38.1 LOCATION OF STRUCTURE:

Alignment at existing km 339/1.

38.2 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 3.00	Silty Sand	Loose
	3.00 to 12.00	Silty Sand	Medium Dense

38.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate %	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.60	0.002	0.0025	NIL	0.0011	0.0038

38.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

38.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	12.50
	3.00	20.00
	4.50	22.00
	6.00	23.00

38.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

38.7 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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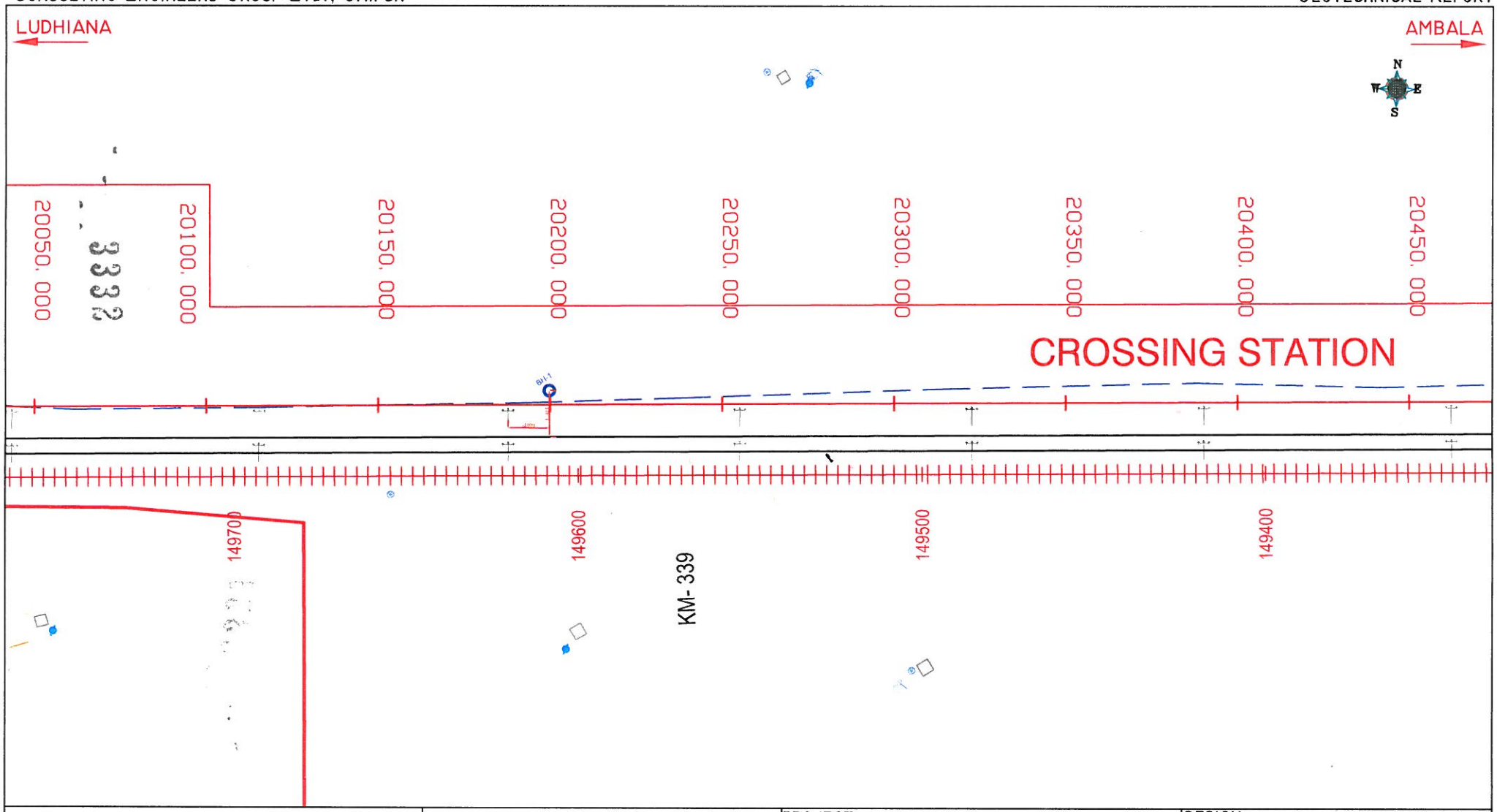

ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 339/1	RL OF BH-I = 260.453	PROJECT :- LUDHIANA-AMBALA (DFCCIL)	DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12,Moji Colony,Malviya Nagar Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegindia.com

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (LHS) OF ALIGNMENT AT CHAINAGE 339/1

Project :	Chainage 339/1			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	260.453	

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	2.10	72.69	19.63	4.22	1.36	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
1.50	5	1.46	7.30	Silty Sand	3.11	28.80	64.86	3.10	0.13	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	3.14	10.19	84.34	2.33	0.00	0.00	0.00	26	NIL	NP	1.69	6.21	1.59	2.66	0.00	26.00
6.00	28	1.00	28.00	Silty Sand	0.00	6.99	87.26	5.24	0.51	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand	3.28	9.26	85.26	1.26	0.94	0.00	0.00	23	NIL	NP	1.75	7.10	1.63	2.67	0.00	27.50
12.00	31	0.76	23.56	Silty Sand	0.00	5.54	90.05	4.06	0.35	0.00	0.00	22	NIL	NP	-	-	-	-	-	-

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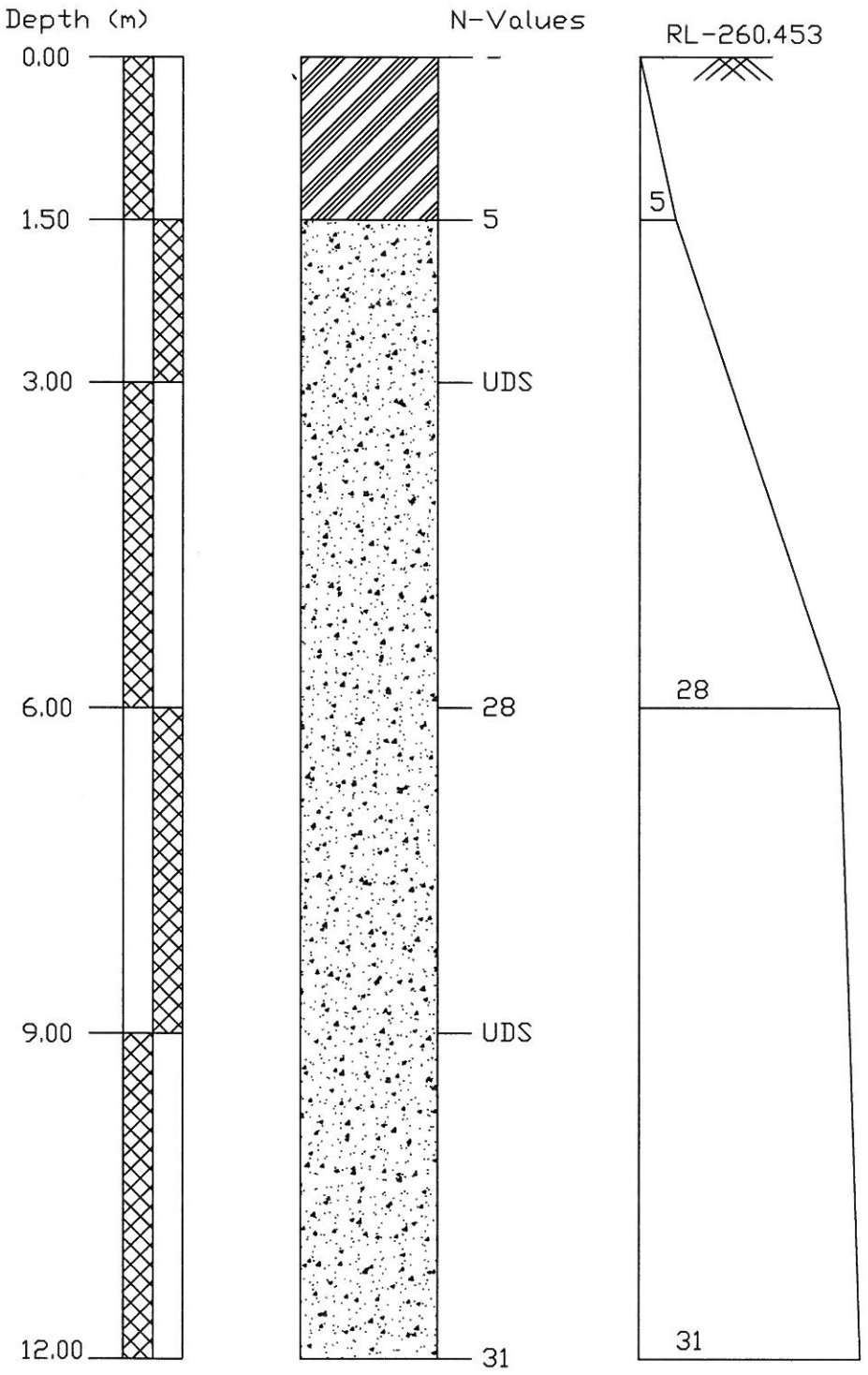
BORELOG OF BH–1(LHS) AT EXISTING KM–339/1 FOR ALIGNMENT

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 339/1 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)	0.57
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	15.10
2	3.00	3.00	8.00	29.11	11.22	27.32
3	4.50	3.00	8.00	31.12	11.99	29.21
4	6.00	3.00	8.00	33.13	12.77	31.09

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	339/1
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	12.50
Average N value	14
Settlement for 10 t/m2 (mm)	24.00
Settlement (mm) for SBC	30.00
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	21.8

Footing Depth (m)	3.00
SBC (t/m2)	20.00
Average N value	20
Settlement for 10 t/m2 (mm)	15.00
Settlement (mm) for SBC	30.00
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	19.9

Footing Depth (m)	4.50
SBC (t/m2)	22.00
Average N value	21
Settlement for 10 t/m2 (mm)	14.40
Settlement (mm) for SBC	31.68
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	18.8

Footing Depth (m)	6.00
SBC (t/m2)	23.00
Average N value	25
Settlement for 10 t/m2 (mm)	13.00
Settlement (mm) for SBC	29.90
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	16.3

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CHAPTER – 39

"Alignment",

3336

Location – Existing Km. – 337/1

39.1 LOCATION OF STRUCTURE:

Alignment at existing km 337/1.

39.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table ≥15.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 0.90	Sandy Silt	Loose
	0.90 to 1.50	Silty Sand	Loose
	1.50 to 3.00	Silty Sand with Clay	Loose
	3.00 to 12.00	Silty Sand	Medium Dense

39.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate %	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1	3.00	8.20	NIL	0.0018	NIL	0.0009	0.023

39.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

39.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	12.50
	3.00	21.00
	4.50	25.00
	6.00	26.00

39.6 CONCLUSIONS

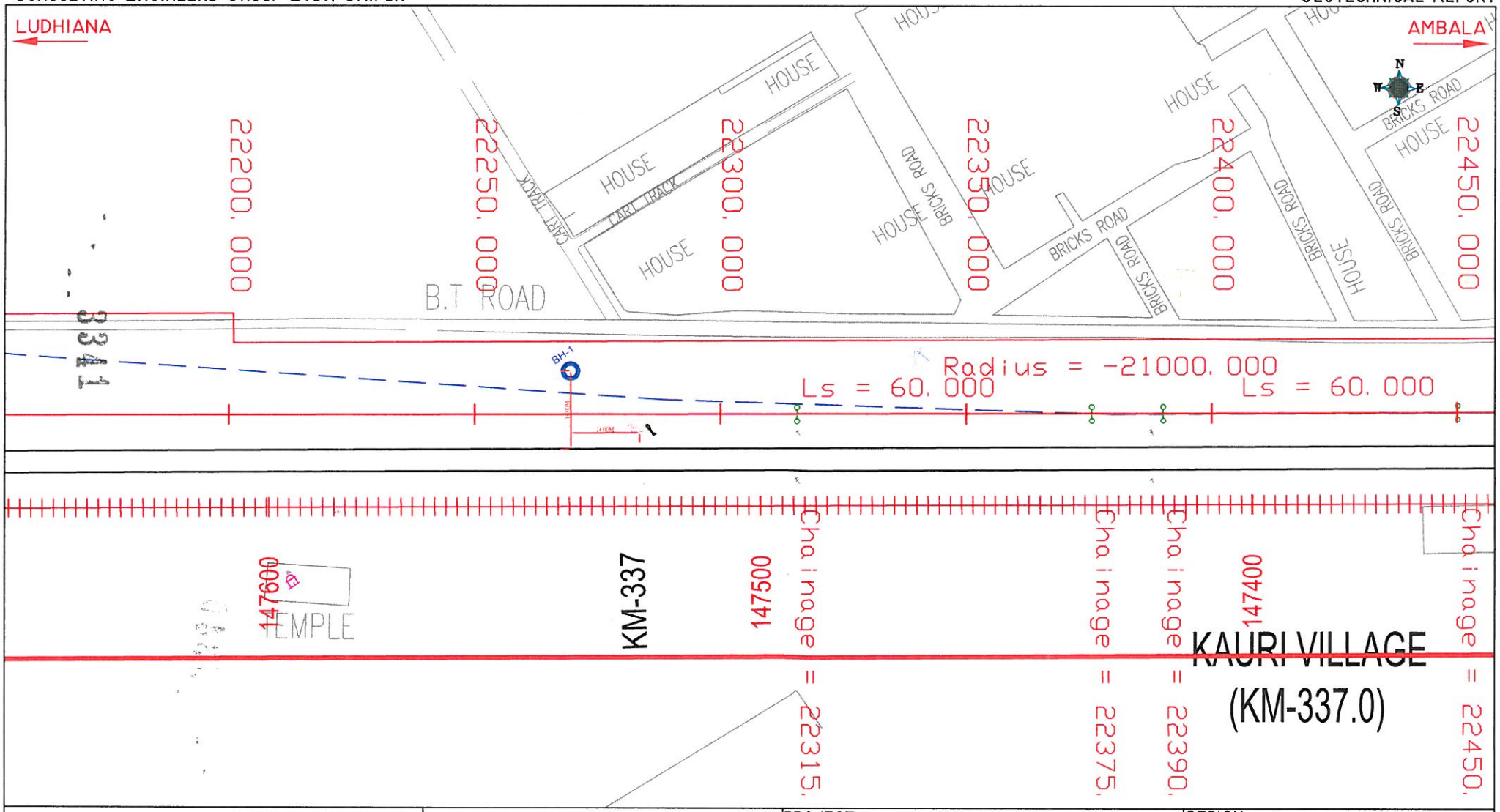
- Subsurface Profiles indicates suitable Soil formation for foundations.

39.7 RECOMMENDATIONS

(i)	*Type of foundation*	Open foundation
(ii)	*Depth of foundation below GL*	Below2.00m 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.

3340



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 337/1	RL OF BH-I = 261.344	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 337/1

Project :	Chainage 337/1 Near Kauri Rail Phatak			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				02.06.2009 to 02.06.2009	1	1 (LHS)	below 15.00 m.	12.00mtr	261.344	

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	1.86	64.27	29.38	2.64	1.21	0.64	0.00	23	NIL	NP	-	-	-	-	-	-
0.90				Silty Sand	2.22	32.42	60.28	3.14	1.94	0.00	0.00	21	NIL	NP						
1.50	6	1.45	8.70	Silty Sand with Clay	9.23	39.76	48.25	1.67	1.09	0.00	0.00	22	15	7	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	3.52	14.25	78.98	1.46	0.21	1.58	0.00	26	NIL	NP	1.77	5.29	1.68	2.66	0.00	28.00
6.00	26	0.98	25.48	Silty Sand	2.94	5.04	80.90	6.88	0.78	3.46	0.00	25	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand	2.91	18.96	70.92	4.59	1.67	0.95	0.00	26	NIL	NP	1.81	6.21	1.70	2.67	0.00	28.50
12.00	30	0.75	22.50	Silty Sand	2.16	5.39	90.32	2.13	0.00	0.00	0.00	29	NIL	NP	-	-	-	-	-	-

DFCCIL *KESARI TO SANEHWAL*

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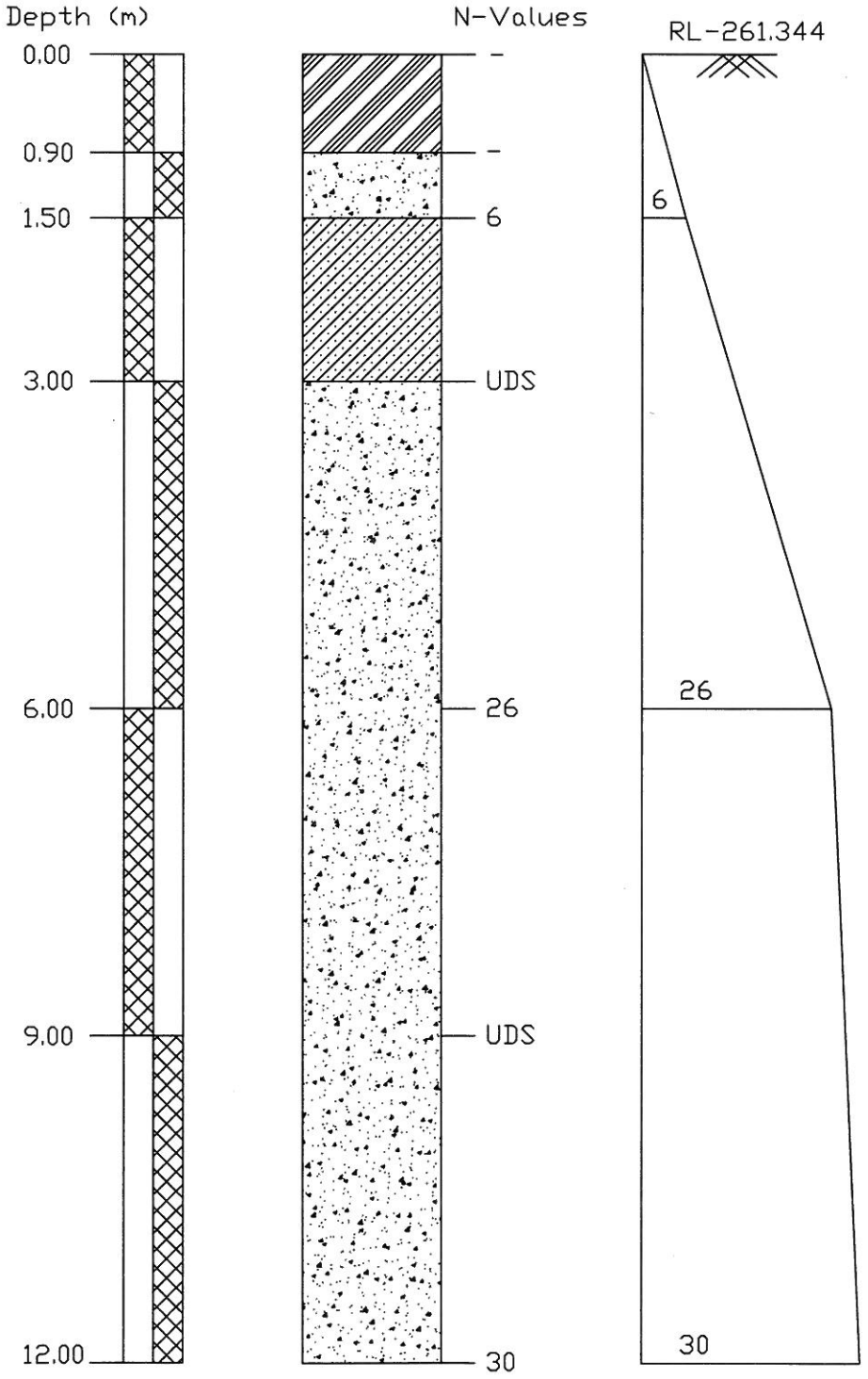
BORELOG OF BH–1(LHS) AT EXISTING KM–337/1 FOR ALIGNMENT

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT
	SILTY SAND
	SILTY SAND WITH CLAY

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ANNEXURE - III

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

INPUT DATA

Alignment at Ch 337/1 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)	0.58
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.77
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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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	21.41	7.26	19.29
2	3.00	3.00	8.00	38.30	13.37	34.56
3	4.50	3.00	8.00	41.03	14.32	37.02
4	6.00	3.00	8.00	43.76	15.28	39.49

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	337/1
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	12.50
Average N value	14
Settlement for 10 t/m2 (mm)	24.00
Settlement (mm) for SBC	30.00
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	21.8

Footing Depth (m)	3.00
SBC (t/m2)	21.00
Average N value	19
Settlement for 10 t/m2 (mm)	16.00
Settlement (mm) for SBC	33.60
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	22.3

Footing Depth (m)	4.50
SBC (t/m2)	25.00
Average N value	22
Settlement for 10 t/m2 (mm)	14.00
Settlement (mm) for SBC	35.00
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	20.7

Footing Depth (m)	6.00
SBC (t/m2)	26.00
Average N value	22
Settlement for 10 t/m2 (mm)	14.00
Settlement (mm) for SBC	36.40
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	19.8

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CHAPTER – 40

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"Alignment",

Location – Existing Km. – 331

40.1 LOCATION OF STRUCTURE:

Alignment at existing km 331

40.2 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 with Clay	Loose
	1.50 to 3.00	Silty Sand	Loose
	3.00 to 5.00	Silty Sand	Medium Dense
	5.00 to 6.00	Silty Sand with Gravels	Medium Dense
	6.00 to 12.00	Silty Sand	Medium Dense

40.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate	Salinity %
BH-1	5.00	8.90	0.019	0.0029	NIL	0.0013	0.022

40.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

40.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	12.00
	3.00	19.00
	4.50	21.00
	6.00	23.00

40.6 CONCLUSIONS

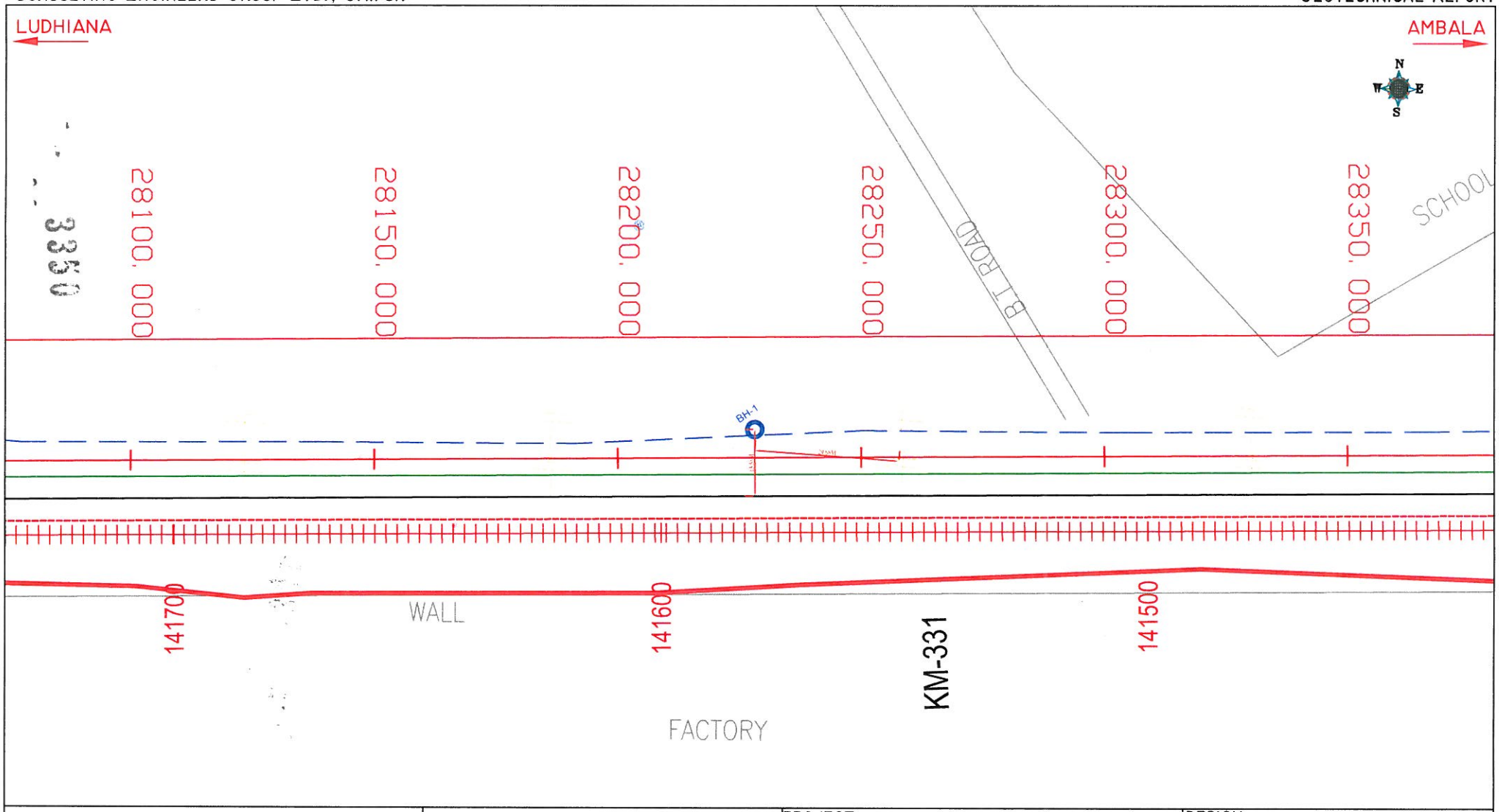
- Subsurface Profiles indicates suitable Soil formation for foundations.

40.7 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.

3349



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 331	RL OF BH-I = 263.48	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 331

Project :	Chainage 331			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				04.06.2009 to 04.06.2009	1	1 (LHS)	below 18.00 m.	12.00mtr	263.480	

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	9.26	51.39	30.36	6.23	0.43	2.33	0.00	32	25	7	-	-	-	-	-	-
1.50	9	1.46	13.14	Silty Sand	2.68	43.99	46.99	0.99	0.53	4.82	0.00	24	NIL	NP	-	-	-	-	-	-
3.00	14	1.23	17.22	Silty Sand	2.66	8.90	80.60	7.72	0.12	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
5.00	UDS	-	-	Silty Sand with Gravels	4.15	10.79	67.58	2.39	1.22	13.87	0.00	30	NIL	NP	1.70	5.49	1.61	2.65	0.00	27.00
6.00	23	1.00	23.00	Silty Sand	2.57	6.63	86.46	4.07	0.27	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
9.00	27	0.86	23.22	Silty Sand	3.11	6.50	85.89	4.19	0.31	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
12.00	12	0.76	9.12	Silty Sand	3.20	45.86	49.49	1.34	0.11	0.00	0.00	25	NIL	NP	-	-	-	-	-	-

DFCCIL *KESARI TO SANEHWAL*

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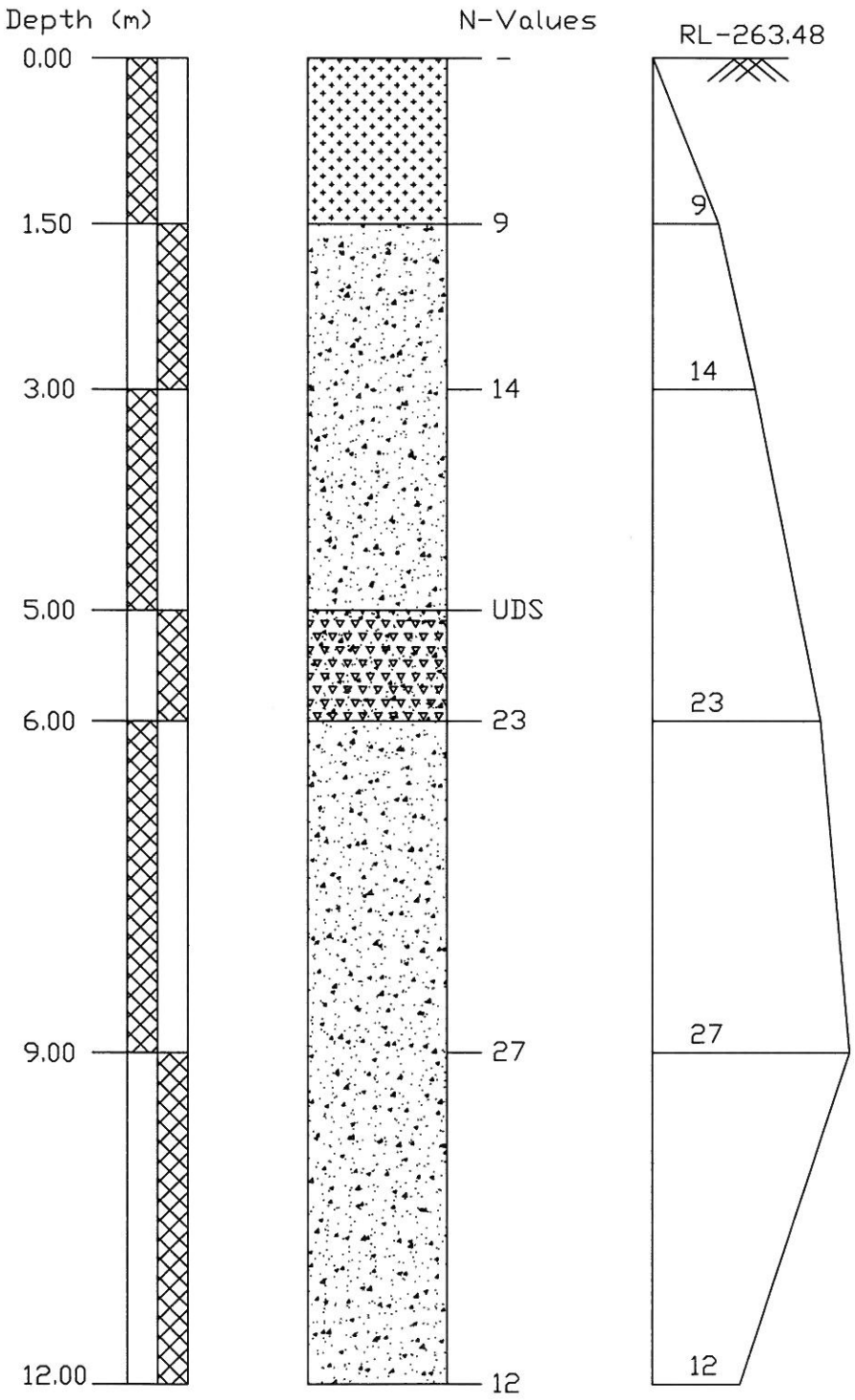
BORELOG OF BH–1(LHS) AT EXISTING KM–331 FOR ALIGNMENT

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

3352

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ANNEXURE - III

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

INPUT DATA

Alignment at Ch 331/1 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)	0.65
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.66
Density of foundation soil (t/m^3)	1.66
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	18.22	6.48	12.35
2	3.00	3.00	8.00	32.83	11.99	22.41
3	4.50	3.00	8.00	35.14	12.83	23.98
4	6.00	3.00	8.00	37.44	13.67	25.55

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	331/1
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	12.00
Average N value	17
Settlement for 10 t/m2 (mm)	18.00
Settlement (mm) for SBC	21.60
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	15.7

Footing Depth (m)	3.00
SBC (t/m2)	19.00
Average N value	20
Settlement for 10 t/m2 (mm)	16.00
Settlement (mm) for SBC	30.40
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	20.2

Footing Depth (m)	4.50
SBC (t/m2)	21.00
Average N value	20
Settlement for 10 t/m2 (mm)	15.00
Settlement (mm) for SBC	31.50
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	18.6

Footing Depth (m)	6.00
SBC (t/m2)	23.00
Average N value	23
Settlement for 10 t/m2 (mm)	13.20
Settlement (mm) for SBC	30.36
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	16.5

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CHAPTER – 41

"Alignment ",

Location – Existing Km. – 330

3356

41.1 LOCATION OF STRUCTURE:

Alignment at existing km 330.

41.2 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 ≥21.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.50	Sandy Silt	Loose
	1.50 to 3.00	Silty Sand	Loose
	3.00 to 5.00	Silty Sand	Medium Dense
	5.00 to 6.00	Silty Sand with Gravels	Medium Dense
	6.00 to 12.00	Silty Sand	Medium Dense

41.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate	Salinity %
BH-1	5.00	9.00	0.015	0.0018	NIL	0.0012	0.027

41.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

41.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	12.50
	3.00	18.00
	4.50	22.00
	6.00	24.00

41.6 CONCLUSIONS

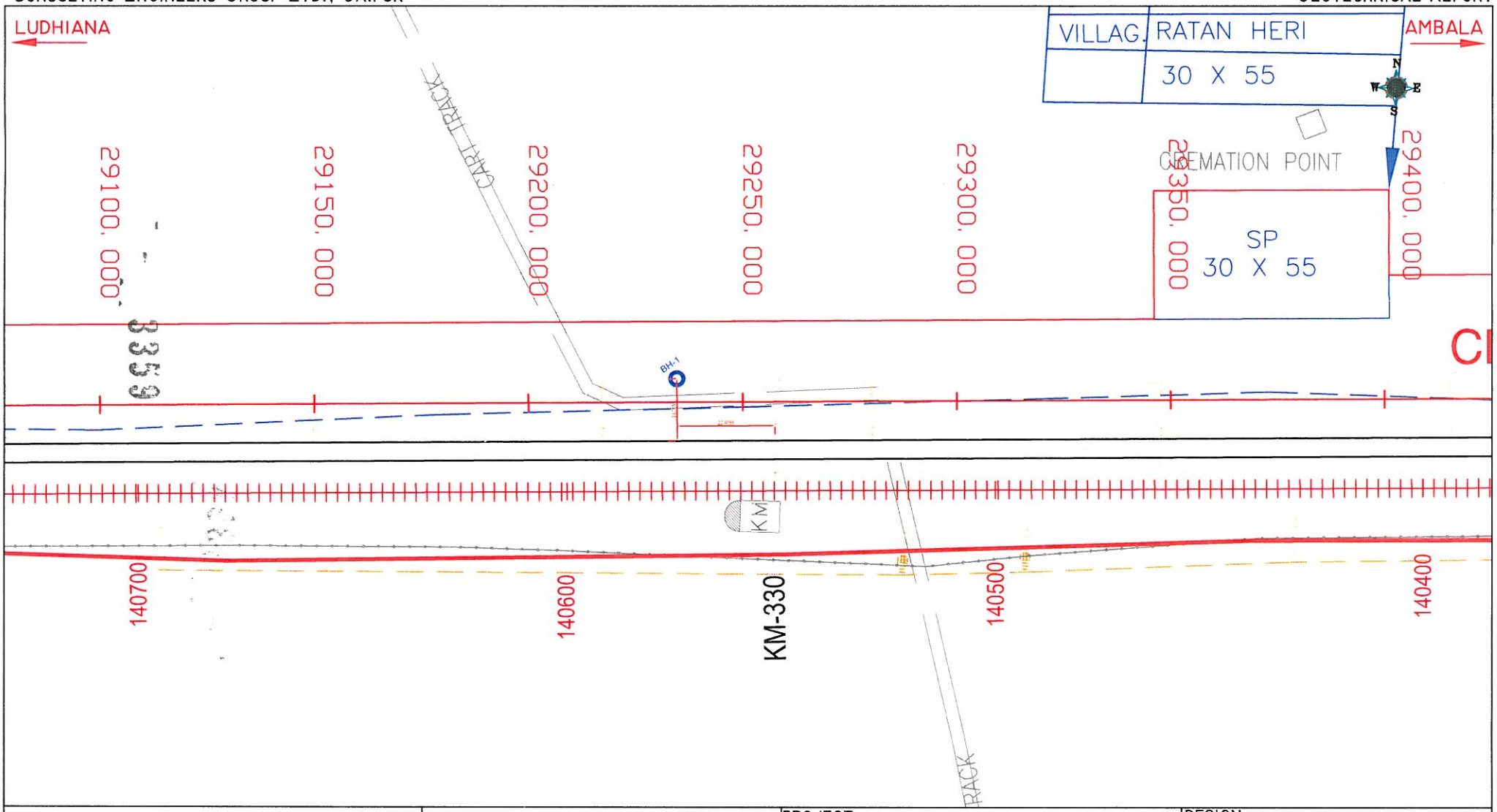
- Subsurface Profiles indicates suitable Soil formation for foundations.

41.7 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.

3358



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 330	RL OF BH-I = 264.882	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 330

Project :	Chainage 330			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				04.06.2009 to 04.06.2009	1	1 (LHS)	below 21.00 m.	12.00mtr	264.882	

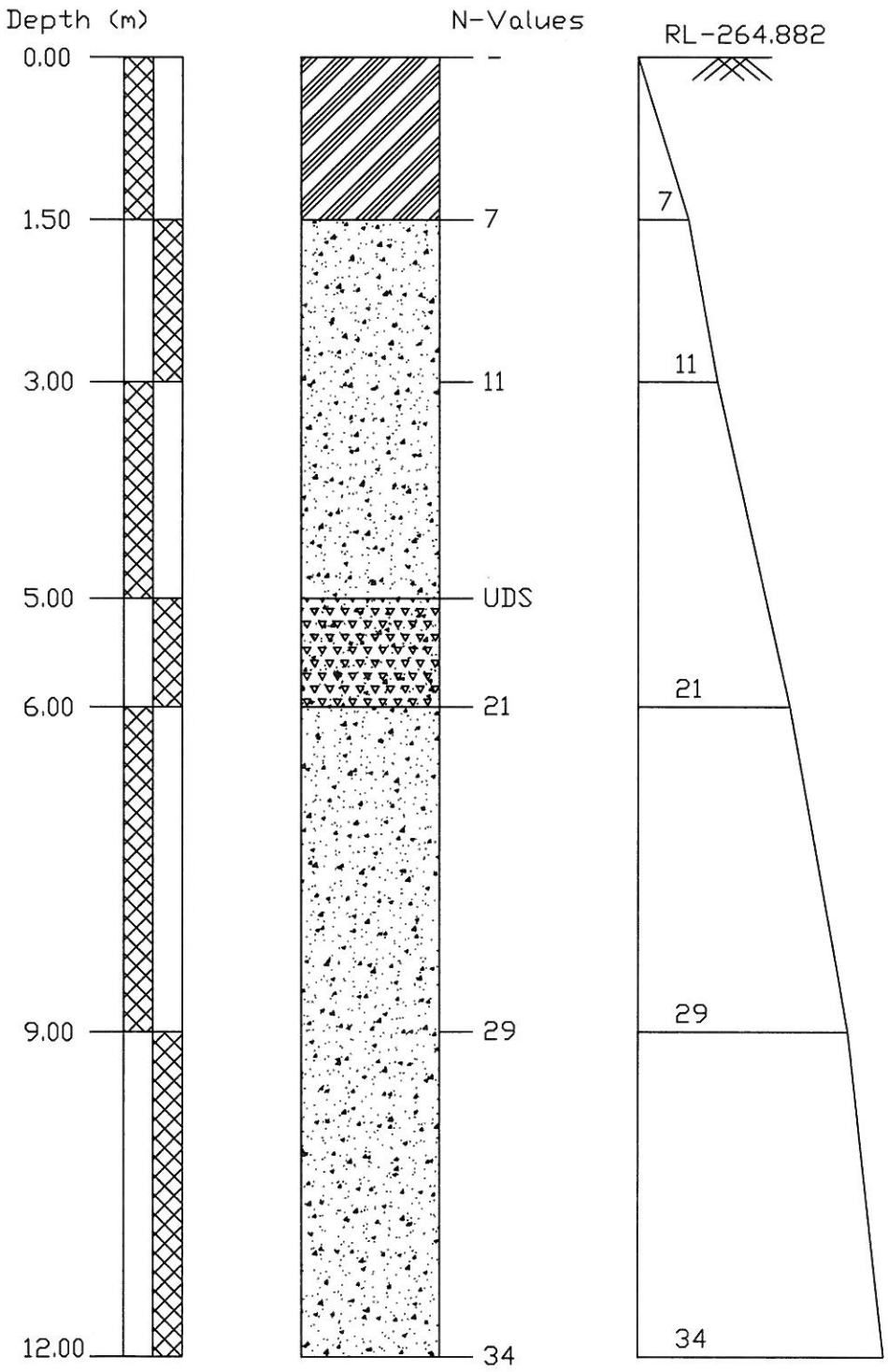
Depth from GL (m)	Observed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel										c kg/cm^2	ϕ degree
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
0.00	-	-	-	Sandy Silt	2.36	67.81	20.39	5.69	3.22	0.53	0.00	22	NIL	NP	-	-	-	-	-	-
1.50	7	1.45	10.15	Silty Sand	2.35	20.49	75.73	1.33	0.10	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
3.00	11	1.22	13.42	Silty Sand	2.11	8.66	85.90	2.70	0.41	0.22	0.00	25	NIL	NP	-	-	-	-	-	-
5.00	UDS	-	-	Silty Sand with Gravels	2.10	5.25	54.18	2.90	0.95	34.62	0.00	27	NIL	NP	1.76	3.26	1.70	2.63	0.00	30.00
6.00	21	0.98	20.58	Silty Sand	1.68	5.68	83.87	5.18	2.38	1.21	0.00	22	NIL	NP	-	-	-	-	-	-
9.00	29	0.85	24.65	Silty Sand	1.85	5.08	83.23	5.75	2.96	1.13	0.00	24	NIL	NP	-	-	-	-	-	-
12.00	34	0.75	25.50	Silty Sand	1.89	5.32	83.58	5.29	2.81	1.11	0.00	26	NIL	NP	-	-	-	-	-	-

DFCCIL *KESARI TO SANEHWAL*

CONSULTING Engineers Group Ltd.

BORELOG OF BH–1(LHS) AT EXISTING KM–330 FOR ALIGNMENT

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT
	SILTY SAND
	SILTY SAND WITH GRAVELS

3361

CONSULTING Engineers Group Ltd.

ANNEXURE - III

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

INPUT DATA

Alignment at Ch 330/1 BH-1

Type of footing

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

Angle of internal friction (ϕ°)	30.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.55
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.76
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	30.00
N_c	30.14
N_q	18.40
N_γ	22.40

ϕ'	21.15
N'_c	16.18
N'_q	7.38
N'_γ	6.65

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	1.09	1.09
2	3.00	3.00	1.35	1.17	1.17
3	4.50	3.00	1.52	1.26	1.26
4	6.00	3.00	1.69	1.35	1.35

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	26.38	9.04	26.38
2	3.00	3.00	8.00	47.13	16.59	47.13
3	4.50	3.00	8.00	50.61	17.82	50.61
4	6.00	3.00	8.00	54.09	19.04	54.09

CONSULTING Engineers Group Ltd.

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	330/1
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	12.50
Average N value	14
Settlement for 10 t/m2 (mm)	24.00
Settlement (mm) for SBC	30.00
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	21.8

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

Footing Depth (m)	4.50
SBC (t/m2)	22.00
Average N value	17
Settlement for 10 t/m2 (mm)	18.00
Settlement (mm) for SBC	39.60
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	23.4

Footing Depth (m)	6.00
SBC (t/m2)	24.00
Average N value	21
Settlement for 10 t/m2 (mm)	14.40
Settlement (mm) for SBC	34.56
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	18.8

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CONSULTING Engineers Group Ltd.

CHAPTER - 42

"Alignment ",

Location - Existing Km. - 329

42.1 LOCATION OF STRUCTURE:

Alignment at existing km 329.

42.2 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 ≥21.00m below EGL.

Subsurface profile at the site

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

42.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate	Salinity %
BH-1	3.00	8.50	0.002	0.0018	NIL	0.0012	0.045
	6.00	8.90	0.010	0.0018	NIL	0.0012	0.031

42.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

42.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	11.00
	3.00	19.00
	4.50	21.00
	6.00	22.00

42.7 CONCLUSIONS

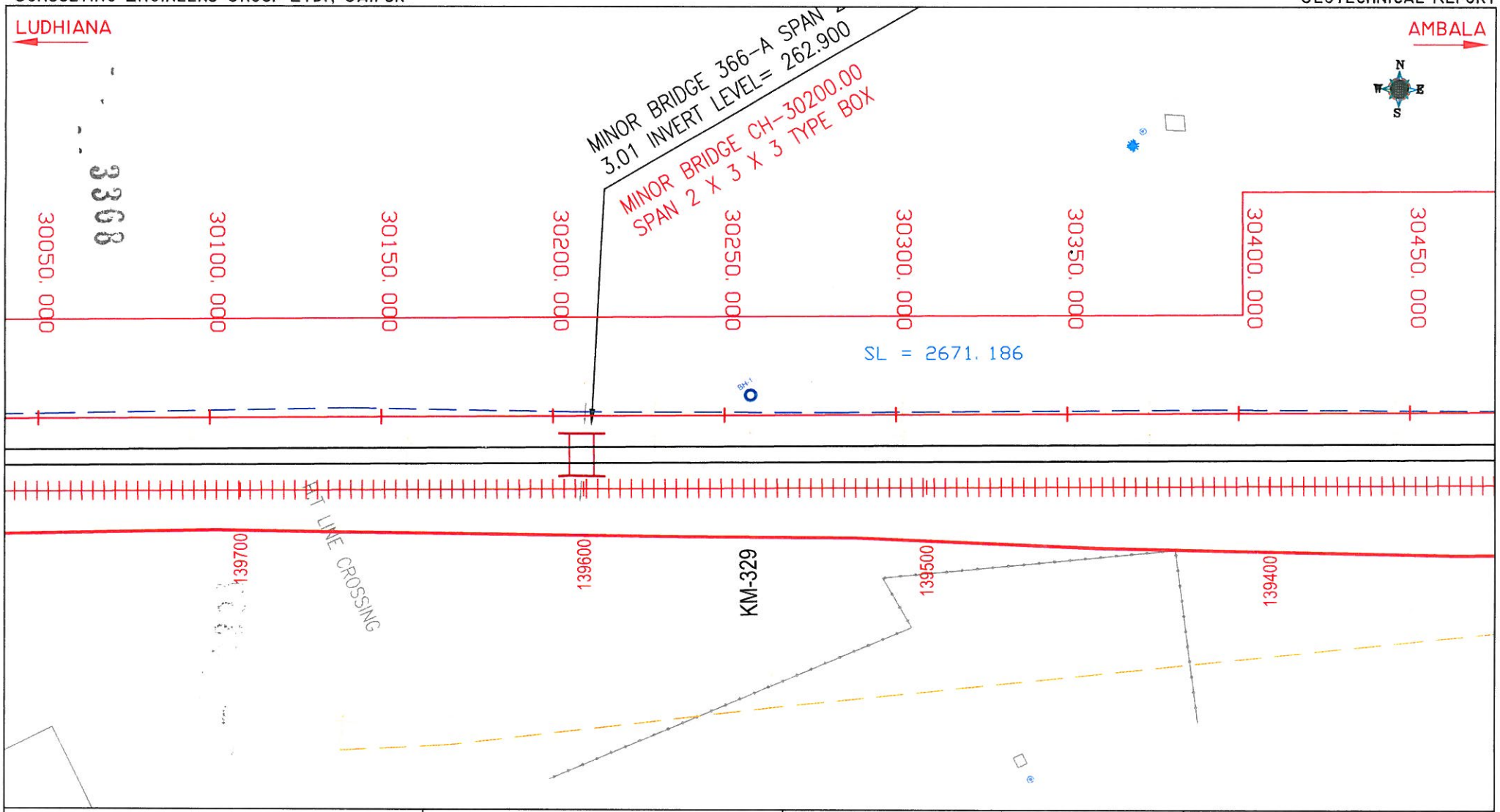
- Subsurface Profiles indicates suitable Soil formation for foundations.

42.8 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.

3367



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 329	RL OF BH-I = 263.224	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

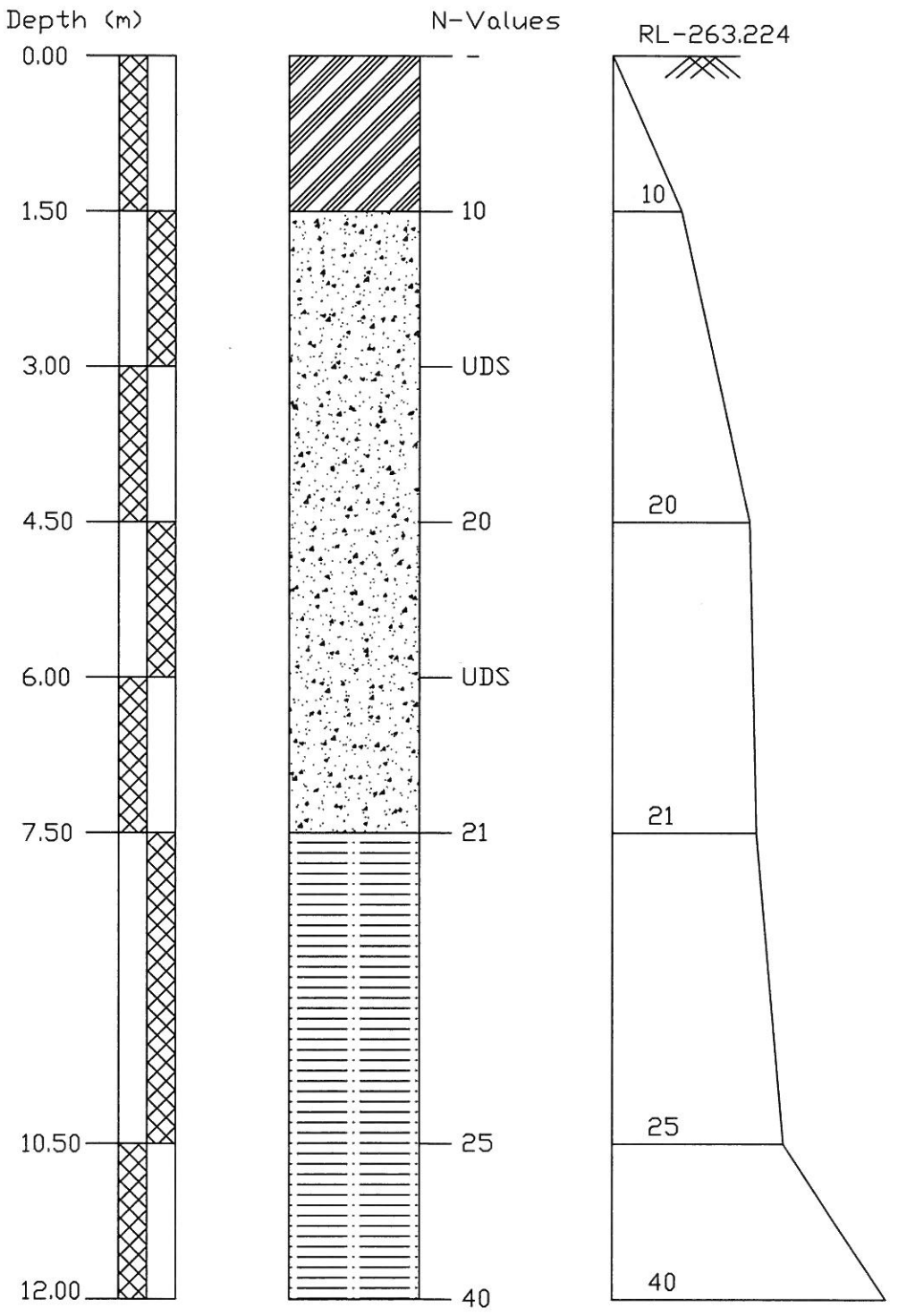
SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (LHS) OF ALIGNMENT AT CHAINAGE 329

Project :	Chainage 329			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				04.06.2009 to 04.06.2009	1	1 (LHS)	below 21.00 m.	12.00mtr	263.224	

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	2.25	77.88	15.36	3.25	1.26	0.00	0.00	22	NP	NIL	-	-	-	-	-	-
1.50	10	1.45	14.50	Silty Sand	2.62	12.75	83.34	1.29	0.00	0.00	0.00	23	NP	NIL	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	3.16	10.25	83.82	1.67	0.11	0.99	0.00	28	NP	NIL	1.72	7.68	1.60	2.67	0.00	27.00
4.50	20	1.09	21.80	Silty Sand	1.18	5.20	90.71	2.29	0.21	0.41	0.00	28	NP	NIL	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	3.30	6.28	83.71	2.67	0.78	3.26	0.00	28	NP	NIL	1.72	4.96	1.64	2.69	0.00	27.50
7.50	21	0.92	19.32	Fine Sand	2.19	2.35	91.24	4.22	0.00	0.00	0.00	26	NP	NIL	-	-	-	-	-	-
10.50	25	0.80	20.00	Fine Sand	2.97	2.59	92.37	2.07	0.00	0.00	0.00	27	NP	NIL	-	-	-	-	-	-
12.00	40	0.76	30.40	Fine Sand	2.86	4.79	88.39	3.83	0.13	0.00	0.00	27	NP	NIL	-	-	-	-	-	-

BORELOG OF BH–1(LHS) AT EXISTING KM–329 FOR ALIGNMENT

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT
	SILTY SAND
	FINE SAND

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ANNEXURE - III

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

INPUT DATA

Alignment at Ch 329/1 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)	0.67
Direction of load with vertical ($^{\circ}$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.72
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	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	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	0.00	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 shea	Local shear	Actual
1	1.50	3.00	8.00	18.73	6.66	11.49
2	3.00	3.00	8.00	33.70	12.30	20.86

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ANNEXURE - III

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

INPUT DATA

	Alignment at Ch 329/1	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)	0.64
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,

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

$d_q = d_\gamma = 1$ 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

Depth factors :

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

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	4.50	3.00	8.00	37.66	13.44	26.76
2	6.00	3.00	8.00	40.15	14.33	28.53

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	329/1
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	11.00
Average N value	18
Settlement for 10 t/m2 (mm)	17.00
Settlement (mm) for SBC	18.70
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	13.6

Footing Depth (m)	3.00
SBC (t/m2)	19.00
Average N value	18
Settlement for 10 t/m2 (mm)	17.00
Settlement (mm) for SBC	32.30
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	21.4

Footing Depth (m)	4.50
SBC (t/m2)	21.00
Average N value	19
Settlement for 10 t/m2 (mm)	15.00
Settlement (mm) for SBC	31.50
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	18.6

Footing Depth (m)	6.00
SBC (t/m2)	22.00
Average N value	19
Settlement for 10 t/m2 (mm)	15.00
Settlement (mm) for SBC	33.00
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	18.0

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CHAPTER - 43

"Alignment ",

Location – Existing Km. – 327

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43.1 LOCATION OF STRUCTURE:

Alignment at existing km 327.

43.2 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 ≥21.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1	0.00 to 1.50	Sandy Silt with clay	Loose
	1.50 to 3.00	Sandy Silt with clay and gravels	Loose
	3.00 to 4.50	Silty Sand	Medium Dense
	4.50 to 6.00	Silty Sand with gravels	Medium Dense
	6.00 to 7.50	Silty Sand	Medium Dense
	7.50 to 10.50	Silty sand with gravels	Medium Dense
	10.50 to 12.00	Silty sand	Medium Dense

43.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate	Salinity %
BH-1	3.00	8.90	0.010	0.0018	NIL	0.0012	0.025

43.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

43.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	11.00
	3.00	17.00
	4.50	19.00
	6.00	21.00

43.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

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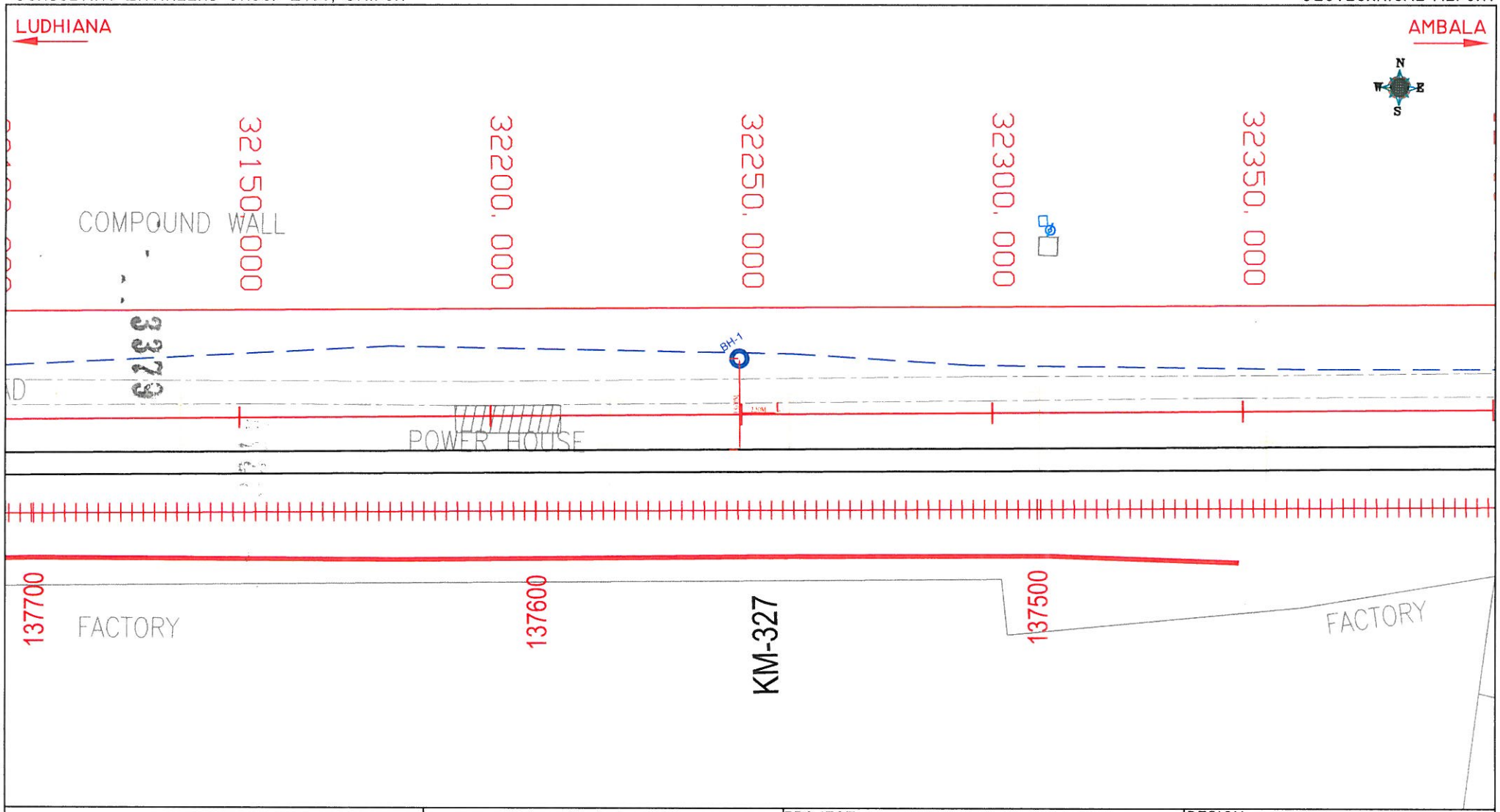
43.7 RECOMMENDATIONS

(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.

3378



ALL DIMENSIONS IN METER

FIG.:-I
LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 327

RL OF BH-I = 265.223

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 327

Project :	Chainage 327			Date of Testing	Location at		B.H. No.			Depth of Water Table			Termination Depth			Surface Elevation			Ref. Code		
				05.06.2009 to 05.06.2009	1		1 (LHS)			below 21.00 m.			12.00mtr			265.223					
Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained								Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel									Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse		L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Sandy Silt with Clay	12.11	49.36	25.36	6.68	2.18	3.65	0.66		30	20	10	-	-	-	-	-	-
1.50	9	1.45	13.05	Sandy Silt with Clayey & Gravels	9.84	47.02	21.29	1.13	1.55	5.69	13.48		27	18	9	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	2.32	16.07	77.42	1.49	1.45	1.25	0.00		23	NIL	NP	1.73	6.59	1.62	2.65	0.00	27.00
4.50	15	1.09	16.35	Silty Sand with Gravels	2.19	10.93	75.12	5.98	0.21	5.57	0.00		23	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	2.11	13.28	78.70	5.26	0.29	0.36	0.00		22	NIL	NP	1.82	12.64	1.62	2.68	0.00	27.00
7.50	19	0.91	17.29	Silty Sand wih Gravels	0.00	8.54	78.16	6.75	0.55	6.00	0.00		21	NIL	NP	-	-	-	-	-	-
10.50	28	0.79	22.12	Silty Sand	0.00	7.41	85.18	7.29	0.12	0.00	0.00		23	NIL	NP	-	-	-	-	-	-
12.00	39	0.75	29.25	Silty Sand	0.00	7.33	85.38	7.10	0.19	0.00	0.00		25	NIL	NP	-	-	-	-	-	-

DFCCIL *KESARI TO SANEHWAL*

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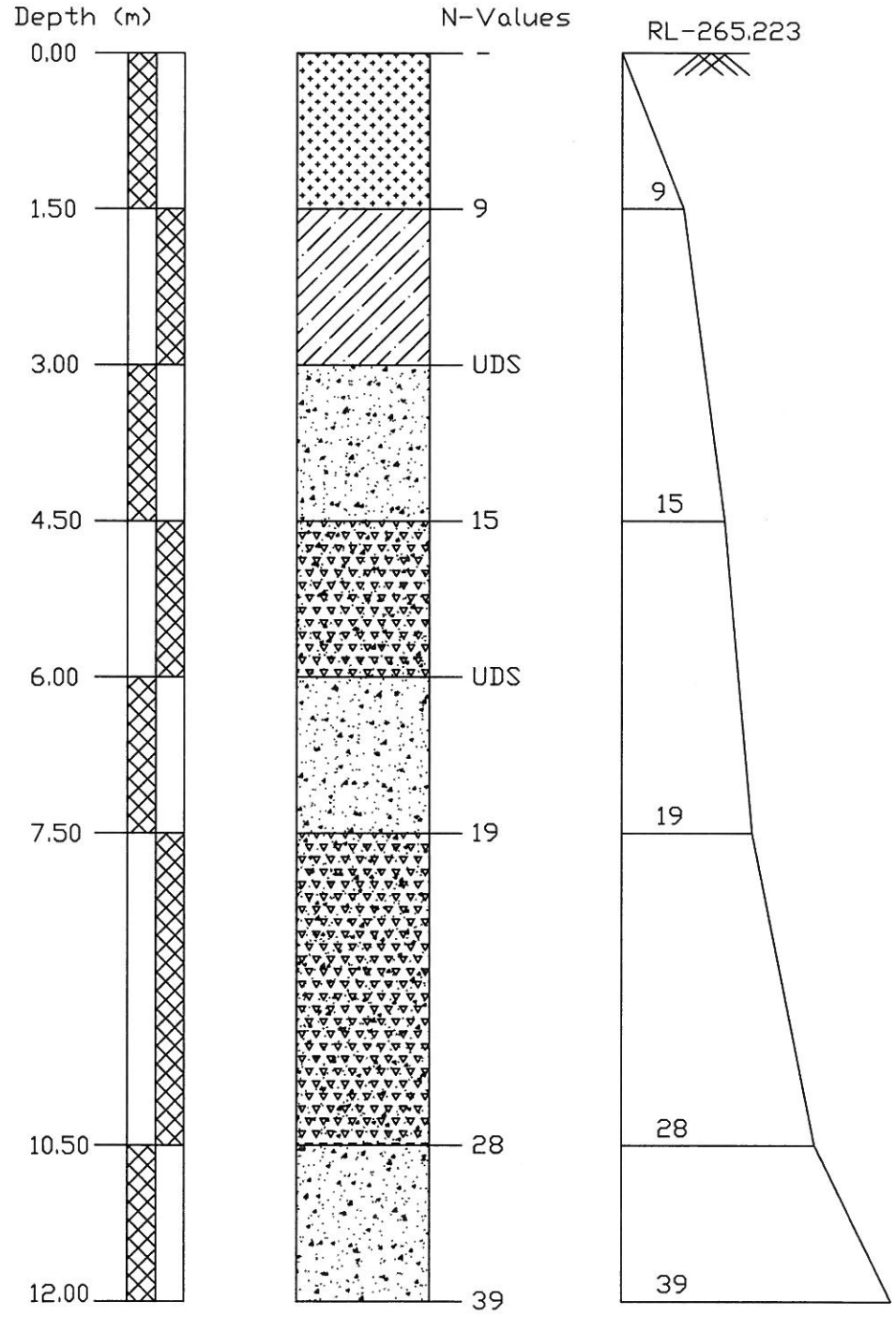
BORELOG OF BH–1(LHS) AT EXISTING KM–327 FOR ALIGNMENT

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

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ANNEXURE - III

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

INPUT DATA

Alignment at Ch 327/1 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)	0.64
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

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

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	0.00	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 shea	Local shear	Actual
1	1.50	3.00	8.00	18.77	6.67	13.32
2	3.00	3.00	8.00	33.74	12.31	24.10

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ANNEXURE -III

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

INPUT DATA

	Alignment at Ch 327/1	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)	0.65
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	4.50	3.00	8.00
2	6.00	3.00	8.00

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE -III

Bearing capacity factors :

ϕ	27.00
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 shea	Local shear	Actual
1	4.50	3.00	8.00	36.39	13.26	24.83
2	6.00	3.00	8.00	38.78	14.13	26.45

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	327/1
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	11.00
Average N value	14
Settlement for 10 t/m2 (mm)	25.00
Settlement (mm) for SBC	27.50
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	20.0

Footing Depth (m)	3.00
SBC (t/m2)	17.00
Average N value	15
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)	19.00
Average N value	16
Settlement for 10 t/m2 (mm)	19.00
Settlement (mm) for SBC	36.10
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	21.4

Footing Depth (m)	6.00
SBC (t/m2)	21.00
Average N value	19
Settlement for 10 t/m2 (mm)	16.00
Settlement (mm) for SBC	33.60
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	18.3

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CHAPTER - 44

"Alignment ",

Location - Existing Km. - 324

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44.1 LOCATION OF STRUCTURE:

Alignment at existing km 324.

44.2 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 3.00	Sandy Silt with Clay	Loose
	3.00 to 6.00	Sandy Silt with Clay	Medium Dense
	6.00 to 7.50	Silty sand	Medium Dense
	7.50 to 10.50	Fine sand	Medium Dense
	10.50 to 12.00	Fine sand	Dense

44.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate	Salinity %
BH-1	3.00	8.90	0.007	0.0022	NIL	0.0008	0.039

44.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1	3.00	11
	6.00	NIL

44.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	11.00
	3.00	18.00
	4.50	20.00
	6.00	24.00

44.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

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44.7 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.

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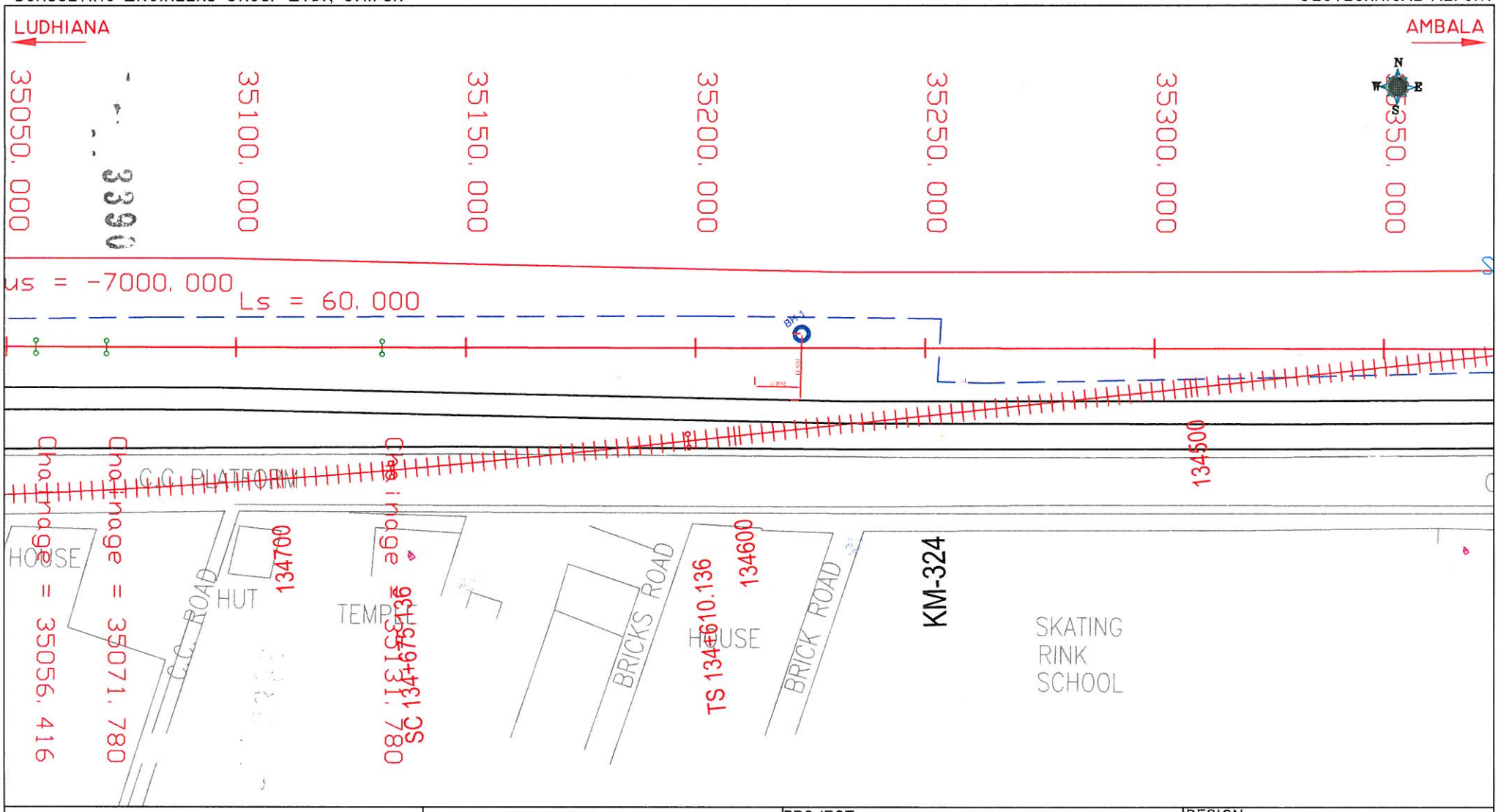

ALL DIMENSIONS IN METER

FIG.:-I

LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 324

RL OF BH-I = 265.973

PROJECT :-

LUDHIANA-AMBALA (DFCCIL)

DESIGN :-

CONSULTING ENGINEERS GROUP LTD.
E-12,Moji Colony,Malviya Nagar Jaipur-17
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SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (LHS) OF ALIGNMENT AT CHAINAGE 324

Project :	Chainage 324			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				05.06.2009 to 05.06.2009	1	1 (LHS)	below 18.00 m.	12.00mtr	265.973	

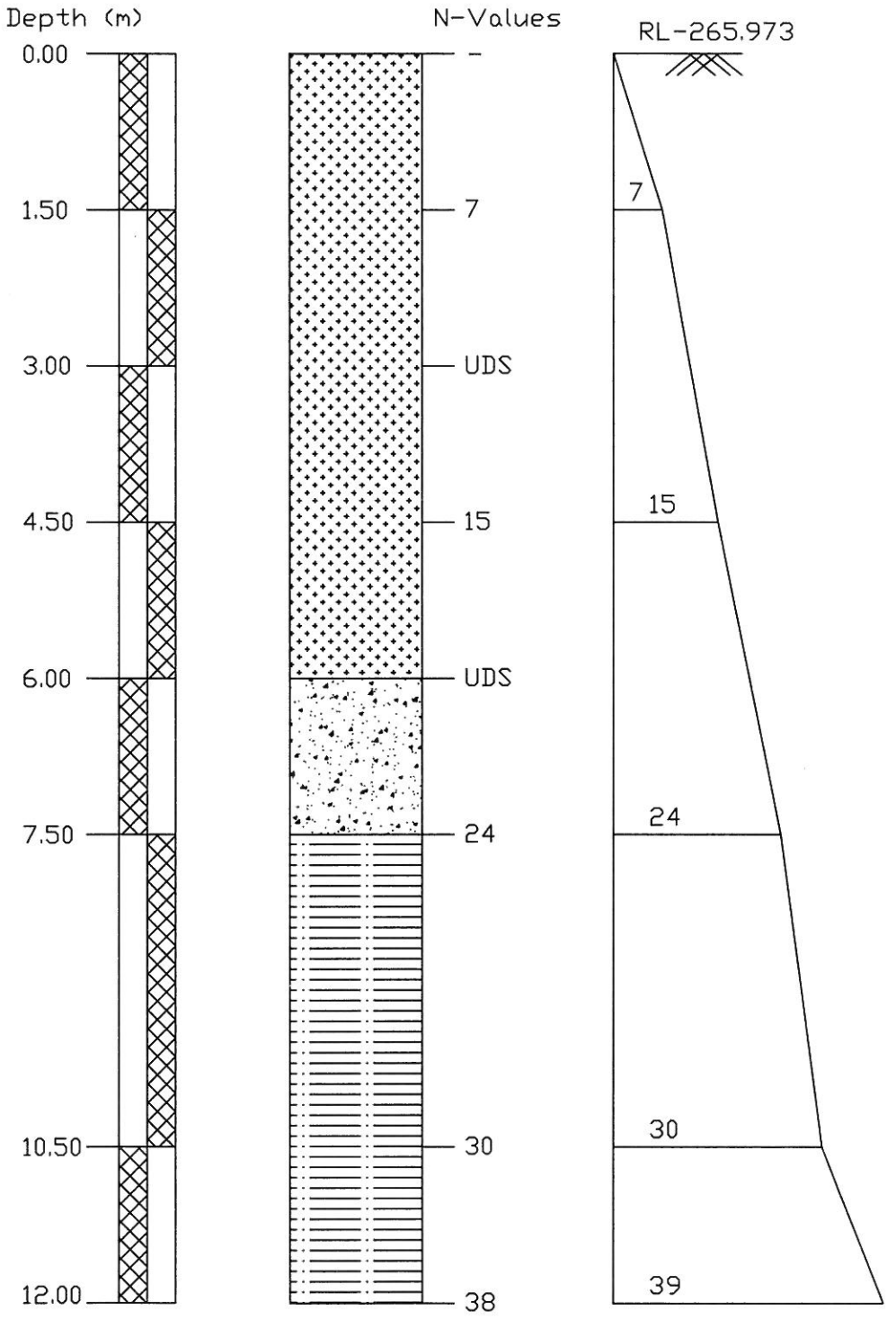
Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel									Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Sandy Silt with Clay	11.64	70.22	12.31	3.26	2.57	0.00	0.00	33	23	10	-	-	-	-	-	-
1.50	7	1.46	10.22	Sandy Silt with Clay	17.48	57.01	20.36	2.99	2.16	0.00	0.00	37	22	15	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt with Clay	10.21	70.01	14.26	3.19	2.33	0.00	0.00	29	21.00	8	1.69	6.24	1.59	2.65	0.10	23.00
4.50	15	1.09	16.35	Sandy Silt with Clay	6.85	72.48	5.05	14.06	1.56	0.00	0.00	26	20	6	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	0.00	9.29	80.33	8.16	2.22	0.00	0.00	23	NIL	NP	1.71	7.28	1.59	2.67	0.00	27.50
7.50	24	0.92	22.08	Fine Sand	0.00	4.89	90.06	5.05	0.00	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
10.50	30	0.81	24.30	Fine Sand	0.00	5.45	89.58	4.97	0.00	0.00	0.00	21	NIL	NP	-	-	-	-	-	-
12.00	38	0.76	28.88	Fine Sand	0.00	3.79	91.08	5.13	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-

DFCCIL *KESARI TO SANEHWAL*

CONSULTING Engineers Group Ltd.

BORELOG OF BH–1(LHS) AT EXISTING KM–324 FOR ALIGNMENT

ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT WITH CLAY
	SILTY SAND
	FINE SAND

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ANNEXURE - III

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

INPUT DATA

Alignment at Ch 324/1 BH-1

Type of footing

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

Angle of internal friction (ϕ °)	23.00
Cohesion (c in t/m2)	1.00
Void ratio (e)	0.67
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.69
Density of foundation soil (t/m^3)	1.69
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)	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 $\phi < 10°$

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	23.00
N_c	18.36
N_q	8.96
N_γ	8.68

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	3.00	1.15	1.08	1.08
2	3.00	3.00	1.30	1.15	1.15

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	18.70	7.71	12.10
2	3.00	3.00	8.00	28.80	11.97	18.70

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ANNEXURE - III

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

INPUT DATA

		Alignment at Ch 324/1	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)	0.68
Direction of load with vertical (^{0})	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.71
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	27.50
N_c	25.43
N_q	14.53
N_γ	16.64

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

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	4.50	3.00	8.00	38.38	13.69	22.33
2	6.00	3.00	8.00	40.91	14.60	23.81

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ANNEXURE - IV

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

BH No. (1)				**Alignment at Ch. 324**
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	=	6.4125	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	=	0.102	
Thickness of clay layer	H	=	4.5	m
Initial Void ratio	e_o	=	0.61	
	$\frac{Pc + \Delta p}{Po}$	=	1.38	

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

	S_f	=	0.039644	m
		=	39.64	mm

Correction for Depth and Rigidity of foundation 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 Pressure correction = 0.85

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

S_{f2} = **24.5** **mm**

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ANNEXURE - IV

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

BH No. (1) **Alignment at Ch. 324**

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	=	7.695	t/m^2
Concentrated load *P*		=	18.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	4.0	t/m^2
Compression Index	Cc	=	0.102	
Thickness of clay layer	H	=	3	m
Initial Void ratio	e_o	=	0.61	
	$\frac{Po + \Delta p}{Po}$	=	1.51	

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

S_f = 0.034 m

= 34.27 mm

Correction for Depth and Rigidity of foundation on total settlement

Depth Factor Calculation

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

D = Depth of Foundation

L/B = 2.67

Depth Factor = 0.83

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

= 0.8

Pore Pressure correction = 0.85

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

S_{f2} = **19.3 mm**

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

Footing Depth (m)	**3.00**
SBC (t/m2)	3.60
Average N value	19
Settlement for 10 t/m2 (mm)	16.00
Settlement (mm) for SBC	5.76
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**3.8**

Total Settlement (mm) = **23.2**

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ANNEXURE - IV

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

BH No. (1)				**Alignment at Ch. 324**
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	=	7.695	t/m^2
Concentrated load *P*		=	20.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	4.4	t/m^2
Compression Index	Cc	=	0.102	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.61	
	$\frac{Po + \Delta p}{Po}$	=	1.57	

Settlement of clay layer

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

S_f	=	0.019	m
	=	18.66	mm

Correction for Depth and Rigidity of foundation on total settlement

Depth Factor Calculation

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

D = Depth of Foundation

L/B	=	2.67
Depth Factor	=	0.74

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

= 0.8

Pore Pressure correction = 0.85

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

S_{f2} = **9.4** **mm**

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

Footing Depth (m)	**4.50**
SBC (t/m2)	4.60
Average N value	20
Settlement for 10 t/m2 (mm)	15.00
Settlement (mm) for SBC	6.90
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**4.1**

Total Settlement (mm) = 13.5

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ANNEXURE - IV

Settlement Calculation for Cohesionless soil As per IS 8009 (Part 1)	
Footing Depth (m)	6.00
SBC (t/m2)	24.00
Average N value	20
Settlement for 10 t/m2 (mm)	15.00
Settlement (mm) for SBC	36.00
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	19.6

CHAPTER - 45

"Alignment ",

Location - Existing Km. - 322

45.1 LOCATION OF STRUCTURE:

Alignment at existing km 322.

45.2 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 ≥23.00m 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 4.50	Silty Sand	Medium Dense
	4.50 to 6.00	Silty Sand with Gravels	Medium Dense
	6.00 to 10.50	Silty Sand	Medium Dense
	10.50 to 12.00	Silty Sand	Dense

45.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate	Salinity %
BH-1	6.00	8.50	0.012	0.0014	NIL	0.0011	0.025

45.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

45.5 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-1	1.50	13.50
	3.00	23.00
	4.50	26.00
	6.00	28.00

45.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

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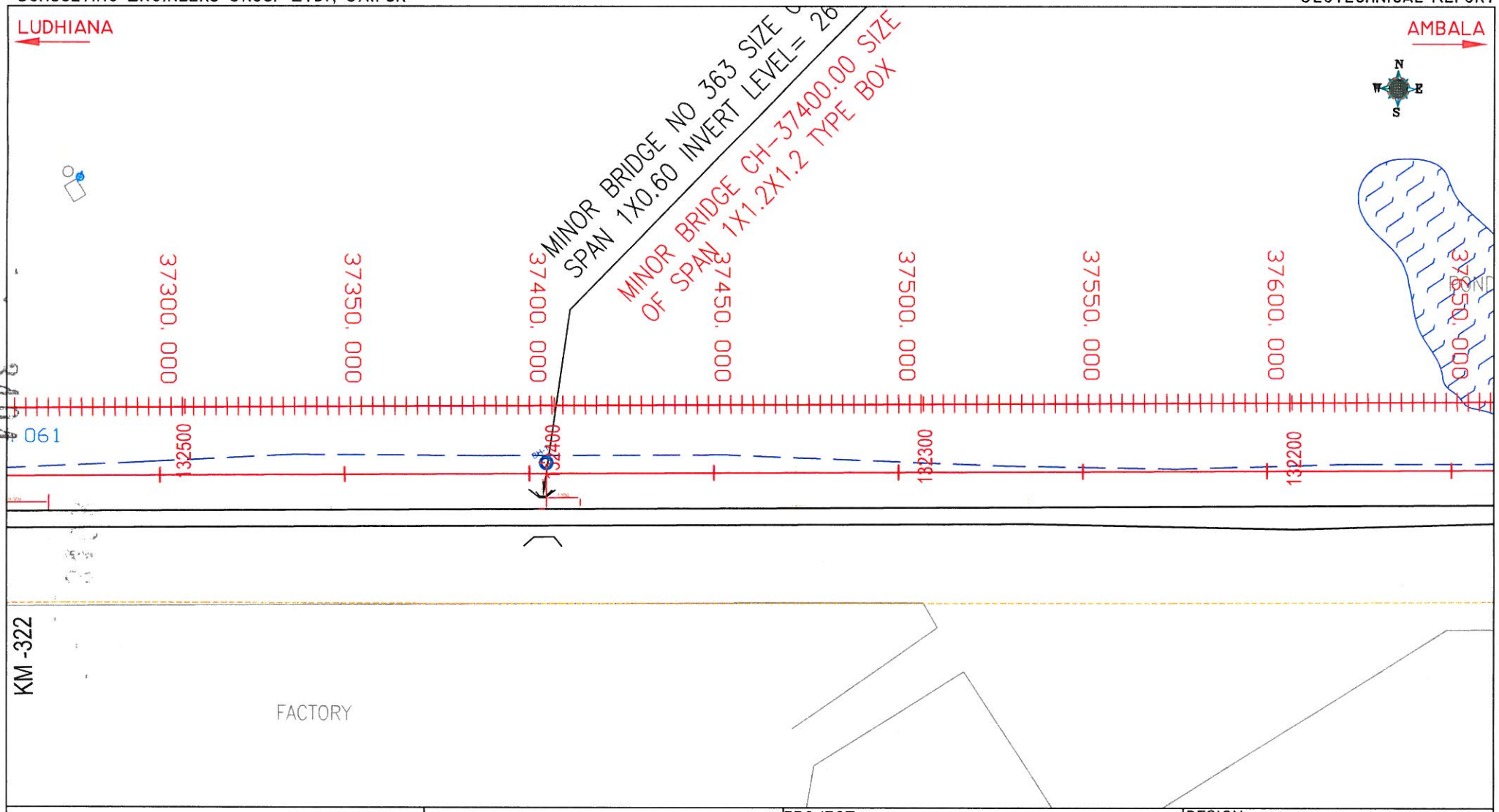
45.7 RECOMMENDATIONS

(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. 322

RL OF BH-I = 265.574

PROJECT :-
LUDHIANA-AMBALA (DFCCIL)

DESIGN :-
CONSULTING
ENGINEERS GROUP LTD.
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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 322

Project :	Chainage 322			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation	Ref. Code
				06.06.2009 to 06.06.2009	1	1 (LHS)	below 23.00 m.	12.00mtr	265.574	

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	2.16	79.47	13.26	3.29	1.2	0.62	0.00	21	NIL	NP	-	-	-	-	-	-
1.50	7	1.43	10.01	Silty Sand	1.15	24.89	72.66	0.86	0.23	0.21	0.00	22	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	2.95	16.52	75.92	2.67	0.32	1.62	0.00	25	NIL	NP	1.84	8.33	1.70	2.66	0.00	28.00
4.50	21	1.06	22.26	Silty Sand with Gravels	3.51	14.89	68.21	3.08	0.55	9.76	0.00	24	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	3.21	14.26	78.73	3.11	0.69	0.00	0.00	26	NIL	NP	1.92	11.35	1.72	2.67	0.00	28.50
7.50	28	0.89	24.92	Silty Sand	2.68	8.45	84.39	3.83	0.38	0.27	0.00	25	NIL	NP	-	-	-	-	-	-
10.50	38	0.77	29.26	Silty Sand	2.51	7.25	82.20	4.44	1.70	1.90	0.00	24	NIL	NP	-	-	-	-	-	-
12.00	43	0.73	31.39	Silty Sand	2.68	8.39	81.93	4.81	1.13	1.06	0.00	24	NIL	NP	-	-	-	-	-	-

DFCCIL *KESARI TO SANEHWAL*

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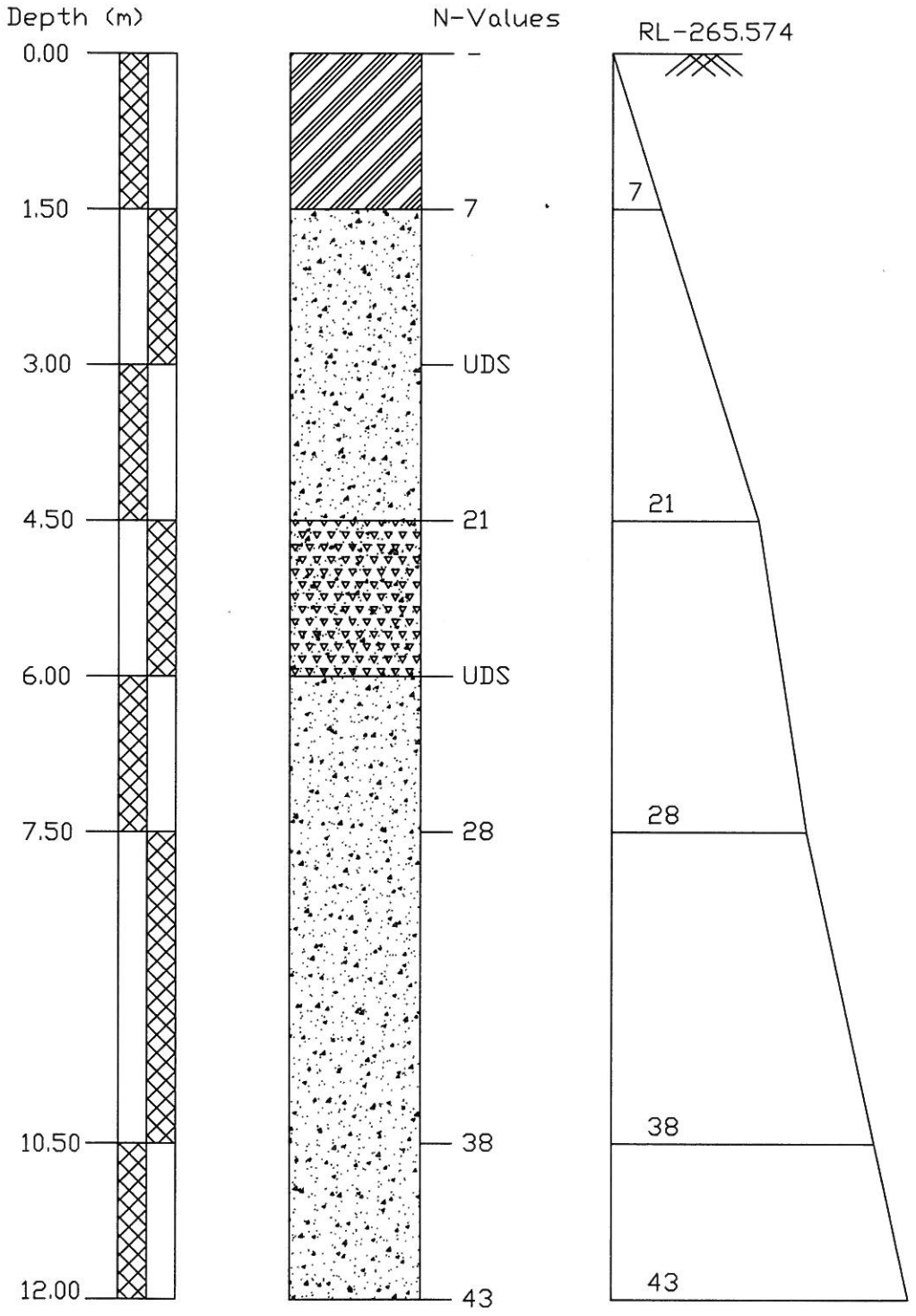
BORELOG OF BH–1(LHS) AT EXISTING KM–322 FOR ALIGNMENT

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 322/1 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)	0.56
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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

$d_q = d_\gamma = 1$ for $\phi < 10°$

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	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

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

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 shea	Local shear	Actual
1	1.50	3.00	8.00	21.53	7.30	20.82
2	3.00	3.00	8.00	38.43	13.41	37.18

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ANNEXURE - III

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

INPUT DATA

Alignment at Ch 322/1 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)	0.55
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.90
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	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

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	4.50	3.00	1.50	1.25	1.25
2	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	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 shea	Local shear	Actual
1	4.50	3.00	8.00	44.08	15.07	44.08
2	6.00	3.00	8.00	47.04	16.08	47.04

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	322/1
Bore Hole No.	1

Footing Depth (m)	1.50
SBC (t/m2)	13.50
Average N value	15
Settlement for 10 t/m2 (mm)	21.00
Settlement (mm) for SBC	28.35
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	20.6

Footing Depth (m)	3.00
SBC (t/m2)	23.00
Average N value	19
Settlement for 10 t/m2 (mm)	16.00
Settlement (mm) for SBC	36.80
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	24.4

Footing Depth (m)	4.50
SBC (t/m2)	26.00
Average N value	23
Settlement for 10 t/m2 (mm)	13.00
Settlement (mm) for SBC	33.80
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	20.0

Footing Depth (m)	6.00
SBC (t/m2)	28.00
Average N value	24
Settlement for 10 t/m2 (mm)	12.60
Settlement (mm) for SBC	35.28
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	19.2

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CHAPTER – 46

"Alignment ",

Location – Existing Km. – 318/26-28

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46.1 LOCATION OF STRUCTURE:

Alignment at existing km 318/26-28.

46.2 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 ≥22.00m 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 3.00	Silty Sand with Gravels	Loose
	3.00 to 3.50	Sandy Silt	Medium Dense
	3.50 to 4.50	Silty Sand	Medium Dense
	4.50 to 6.00	Silty Sand	Medium Dense
	6.00 to 7.50	Silty Sand with Gravels	Medium Dense
	7.50 to 10.50	Silty Sand	Medium Dense
	10.50 to 12.00	Silty Sand	Dense

46.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate	Salinity %
BH-1	3.00	9.00	0.010	0.0018	NIL	0.0011	0.024

46.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

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

46.5 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	19.00
	6.00	20.00

46.6 CONCLUSIONS

- Subsurface Profiles indicates suitable Soil formation for foundations.

46.7 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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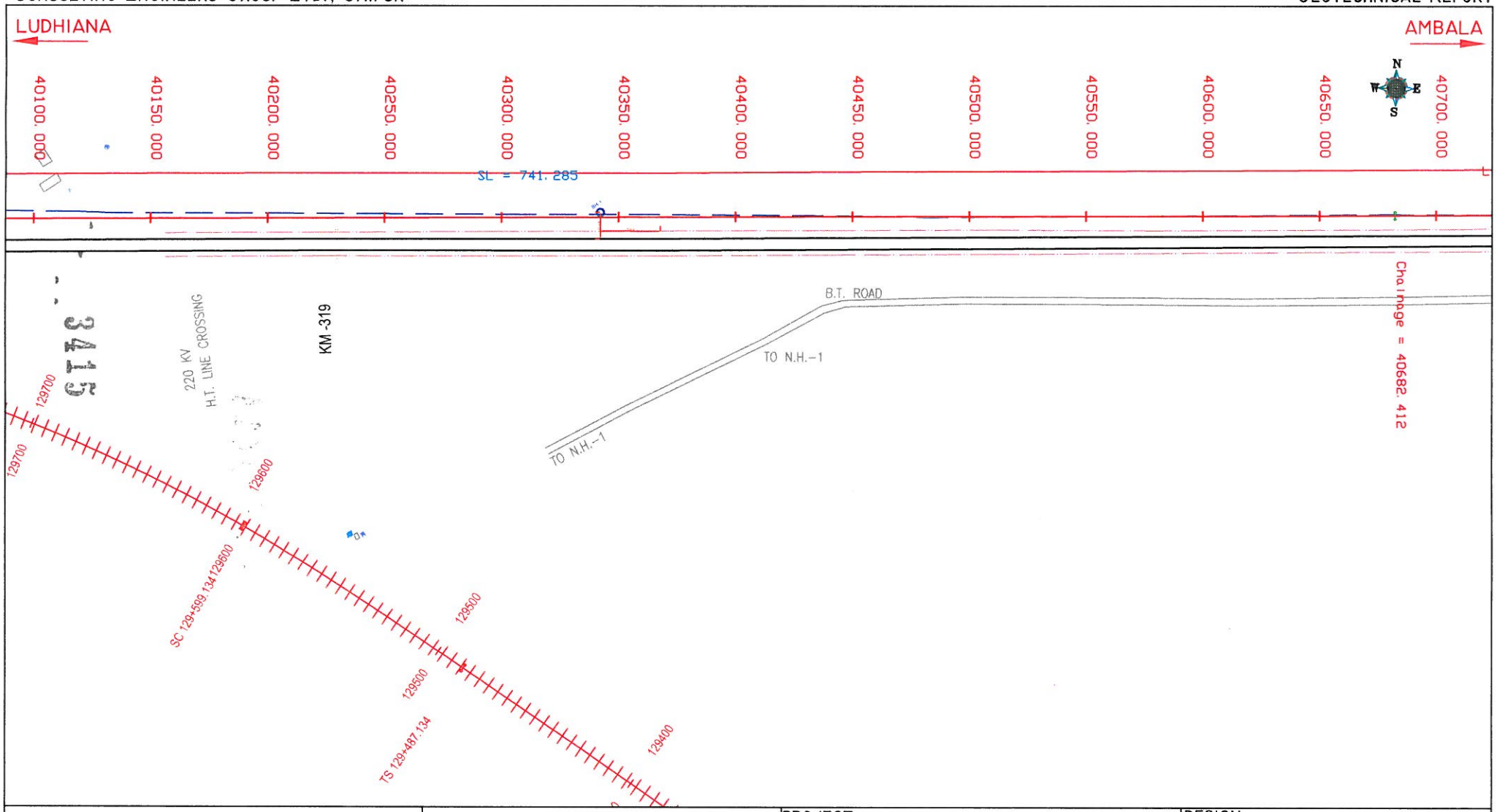

ALL DIMENSIONS IN METER

FIG.:-I

LOCATION PLAN OF PROPOSED ALIGNMENT AT CH. 318/26-28

RL OF BH-I = 265.804

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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ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (LHS) OF ALIGNMENT AT CHAINAGE 318/26-28

Project :	Chainage 318/26-28			Date of Testing	Location at		B.H. No.			Depth of Water Table		Termination Depth			Surface Elevation			Ref. Code		
				08.06.2009 to 08.06.2009	1		1 (LHS)			below 22.00 m.		12.00mtr			265.804					
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	2.67	12.64	63.35	13.39	5.69	1.62	0.64	23	NIL	NP	-	-	-	-	-	-
1.50	9	1.43	12.87	Silty Sand with Gravels	3.15	34.10	43.62	2.62	0.92	15.59	0.00	24	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt	2.69	50.41	43.68	0.86	0.48	1.88	0.00	27	NIL	NP	1.85	13.76	1.63	2.62	0.00	26.00
3.50				Silty Sand	3.29	19.60	66.59	8.29	1.28	0.95	0.00	25	NIL	NP	-	-	-	-	-	-
4.50	19	1.06	20.14	Silty Sand	2.94	9.18	81.71	6.10	0.07	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand with Gravels	1.38	11.91	48.32	1.56	3.06	24.94	8.83	28	NIL	NP	1.88	4.43	1.80	2.66	0.00	30.00
7.50	27	0.89	24.03	Silty Sand	2.17	11.75	78.82	7.04	0.22	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
10.50	36	0.78	28.08	Silty Sand	2.66	11.72	80.04	4.11	0.81	0.66	0.00	23	NIL	NP	-	-	-	-	-	-
12.00	47	0.73	34.31	Silty Sand	3.67	9.27	80.34	6.43	0.16	0.13	0.00	25	NIL	NP	-	-	-	-	-	-

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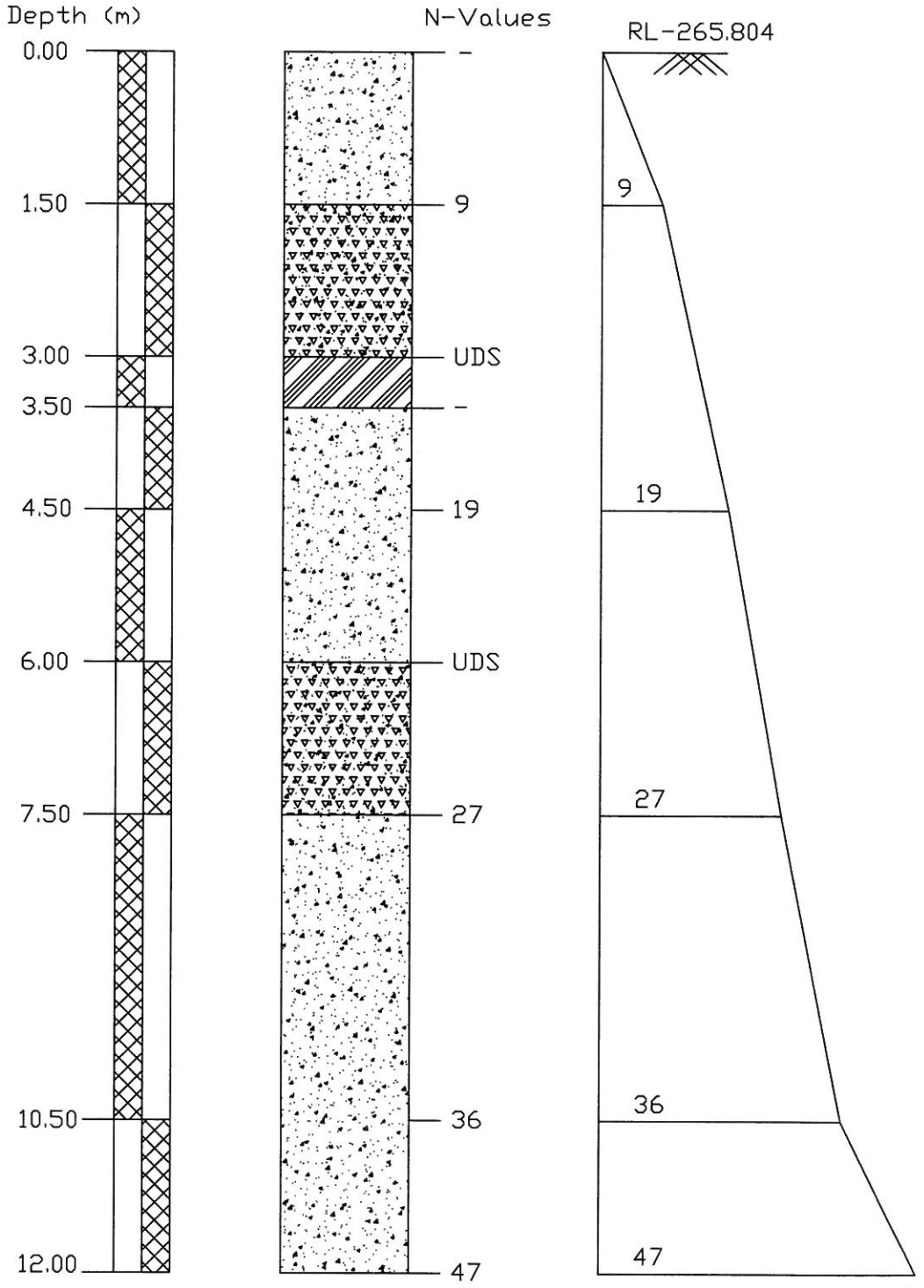
BORELOG OF BH–1(LHS) AT EXISTING KM–318/26–28 FOR ALIGNMENT ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SILTY SAND
	SILTY SAND WITH GRAVELS
	SANDY SILT

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ANNEXURE - III

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

INPUT DATA

	Alignment at Ch 318/1	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)	0.61
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.85
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	26.00
N_c	22.60
N_q	12.21
N_γ	13.18

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

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shea	Local shear	Actual
1	1.50	3.00	8.00	16.66	6.25	13.54
2	3.00	3.00	8.00	29.77	11.44	24.27

CONSULTING Engineers Group Ltd.

ANNEXURE - III

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

INPUT DATA

Alignment at Ch 318/1 BH-1

Type of footing

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

Angle of internal friction (ϕ °)	30.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.48
Direction of load with vertical (°)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.88
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	30.00
N_c	30.14
N_q	18.40
N_γ	22.40

ϕ'	21.15
N'_c	16.18
N'_q	7.38
N'_γ	6.65

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	1.52	1.26	1.26
2	6.00	3.00	1.69	1.35	1.35

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 shea	Local shear	Actual
1	4.50	3.00	8.00	51.33	18.03	51.33
2	6.00	3.00	8.00	54.86	19.27	54.86

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Alignment
Chainage	318/26-28
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)	18.00
Average N value	19
Settlement for 10 t/m2 (mm)	16.00
Settlement (mm) for SBC	28.80
Depth Correction	0.83
Rigidity Correction	0.8
Corrected Total Settlement (mm)	19.1

Footing Depth (m)	4.50
SBC (t/m2)	19.00
Average N value	22
Settlement for 10 t/m2 (mm)	13.00
Settlement (mm) for SBC	24.70
Depth Correction	0.74
Rigidity Correction	0.8
Corrected Total Settlement (mm)	14.6

Footing Depth (m)	6.00
SBC (t/m2)	20.00
Average N value	22
Settlement for 10 t/m2 (mm)	13.80
Settlement (mm) for SBC	27.60
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	15.0

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Engineers Group Ltd.