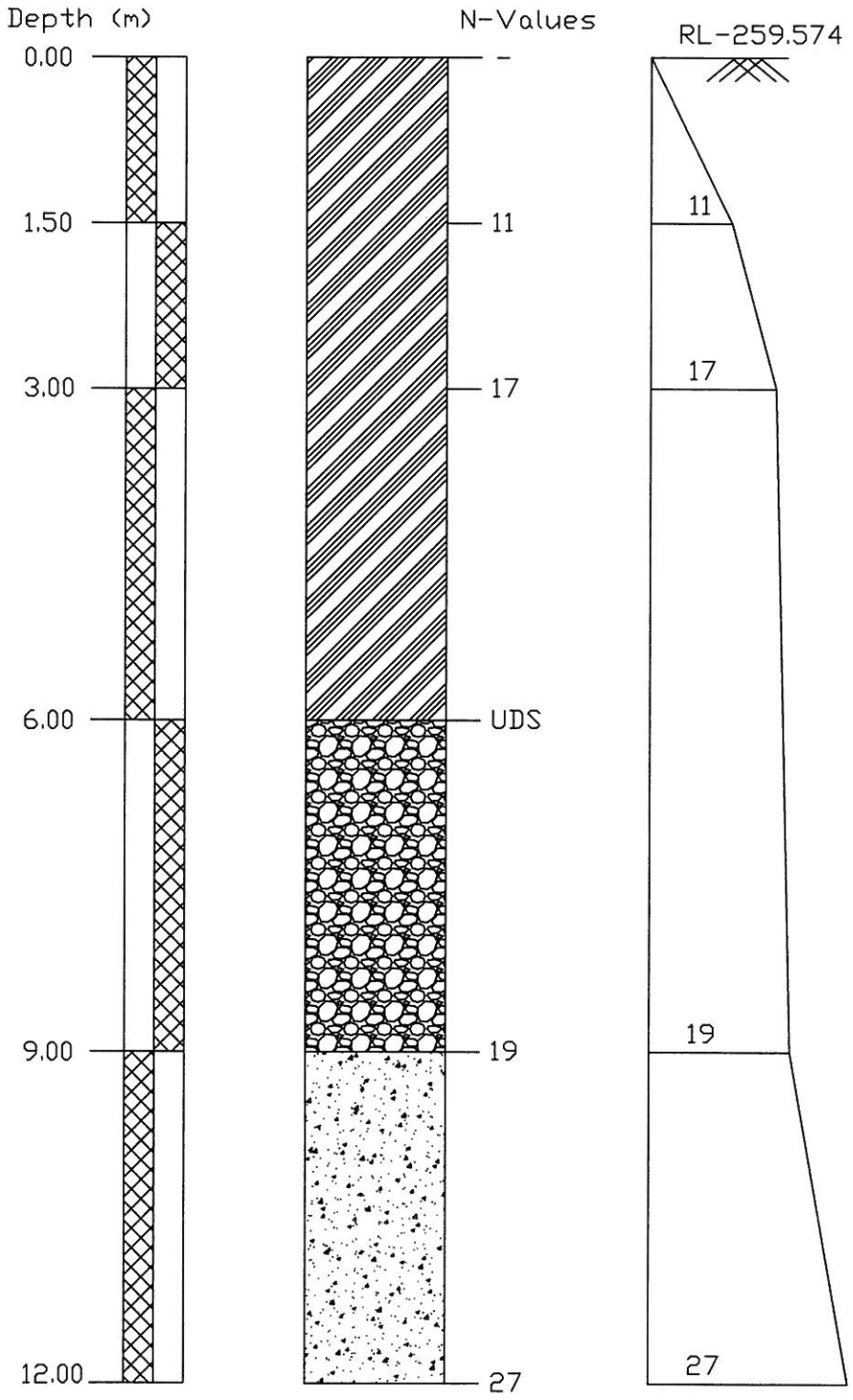
BORELOG OF BH–1(LHS) AT EXISTING KM–347/25–27 FOR ALIGNMENT ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT
	SANDY SILT WITH GRAVELS
	SILTY SAND

3289

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ANNEXURE - III

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

INPUT DATA

Alignment at Ch 347/25-27 BH-1

Type of footing

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

Angle of internal friction (ϕ °)	26.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.67
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.60
Density of foundation soil (t/m^3)	1.60
Depth of water table(m)	1.50
Factor of safety	3.00

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

3290

CONSULTING Engineers Group Ltd.

ANNEXURE - III

Bearing capacity factors :

ϕ	26.00
N_c	22.60
N_q	12.21
N_γ	13.18

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.16	1.08	1.08
2	3.00	3.00	1.32	1.16	1.16
3	4.50	3.00	1.48	1.24	1.24
4	6.00	3.00	1.64	1.32	1.32

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	15.25	5.74	9.55
2	3.00	3.00	8.00	27.56	10.62	17.40
3	4.50	3.00	8.00	29.46	11.35	18.60
4	6.00	3.00	8.00	31.37	12.09	19.80

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	347/25-27
Bore Hole No.	1

Footing Depth (m)	**1.50**
SBC (t/m2)	9.50
Average N value	18
Settlement for 10 t/m2 (mm)	17.00
Settlement (mm) for SBC	16.15
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**11.8**

Footing Depth (m)	**3.00**
SBC (t/m2)	17.00
Average N value	19
Settlement for 10 t/m2 (mm)	16.00
Settlement (mm) for SBC	27.20
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**18.1**

Footing Depth (m)	**4.50**
SBC (t/m2)	18.00
Average N value	18
Settlement for 10 t/m2 (mm)	18.00
Settlement (mm) for SBC	32.40
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**19.2**

Footing Depth (m)	**6.00**
SBC (t/m2)	20.00
Average N value	16
Settlement for 10 t/m2 (mm)	20.00
Settlement (mm) for SBC	40.00
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**21.8**

3292

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Engineers Group Ltd.

CHAPTER – 34

"Alignment",

Location – Existing Km. – 346/1

34.1 LOCATION OF STRUCTURE:

Alignment at existing km 346/1

34.2 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 ≥16.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.50	Silty Sand	Loose
	1.50 to 9.00	Silty Sand	Medium Dense
	9.00 to 12.00	Silty Sand	Dense

34.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate %	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	9.00	0.012	0.0014	NIL	0.0012	0.030

34.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

34.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	9.00
	3.00	16.00
	4.50	17.50
	6.00	19.00

34.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

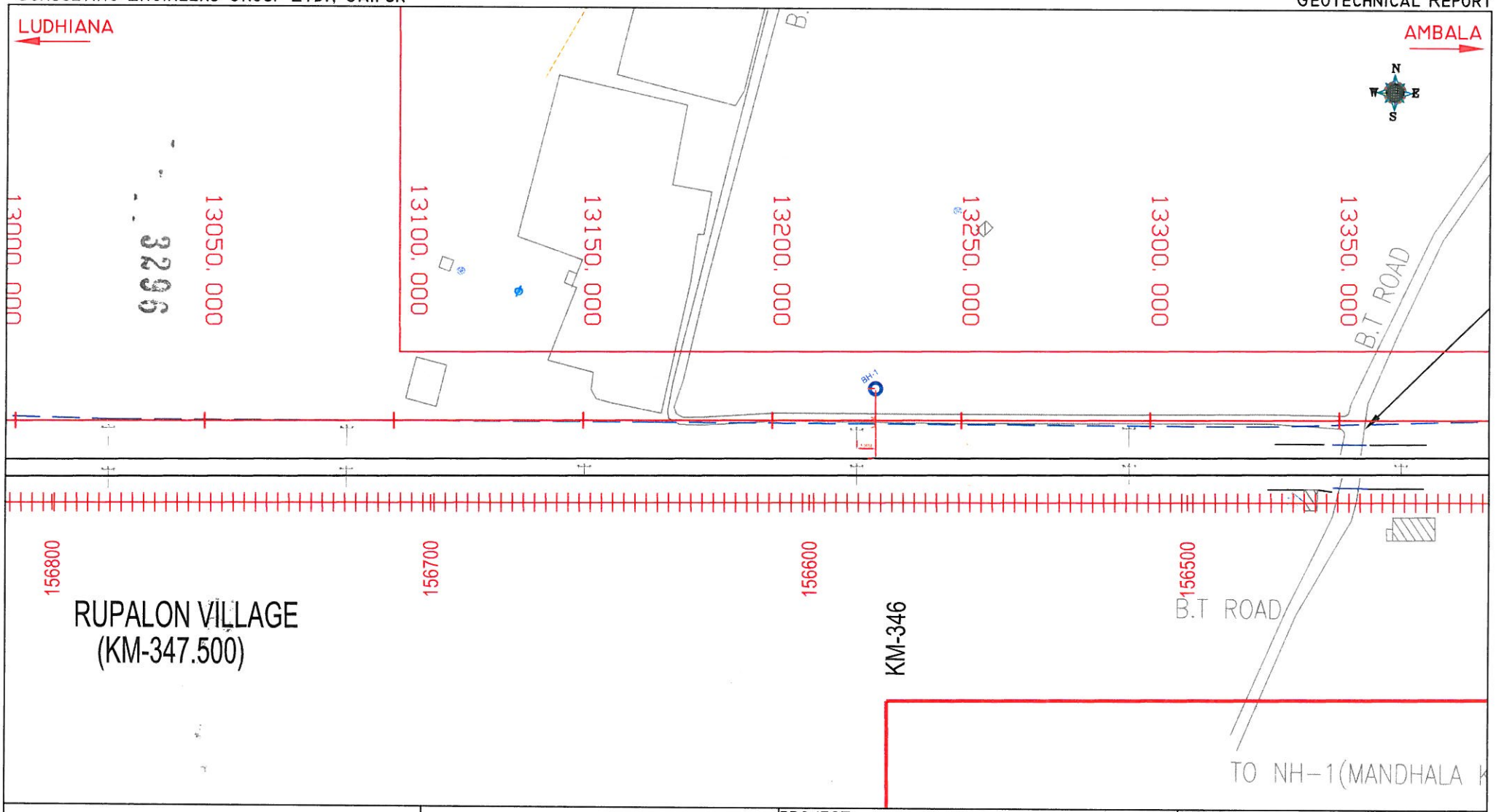
3294

34.7 RECOMMENDATIONS

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

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

3295



ALL DIMENSIONS IN METER

FIG.:-I

LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 346/1

RL OF BH-I = 261.885

PROJECT :-

LUDHIANA-AMBALA (DFCCIL)

DESIGN :-

CONSULTING ENGINEERS GROUP LTD.
E-12,Moji Colony,Malviya Nagar Jaipur-17
Tel. +91-141- 2520899, 2521899, 2520556
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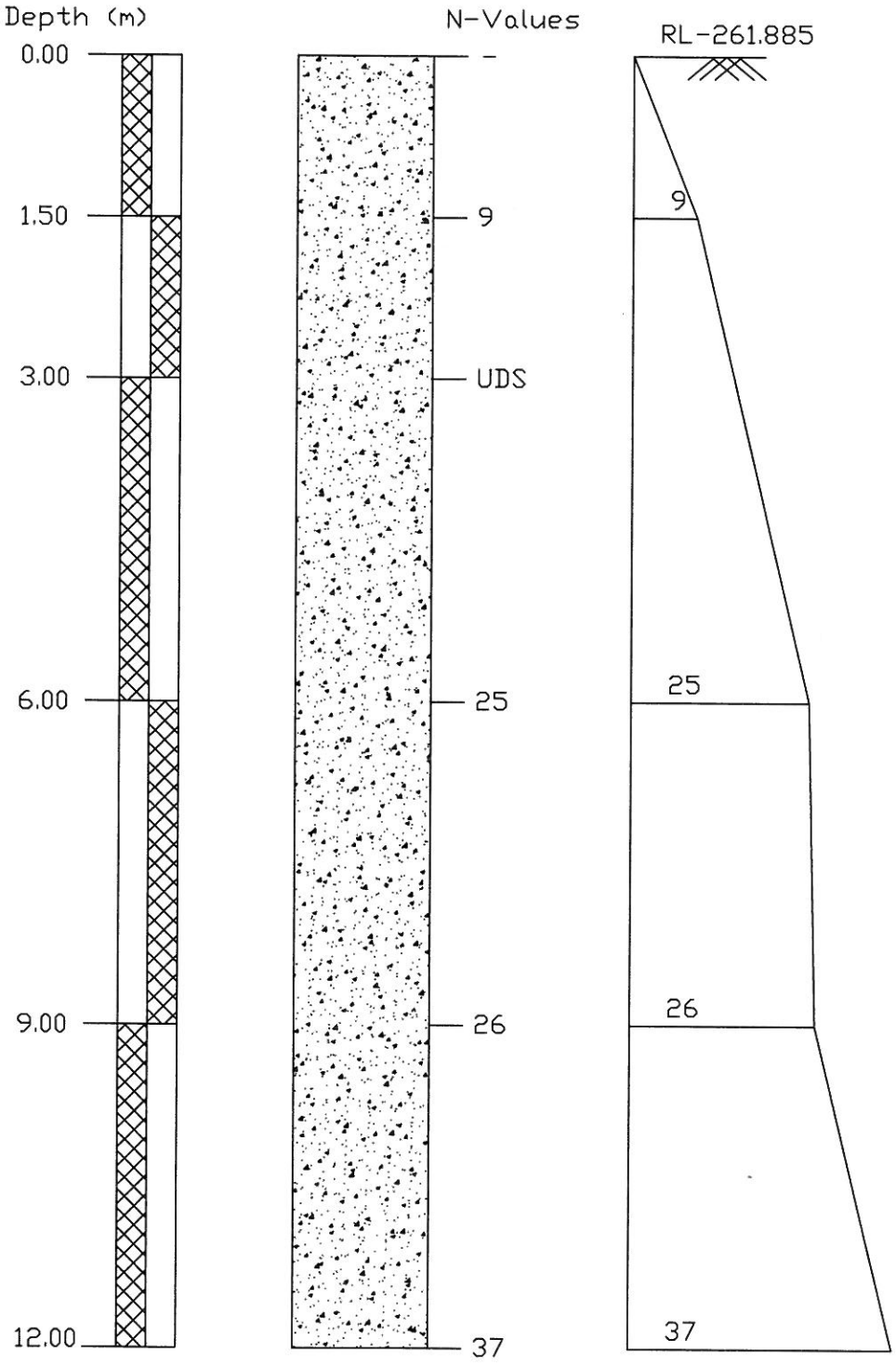
SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (LHS) OF ALIGNMENT AT CHAINAGE 346/1

Project :	Chainage 346/1			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				31.05.2009 to 31.05.2009	1	1 (LHS)	below 16.00 m.	12.00mtr	261.885	

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	1.46	22.21	60.36	12.36	0.94	2.67	0.00	22	NIL	NP	-	-	-	-	-	-
1.50	9	1.46	13.14	Silty Sand	1.37	21.41	73.86	2.53	0.83	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	3.67	7.77	76.46	4.97	2.19	4.94	0.00	29	NIL	NP	1.69	9.76	1.54	2.60	0.00	26.00
6.00	25	1.00	25.00	Silty Sand	2.48	7.43	81.92	2.74	1.06	4.37	0.00	27	NIL	NP	-	-	-	-	-	-
9.00	26	0.86	22.36	Silty Sand	2.59	6.12	83.62	4.64	0.50	2.53	0.00	25	NIL	NP	-	-	-	-		-
12.00	37	0.77	21.75	Silty Sand	2.21	8.31	84.23	4.58	0.58	0.09	0.00	25	NIL	NP	-	-	-	-	-	-

CONSULTING Engineers Group Ltd.

BORELOG OF BH–1(LHS) AT EXISTING KM–346/1 FOR ALIGNMENT ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SILTY SAND

3298

CONSULTING Engineers Group Ltd.

ANNEXURE - III

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

INPUT DATA

Alignment at Ch 346/1 BH-1

Type of footing

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

Angle of internal friction (ϕ°)	26.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.69
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.69
Density of foundation soil (t/m^3)	1.69
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.00
N_c	22.60
N_q	12.21
N_γ	13.18

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.16	1.08	1.08
2	3.00	3.00	1.32	1.16	1.16
3	4.50	3.00	1.48	1.24	1.24
4	6.00	3.00	1.64	1.32	1.32

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	16.11	6.06	9.08
2	3.00	3.00	8.00	29.11	11.22	16.59
3	4.50	3.00	8.00	31.12	11.99	17.73
4	6.00	3.00	8.00	33.13	12.77	18.87

3300

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	346/1
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	9.00
Average N value	17
Settlement for 10 t/m2 (mm)	18.00
Settlement (mm) for SBC	16.20
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	11.8

Footing Depth (m)	3.00
SBC (t/m2)	16.00
Average N value	21
Settlement for 10 t/m2 (mm)	15.00
Settlement (mm) for SBC	24.00
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	15.9

Footing Depth (m)	4.50
SBC (t/m2)	17.50
Average N value	21
Settlement for 10 t/m2 (mm)	14.40
Settlement (mm) for SBC	25.20
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	14.9

Footing Depth (m)	6.00
SBC (t/m2)	19.00
Average N value	22
Settlement for 10 t/m2 (mm)	14.00
Settlement (mm) for SBC	26.60
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	14.5

3301

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CHAPTER – 35

"Alignment",

Location – Existing Km. – 344/1

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35.1 LOCATION OF STRUCTURE:

Alignment at existing km 344/1.

35.2 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 ≥30.00m 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 9.00	Silty Sand	Medium Dense
	9.00 to 12.00	Silty Sand	Dense
	Below 12.00	Sandy Silt with Clay	Dense

35.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate %	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.50	0.009	0.0018	NIL	0.0010	0.021

35.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

35.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	13.00
	3.00	17.50
	4.50	27.00
	6.00	33.00

35.7 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

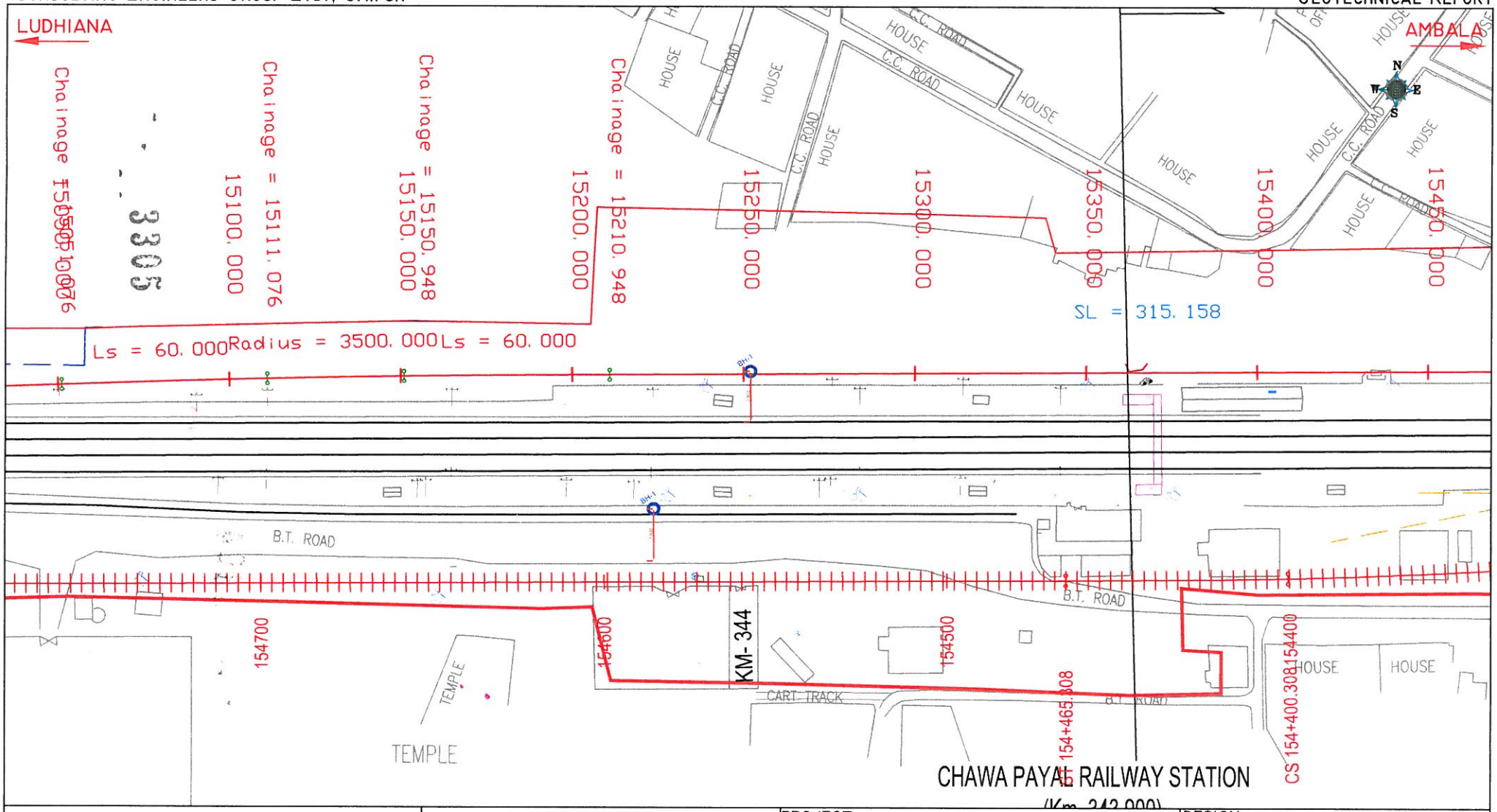
3303

35.8 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 2.00 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.

3304



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 344/1	RL OF BH-I = 262.602	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (LHS) OF ALIGNMENT AT CHAINAGE 344/1

Project :	Chainage 344/1			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				31.05.2009 to 31.05.2009	1	1 (LHS)	below 30.00 m.	12.00mtr	262.602	

Depth from GL (m)	Observ-ed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel										c kg/cm^2	ϕ degree
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
0.00	-	-	-	Silty Sand	3.18	5.95	79.61	9.35	1.23	0.68	0.00	26	NIL	NP	-	-	-	-	-	-
1.50	9	1.45	13.05	Silty Sand	3.10	8.02	84.48	3.49	0.00	0.91	0.00	27	NIL	NP	-	-	-	-	-	-
3.00	11	1.22	13.42	Silty Sand	1.82	5.16	84.86	7.90	0.26	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	2.97	6.73	77.91	10.39	2.00	0.00	0.00	25	NIL	NP	1.74	5.59	1.65	2.66	0.00	27.50
9.00	44	0.85	37.40	Silty Sand	2.15	8.67	82.64	6.23	0.31	0.00	0.00	25	NIL	NP	-	-	-	-		-
12.00	46	0.76	34.96	Sandy Silt with Clay	12.67	73.50	10.42	0.58	0.95	1.88	0.00	27	18	9	-	-	-	-	-	-

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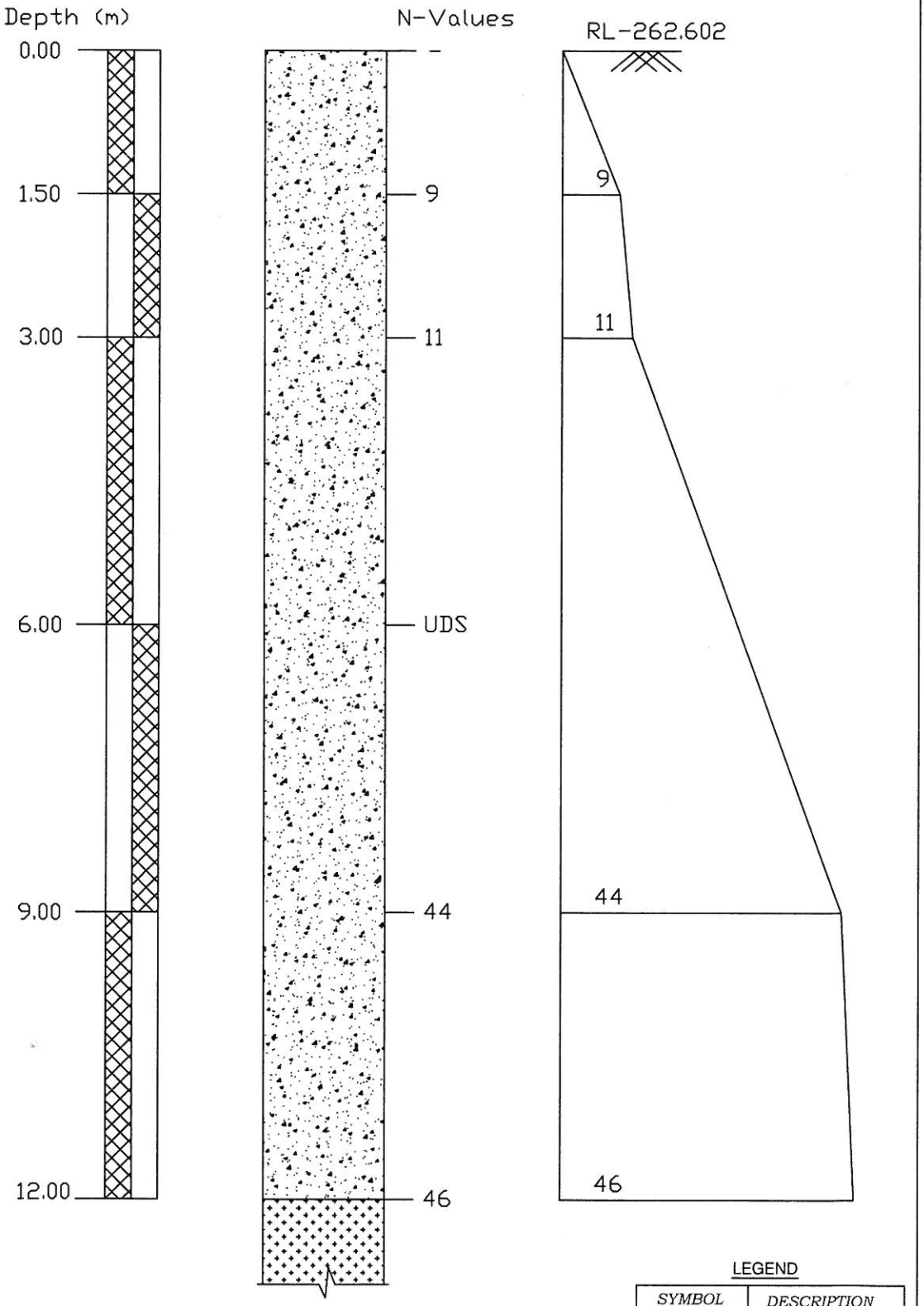
BORELOG OF BH–1(LHS) AT EXISTING KM–344/1 FOR ALIGNMENT ON KESARI TO SANEHWAL, LUDHIANA



3307

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ANNEXURE - III

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

INPUT DATA

Alignment at Ch 344/1 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)	0.61
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.74
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	27.50
N_c	25.43
N_q	14.53
N_γ	16.64

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.16	1.08	1.08
2	3.00	3.00	1.33	1.16	1.16
3	4.50	3.00	1.49	1.25	1.25
4	6.00	3.00	1.66	1.33	1.33

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	20.04	6.95	16.11
2	3.00	3.00	8.00	35.97	12.83	29.02
3	4.50	3.00	8.00	38.51	13.73	31.08
4	6.00	3.00	8.00	41.06	14.64	33.13

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	344/1
Bore Hole No.	1

Footing Depth (m)	**1.50**
SBC (t/m2)	13.00
Average N value	15
Settlement for 10 t/m2 (mm)	21.00
Settlement (mm) for SBC	27.30
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**19.9**

Footing Depth (m)	**3.00**
SBC (t/m2)	17.50
Average N value	15
Settlement for 10 t/m2 (mm)	21.00
Settlement (mm) for SBC	36.75
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**24.4**

Footing Depth (m)	**4.50**
SBC (t/m2)	27.00
Average N value	19
Settlement for 10 t/m2 (mm)	15.00
Settlement (mm) for SBC	40.50
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**24.0**

Footing Depth (m)	**6.00**
SBC (t/m2)	33.00
Average N value	25
Settlement for 10 t/m2 (mm)	12.00
Settlement (mm) for SBC	39.60
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**21.5**

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CHAPTER – 36

"Alignment",

Location – Existing Km. – 343/1

36.1 LOCATION OF STRUCTURE:

Alignment at existing km 343/1.

36.2 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 ≥30.00m below EGL.

Subsurface profile at the site

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

36.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate %	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.70	0.003	0.0019	NIL	0.0012	0.013

36.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

36.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	12.50
	3.00	17.00
	4.50	18.50
	6.00	20.00

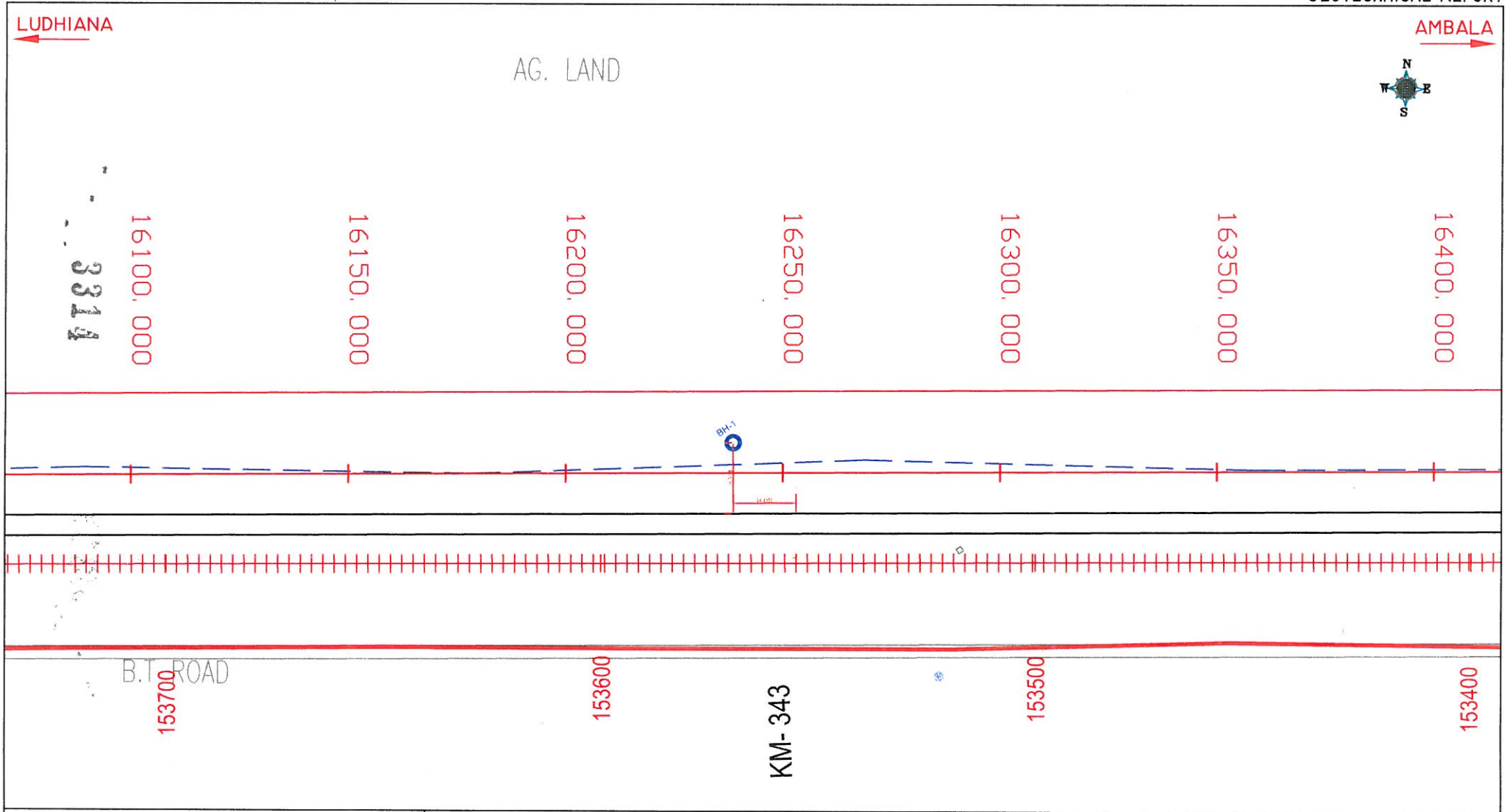
36.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

36.7 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 2.00m 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 AT CH. 343/1	RL OF BH-I = 260.094	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel. +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (LHS) OF ALIGNMENT AT CHAINAGE 343/1

Project :	Chainage 343/1			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				31.05.2009 to 31.05.2009	1	1 (LHS)	30.00 m.	below 12.00mtr	260.094	

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	10.63	64.44	12.39	6.39	4.16	1.38	0.61	27	19	8	-	-	-	-	-	-
1.50	9	1.45	13.05	Sandy Silt with Clay & Gravels	8.62	50.98	14.58	2.21	5.66	17.95	0.00	26	18	8	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand with Gravels	1.95	12.55	48.20	1.69	1.25	26.25	8.11	24	NIL	NP	1.75	5.30	1.66	2.64	0.00	27.00
6.00	17	0.99	16.83	Sandy Silt with Gravels	2.26	69.55	8.52	4.11	3.37	12.19	0.00	28	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Sandy Silt with Gravels	3.20	72.02	12.62	3.26	1.62	6.34	0.94	26	NIL	NP	1.79	6.21	1.68	2.66	0.00	28.00
12.00	27	0.75	20.25	Sandy Silt with Gravels	1.65	70.87	10.97	4.26	3.21	7.94	1.10	24	NIL	NP	-	-	-	-	-	-

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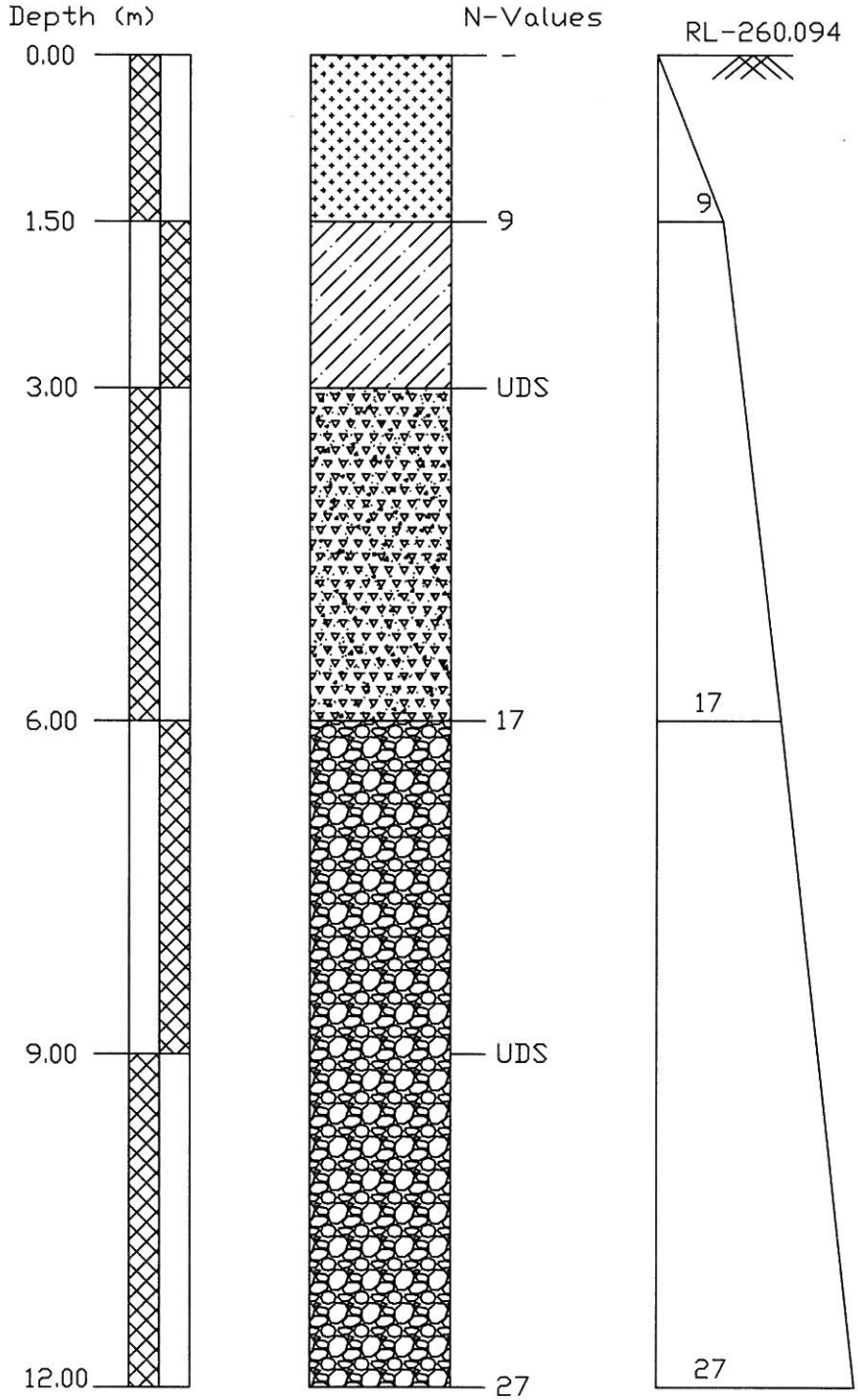
BORELOG OF BH–1(LHS) AT EXISTING KM–343/1 FOR ALIGNMENT

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

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ANNEXURE - III

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

INPUT DATA

		Alignment at Ch 343/1	BH-1
Type of footing			
1	Continuous Strip		
2	Rectangular	***Rectangular***	**2**
3	Square		
4	Circular		

Angle of internal friction (ϕ°)	27.00
Conesion (c in t/m2)	0.00
Void ratio (e)	0.59
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.75
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	27.00
N_c	24.49
N_q	13.76
N_γ	15.49

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

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	18.84	6.69	16.41
2	3.00	3.00	8.00	33.82	12.33	29.52
3	4.50	3.00	8.00	36.19	13.20	31.59
4	6.00	3.00	8.00	38.56	14.06	33.66

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	343/1
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	12.50
Average N value	14
Settlement for 10 t/m2 (mm)	23.00
Settlement (mm) for SBC	28.75
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	20.9

Footing Depth (m)	3.00
SBC (t/m2)	17.00
Average N value	15
Settlement for 10 t/m2 (mm)	21.00
Settlement (mm) for SBC	35.70
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	23.7

Footing Depth (m)	4.50
SBC (t/m2)	18.50
Average N value	16
Settlement for 10 t/m2 (mm)	19.00
Settlement (mm) for SBC	35.15
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	20.8

Footing Depth (m)	6.00
SBC (t/m2)	20.00
Average N value	17
Settlement for 10 t/m2 (mm)	18.00
Settlement (mm) for SBC	36.00
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	19.6

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CHAPTER – 37

"Alignment",

Location – Existing Km. – 342/1

37.1 LOCATION OF STRUCTURE:

Alignment at existing km 342/1

37.2 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 ≥18.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.50	Sandy Silt	Loose
	1.50 to 2.00	Sandy Silt with Clay	Loose
	2.00 to 3.00	Silty Sand	Loose
	3.00 to 12.00	Silty Sand	Medium Dense

37.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate %	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	9.10	0.005	0.0012	NIL	0.0011	0.041

37.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

37.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	12.00
	3.00	17.50
	4.50	23.00
	6.00	24.00

37.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

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37.7 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below 2.00m from EGL

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

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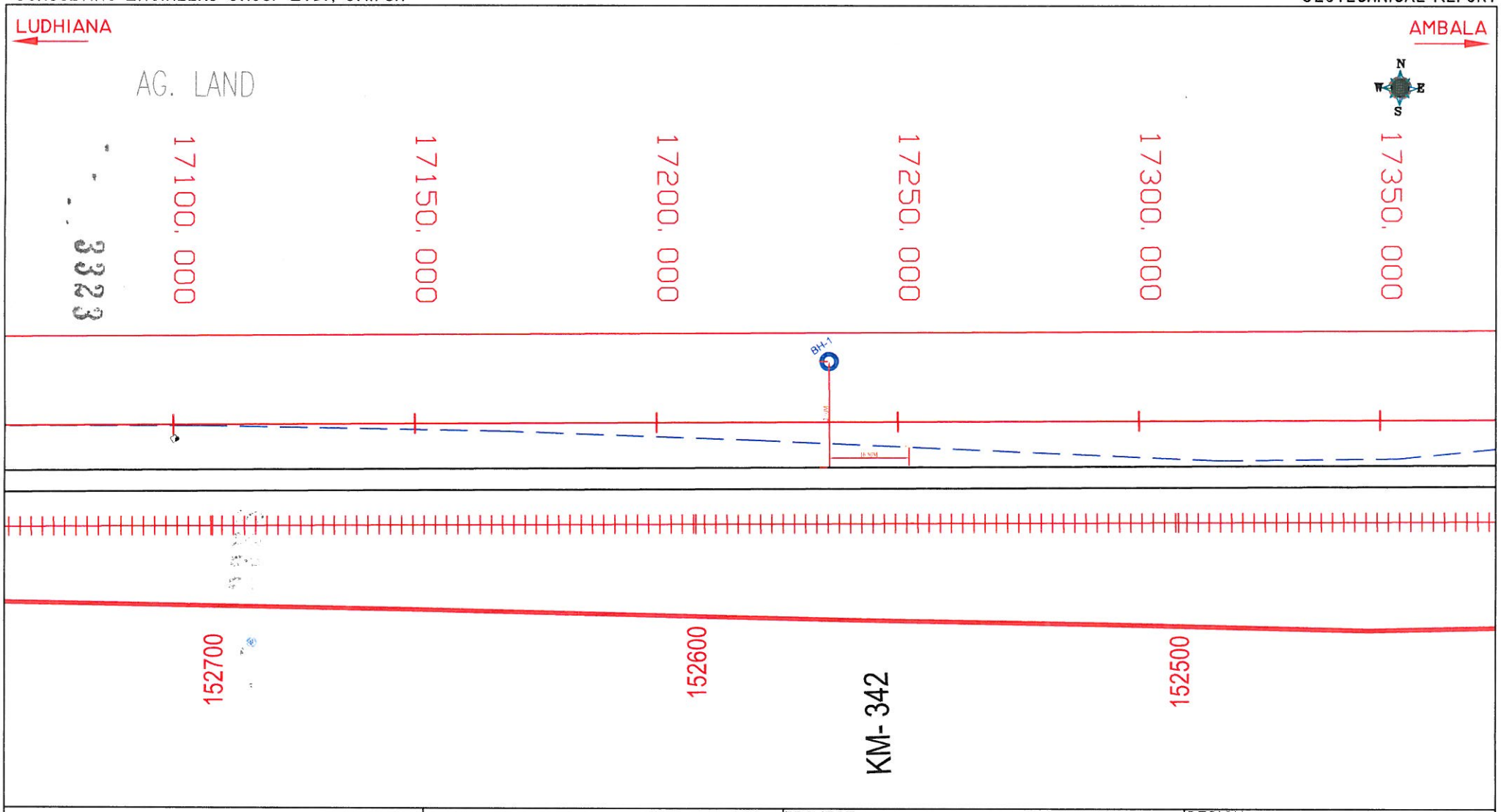

ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 342/1	RL OF BH-I = 260.329	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (LHS) OF ALIGNMENT AT CHAINAGE 342/1

Project :	Chainage 342/1			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				01.06.2009 to 01.06.2009	1	1 (LHS)	below 18.00 m.	12.00mtr	260.329	

Depth from	Observ-ed	Correction Factor	Corrected	Soil Description	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel									c kg/cm^2	ϕ
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
GL (m)	N	C_n	N_n	(Soil Group)											gm/cc	%	gm/cc		degree	
0.00	-	-	-	Sandy Silt	2.64	79.19	9.36	3.69	4.23	0.67	0.22	25	NIL	NP	-	-	-	-	-	-
1.50	7	1.46	10.22	Sandy Silt with Clay	5.07	49.63	42.10	2.00	0.40	0.80	0.00	25	19	6	-	-	-	-	-	-
2.00				Silty Sand	3.21	18.70	72.36	3.26	1.25	1.22	0.00	26	NIL	NP						
3.00	UDS	-	-	Silty Sand	2.16	12.06	80.33	2.69	2.10	0.66	0.00	23	NIL	NP	1.67	5.26	1.59	2.65	0.00	27.50
6.00	25	1.00	25.00	Silty Sand	2.51	11.24	85.20	1.05	0.00	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand	2.10	8.20	87.33	1.69	0.68	0.00	0.00	22	NIL	NP	1.73	6.94	1.62	2.66	0.00	27.50
12.00	28	0.76	21.28	Silty Sand	1.68	11.88	86.10	0.34	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-

DFCCIL *KESARI TO SANEHWAL*

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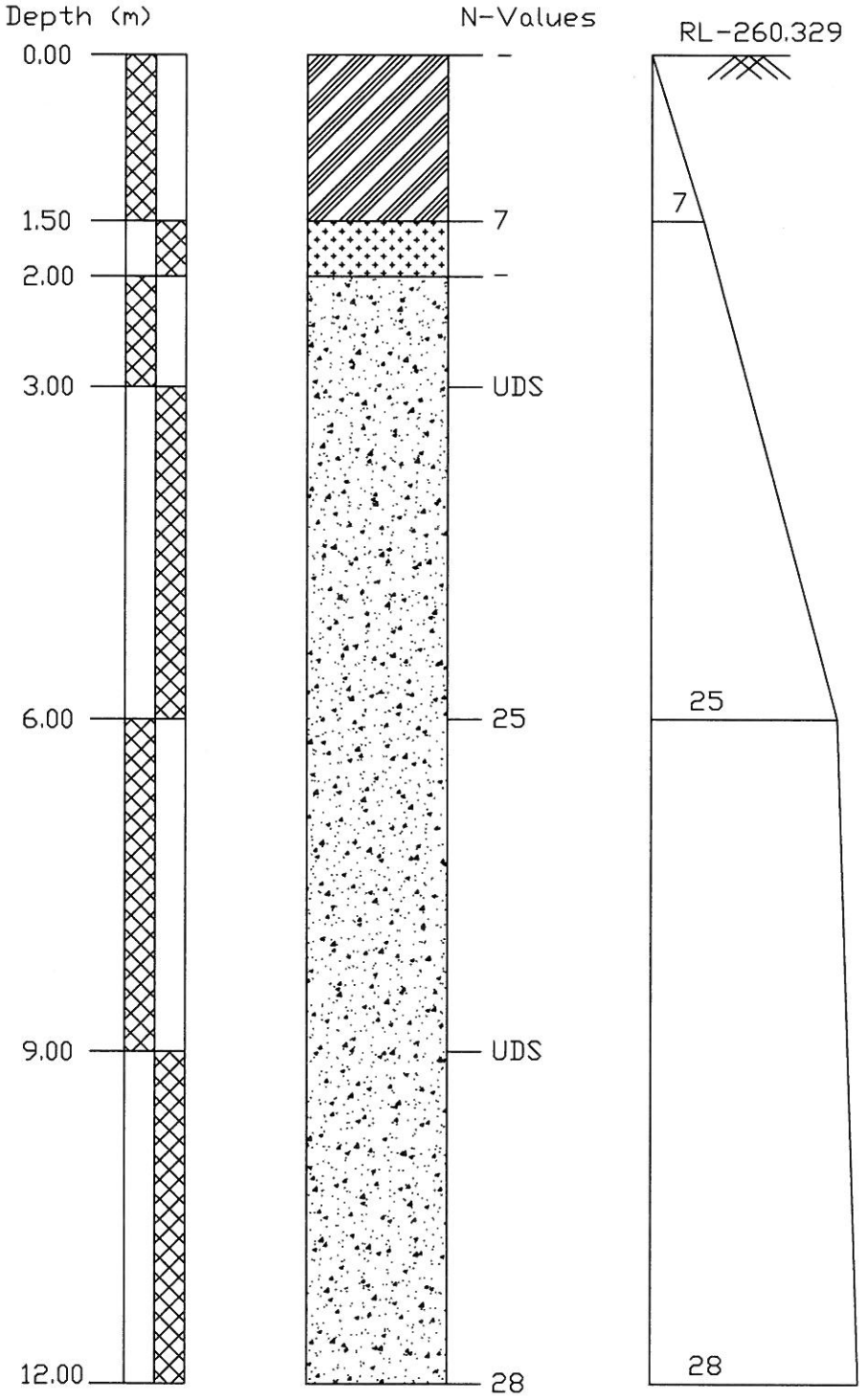
BORELOG OF BH–1(LHS) AT EXISTING KM–342/1 FOR ALIGNMENT ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT
	SILTY SAND
	SANDY SILT WITH CLAY

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ANNEXURE - III

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

INPUT DATA

Alignment at Ch 342/1 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)	0.67
Direction of load with vertical ($^\circ$)	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
3	4.50	3.00	8.00
4	6.00	3.00	8.00

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	27.50
N_c	25.43
N_q	14.53
N_γ	16.64

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.16	1.08	1.08
2	3.00	3.00	1.33	1.16	1.16
3	4.50	3.00	1.49	1.25	1.25
4	6.00	3.00	1.66	1.33	1.33

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	19.54	6.79	11.89
2	3.00	3.00	8.00	35.17	12.55	21.60
3	4.50	3.00	8.00	37.66	13.44	23.13
4	6.00	3.00	8.00	40.15	14.33	24.65

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	342/1
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	12.00
Average N value	15
Settlement for 10 t/m2 (mm)	21.00
Settlement (mm) for SBC	25.20
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	18.3

Footing Depth (m)	3.00
SBC (t/m2)	17.50
Average N value	15
Settlement for 10 t/m2 (mm)	21.00
Settlement (mm) for SBC	36.75
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	24.4

Footing Depth (m)	4.50
SBC (t/m2)	23.00
Average N value	22
Settlement for 10 t/m2 (mm)	13.00
Settlement (mm) for SBC	29.90
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	17.7

Footing Depth (m)	6.00
SBC (t/m2)	24.00
Average N value	22
Settlement for 10 t/m2 (mm)	13.00
Settlement (mm) for SBC	31.20
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	17.0

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CHAPTER – 38

"Alignment",

Location – Existing Km. – 339/1