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

BH No. (A1) — **Minor Bridge at Ch. 317/28-30**

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	=	6.75	t/m^2
Concentrated load *P*		=	15.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	3.3	t/m^2
Compression Index	Cc	=	0.11	
Thickness of clay layer	H	=	3	m
Initial Void ratio	e_o	=	0.64	
	$\frac{Po + \Delta p}{Po}$	=	1.4888889	

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

S_f = 0.0347833 m

= 34.783265 mm

Correction for Depth and Rigidity of foundation on total settlement

Depth Factor Calculation

$D/(LB)^{0.5}$ = 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} = **19.6 mm**

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

Footing Depth (m)	**3.00**
SBC (t/m2)	3.45
Average N value	37
Settlement for 10 t/m2 (mm)	7.00
Total Settlement (mm)	2.42
Depth Correction	0.91
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**1.76**

Total Settlement (mm) 21.4

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Minor Bridge No. 361
Chainage	317/28-30
Bore Hole No.	A1

Footing Depth (m)	**4.50**
SBC (t/m2)	36.00
Average N value	33.0
Settlement for 10 t/m2 (mm)	9.00
Total Settlement (mm)	32.40
Depth Correction	0.68
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**17.5**

Footing Depth (m)	**6.00**
SBC (t/m2)	36.00
Average N value	33.5
Settlement for 10 t/m2 (mm)	9.00
Total Settlement (mm)	32.40
Depth Correction	0.63
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**16.3**

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'MAJOR BRIDGES'

CHAPTER – 25

"Major Bridge No. 385",

Location – Existing Km. - 353/35, 354/4

25.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 3 x 24.4

25.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table 3.15m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1(A1)	0.00 to 1.50	Clayey silt	Loose
	1.50 to 4.60	Clayey silt	Medium Dense
	4.60 to 9.00	Silty Sand	Medium Dense
	9.00 to 12.00	Silty Sand	Dense
	12.00 to 15.00	Clayey silt	Dense
	15.00 to 18.00	Silty sand	Dense
	18.00 to 30.00	Silty sand	Very dense
BH-2(P1)	0.00 to 1.50	Filled up strata	-
	1.50 to 3.00	Sandy silt with gravels	Loose
	3.00 to 6.00	Sandy silt	Loose
	6.00 to 6.80	Sandy silt	Medium Dense
	6.80 to 9.00	Silty sand	Medium Dense
	9.00 to 12.00	Silty sand with gravels	Medium Dense
	12.00 to 15.00	Clayey silt with sand and gravels	Medium Dense
	15.00 to 30.00	Silty sand	Very dense
BH-3(P4)	0.00 to 1.50	Clayey silt	Loose
	1.50 to 3.00	Clayey silt	Medium Dense
	3.00 to 6.00	Sandy silt with gravels	Medium Dense
	6.00 to 15.00	Silty sand	Medium Dense
	15.00 to 24.00	Silty sand	Dense
	24.00 to 30.00	Silty sand	Very dense
BH-4 (A2)	0.00 to 1.50	Clayey silt with gravels	Loose
	1.50 to 3.00	Clayey silt with gravels	Medium Dense
	3.00 to 6.00	Sandy silt with gravels	Medium Dense
	6.00 to 9.00	Silty sand	Medium Dense
	9.00 to 12.00	Silty sand with gravels	Medium Dense
	12.00 to 18.00	Silty sand	Medium Dense
	18.00 to 21.00	Silty sand	Dense
	21.00 to 30.00	Silty sand	Very dense

25.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate	Salinity %
BH-1 (A1)	3.00	8.50	0.002	0.0014	NIL	0.0009	0.019
	21.00	8.50	0.002	0.0014	NIL	0.0009	0.022
BH-2 (P1)	3.00	7.20	NIL	0.0035	NIL	0.0012	0.067
	9.00	8.80	0.007	0.0014	NIL	0.0011	0.026
BH-3 (P4)	6.00	8.10	0.006	01.0015	NIL	0.0011	0.021
BH-4 (A2)	3.00	8.40	NIL	0.0014	NIL	0.0010	0.028
	9.00	8.80	0.010	0.0014	NIL	0.0010	0.025
	24.00	8.80	0.010	0.0011	NIL	0.0010	0.025

25.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1 (A1)	3.00	14
	12.00	17
	21.00	NIL
BH-2 (P1)	3.00	NIL
	9.00	NIL
	21.00	NIL
BH-3 (P4)	6.00	NIL
	12.00	NIL
	21.00	NIL
BH-4 (A2)	3.00	NIL
	9.00	NIL
	24.00	NIL

25.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BOREHOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (mg)
Test Result	7.3	125	109	157	1002	0.20	4.0	11.25	812
Requirment as per IS: 456 / Mosrth's	Not less then 6.0	2000 for CC and 500 for RCC	400	200	3000	5 ml of 0.02 normal NaoH	25 ml of 0.02 normal H_2SO_4	-	-

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25.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-A1	1.50	14.00
	3.00	18.00
	4.50	21.00
	2.00	22.00
BH-A2	1.50	11.50
	3.00	20.00
	4.50	20.50
	2.00	21.00

25.7 PILE LOAD CARRYING CAPACITY

25.7.1 Normal Bored Cast in- situ Pile Foundations:

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

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

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

Pile load carrying capacity in t/m²

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE
		DIAMETER OF THE PILE 1.00 mtr
BH-1 (A1)	18.00	160.00
	21.00	230.00
	24.00	300.00
BH-2 (P1)	18.00	170.00
	21.00	230.00
	24.00	280.00

BH-3 (P4)	18.00	160.00
	21.00	200.00
	24.00	250.00
BH-4 (A2)	18.00	210.00
	21.00	270.00
	24.00	330.00

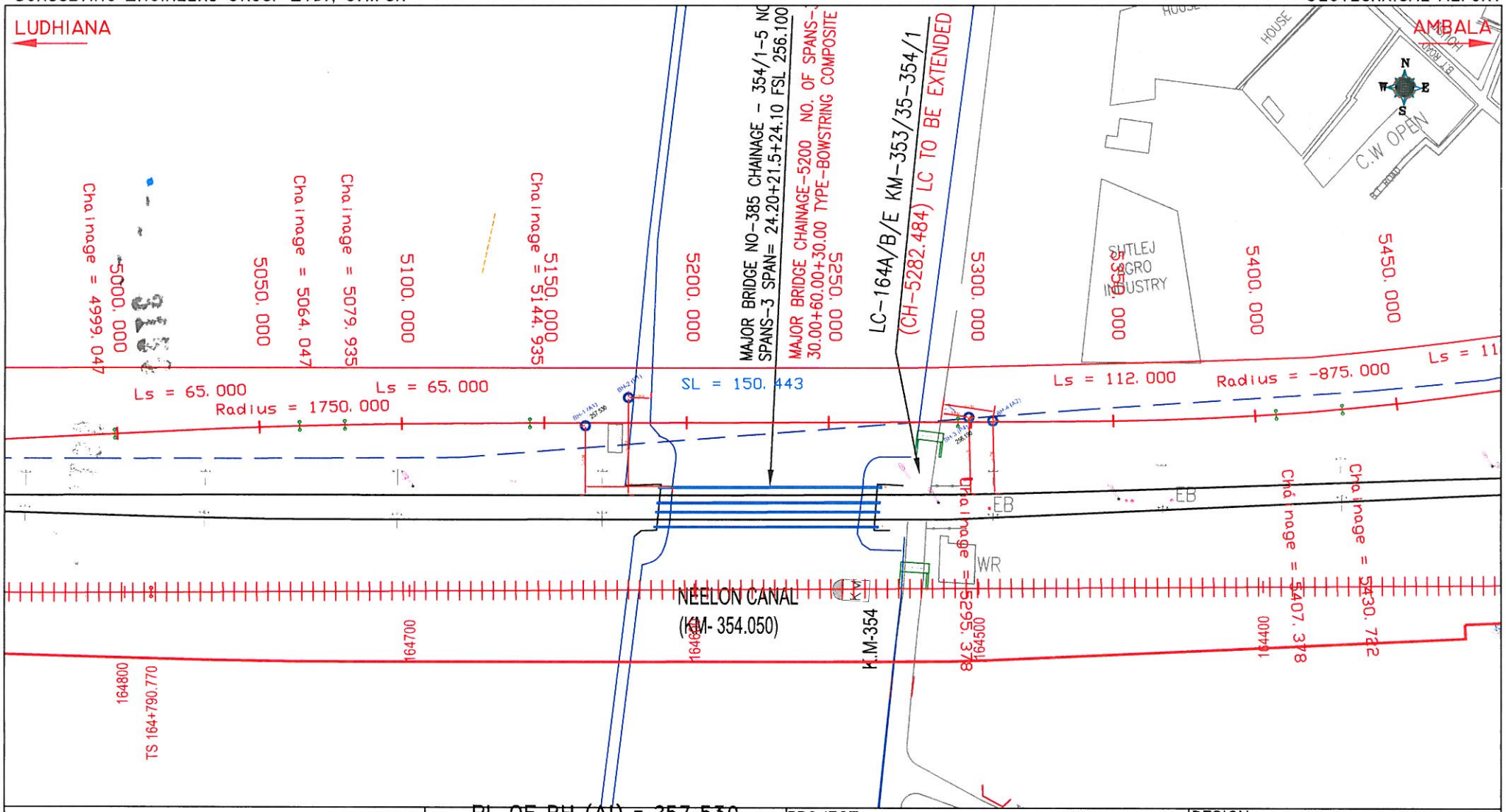
25.8 CONCLUSIONS

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

25.9 RECOMMENDATIONS

(i)	*Type of foundation*	Pile foundation

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



ALL DIMENSIONS IN METER FIG.:-I LOCATION PLAN OF PROPOSED MAJOR BRIDGE AT CH. 353/35-354/4	RL OF BH (A1) = 257.530 RL OF BH (P1) = 257.578 RL OF BH (P4) = 256.190 RL OF BH (A2) = 255.58	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(A1) OF MAJOR BRIDGE No. 385 AT CHAINAGE 354/0-1

Project :	Chainage 354/0-1 Bridge No. 385			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				27.05.2009 to 28.05.2009	A1	1	4.30 m.	30.00mtr	257.530

Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Clayey Silt	13.68	79.15	6.35	0.82	0.00	0.00	0.00	25	15	10	-	-	-	-	-	-
1.50	12	1.46	17.52	Clayey Silt	13.60	79.83	5.86	0.61	0.10	0.00	0.00	24	15	9	-	-	-	-	-	-
3.00	UDS	-	-	Clayey Silt	15.95	70.61	10.90	0.30	0.14	2.10	0.00	27	16	11	1.71	4.11	1.64	2.64	0.11	21.00
4.60	-	-	-	Silty Sand	2.98	18.13	75.36	2.67	0.86	0.00	0.00	23	NIL	NP						
6.00	25	0.99	19.88	Silty Sand	3.15	9.65	85.73	1.47	0.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
9.00	30	0.86	20.40	Silty Sand	2.67	11.27	83.99	1.46	0.61	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
12.00	UDS	-	-	Clayey Silt	16.95	76.83	6.22	0.00	0.00	0.00	0.00	32	19	13	1.96	15.84	1.69	2.63	0.13	19.50
15.00	50	0.67	24.25	Silty Sand	2.36	12.99	82.63	2.02	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
18.00	55	0.60	24.00	Silty Sand	2.49	10.01	86.38	1.12	0.00	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
21.00	UDS	-	-	Silty Sand	3.25	8.65	85.17	2.93	0.00	0.00	0.00	25	NIL	NP	2.01	16.32	1.73	2.65	0.00	28.50
24.00	70	0.50	25.00	Silty Sand	2.69	9.46	79.76	2.55	1.47	4.07	0.00	26	NIL	NP	-	-	-	-	-	-
27.00	76	0.46	24.98	Silty Sand	3.48	6.02	87.47	3.03	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
30.00	33	0.42	13.86	Silty Sand	2.99	40.04	54.52	1.50	0.68	0.27	0.00	23	NIL	NP	-	-	-	-	-	-

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (P1) OF MAJOR BRIDGE No. 385 AT CHAINAGE 354/0-1

Project :	Chainage 354/0-1 Bridge No. 385			Date of Testing	Location at		B.H. No.		Depth of Water Table			Termination Depth			Surface Eievation					
				26.05.2009 to 27.05.2009	P1		2		5.15 m.			30.00mtr			257.578					
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 c kg/cm^2	Shear Strength ϕ degree
					Clay	Silt	Sand			Gravel		L.L.	P.L.	P.I.						
							Fine	Medium	Coarse	Fine	Coarse									
0.00	-	-	-	Filled up Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.50	7	1.50	10.50	Sandy Silt with Gravels	4.00	77.73	5.86	1.54	2.88	7.99	0.00	23	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt	4.59	78.35	15.33	1.68	0.05	0.00	0.00	21	NIL	NP	1.66	3.41	1.61	2.64	0.00	27.00
6.00	11	1.00	11.00	Sandy Silt	3.54	75.83	13.20	1.03	0.71	5.69	0.00	23	NIL	NP	-	-	-	-	-	-
6.80	-	-	-	Silty Sand	3.15	10.80	79.94	5.26	0.85	0.00	0.00	23	NIL	NP						
9.00	UDS	-	-	Silty Sand with Gravels	4.39	16.33	67.23	1.81	1.41	8.83	0.00	29	NIL	NP	1.89	16.23	1.63	2.65	0.00	27.50
12.00	19	0.75	14.25	Clayey Silt with Sand & Gravels	6.69	68.28	8.25	0.50	1.15	15.13	0.00	25	19	6	-	-	-	-	-	-
15.00	52	0.67	24.92	Silty Sand	3.59	10.82	84.54	1.05	0.00	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
18.00	58	0.61	25.19	Silty Sand	4.12	12.42	80.85	2.61	0.00	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
21.00	81	0.55	29.78	Silty Sand	2.69	12.47	79.26	5.58	0.00	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
24.00	UDS	-	-	Silty Sand	3.33	10.09	74.26	7.29	3.12	0.65	1.26	23	NIL	NP	2.00	17.12	1.71	2.64	0.00	28.50
27.00	75	0.46	24.75	Silty Sand	2.97	13.56	82.15	1.32	0.00	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
30.00	76	0.42	23.46	Silty Sand	4.12	39.57	52.67	3.64	0.00	0.00	0.00	21	NIL	NP	-	-	-	-	-	-

DFCCIL *KESARI TO SANEHWAL*

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ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-3 (P4) OF MAJOR BRIDGE No. 385 AT CHAINAGE 354/0-1

Project :	Chainage 354/0-1 Bridge No. 385			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				29.05.2009 to 30.05.2009	P4	5	3.45 m.	30.00mtr	256.190

Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Clayey Silt	14.56	80.87	4.26	0.31	0.00	0.00	0.00	30	19	11	-	-	-	-	-	-
1.50	13	1.45	18.85	Clayey Silt	14.26	80.47	5.00	0.19	0.08	0.00	0.00	30	18	12	-	-	-	-	-	-
3.00	19	1.22	23.18	Sandy Silt with Gravels	3.69	77.94	10.63	0.83	1.30	5.61	0.00	28	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	2.25	8.92	87.30	1.53	0.00	0.00	0.00	28	NIL	NP	1.72	18.08	1.46	2.64	0.00	28.00
9.00	26	0.85	18.55	Silty Sand	3.25	4.51	89.04	3.20	0.00	0.00	0.00	24	NIL	NP		-	-	-	-	-
12.00	UDS	-	-	Silty Sand	2.49	13.86	78.69	4.29	0.67	0.00	0.00	25	NIL	NP	1.81	19.38	1.52	2.65	0.00	28.50
15.00	30	0.67	17.55	Silty Sand	3.25	19.18	73.73	2.92	0.64	0.28	0.00	22	NIL	NP	-	-	-	-	-	-
18.00	39	0.61	19.40	Silty Sand	3.25	5.68	88.57	2.43	0.07	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
21.00	UDS	-	-	Silty Sand	3.18	10.94	82.69	3.19	0.00	0.00	0.00	23	NIL	NP	1.84	18.77	1.55	2.66	0.00	28.00
24.00	62	0.51	23.31	Silty Sand	2.52	8.04	87.94	1.50	0.00	0.00	0.00	25	NIL	NP		-	-	-	-	-
27.00	66	0.47	23.01	Silty Sand	2.84	7.31	87.30	2.55	0.00	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
30.00	73	0.44	23.56	Silty Sand	2.93	10.94	83.91	2.22	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-

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ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-4 (A2) OF MAJOR BRIDGE No. 385 AT CHAINAGE 354/0-1

Project :	Chainage 354/0-1 Bridge No. 385			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				28.05.2009 to 29.05.2009	A2	4	3.15 m.	30.00mtr	255.580

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										
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.					c kg/cm^2	ϕ degree
0.00	-	-	-	Clayey Silt with Gravels	14.95	70.74	3.26	1.25	0.22	9.58	0.00	31	19	12	-	-	-	-	-	-
1.50	13	1.41	18.33	Clayey Silt with Gravels	18.22	57.83	4.23	2.56	4.47	12.69	0.00	34	20	14	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt with Gravels	4.69	70.51	18.85	1.10	0.15	4.70	0.00	29	NIL	NP	1.98	10.41	1.79	2.66	0.00	29.50
6.00	25	0.94	19.25	Silty Sand	2.00	9.31	87.86	0.83	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand with Gravels	3.25	38.25	40.74	2.62	7.09	8.05	0.00	24	NIL	NP	2.02	16.83	1.73	2.66	0.00	31.50
12.00	-	-	-	Silty Sand	3.11	7.31	84.24	1.60	1.42	2.32	0.00	25	NIL	NP	-	-	-	-	-	-
15.00	28	0.63	16.32	Silty Sand	2.68	9.93	83.94	3.21	0.24	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
18.00	35	0.57	17.48	Silty Sand	2.67	25.26	64.96	5.02	1.00	1.09	0.00	21	NIL	NP	-	-	-	-	-	-
21.00	59	0.52	22.84	Silty Sand	2.96	8.47	85.68	2.72	0.07	0.10	0.00	24	NIL	NP		-	-	-	-	-
24.00	UDS	-	-	Silty Sand	3.19	25.08	61.24	4.53	2.84	3.12	0.00	27	NIL	NP	1.99	19.90	1.66	2.64	0.00	28.00
27.00	61	0.44	20.92	Silty Sand	3.51	15.81	73.82	3.70	2.05	1.11	0.00	25	NIL	NP	-	-	-	-	-	-
30.00	69	0.40	21.30	Silty Sand	2.51	7.33	84.24	5.92	0.00	0.00	0.00	19	NIL	NP	-	-	-	-	-	-

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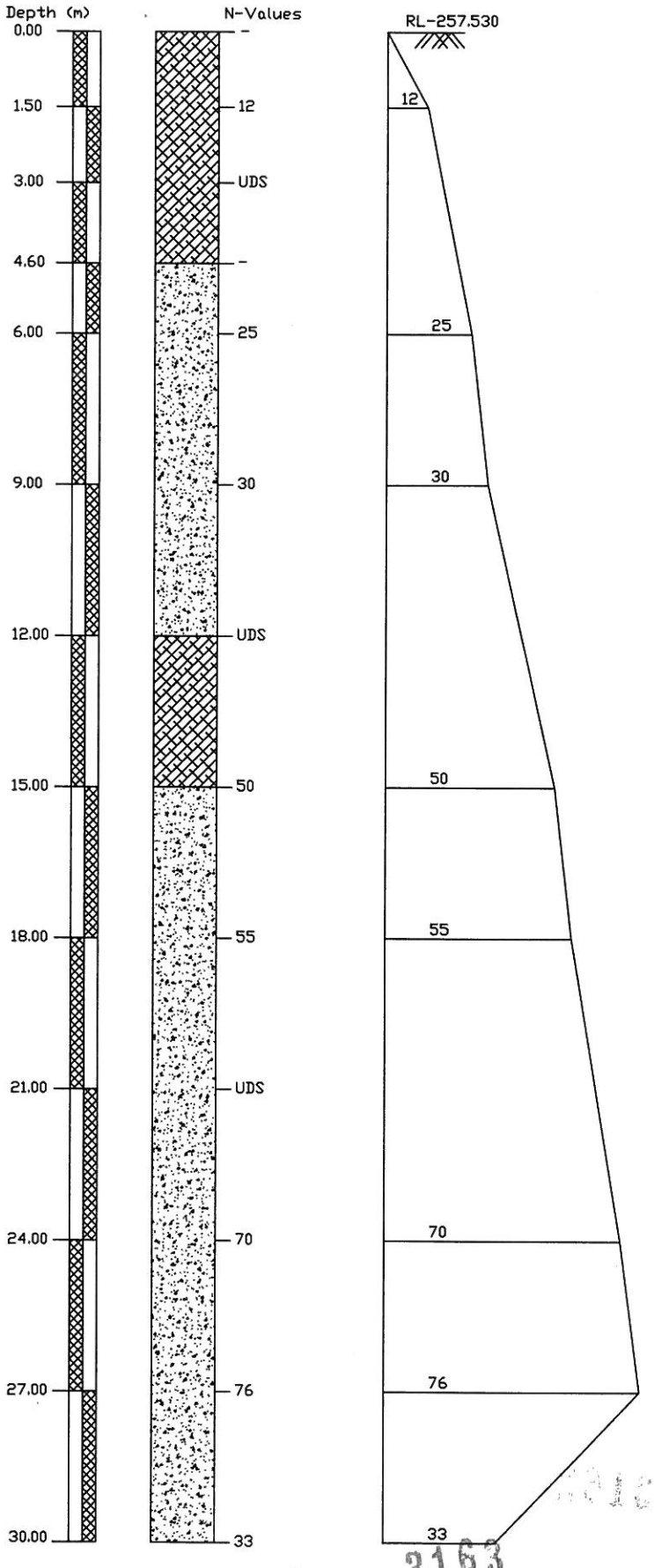
DFCCIL KESARI TO SANEHWAL

BORELOG OF BH–1(A1) AT EXISTING KM–353/35–354/4 FOR MAJOR BRIDGE NO.–385,
ON KESARI TO SANEHWAL, LUDHIANA

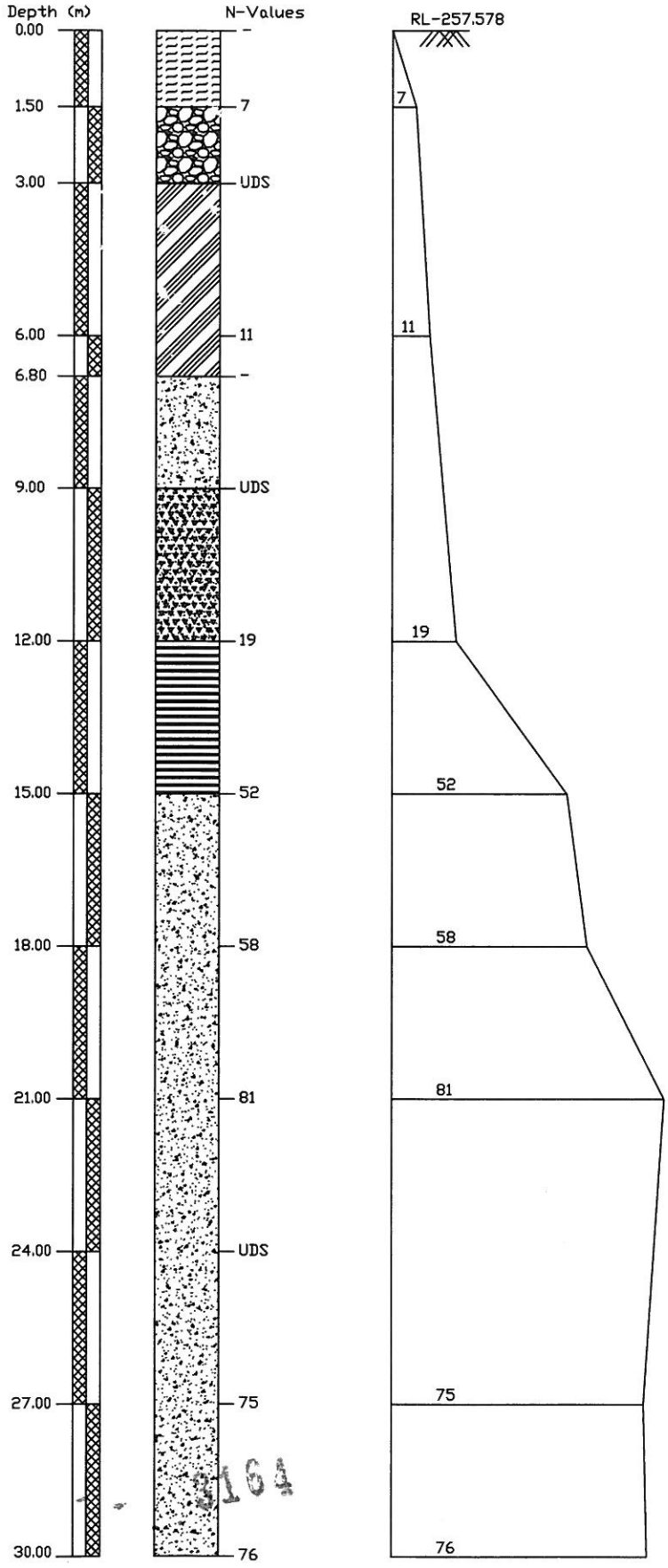


LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT
	SILTY SAND

3163

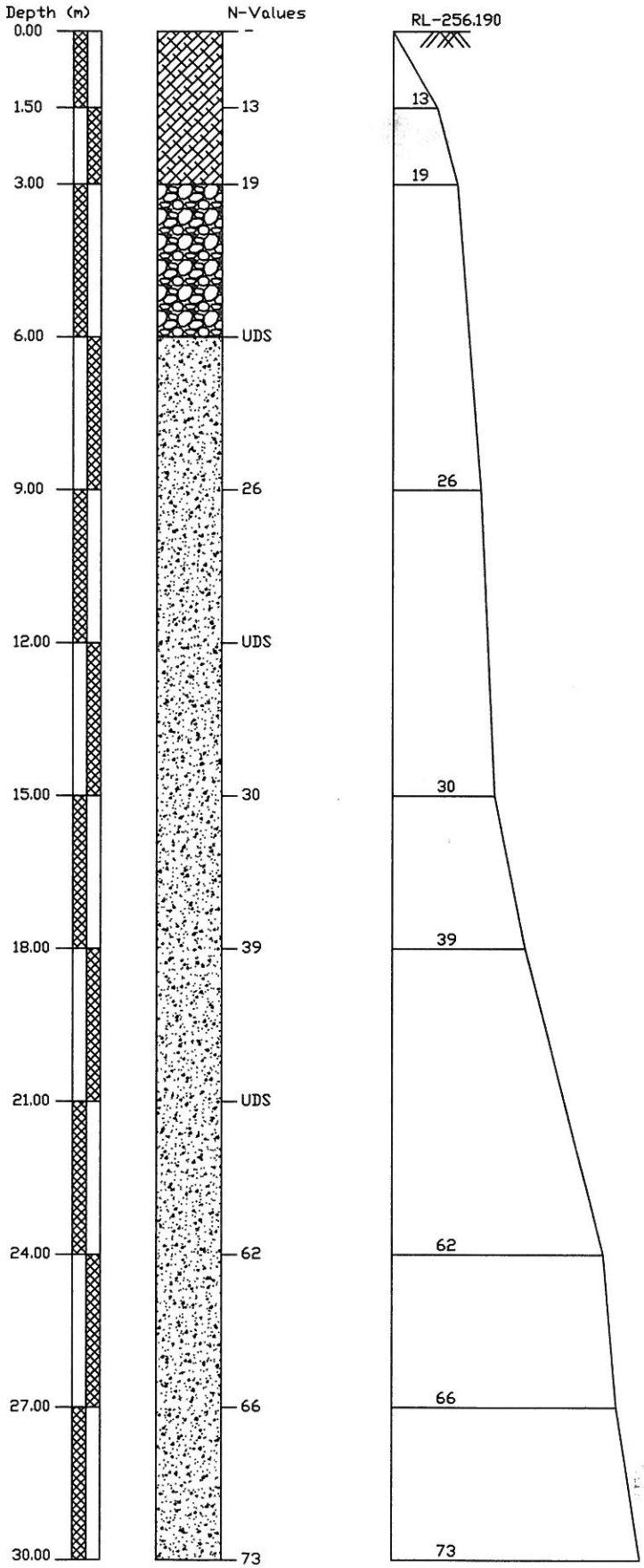
BORELOG OF BH–2(P1) AT EXISTING KM–353/35–354/4 FOR MAJOR BRIDGE NO.–385, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	FILLED UP STRATA
	SANDY SILT WITH GRAVELS
	SANDY SILT
	SILTY SAND
	SILTY SAND WITH GRAVELS
	CLAYEY SILT WITH SAND & GRAVELS

BORELOG OF BH–3(P4) AT EXISTING KM–353/35–354/4 FOR MAJOR BRIDGE NO.–385,
ON KESARI TO SANEHWAL, LUDHIANA

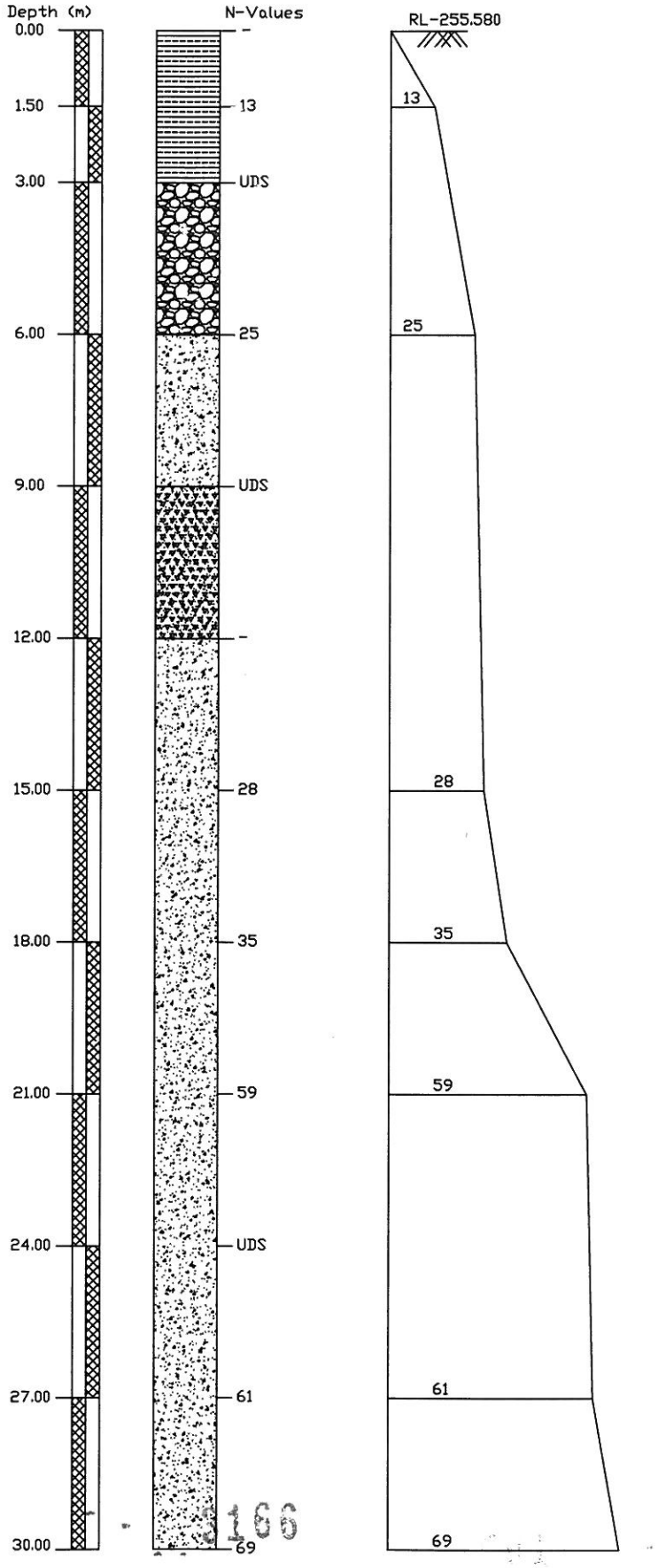


LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT
	SANDY SILT WITH GRAVELS
	SILTY SAND

3165

BORELOG OF BH–4(A2) AT EXISTING KM–353/35–354/4 FOR MAJOR BRIDGE NO.–385, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

25.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 3 x 24.4

25.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table 3.15m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1(A1)	0.00 to 1.50	Clayey silt	Loose
	1.50 to 4.60	Clayey silt	Medium Dense
	4.60 to 9.00	Silty Sand	Medium Dense
	9.00 to 12.00	Silty Sand	Dense
	12.00 to 15.00	Clayey silt	Dense
	15.00 to 18.00	Silty sand	Dense
	18.00 to 30.00	Silty sand	Very dense
BH-2(P1)	0.00 to 1.50	Filled up strata	-
	1.50 to 3.00	Sandy silt with gravels	Loose
	3.00 to 6.00	Sandy silt	Loose
	6.00 to 6.80	Sandy silt	Medium Dense
	6.80 to 9.00	Silty sand	Medium Dense
	9.00 to 12.00	Silty sand with gravels	Medium Dense
	12.00 to 15.00	Clayey silt with sand and gravels	Medium Dense
	15.00 to 30.00	Silty sand	Very dense
BH-3(P4)	0.00 to 1.50	Clayey silt	Loose
	1.50 to 3.00	Clayey silt	Medium Dense
	3.00 to 6.00	Sandy silt with gravels	Medium Dense
	6.00 to 15.00	Silty sand	Medium Dense
	15.00 to 24.00	Silty sand	Dense
	24.00 to 30.00	Silty sand	Very dense
BH-4 (A2)	0.00 to 1.50	Clayey silt with gravels	Loose
	1.50 to 3.00	Clayey silt with gravels	Medium Dense
	3.00 to 6.00	Sandy silt with gravels	Medium Dense
	6.00 to 9.00	Silty sand	Medium Dense
	9.00 to 12.00	Silty sand with gravels	Medium Dense
	12.00 to 18.00	Silty sand	Medium Dense
	18.00 to 21.00	Silty sand	Dense
	21.00 to 30.00	Silty sand	Very dense

25.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate	Salinity %
BH-1 (A1)	3.00	8.50	0.002	0.0014	NIL	0.0009	0.019
	21.00	8.50	0.002	0.0014	NIL	0.0009	0.022
BH-2 (P1)	3.00	7.20	NIL	0.0035	NIL	0.0012	0.067
	9.00	8.80	0.007	0.0014	NIL	0.0011	0.026
BH-3 (P4)	6.00	8.10	0.006	01.0015	NIL	0.0011	0.021
BH-4 (A2)	3.00	8.40	NIL	0.0014	NIL	0.0010	0.028
	9.00	8.80	0.010	0.0014	NIL	0.0010	0.025
	24.00	8.80	0.010	0.0011	NIL	0.0010	0.025

25.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1 (A1)	3.00	14
	12.00	17
	21.00	NIL
BH-2 (P1)	3.00	NIL
	9.00	NIL
	21.00	NIL
BH-3 (P4)	6.00	NIL
	12.00	NIL
	21.00	NIL
BH-4 (A2)	3.00	NIL
	9.00	NIL
	24.00	NIL

25.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BOREHOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (mg)
Test Result	7.3	125	109	157	1002	0.20	4.0	11.25	812
Requirment as per IS: 456 / Mosrth's	Not less then 6.0	2000 for CC and 500 for RCC	400	200	3000	5 ml of 0.02 normal NaoH	25 ml of 0.02 normal H_2SO_4	-	-

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25.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-A1	1.50	14.00
	3.00	18.00
	4.50	21.00
	2.00	22.00
BH-A2	1.50	11.50
	3.00	20.00
	4.50	20.50
	2.00	21.00

25.7 PILE LOAD CARRYING CAPACITY

25.7.1 Normal Bored Cast in- situ Pile Foundations:

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

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

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

Pile load carrying capacity in t/m²

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE
		DIAMETER OF THE PILE 1.00 mtr
BH-1 (A1)	18.00	160.00
	21.00	230.00
	24.00	300.00
BH-2 (P1)	18.00	170.00
	21.00	230.00
	24.00	280.00

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BH-3 (P4)	18.00	160.00
	21.00	200.00
	24.00	250.00
BH-4 (A2)	18.00	210.00
	21.00	270.00
	24.00	330.00

25.8 CONCLUSIONS

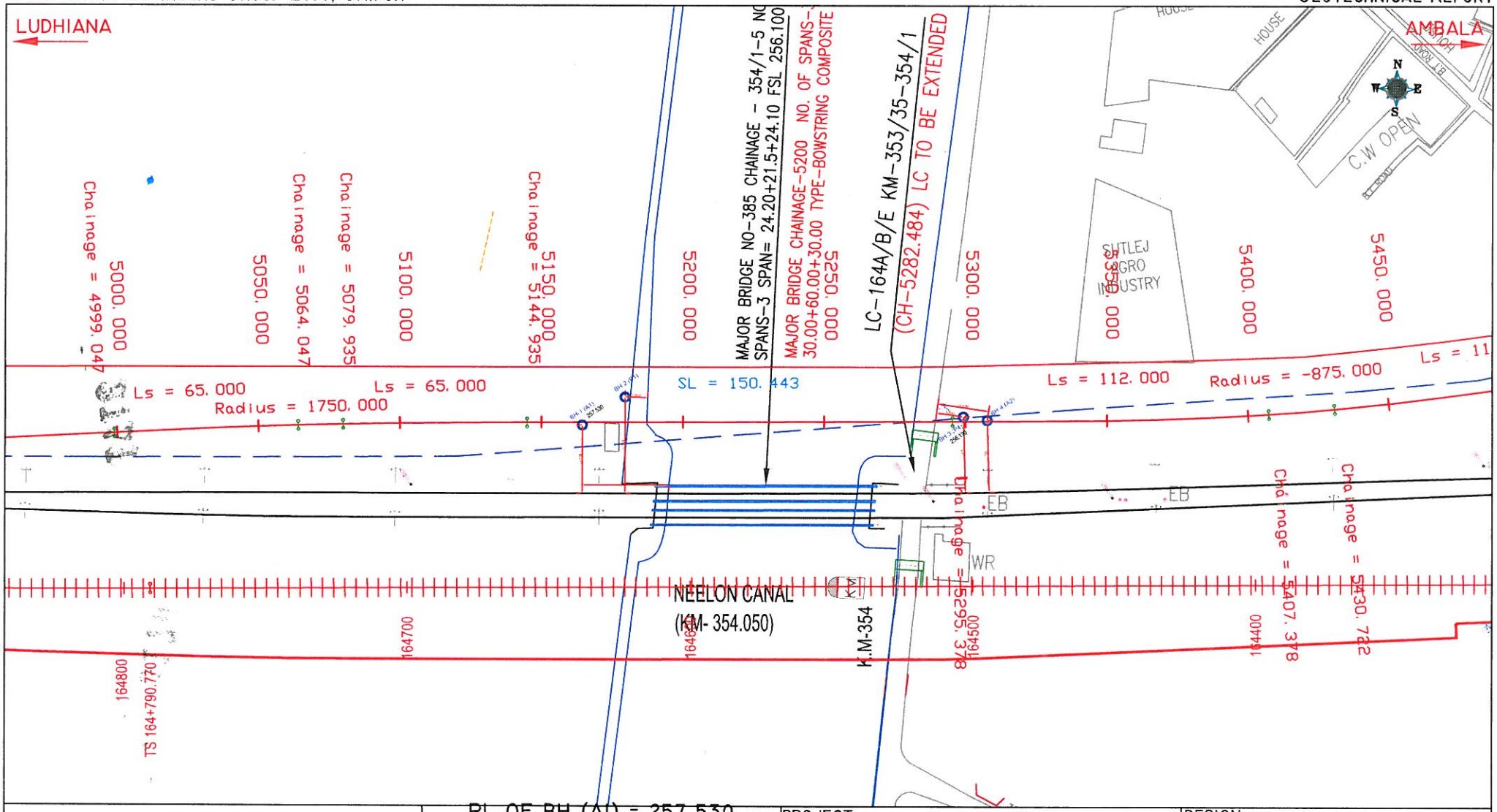
- Subsurface Profiles indicates suitable Soil formation for foundations.
- Chemical contents of Water are within the safe limits for construction purpose.

25.9 RECOMMENDATIONS

(i)	*Type of foundation*	Pile foundation

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

3170



ALL DIMENSIONS IN METER

FIG.:-I

LOCATION PLAN OF PROPOSED MAJOR BRIDGE AT CH. 353/35-354/4

RL OF BH (A1) = 257.530
RL OF BH (P1) = 257.578
RL OF BH (P4) = 256.190
RL OF BH (A2) = 255.58

PROJECT :-

LUDHIANA-AMBALA (DFCCIL)

DESIGN :-

CONSULTING ENGINEERS GROUP LTD.
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ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1(A1) OF MAJOR BRIDGE No. 385 AT CHAINAGE 354/0-1

Project :	Chainage 354/0-1 Bridge No. 385			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				27.05.2009 to 28.05.2009	A1	1	4.30 m.	30.00mtr	257.530

Depth	Observ-	Correction	Corrected	Soil	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific	Shear Strength	
from	ed	Factor		Description	Clay	Silt	Sand			Gravel								Gravity	c kg/cm^2	ϕ
GL (m)	N	C_n	N_n	(Soil Group)			Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			degree
0.00	-	-	-	Clayey Silt	13.68	79.15	6.35	0.82	0.00	0.00	0.00	25	15	10	-	-	-	-	-	-
1.50	12	1.46	17.52	Clayey Silt	13.60	79.83	5.86	0.61	0.10	0.00	0.00	24	15	9	-	-	-	-	-	-
3.00	UDS	-	-	Clayey Silt	15.95	70.61	10.90	0.30	0.14	2.10	0.00	27	16	11	1.71	4.11	1.64	2.64	0.11	21.00
4.60	-	-	-	Silty Sand	2.98	18.13	75.36	2.67	0.86	0.00	0.00	23	NIL	NP						
6.00	25	0.99	19.88	Silty Sand	3.15	9.65	85.73	1.47	0.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
9.00	30	0.86	20.40	Silty Sand	2.67	11.27	83.99	1.46	0.61	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
12.00	UDS	-	-	Clayey Silt	16.95	76.83	6.22	0.00	0.00	0.00	0.00	32	19	13	1.96	15.84	1.69	2.63	0.13	19.50
15.00	50	0.67	24.25	Silty Sand	2.36	12.99	82.63	2.02	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
18.00	55	0.60	24.00	Silty Sand	2.49	10.01	86.38	1.12	0.00	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
21.00	UDS	-	-	Silty Sand	3.25	8.65	85.17	2.93	0.00	0.00	0.00	25	NIL	NP	2.01	16.32	1.73	2.65	0.00	28.50
24.00	70	0.50	25.00	Silty Sand	2.69	9.46	79.76	2.55	1.47	4.07	0.00	26	NIL	NP	-	-	-	-	-	-
27.00	76	0.46	24.98	Silty Sand	3.48	6.02	87.47	3.03	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
30.00	33	0.42	13.86	Silty Sand	2.99	40.04	54.52	1.50	0.68	0.27	0.00	23	NIL	NP	-	-	-	-	-	-

DFCCIL *KESARI TO SANEHWAL*

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ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (P1) OF MAJOR BRIDGE No. 385 AT CHAINAGE 354/0-1

Project :	Chainage 354/0-1 Bridge No. 385			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				26.05.2009 to 27.05.2009	P1	2	5.15 m.	30.00mtr	257.578

Depth from GL (m)	Observ-ed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel									c kg/cm^2	ϕ degree
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
0.00	-	-	-	Filled up Strata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.50	7	1.50	10.50	Sandy Silt with Gravels	4.00	77.73	5.86	1.54	2.88	7.99	0.00	23	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt	4.59	78.35	15.33	1.68	0.05	0.00	0.00	21	NIL	NP	1.66	3.41	1.61	2.64	0.00	27.00
6.00	11	1.00	11.00	Sandy Silt	3.54	75.83	13.20	1.03	0.71	5.69	0.00	23	NIL	NP	-	-	-	-	-	-
6.80	-	-	-	Silty Sand	3.15	10.80	79.94	5.26	0.85	0.00	0.00	23	NIL	NP						
9.00	UDS	-	-	Silty Sand with Gravels	4.39	16.33	67.23	1.81	1.41	8.83	0.00	29	NIL	NP	1.89	16.23	1.63	2.65	0.00	27.50
12.00	19	0.75	14.25	Clayey Silt with Sand & Gravels	6.69	68.28	8.25	0.50	1.15	15.13	0.00	25	19	6	-	-	-	-	-	-
15.00	52	0.67	24.92	Silty Sand	3.59	10.82	84.54	1.05	0.00	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
18.00	58	0.61	25.19	Silty Sand	4.12	12.42	80.85	2.61	0.00	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
21.00	81	0.55	29.78	Silty Sand	2.69	12.47	79.26	5.58	0.00	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
24.00	UDS	-	-	Silty Sand	3.33	10.09	74.26	7.29	3.12	0.65	1.26	23	NIL	NP	2.00	17.12	1.71	2.64	0.00	28.50
27.00	75	0.46	24.75	Silty Sand	2.97	13.56	82.15	1.32	0.00	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
30.00	76	0.42	23.46	Silty Sand	4.12	39.57	52.67	3.64	0.00	0.00	0.00	21	NIL	NP	-	-	-	-	-	-

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-3 (P4) OF MAJOR BRIDGE No. 385 AT CHAINAGE 354/0-1

Project :	Chainage 354/0-1 Bridge No. 385			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				29.05.2009 to 30.05.2009	P4	5	3.45 m.	30.00mtr	256.190

Depth from GL (m)	Observed N	Correction Factor C_n	Corrected N_n	Soil Description (Soil Group)	Grain Size Distribution % wt retained							Atterberg Limits %			B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel										c kg/cm^2	ϕ degree
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.						
0.00	-	-	-	Clayey Silt	14.56	80.87	4.26	0.31	0.00	0.00	0.00	30	19	11	-	-	-	-	-	-
1.50	13	1.45	18.85	Clayey Silt	14.26	80.47	5.00	0.19	0.08	0.00	0.00	30	18	12	-	-	-	-	-	-
3.00	19	1.22	23.18	Sandy Silt with Gravels	3.69	77.94	10.63	0.83	1.30	5.61	0.00	28	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	2.25	8.92	87.30	1.53	0.00	0.00	0.00	28	NIL	NP	1.72	18.08	1.46	2.64	0.00	28.00
9.00	26	0.85	18.55	Silty Sand	3.25	4.51	89.04	3.20	0.00	0.00	0.00	24	NIL	NP		-	-	-	-	-
12.00	UDS	-	-	Silty Sand	2.49	13.86	78.69	4.29	0.67	0.00	0.00	25	NIL	NP	1.81	19.38	1.52	2.65	0.00	28.50
15.00	30	0.67	17.55	Silty Sand	3.25	19.18	73.73	2.92	0.64	0.28	0.00	22	NIL	NP	-	-	-	-	-	-
18.00	39	0.61	19.40	Silty Sand	3.25	5.68	88.57	2.43	0.07	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
21.00	UDS	-	-	Silty Sand	3.18	10.94	82.69	3.19	0.00	0.00	0.00	23	NIL	NP	1.84	18.77	1.55	2.66	0.00	28.00
24.00	62	0.51	23.31	Silty Sand	2.52	8.04	87.94	1.50	0.00	0.00	0.00	25	NIL	NP		-	-	-	-	-
27.00	66	0.47	23.01	Silty Sand	2.84	7.31	87.30	2.55	0.00	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
30.00	73	0.44	23.56	Silty Sand	2.93	10.94	83.91	2.22	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-

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ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-4 (A2) OF MAJOR BRIDGE No. 385 AT CHAINAGE 354/0-1

Project :	Chainage 354/0-1 Bridge No. 385			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				28.05.2009 to 29.05.2009	A2	4	3.15 m.	30.00mtr	255.580

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	-	-	-	Clayey Silt with Gravels	14.95	70.74	3.26	1.25	0.22	9.58	0.00	31	19	12	-	-	-	-	-	-
1.50	13	1.41	18.33	Clayey Silt with Gravels	18.22	57.83	4.23	2.56	4.47	12.69	0.00	34	20	14	-	-	-	-	-	-
3.00	UDS	-	-	Sandy Silt with Gravels	4.69	70.51	18.85	1.10	0.15	4.70	0.00	29	NIL	NP	1.98	10.41	1.79	2.66	0.00	29.50
6.00	25	0.94	19.25	Silty Sand	2.00	9.31	87.86	0.83	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand with Gravels	3.25	38.25	40.74	2.62	7.09	8.05	0.00	24	NIL	NP	2.02	16.83	1.73	2.66	0.00	31.50
12.00	-	-	-	Silty Sand	3.11	7.31	84.24	1.60	1.42	2.32	0.00	25	NIL	NP	-	-	-	-	-	-
15.00	28	0.63	16.32	Silty Sand	2.68	9.93	83.94	3.21	0.24	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
18.00	35	0.57	17.48	Silty Sand	2.67	25.26	64.96	5.02	1.00	1.09	0.00	21	NIL	NP	-	-	-	-	-	-
21.00	59	0.52	22.84	Silty Sand	2.96	8.47	85.68	2.72	0.07	0.10	0.00	24	NIL	NP		-	-	-	-	-
24.00	UDS	-	-	Silty Sand	3.19	25.08	61.24	4.53	2.84	3.12	0.00	27	NIL	NP	1.99	19.90	1.66	2.64	0.00	28.00
27.00	61	0.44	20.92	Silty Sand	3.51	15.81	73.82	3.70	2.05	1.11	0.00	25	NIL	NP	-	-	-	-	-	-
30.00	69	0.40	21.30	Silty Sand	2.51	7.33	84.24	5.92	0.00	0.00	0.00	19	NIL	NP	-	-	-	-	-	-

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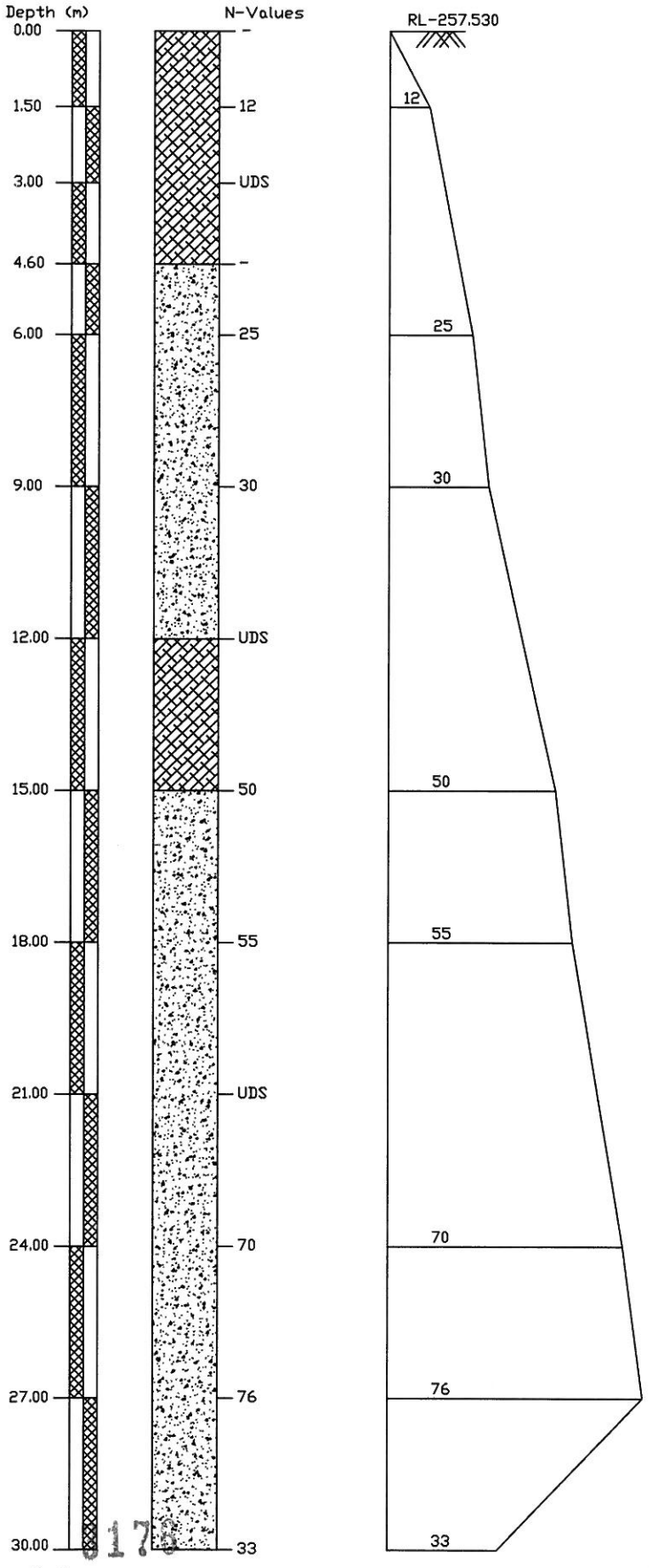
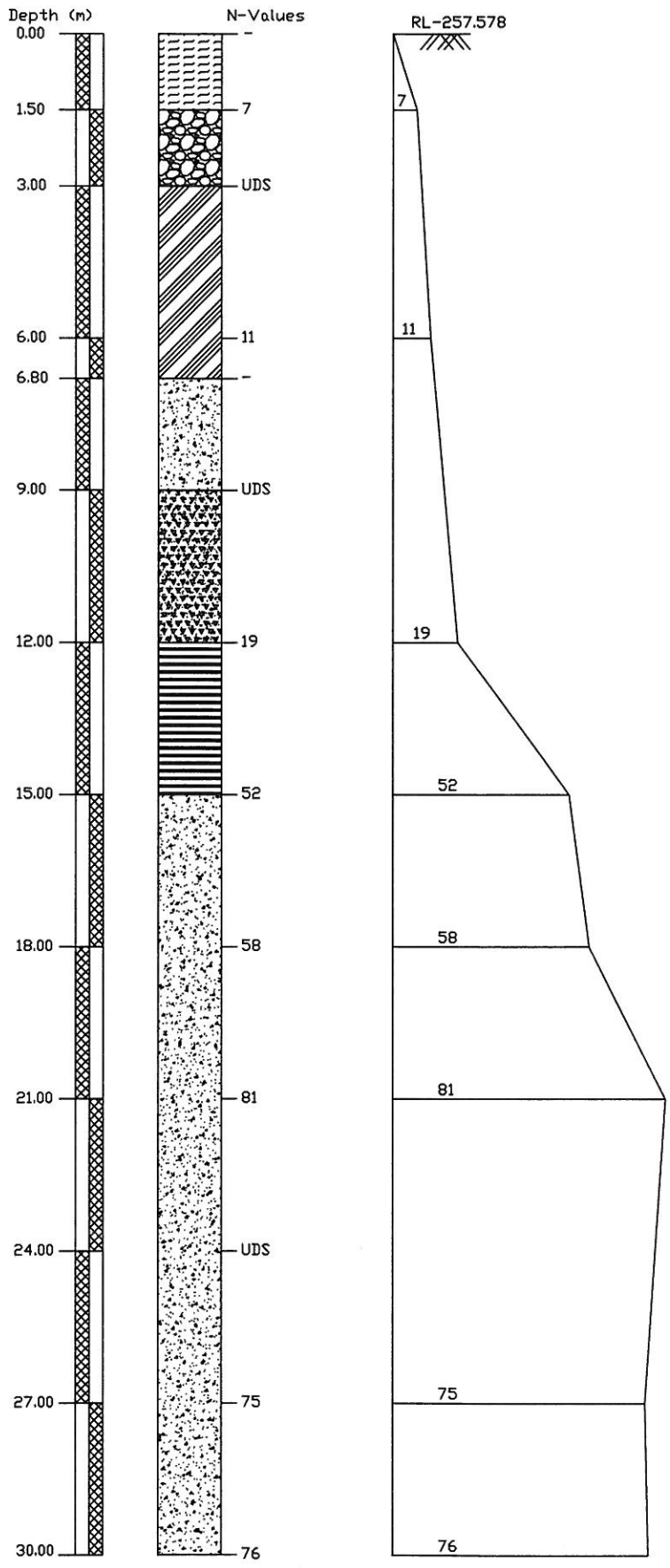
BORELOG OF BH–1(A1) AT EXISTING KM–353/35–354/4 FOR MAJOR BRIDGE NO.–385,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT
	SILTY SAND

BORELOG OF BH–2(P1) AT EXISTING KM–353/35–354/4 FOR MAJOR BRIDGE NO.–385, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	FILLED UP STRATA
	SANDY SILT WITH GRAVELS
	SANDY SILT
	SILTY SAND
	SILTY SAND WITH GRAVELS
	CLAYEY SILT WITH SAND & GRAVELS

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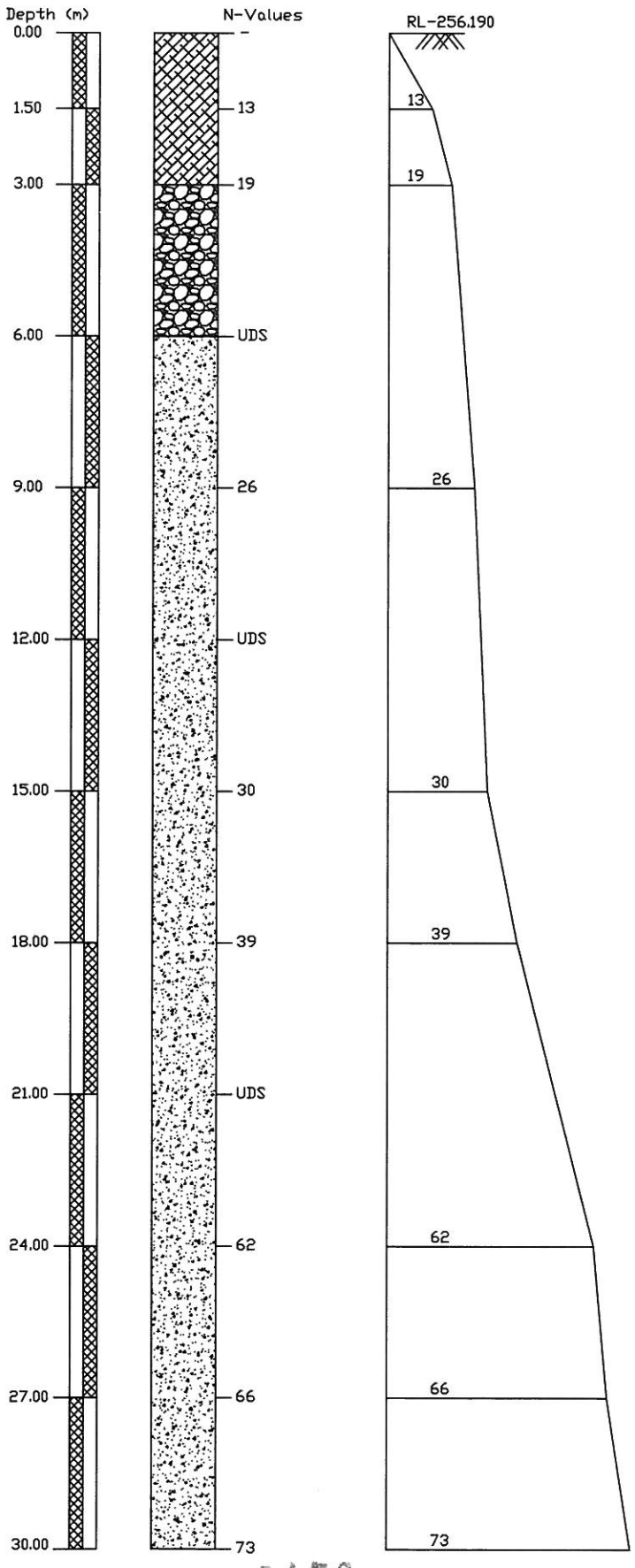
BORELOG OF BH–3(P4) AT EXISTING KM–353/35–354/4 FOR MAJOR BRIDGE NO.–385, ON KESARI TO SANEHWAL, LUDHIANA

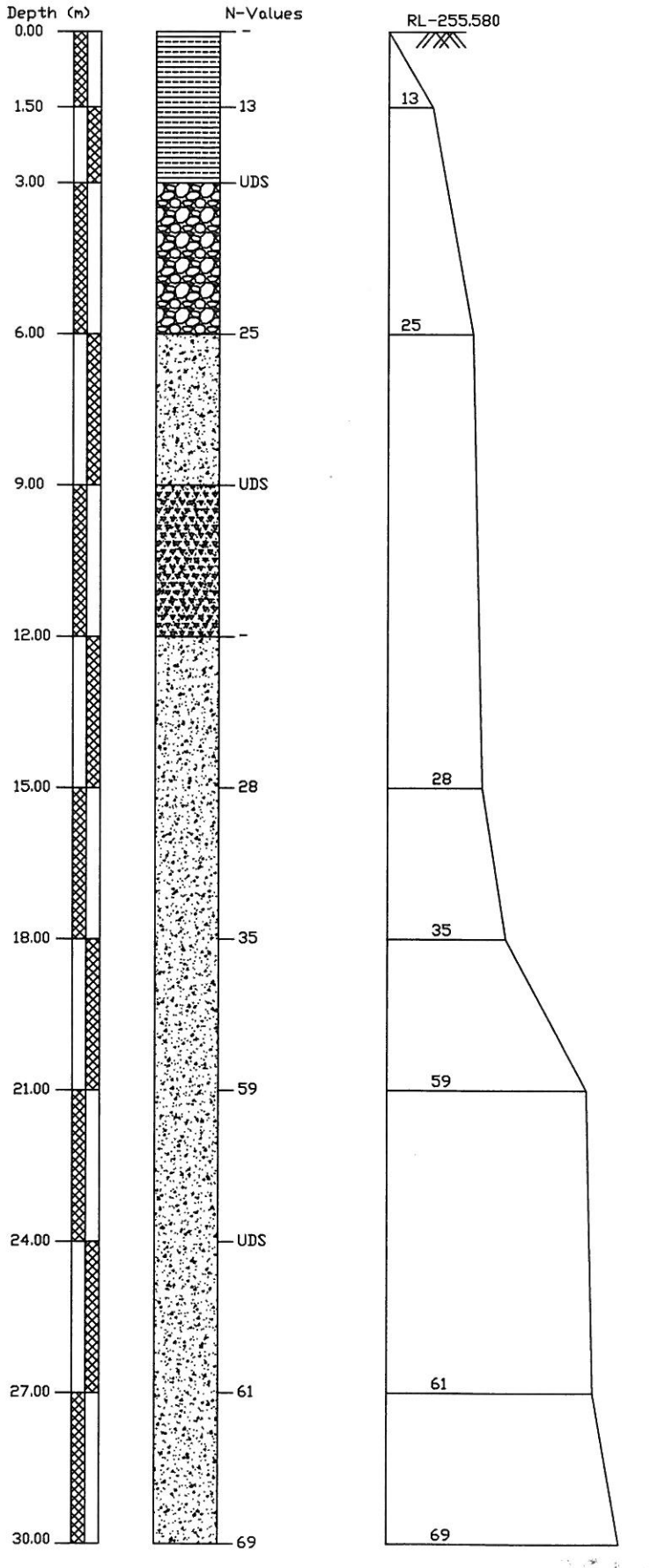


LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT
	SANDY SILT WITH GRAVELS
	SILTY SAND

3178

BORELOG OF BH–4(A2) AT EXISTING KM–353/35–354/4 FOR MAJOR BRIDGE NO.–385,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

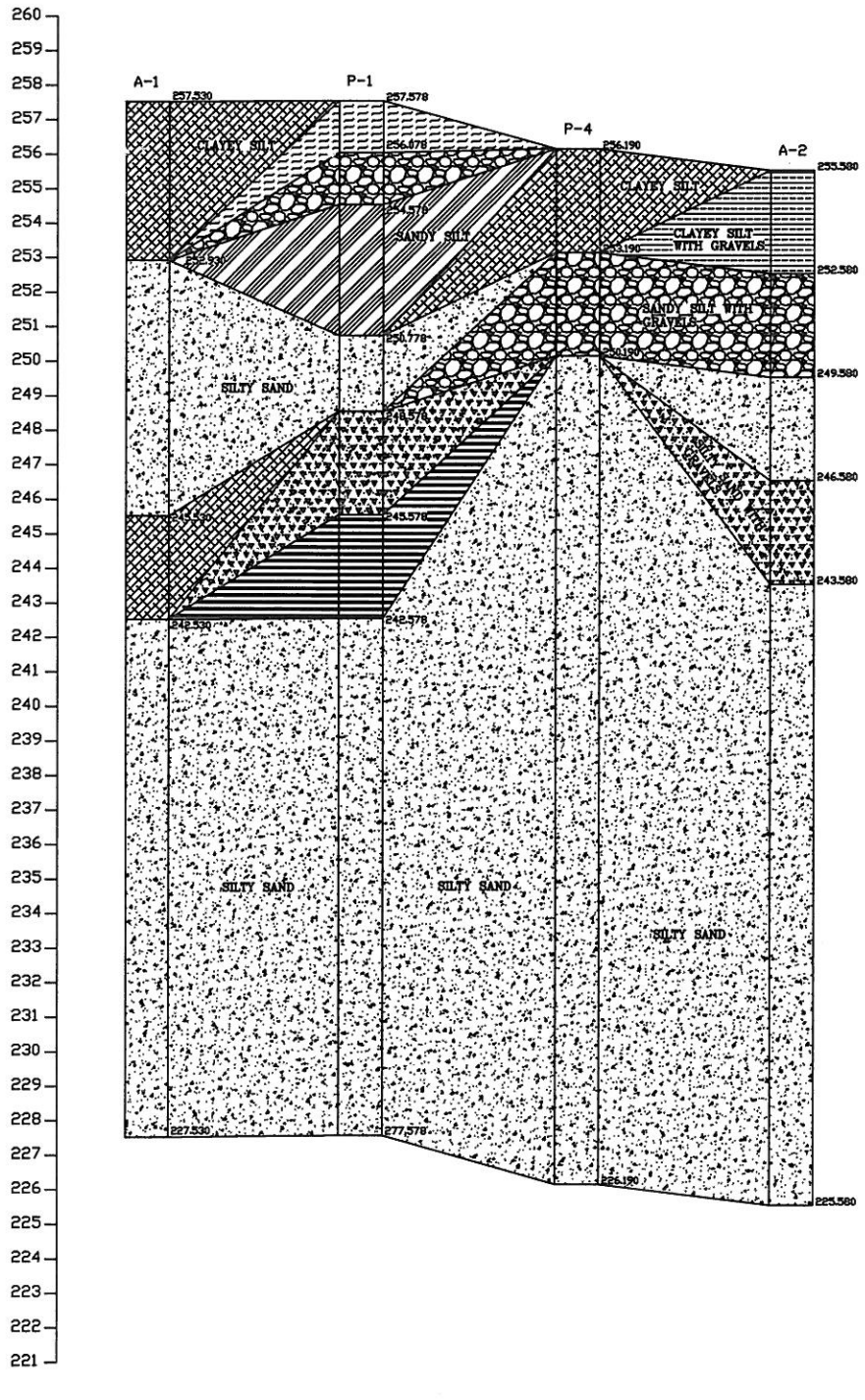
SYMBOL	DESCRIPTION
	CLAYEY SILT WITH GRAVELS
	SANDY SILT WITH GRAVELS
	SILTY SAND
	SILTY SAND WITH GRAVELS

3179

LUDHIANA

BORE HOLE DETAIL AT MAJOR BRIDGE NO. 385 CH.- 354/0-1 (NEELON CANAL)

AMBALA



LEGEND

SYMBOL	DESCRIPTION
	FILLED UP STRATA
	SILTY SAND
	SANDY SILT
	CLAYEY SILT
	SANDY SILT WITH GRAVELS
	SILTY SAND WITH GRAVELS
	CLAYEY SILT WITH SAND & GRAVELS
	CLAYEY SILT WITH GRAVELS

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ANNEXURE - III

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

INPUT DATA **Major Bridge No. 385** **BH-A1**

Type of footing

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

Angle of internal friction (ϕ °)	22.00
Cohesion (c in t/m2)	1.10
Void ratio (e)	0.61
Direction of load with vertical (^{o})	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)
1	1.50	2.00
2	3.00	2.00

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	22.00
N_c	17.19
N_q	8.10
N_γ	7.59

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

Shape factors :

S.no.	Width(m)	S_c	S_q	S_γ
1	2.00	1.00	1.00	1.00
2	2.00	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	2.00	1.22	1.11	1.11
2	3.00	2.00	1.44	1.22	1.22

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	2.00	0.00	0.50
2	3.00	2.00	-0.75	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shear	Local shear	Actual
1	1.50	2.00	16.82	7.02	13.88
2	3.00	2.00	21.59	9.04	17.82

ANNEXURE - III

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

INPUT DATA **Major Bridge No. 385** **BH-A1**

Type of footing

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

Angle of internal friction (ϕ °)	27.00
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)	1.71
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)
1	4.50	2.00
2	6.00	2.00

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)	S_c	S_q	S_γ
1	2.00	1.00	1.00	1.00
2	2.00	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	4.50	2.00	1.73	1.37	1.37
2	6.00	2.00	1.98	1.49	1.49

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	2.00	-1.50	0.50
2	6.00	2.00	-2.25	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shear	Local shear	Actual
1	4.50	2.00	25.80	9.34	20.86
2	6.00	2.00	28.11	10.18	22.73

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ANNEXURE - III

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

INPUT DATA **Major Bridge No. 385** **BH-1**

Type of footing

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

Angle of internal friction (ϕ°)	21.00
Cohesion (c in t/m2)	1.20
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)	1.90
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)
1	1.50	2.00

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	21.00
N_c	16.01
N_q	7.25
N_γ	6.49

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

Shape factors :

S.no.	Width(m)	S_c	S_q	S_γ
1	2.00	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	2.00	1.22	1.11	1.11

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	2.00	0.00	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shear	Local shear	Actual
1	1.50	2.00	15.97	6.95	11.46

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ANNEXURE - III

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

INPUT DATA **Major Bridge No. 385** **BH-1**

Type of footing

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

Angle of internal friction (ϕ °)	29.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.49
Direction of load with vertical (^{0})	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.98
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)
1	3.00	2.00
2	4.50	2.00
3	6.00	2.00

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.

CONSULTING Engineers Group Ltd.

ANNEXURE - III

Bearing capacity factors :

ϕ	29.50
N_c	29.20
N_q	17.63
N_γ	21.25

ϕ'	20.76
N'_c	15.73
N'_q	7.05
N'_γ	6.22

Shape factors :

S.no.	Width(m)	S_c	S_q	S_γ
1	2.00	1.00	1.00	1.00
2	2.00	1.00	1.00	1.00
3	2.00	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	3.00	2.00	1.51	1.26	1.26
2	4.50	2.00	1.77	1.39	1.39
3	6.00	2.00	2.03	1.51	1.51

Inclination factors :

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

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	3.00	2.00	-0.75	0.50
2	4.50	2.00	-1.50	0.50
3	6.00	2.00	-2.25	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shear	Local shear	Actual
1	3.00	2.00	32.50	11.20	32.50
2	4.50	2.00	35.83	12.34	35.83
3	6.00	2.00	39.15	13.49	39.15

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

BH No. (A1)			**Major Bridge at Ch. 353/35-354/4**	
Depth of foundation		=	1.5	m
Length of footing (L)		=	2.0	m
Width of footing (B)		=	2.0	m
Initial effective stress at mid of layer	Po	=	5.1	t/m^2
Concentrated load *P*		=	14.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.22	
	ΔP	=	3.1	t/m^2
Compression Index	Cc	=	0.1	
Thickness of clay layer	H	=	3	m
Initial Void ratio	e_o	=	0.61	
	$\frac{Po + \Delta p}{Po}$	=	1.6039216	
Settlement of clay layer	S_f	=	$\frac{Cc}{1+ eo} \quad H \quad \log_{10} \frac{Po + \Delta P}{Po}$	
	S_f	=	0.0382329	m
		=	38.232881	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	=	1.00
Depth Factor		=	0.78

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

= 0.8

Pore Pressure correction = N.A.

Total Settlement		=	Sf x D.F.x R.F.x Pore Pr. Correction
	S_{f2}	=	**23.9 mm**

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

BH No. (A1)			**Major Bridge at Ch. 353/35-354/4**	
Depth of foundation		=	3.0	m
Length of footing (L)		=	2.0	m
Width of footing (B)		=	2.0	m
Initial effective stress at mid of layer	Po	=	6.375	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	=	0.248	
	ΔP	=	4.5	t/m^2
Compression Index	Cc	=	0.1	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.61	
	$\frac{Po + \Delta p}{Po}$	=	1.70024	

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

S_f = 0.02148 m

= 21.476 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 = 1.00

Depth Factor = 0.67

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} = 9.8 mm

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

Footing Depth (m)	**3.00**
SBC (t/m2)	3.87
Average N value	19
Settlement for 10 t/m2 (mm)	15.00
Settlement (mm) for SBC	5.81
Depth Correction	0.66
Corrected Settlement (mm)	**3.8**

Total Settlement (mm) **13.6**

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Major BridgeNo. 385
Chainage	353/35-354/4
Bore Hole No.	A1

Footing Depth (m)	4.50
SBC (t/m2)	21.00
Average N value	19
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	31.50
Depth Correction	0.57
Rigidity Correction	0.8
Corrected Total Settlement (mm)	14.4

Footing Depth (m)	6.00
SBC (t/m2)	22.00
Average N value	19
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	33.00
Depth Correction	0.57
Rigidity Correction	0.8
Corrected Total Settlement (mm)	15.0

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Major Bridge No. 385 (P1)
Chainage	353/35-354/4

Footing Depth (m)	3.00
SBC (t/m2)	11.50
Average N value	11
Settlement for 10 t/m2 (mm)	29.00
Total Settlement (mm)	33.35
Depth Correction	0.67
Rigidity Correction	0.8
Corrected Total Settlement (mm)	17.9

Footing Depth (m)	4.50
SBC (t/m2)	12.00
Average N value	11
Settlement for 10 t/m2 (mm)	29.00
Total Settlement (mm)	34.80
Depth Correction	0.63
Rigidity Correction	0.8
Corrected Total Settlement (mm)	17.5

Footing Depth (m)	6.00
SBC (t/m2)	13.00
Average N value	11
Settlement for 10 t/m2 (mm)	29.00
Total Settlement (mm)	37.70
Depth Correction	0.57
Rigidity Correction	0.8
Corrected Total Settlement (mm)	17.2

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Major Bridge No. 385 (P4)
Chainage	353/35-354/4
Bore Hole No.	P4

Footing Depth (m)	3.00
SBC (t/m2)	10.00
Average N value	23
Settlement for 10 t/m2 (mm)	11.60
Total Settlement (mm)	11.60
Depth Correction	0.67
Rigidity Correction	0.8
Corrected Total Settlement (mm)	6.2

Footing Depth (m)	4.50
SBC (t/m2)	11.00
Average N value	22
Settlement for 10 t/m2 (mm)	12.40
Total Settlement (mm)	13.64
Depth Correction	0.63
Rigidity Correction	0.8
Corrected Total Settlement (mm)	6.9

Footing Depth (m)	6.00
SBC (t/m2)	12.00
Average N value	21
Settlement for 10 t/m2 (mm)	13.20
Total Settlement (mm)	15.84
Depth Correction	0.57
Rigidity Correction	0.8
Corrected Total Settlement (mm)	7.2

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ANNEXURE - IV

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

BH No. (A2)			**Major Bridge at Ch. 353/35-354/4**	
Depth of foundation		=	1.5	m
Length of footing (L)		=	2.0	m
Width of footing (B)		=	2.0	m
Initial effective stress at mid of layer	Po	=	6.65	t/m^2
Concentrated load *P*		=	11.50	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.248	
	ΔP	=	2.9	t/m^2
Compression Index	Cc	=	0.063	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.49	
	$\frac{Po + \Delta p}{Po}$	=	1.43	

Settlement of clay layer

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

S_f = 0.00983012 m

= 9.8301171 mm

Correction for Depth and Rigidity of foundation on total settlement

Depth Factor Calculation

$D/(LB)^{\wedge 0.5}$ = 0.75

D = Depth of Foundation

L/B = 1.00

Depth Factor = 0.77

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

= 0.8

Pore Pressure correction = 0.85

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

S_{f2} = **5.1** **mm**

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

Footing Depth (m)	**1.50**
Effective Pr. (t/m2)	2.30
Average N value	19
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	3.45
Depth Correction	0.77
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**2.7**

Total Settlement (mm) **7.8**

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Major Bridge No. 385 (A2)
Chainage	354/0-1
Bore Hole No.	A2

Footing Depth (m)	3.00
SBC (t/m2)	20.00
Average N value	19
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	30.00
Depth Correction	0.66
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**15.8**

Footing Depth (m)	4.50
SBC (t/m2)	20.50
Average N value	19
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	30.75
Depth Correction	0.78
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**19.2**

Footing Depth (m)	6.00
SBC (t/m2)	15.00
Average N value	19
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	22.50
Depth Correction	0.69
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**12.4**

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CHAPTER – 26

"Major Bridge No. 361A",

Location – Existing Km. - 319/25-27

26.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 1x45.7

26.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table 13.80m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1 (A1)	0.00 to 1.50	Silty Sand	Loose
	1.50 to 3.00	Silty Sand with Gravels	Medium Dense
	3.00 to 4.50	Clayey Silt	Medium Dense
	4.50 to 6.00	Sandy Silt	Medium Dense
	6.00 to 10.50	Silty Sand	Medium Dense
	10.50 to 13.50	Silty Sand	Dense
	13.50 to 30.00	Silty Sand	Very Dense
BH-2 (A2)	0.00 to 0.50	Silty Sand	Loose
	0.50 to 1.50	Clayey Silt with Gravels	Loose
	1.50 to 3.00	Clayey Silt with Gravels	Medium Dense
	3.00 to 4.50	Silty Sand	Medium Dense
	4.50 to 10.50	Silty Sand	Dense
	10.50 to 12.00	Sandy Silt	Dense
	12.00 to 13.50	Clayey Silt	Dense
	13.50 to 19.50	Silty Sand	Dense
	19.50 to 30.00	Silty Sand	Very Dense

26.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate	Salinity %
BH-A1	3.00	8.50	0.005	0.0014	NIL	0.0010	0.033
	6.00	9.60	0.020	0.0014	NIL	0.0009	0.023
	15.00	8.70	0.007	0.0014	NIL	0.0009	0.021
BH-A2	3.00	8.40	0.002	0.0014	NIL	0.0009	0.022
	6.00	8.90	0.017	0.0011	NIL	0.0010	0.019
	18.00	8.70	0.010	0.0018	NIL	0.0010	0.022

26.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-A1	3.00	12
	6.00	NIL
	15.00	NIL

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BH-A2	3.00	NIL
	6.00	NIL
	18.00	NIL

26.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BOREHOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (µS/cm)
Test Result	7.5	106	95	195	875	0.1	3.0	1134	726
Requirment as per IS: 456 / Mosrth's	Not less then 6.0	2000 for CC and 500 for RCC	400	200	3000	5 ml of 0.02 normal NaoH	25 ml of 0.02 normal H_2SO_4	-	-

26.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m²)
BH-A1	1.50	9.00
	3.00	11.00
	4.50	27.00
	2.00	28.00
BH-A2	1.50	10.00
	3.00	16.00
	4.50	18.00
	2.00	19.00

26.7 PILE LOAD CARRYING CAPACITY

26.7.1 Normal Bored Cast in- situ Pile Foundations:

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

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

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

Pile load carrying capacity in t/m²

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE
		DIAMETER OF THE PILE 1.00 mtr
BH-1 (A1)	18.00	220.00
	21.00	280.00
	24.00	350.00
BH-2 (A2)	18.00	165.00
	21.00	230.00
	24.00	290.00

26.8 CONCLUSIONS

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

269RECOMMENDATIONS

(i)	*Type of foundation*	Pile foundation

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

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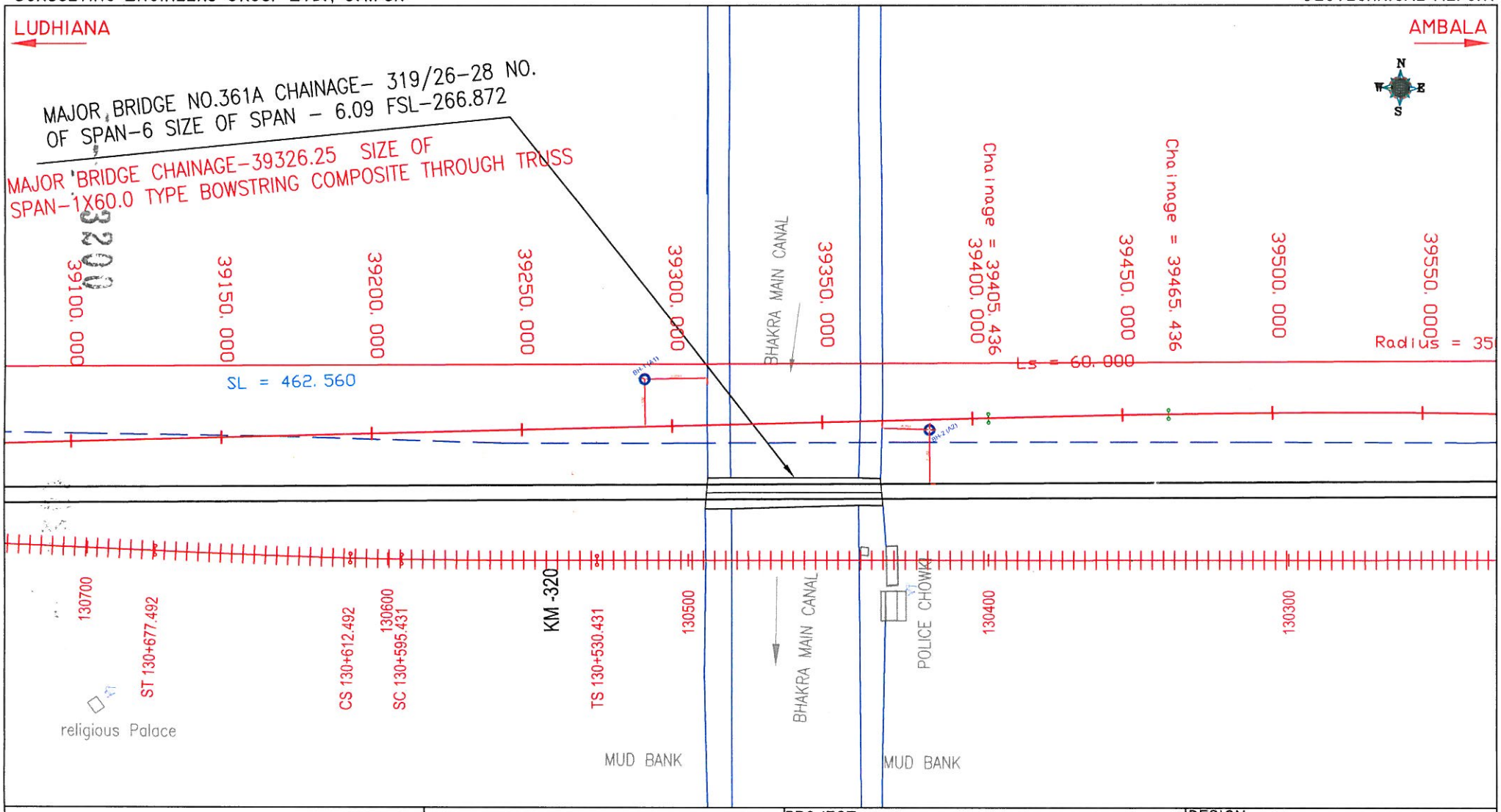

ALL DIMENSIONS IN METER

FIG.:-I
LOCATION PLAN OF PROPOSED MAJOR BRIDGE AT CH. 319/25-27

RL OF BH-(A1) = 263.403
RL OF BH-(A2) =263.643

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 (A1) OF MAJOR BRIDGE No. 361-A AT CHAINAGE 319/26-28

Project :	Chainage 319/26-28 Bridge No. 361-A			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				06.06.2009 to 07.06.2009	A1	1	13.80 m.	30.00mtr	263.403

Depth from	Observed	Correction Factor	Corrected	Soil Description	Grain Size Distribution % wt retained							Atterberg Limits %			B.D.	M.C.	D.D.	Specific Gravity	Shear Strength	
					Clay	Silt	Sand			Gravel									c kg/cm^2	ϕ
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	3.25	18.79	69.58	6.26	1.29	0.83	0.00	24	NIL	NP	-	-	-	-	-	-
1.50	12	1.44	17.28	Silty Sand with Gravels	3.39	28.34	60.76	1.44	0.78	5.29	0.00	26	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Clayey Silt	12.69	82.19	3.61	0.93	0.14	0.44	0.00	31	22	9	1.82	15.50	1.58	2.68	0.10	21.50
4.50	23	1.07	24.61	Sandy Silt	2.66	77.99	15.77	0.76	0.86	1.96	0.00	22	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	3.26	19.41	75.05	0.94	1.34	0.00	0.00	23	NIL	NP	1.96	7.05	1.83	2.64	0.00	27.50
7.50	29	0.89	25.81	Silty Sand	4.25	10.63	83.13	1.99	0.00	0.00	0.00	29	NIL	NP	-	-	-	-	-	-
10.50	47	0.77	36.19	Silty Sand	2.95	9.58	84.26	3.21	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
13.50	50	0.68	34.00	Silty Sand	3.25	13.19	81.03	2.23	0.08	0.22	0.00	26	NIL	NP	-	-	-	-	-	-
15.00	UDS	-	-	Silty Sand	0.00	7.69	80.09	8.36	1.34	2.52	0.00	30	NIL	NP	2.07	18.54	1.75	2.62	0.00	30.00
16.50	40	0.61	19.70	Silty Sand	0.00	12.11	85.59	2.30	0.00	0.00	0.00	28	NIL	NP		-	-	-	-	-
19.50	69	0.55	26.48	Silty Sand	2.45	12.54	83.39	1.54	0.08	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
22.50	44	0.50	18.50	Silty Sand	0.00	11.91	79.83	8.26	0.00	0.00	0.00	28	NIL	NP	-	-	-	-	-	-
25.50	48	0.46	18.54	Silty Sand	3.25	12.66	81.62	2.47	0.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
28.50	55	0.42	19.05	Silty Sand	2.69	14.14	80.95	2.11	0.11	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
30.00	66	0.40	20.70	Silty Sand	3.58	15.05	79.38	1.99	0.00	0.00	0.00	27	NIL	NP	-	-	-	-	-	-

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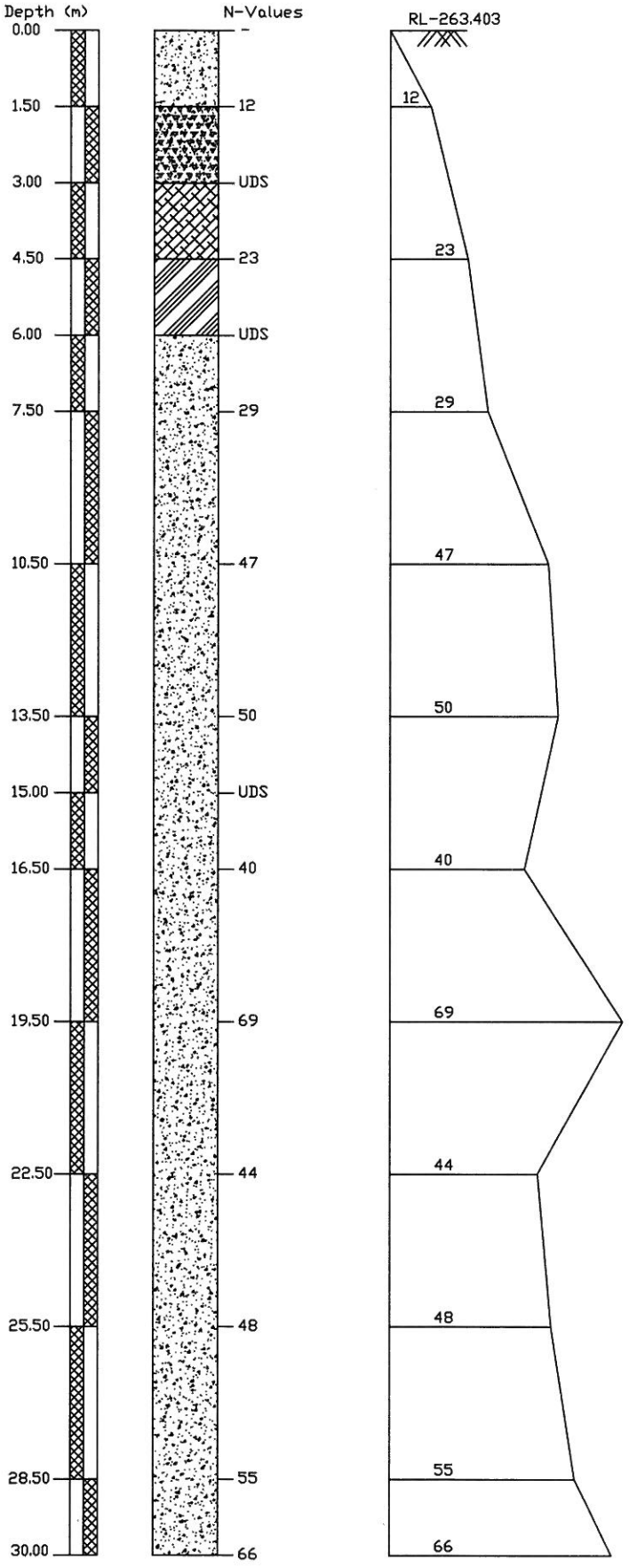
ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (A2) OF MAJOR BRIDGE No. 361-A AT CHAINAGE 319/25-27

Project :	Chainage 319/25-27 Bridge No. 361-A			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				07.06.2009 to 07.06.2009	A2	2	14.00 m.	30.00mtr	263.643

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	3.24	28.86	62.36	4.59	0.95	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
0.50				Clayey Silt with Gravels	12.69	71.02	3.25	2.59	0.12	10.33	0.00	29	20	9						
1.50	25	1.42	35.50	Clayey Silt with Gravels	10.37	58.67	6.25	3.89	7.74	13.08	0.00	27	19	8	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	2.36	44.44	53.00	0.20	0.00	0.00	0.00	25	NIL	NP	1.89	7.24	1.76	2.68	0.00	28.00
4.50	30	1.06	31.80	Silty Sand	2.59	35.39	59.64	1.58	0.71	0.09	0.00	23	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	2.12	5.53	91.30	1.05	0.00	0.00	0.00	28	NIL	NP	1.75	10.74	1.58	2.63	0.00	29.00
7.50	22	0.90	19.80	Silty Sand	0.00	16.85	79.22	3.66	0.27	0.00	0.00	21	NIL	NP	-	-	-	-	-	-
10.50	26	0.79	20.54	Sandy Silt	3.75	59.98	34.30	1.09	0.57	0.31	0.00	22	NIL	NP	-	-	-	-	-	-
12.00	37	0.74	27.38	Clayey Silt	16.25	81.20	2.26	0.21	0.08	0.00	0.00	36	23	13	-	-	-	-	-	-
13.50	47	0.71	33.37	Silty Sand	3.97	11.40	82.93	1.70	0.00	0.00	0.00	25	NIL	NP		-	-	-	-	-
16.50	42	0.64	20.94	Silty Sand	2.57	12.24	83.07	2.12	0.00	0.00	0.00	25	NIL	NP		-	-	-	-	-
18.00	UDS	-	-	Silty Sand	3.67	7.25	87.00	2.05	0.03	0.00	0.00	25	NIL	NP	1.89	19.74	1.58	2.64	0.00	27.50
19.50	69	0.58	27.51	Silty Sand	2.29	13.31	79.59	3.29	1.52	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
22.50	40	0.53	18.10	Silty Sand	2.67	6.57	89.21	1.40	0.15	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
25.50	59	0.49	21.96	Silty Sand	0	19.26	78.96	1.68	0.10	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
28.50	63	0.45	21.68	Silty Sand	3.19	12.19	82.62	2.00	0.00	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
30.00	68	0.43	22.12	Silty Sand	3.28	21.85	73.27	1.52	0.08	0.00	0.00	25	NIL	NP	-	-	-	-	-	-

BORELOG OF BH–1(A1) AT EXISTING KM–319/25–27 FOR MAJOR BRIDGE NO.–361 A,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

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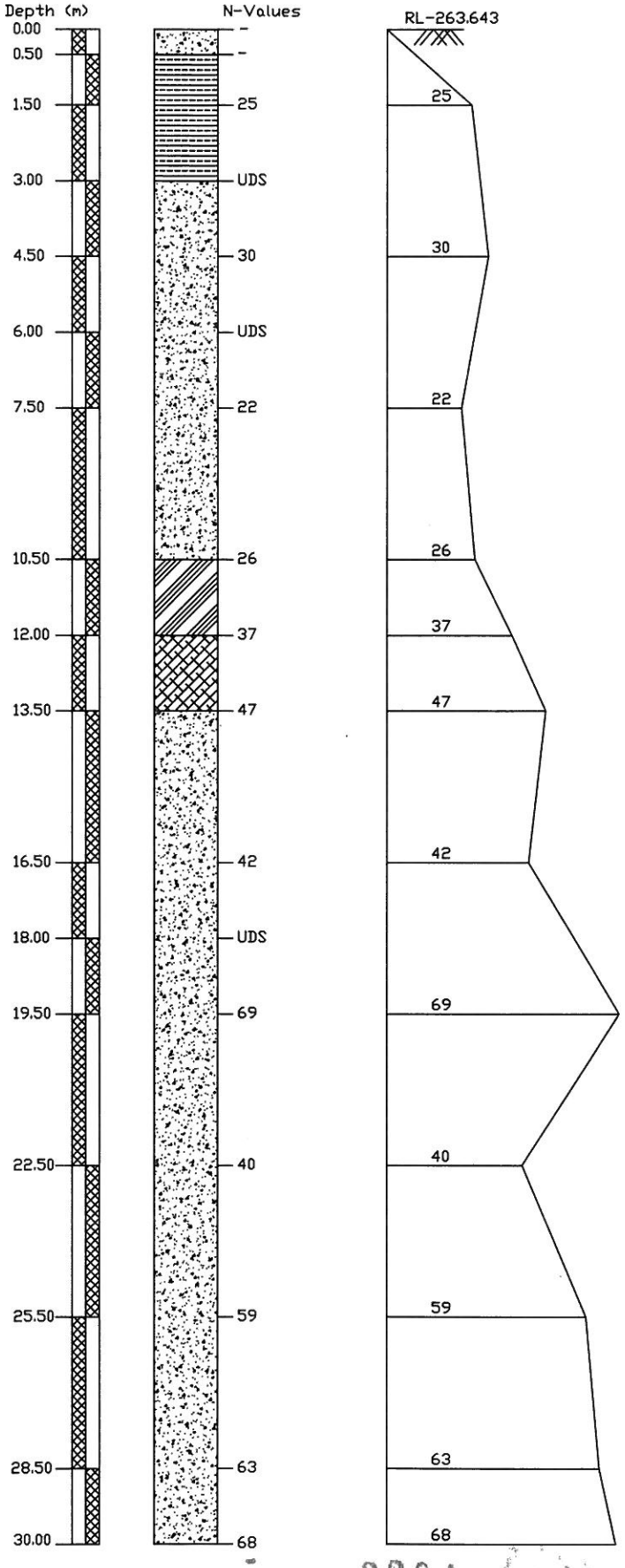
BORELOG OF BH–2(A2) AT EXISTING KM–319/25–27 FOR MAJOR BRIDGE NO.–361 A,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

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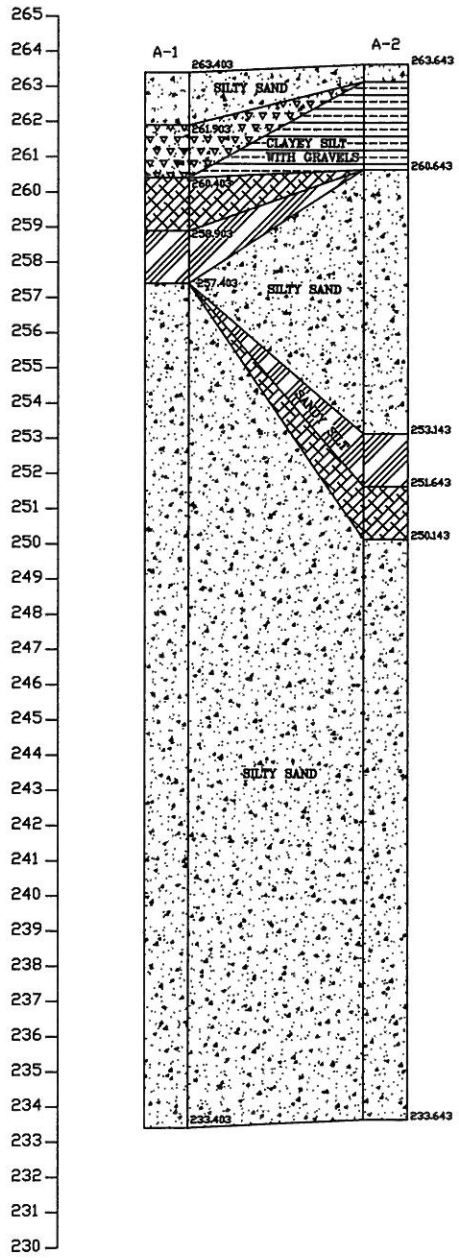
LUDHIANA

BORE HOLE DETAIL AT MAJOR BRIDGE NO. 361 A, CH.- 319/25-27 (BHAKRA CANAL)

AMBALA



LEGEND

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

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ANNEXURE - III

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

INPUT DATA **Major Bridge No. 361 A** **BH-A1**

Type of footing

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

Angle of internal friction (ϕ °)	21.50
Cohesion (c in t/m2)	1.00
Void ratio (e)	0.70
Direction of load with vertical (^{0})	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.82
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)
1	1.50	2.00
2	3.00	2.00

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	21.50
N_c	16.60
N_q	7.68
N_γ	7.04

ϕ'	14.78
N'_c	10.87
N'_q	3.88
N'_γ	2.59

Shape factors :

S.no.	Width(m)	S_c	S_q	S_γ
1	2.00	1.00	1.00	1.00
2	2.00	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	2.00	1.22	1.11	1.11
2	3.00	2.00	1.44	1.22	1.22

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	2.00	0.00	0.50
2	3.00	2.00	-0.75	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shear	Local shear	Actual
1	1.50	2.00	15.42	6.53	8.76
2	3.00	2.00	19.81	8.42	11.26

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ANNEXURE - III

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

INPUT DATA **Major Bridge No. 361 A** **BH-1**

Type of footing

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

Angle of internal friction (ϕ °)	27.50
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.44
Direction of load with vertical (^{o})	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)
1	4.50	2.00
2	6.00	2.00

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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ANNEXURE - III

Bearing capacity factors :

ϕ	27.50
N_c	25.43
N_q	14.53
N_γ	16.64

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

Shape factors :

S.no.	Width(m)	S_c	S_q	S_γ
1	2.00	1.00	1.00	1.00
2	2.00	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	4.50	2.00	1.74	1.37	1.37
2	6.00	2.00	1.99	1.49	1.49

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	2.00	-1.50	0.50
2	6.00	2.00	-2.25	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shear	Local shear	Actual
1	4.50	2.00	28.24	9.95	28.24
2	6.00	2.00	30.79	10.85	30.79

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ANNEXURE - III

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

INPUT DATA **Major Bridge No. 361 A** **BH-A2**

Type of footing

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

Angle of internal friction (ϕ °)	23.00
Cohesion (c in t/m2)	0.90
Void ratio (e)	0.69
Direction of load with vertical (^{o})	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)
1	1.50	2.00

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

OUTPUT

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

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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)	S_c	S_q	S_γ
1	2.00	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	2.00	1.23	1.11	1.11

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	2.00	0.00	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shear	Local shear	Actual
1	1.50	2.00	17.11	7.07	10.08

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ANNEXURE - III

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

INPUT DATA **Major Bridge No. 361 A** **BH-A2**

Type of footing

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

Angle of internal friction (ϕ °)	29.00
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)	1.70
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)
1	3.00	2.00
2	4.50	2.00
3	6.00	2.00

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	29.00
N_c	28.26
N_q	16.85
N_γ	20.10

ϕ'	20.37
N'_c	15.27
N'_q	6.72
N'_γ	5.80

Shape factors :

S.no.	Width(m)	S_c	S_q	S_γ
1	2.00	1.00	1.00	1.00
2	2.00	1.00	1.00	1.00
3	2.00	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	3.00	2.00	1.51	1.25	1.25
2	4.50	2.00	1.76	1.38	1.38
3	6.00	2.00	2.02	1.51	1.51

Inclination factors :

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

Water table factor :

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	3.00	2.00	-0.75	0.50
2	4.50	2.00	-1.50	0.50
3	6.00	2.00	-2.25	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shear	Local shear	Actual
1	3.00	2.00	29.89	10.25	16.15
2	4.50	2.00	32.93	11.30	17.79
3	6.00	2.00	35.96	12.34	19.42

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ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)

Major Bridge at Ch. 319/25-27, Bore hole no. A1

Footing Depth (m)	**1.50**
SBC (t/m2)	9.00
Average N value	17
Settlement for 10 t/m2 (mm)	17.00
Settlement (mm) for SBC	15.30
Depth Correction	0.78
Corrected Settlement (mm)	**11.9**

Settlement Calculation As per IS 8009 (Part 1)

BH No. (A1) — **Major Bridge at Ch. 319/25-27**

Depth of foundation		=	1.5	m
Length of footing (L)		=	2.0	m
Width of footing (B)		=	2.0	m
Initial effective stress at mid of layer	Po	=	6.75	t/m^2
Concentrated load *P*		=	9.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.248	
	ΔP	=	2.2	t/m^2
Compression Index	Cc	=	0.16	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.79	
	$\frac{Po + \Delta p}{Po}$	=	1.3306667	

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

S_f = 0.016635 m

= 16.634987 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 = 1.00

Depth Factor = 0.67

Rigidity Factor = $\frac{\text{Total Settlement of Rigid foundation}}{\text{Pore water pressure correction}}$ = N.A.

Total Settlement at the centre of Flexible foundation

= 0.8

Pore Pressure correction = N.A.

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

S_{f2} = **8.9** **mm**

Total settlement (mm) **20.9**

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Settlement Calculation As per IS 8009 (Part 1)

BH No. (A1) — **Major Bridge at Ch. 319/25-27**

Depth of foundation		=	3.0	m
Length of footing (L)		=	2.0	m
Width of footing (B)		=	2.0	m
Initial effective stress at mid of layer	Po	=	6.75	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	=	0.248	
	ΔP	=	2.7	t/m^2
Compression Index	Cc	=	0.16	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.79	
	$\frac{Po + \Delta p}{Po}$	=	1.4041481	

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

S_f = 0.0197649 m

= 19.764862 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 = 1.00

Depth Factor = 0.67

$$\text{Rigidity Factor} = \frac{\text{Total Settlement of Rigid foundation}}{\text{Pore water pressure correction}} = \text{N.A.}$$

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} = 9.0 mm

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

Footing Depth (m)	**3.00**
SBC (t/m2)	11.00
Average N value	25
Settlement for 10 t/m2 (mm)	10.00
Total Settlement (mm)	11.00
Depth Correction	0.67
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**5.9**

Total Settlement (mm) **14.9**

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Major Bridge No. 361A (A1)
Chainage	319/25-27
Bore Hole No.	A1

Footing Depth (m)	4.50
SBC (t/m2)	27.00
Average N value	25
Settlement for 10 t/m2 (mm)	10.00
Total Settlement (mm)	27.00
Depth Correction	0.73
Rigidity Correction	0.8
Corrected Total Settlement (mm)	15.8

Footing Depth (m)	6.00
SBC (t/m2)	28.00
Average N value	25
Settlement for 10 t/m2 (mm)	10.00
Total Settlement (mm)	28.00
Depth Correction	0.73
Rigidity Correction	0.8
Corrected Total Settlement (mm)	16.4

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

BH No. (A2) — **Major Bridge at Ch. 319/25-27**

Depth of foundation		=	1.5	m
Length of footing (L)		=	2.0	m
Width of footing (B)		=	2.0	m
Initial effective stress at mid of layer	Po	=	6.75	t/m^2
Concentrated load *P*		=	10.00	t/m^2
Incerase in pressure at mid of layer	ΔP	=	$P \times I_B$	
	I_B	=	0.248	
	ΔP	=	2.5	t/m^2
Compression Index	Cc	=	0.08	
Thickness of clay layer	H	=	1.5	m
Initial Void ratio	e_o	=	0.52	
	$\frac{Po + \Delta p}{Po}$	=	1.3674074	

Settlement of clay layer

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

S_f = 0.0107288 m

= 10.728784 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 = 1.00

Depth Factor = 0.78

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

= 0.8

Pore Pressure correction = 0.85

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

S_{f2} = **5.7** **mm**

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

Footing Depth (m)	**1.50**
SBC (t/m2)	10.00
Average N value	33
Settlement for 10 t/m2 (mm)	7.20
Total Settlement (mm)	7.20
Depth Correction	0.57
Rigidity Correction	0.8
Corrected Total Settlement (mm)	**3.3**

Total settlement (mm) **9.0**

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Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Major Bridge No. 361A (A2)
Chainage	319/25-27
Bore Hole No.	A2

Footing Depth (m)	3.00
SBC (t/m2)	16.00
Average N value	34
Settlement for 10 t/m2 (mm)	7.00
Total Settlement (mm)	11.20
Depth Correction	0.67
Rigidity Correction	0.8
Corrected Total Settlement (mm)	6.0

Footing Depth (m)	4.50
SBC (t/m2)	18.00
Average N value	32
Settlement for 10 t/m2 (mm)	7.50
Total Settlement (mm)	13.50
Depth Correction	0.63
Rigidity Correction	0.8
Corrected Total Settlement (mm)	6.8

Footing Depth (m)	6.00
SBC (t/m2)	19.00
Average N value	26
Settlement for 10 t/m2 (mm)	9.60
Total Settlement (mm)	18.24
Depth Correction	0.57
Rigidity Correction	0.8
Corrected Total Settlement (mm)	8.3

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CHAPTER – 27

"Major Bridge No. 359",

Location – Existing Km. - 316/22-24

27.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 1x18.3

27.2 BOREHOLE DESCRIPTIONS:

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

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

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

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

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

(f) Depth of water Table 13.50m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1 (A1)	0.00 to 1.50	Sandy Silt	Loose
	1.50 to 3.00	Sandy Silt	Medium Dense
	3.00 to 13.50	Silty Sand	Medium Dense
	13.50 to 25.50	Silty Sand	Dense
	25.50 to 30.00	Silty Sand	Very Dense
BH-2 (P2)	0.00 to 1.50	Sandy Silt	Loose
	1.50 to 3.00	Sandy Silt with Gravels	Medium Dense
	3.00 to 12.00	Silty Sand	Medium Dense
	12.00 to 25.50	Silty Sand	Dense
	25.50 to 30.00	Silty Sand	Very Dense
BH-3 (A2)	0.00 to 1.50	Sandy Silt with Clay	Loose
	1.50 to 3.00	Silty Sand with Clay	Medium Dense
	3.00 to 10.50	Silty Sand	Medium Dense
	10.50 to 22.50	Silty Sand	Dense
	22.50 to 30.00	Silty Sand	Very Dense

27.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate	Salinity %
BH-1 (A1)	3.00	8.90	0.012	0.0011	NIL	0.0009	0.023
	6.00	9.00	0.017	0.0021	NIL	0.0011	0.031
BH-2 (P2)	3.00	8.30	0.002	0.0014	NIL	0.0010	0.030
	6.00	9.10	0.017	0.0018	NIL	0.0012	0.020
BH-3 (A2)	3.00	8.40	NIL	0.0014	NIL	0.0010	0.021
	6.00	9.40	0.022	0.0025	NIL	0.0013	0.043
	18.00	8.80	0.015	0.0011	NIL	0.0010	0.020
	24.00	9.40	0.030	0.0028	NIL	0.0014	0.046

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27.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1 (A1)	3.00	NIL
	6.00	NIL
	22.50	NIL
BH-2 (P2)	3.00	NIL
	6.00	NIL
	18.00	NIL
BH-3 (A2)	3.00	NIL
	6.00	NIL
	18.00	NIL
	24.00	NIL

27.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BOREHOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (mg)
Test Result	7.2	110	112	185	1125	0.1	4.0	1236	823
Requirment as per IS: 456 / Mosrth's	Not less then 6.0	2000 for CC and 500 for RCC	400	200	3000	5 ml of 0.02 normal NaoH	25 ml of 0.02 normal H_2SO_4	-	-

27.6 NET ALLOWABLE BEARING PRESSURE

Borehole No.	Depth from EGL (m)	Net Allowable Bearing Pressure (t/m^2)
BH-A1	1.50	8.00
	3.00	10.00
	4.50	11.00
	2.00	12.00
BH-A2	1.50	16.00
	3.00	20.00
	4.50	20.50
	2.00	21.00

27.7 PILE LOAD CARRYING CAPACITY

27.7.1 Normal Bored Cast in- situ Pile Foundations:

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

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

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

Pile load carrying capacity in t/m²

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE
		DIAMETER OF THE PILE 1.00 mtr
BH-1 (A1)	18.00	180.00
	21.00	230.00
	24.00	280.00
BH-2 (P2)	18.00	160.00
	21.00	210.00
	24.00	260.00
BH-3 (A2)	18.00	210.00
	21.00	260.00
	24.00	330.00

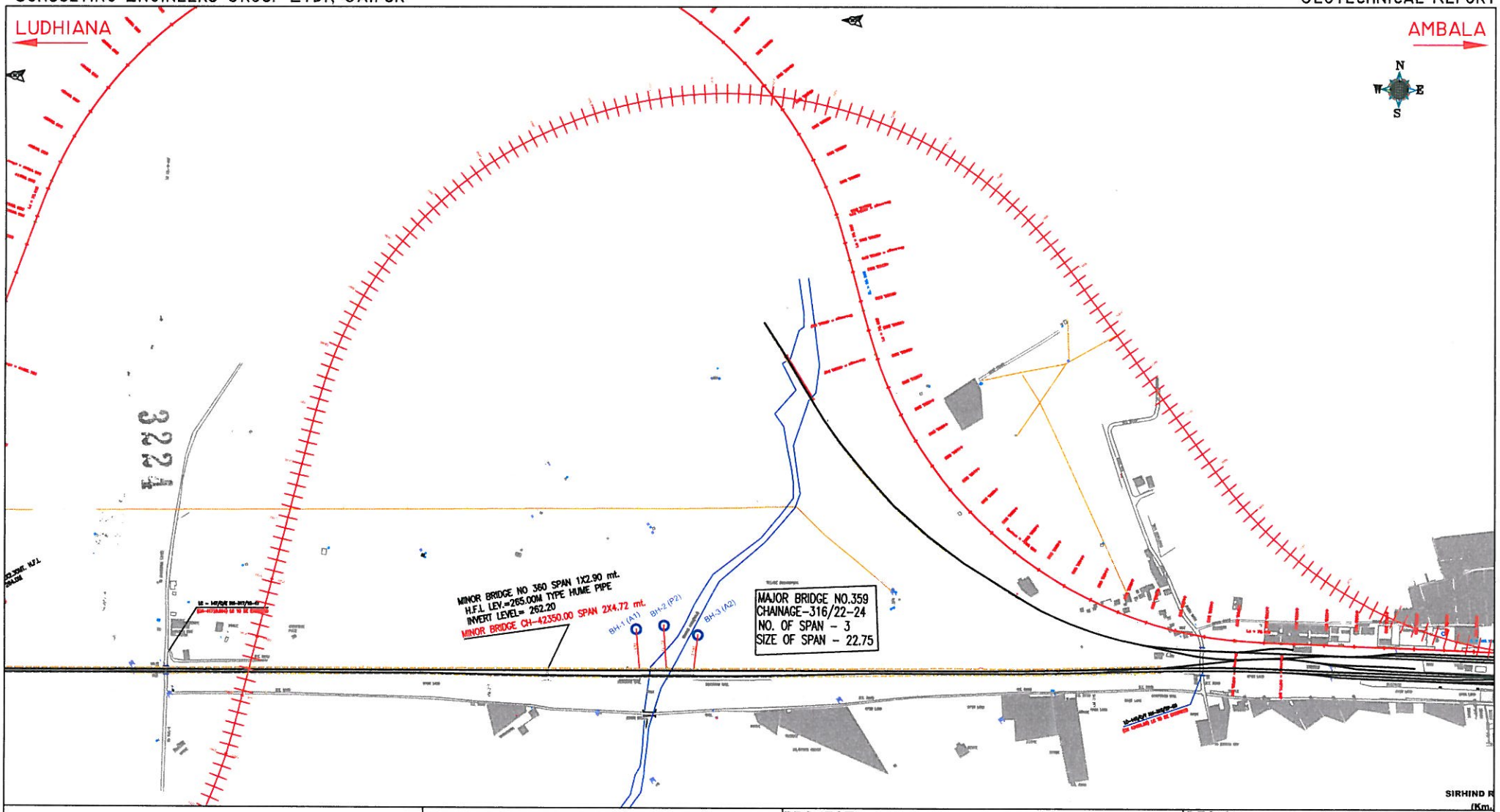
27.8 CONCLUSIONS

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

27.9 RECOMMENDATIONS

(i)	*Type of foundation*	Pile foundation

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



ALL DIMENSIONS IN METER

FIG.:-I

LOCATION PLAN OF PROPOSED MAJOR BRIDGE AT CH. 316/22-24

RL OF BH (AI) = 263.353
RL OF BH (P2) = 262.891
RL OF BH (A2) =262.766

PROJECT :-

LUDHIANA-AMBALA (DFCCIL)

DESIGN :-

CONSULTING ENGINEERS GROUP LTD.
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ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (A1) OF MAJOR BRIDGE No. 359 AT CHAINAGE 316/22-24

Project :	Chainage 316/22-24 Bridge No. 359			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				08.06.2009 to 08.06.2009	A1	1	13.50 m.	30.00mtr	263.353

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	61.69	30.29	3.28	0.65	0.83	0.00	26	NIL	NP	-	-	-	-	-	-
1.50	12	1.41	16.92	Sandy Silt	4.59	49.69	40.38	2.14	1.52	1.68	0.00	32	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	3.25	14.36	80.88	1.51	0.00	0.00	0.00	24	NIL	NP	1.94	5.83	1.83	2.63	0.00	28.00
4.50	16	1.05	16.80	Silty Sand	3.66	7.75	83.53	2.58	0.68	1.80	0.00	25	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	2.49	3.70	86.78	5.14	0.53	1.36	0.00	30	NIL	NP	1.66	7.87	1.54	2.67	0.00	28.00
7.50	21	0.90	18.90	Silty Sand	2.53	11.54	80.29	3.69	1.95	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
10.50	25	0.79	19.75	Silty Sand	4.21	5.67	84.60	2.14	0.91	2.47	0.00	29	NIL	NP	-	-	-	-	-	-
12.00	28	0.75	21.00	Silty Sand	4.59	10.65	77.29	5.22	2.25	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
13.50	33	0.71	19.22	Silty Sand	3.21	9.48	78.55	6.76	2.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
16.50	38	0.65	19.85	Silty Sand	2.26	8.40	83.72	4.68	0.94	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
18.00	41	0.62	20.21	Silty Sand	2.94	1.85	86.26	8.26	0.69	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
19.50	45	0.60	21.00	Silty Sand	2.94	9.08	80.24	5.76	1.98	0.00	0.00	27	NIL	NP	-	-	-	-	-	-
22.50	UDS	-	-	Silty Sand	2.20	7.66	87.26	2.36	0.52	0.00	0.00	25	NIL	NP	1.83	18.04	1.55	2.67	0.00	28.50
25.50	52	0.50	20.50	Silty Sand	2.31	10.84	82.59	3.31	0.95	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
28.50	60	0.46	21.30	Silty Sand	3.00	2.85	85.36	8.56	0.23	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
30.00	66	0.45	22.35	Silty Sand	3.10	5.82	83.47	5.30	2.01	0.30	0.00	25	NIL	NP	-	-	-	-	-	-

CONSULTING Engineers Group Ltd.

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (P2) OF MAJOR BRIDGE No. 359 AT CHAINAGE 316/22-24

Project :	Chainage 316/22-24 Bridge No. 359			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				08.06.2009 to 09.06.2009	P2	2	13.50 m.	30.00mtr	262.891

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	2.25	68.05	20.68	3.67	2.20	3.15	0.00	23	NIL	NP	-	-	-	-	-	-
1.50	10	1.53	15.30	Sandy Silt with Gravels	2.10	68.17	13.82	4.64	3.09	6.42	1.76	22	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	2.21	22.86	64.55	10.38	0.00	0.00	0.00	24	NIL	NP	1.57	8.22	1.45	2.65	0.00	27.00
4.50	13	1.12	14.56	Silty Sand	1.31	5.12	89.85	3.07	0.28	0.37	0.00	26	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	2.69	2.60	89.00	5.71	0.00	0.00	0.00	30	NIL	NP	1.72	13.63	1.51	2.65	0.00	27.00
7.50	18	0.93	16.74	Silty Sand	3.22	8.38	79.01	4.20	2.07	3.12	0.00	27	NIL	NP	-	-	-	-	-	-
10.50	13	0.82	10.66	Silty Sand	3.59	6.53	79.10	8.20	1.49	1.09	0.00	29	NIL	NP	-	-	-	-	-	-
12.00	31	0.77	23.87	Silty Sand	2.25	14.05	72.89	6.85	2.70	1.26	0.00	24	NIL	NP	-	-	-	-	-	-
13.50	32	0.73	19.18	Silty Sand	2.69	8.75	77.95	9.32	1.29	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
16.50	37	0.66	19.71	Silty Sand	3.94	4.32	82.93	7.85	0.66	0.30	0.00	27	NIL	NP	-	-	-	-	-	-
18.00	UDS	-	-	Silty Sand	3.94	3.20	82.63	9.47	0.76	0.00	0.00	28	NIL	NP	1.85	18.74	1.56	2.66	0.00	27.50
19.50	42	0.60	20.10	Silty Sand	3.54	6.47	89.36	0.63	0.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
22.50	47	0.55	20.43	Silty Sand	1.94	6.11	85.94	4.91	0.88	0.22	0.00	28	NIL	NP	-	-	-	-	-	-
25.50	52	0.50	20.50	Silty Sand	2.56	5.39	82.00	7.95	2.10	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
28.50	58	0.46	20.84	Silty Sand	3.25	10.77	80.82	4.91	0.25	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
30.00	64	0.45	21.90	Silty Sand	3.67	5.54	85.54	3.72	0.51	1.02	0.00	27	NIL	NP	-	-	-	-	-	-

DFCCIL *KESARI TO SANEHWAL*

CONSULTING Engineers Group Ltd.

ANNEXURE - I

SOIL CHARACTERISTICS OF BORE HOLE AT BH-3 (A2) OF MAJOR BRIDGE No. 359 AT CHAINAGE 316/22-24

Project :	Chainage 316/22-24 Bridge No. 359			Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation
				08.06.2009 to 09.06.2009	A2	3	13.50 m.	30.00mtr	262.766

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	10.10	21.69	65.95	1.62	0.64	0.00	0.00	25	18	7	-	-	-	-	-	-
1.50	12	1.45	17.40	Silty Sand with Clay	8.36	31.68	59.71	0.25	0.00	0.00	0.00	24	17	7	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	2.62	9.16	87.89	0.33	0.00	0.00	0.00	26	NIL	NP	1.74	5.53	1.65	2.64	0.00	28.00
4.50	17	1.08	18.36	Silty Sand	3.28	32.82	63.07	0.83	0.00	0.00	0.00	27	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	2.94	8.69	87.11	1.26	0.00	0.00	0.00	29	NIL	NP	1.98	6.59	1.86	2.67	0.00	28.00
7.50	22	0.89	19.58	Silty Sand	2.67	7.68	84.78	4.87	0.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
10.50	30	0.77	23.10	Silty Sand	3.69	13.67	80.85	1.29	0.12	0.38	0.00	27	NIL	NP	-	-	-	-	-	-
12.00	34	0.73	24.82	Silty Sand	2.69	19.95	75.26	2.10	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
13.50	38	0.69	20.61	Silty Sand	3.25	12.50	83.29	0.96	0.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
16.50	42	0.62	20.52	Silty Sand	3.59	17.64	78.16	0.61	0.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
18.00	UDS	-	-	Silty Sand	2.94	3.82	84.00	8.86	0.38	0.00	0.00	26	NIL	NP	1.91	11.67	1.71	2.62	0.00	28.00
19.50	46	0.56	20.38	Silty Sand	3.52	8.23	86.29	1.96	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
22.50	52	0.51	20.76	Silty Sand	3.99	11.87	83.14	1.00	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
24.00	UDS	-	-	Silty Sand	2.29	28.74	67.77	1.20	0.00	0.00	0.00	24	NIL	NP	1.92	16.98	1.64	2.66	0.00	27.00
25.50	57	0.47	20.90	Silty Sand	1.58	10.20	87.11	1.03	0.08	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
28.50	61	0.43	20.62	Silty Sand	2.69	24.34	70.77	1.72	0.09	0.39	0.00	26	NIL	NP	-	-	-	-	-	-
30.00	68	0.42	21.78	Silty Sand	3.22	9.61	86.50	0.67	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-

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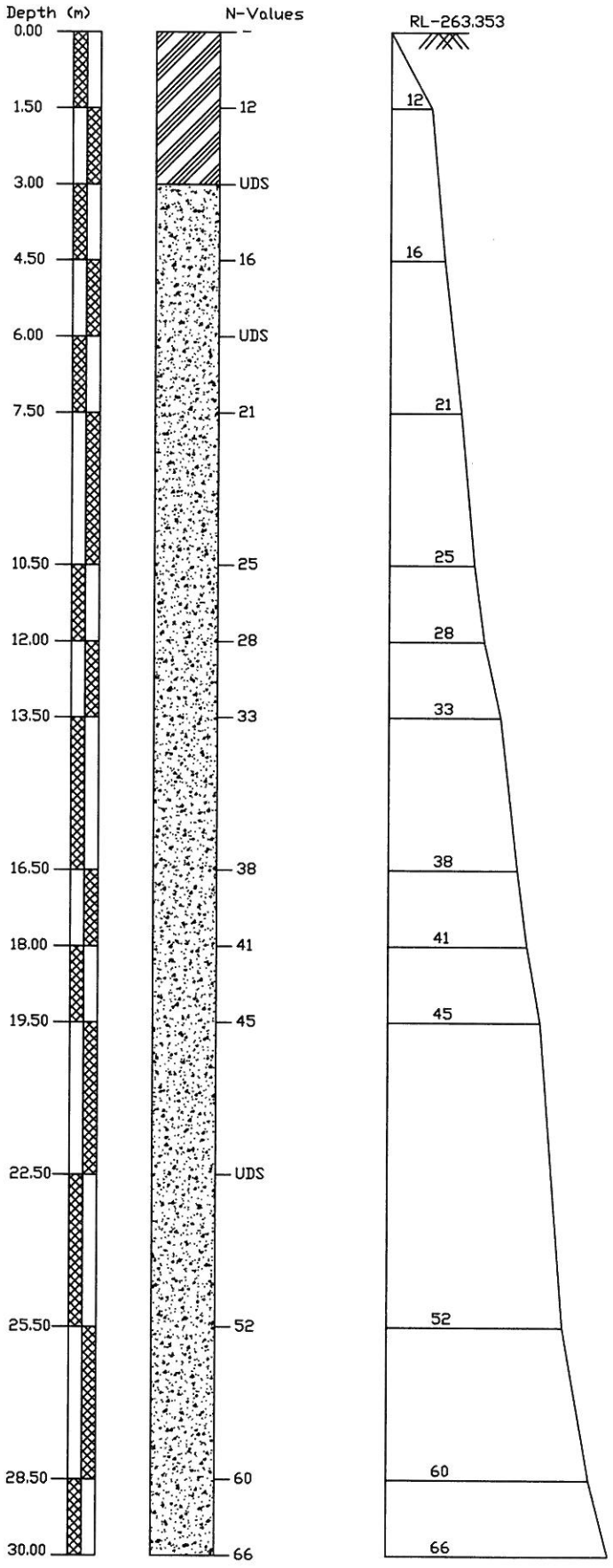
BORELOG OF BH–1(A1) AT EXISTING KM–316/22–24 FOR MAJOR BRIDGE NO.–359,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT
	SILTY SAND

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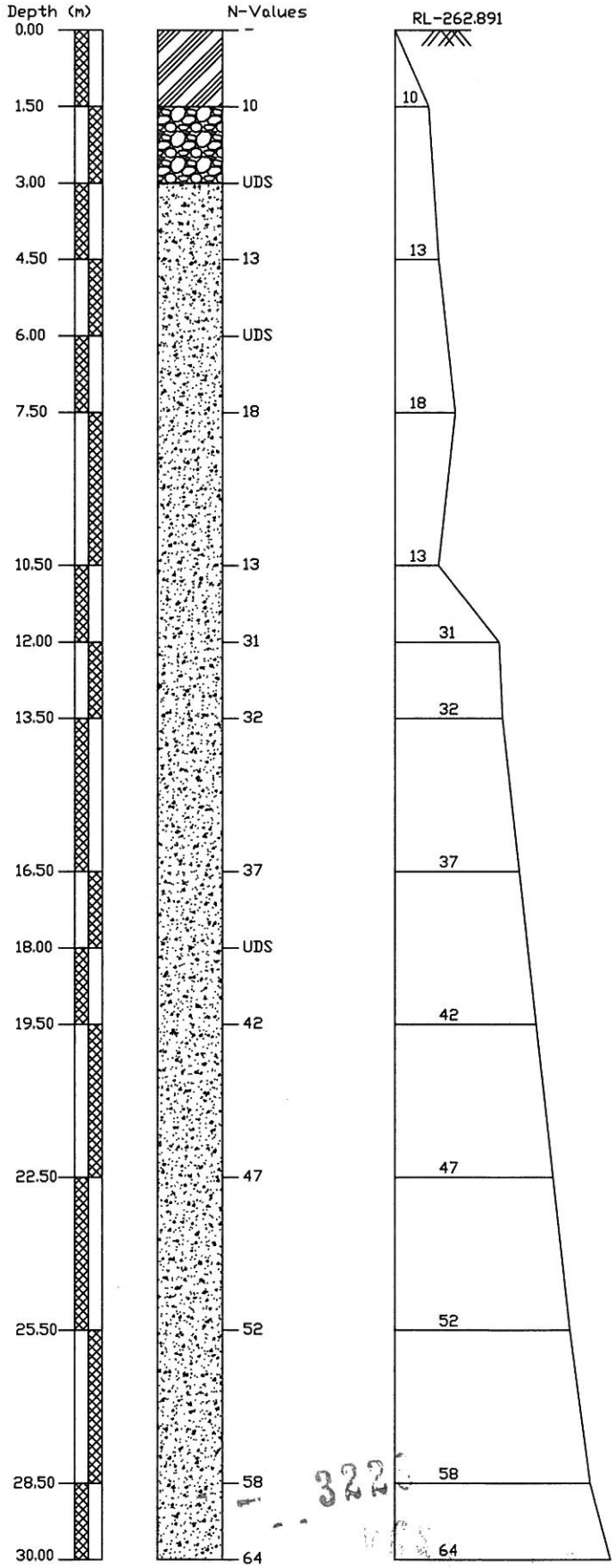
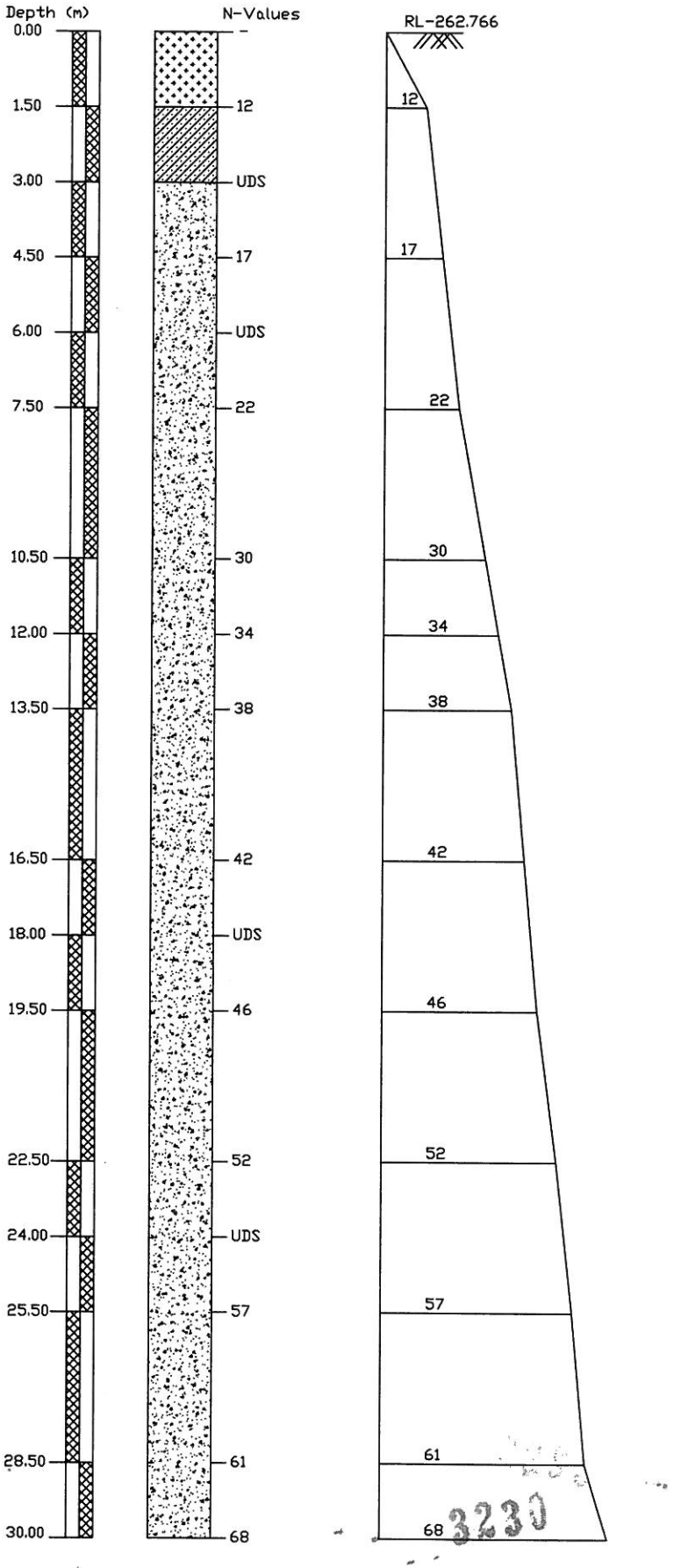
BORELOG OF BH–2(P2) AT EXISTING KM–316/22–24 FOR MAJOR BRIDGE NO.–359,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SANDY SILT
	SANDY SILT WITH GRAVELS
	SILTY SAND

BORELOG OF BH–3(A2) AT EXISTING KM–316/22–24 FOR MAJOR BRIDGE NO.–359, ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

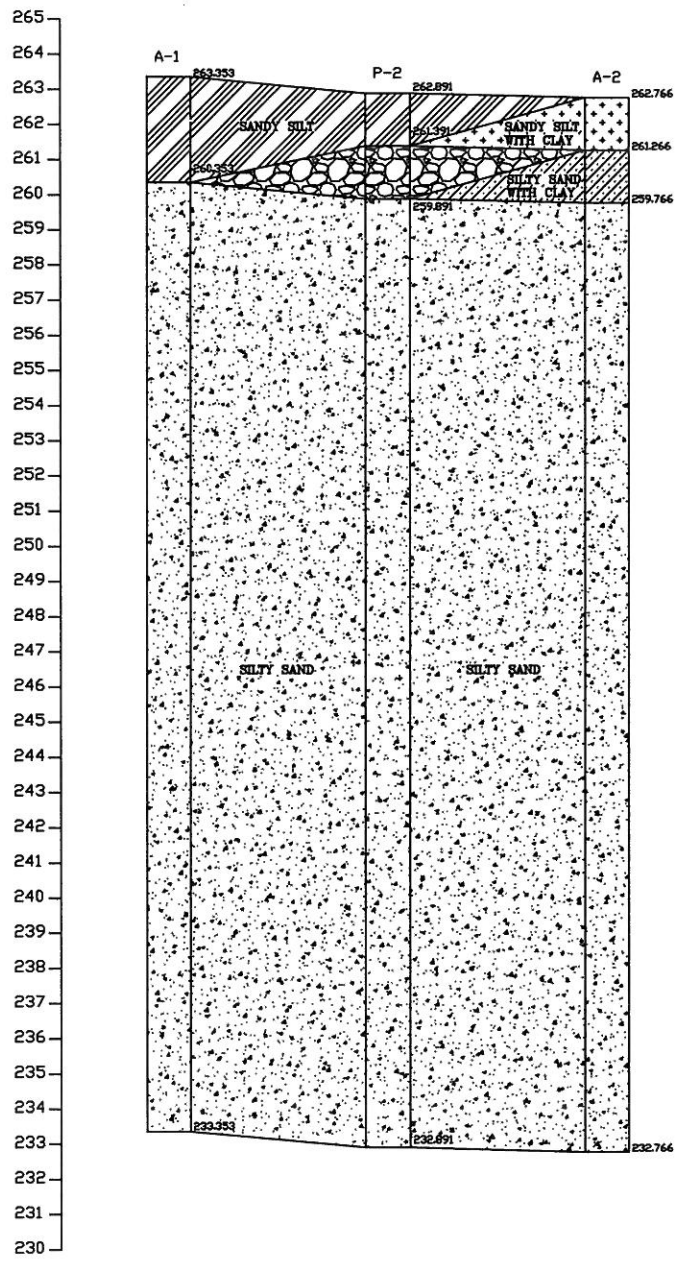
SYMBOL	DESCRIPTION
	SANDY SILT WITH CLAY
	SILTY SAND WITH CLAY
	SILTY SAND

3230

LUDHIANA

BORE HOLE DETAIL AT MAJOR BRIDGE NO. 359, CH.- 316/22-24

AMBALA



LEGEND

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

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ANNEXURE - III

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

INPUT DATA **Major Br. No. 359** **BH-A1**

Type of footing

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

Angle of internal friction (ϕ °)	28.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.73
Direction of load with vertical (i^c)	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)
1	1.50	2.00
2	3.00	2.00
3	4.50	2.00
4	6.00	2.00

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)	S_c	S_q	S_γ
1	2.00	1.00	1.00	1.00
2	2.00	1.00	1.00	1.00
3	2.00	1.00	1.00	1.00
4	2.00	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	2.00	1.25	1.12	1.12
2	3.00	2.00	1.50	1.25	1.25
3	4.50	2.00	1.75	1.37	1.37
4	6.00	2.00	2.00	1.50	1.50

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	2.00	0.00	0.50
2	3.00	2.00	-0.75	0.50
3	4.50	2.00	-1.50	0.50
4	6.00	2.00	-2.25	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shear	Local shear	Actual
1	1.50	2.00	18.89	6.47	7.71
2	3.00	2.00	25.93	8.99	10.68
3	4.50	2.00	28.52	9.89	11.75
4	6.00	2.00	31.11	10.79	12.82

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ANNEXURE - III

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

INPUT DATA **Major Br No. 359** **BH-A2**

Type of footing

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

Angle of internal friction (ϕ°)	28.00
Cohesion (c in t/m2)	0.00
Void ratio (e)	0.60
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m^3)	1.70
Density of foundation soil (t/m^3)	1.74
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)
1	1.50	2.00
2	3.00	2.00
3	4.50	2.00
4	6.00	2.00

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.

CONSULTING Engineers Group Ltd.

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ANNEXURE - III

Bearing capacity factors :

ϕ	28.00
N_c	26.37
N_q	15.30
N_γ	17.79

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

Shape factors :

S.no.	Width(m)	S_c	S_q	S_γ
1	2.00	1.00	1.00	1.00
2	2.00	1.00	1.00	1.00
3	2.00	1.00	1.00	1.00
4	2.00	1.00	1.00	1.00

Depth factors :

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.50	2.00	1.25	1.12	1.12
2	3.00	2.00	1.50	1.25	1.25
3	4.50	2.00	1.75	1.37	1.37
4	6.00	2.00	2.00	1.50	1.50

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	2.00	0.00	0.50
2	3.00	2.00	-0.75	0.50
3	4.50	2.00	-1.50	0.50
4	6.00	2.00	-2.25	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shear	Local shear	Actual
1	1.50	2.00	19.48	6.67	16.28
2	3.00	2.00	26.71	9.25	22.34
3	4.50	2.00	29.37	10.17	24.57
4	6.00	2.00	32.04	11.10	26.81

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Major Bridge No. 359 (A1)
Chainage	316/22-24
Bore Hole No.	A1

Footing Depth (m)	1.50
SBC (t/m2)	8.00
Average N value	16
Settlement for 10 t/m2 (mm)	18.00
Total Settlement (mm)	14.40
Depth Correction	0.78
Rigidity Correction	0.8
Corrected Total Settlement (mm)	9.0

Footing Depth (m)	3.00
SBC (t/m2)	10.00
Average N value	17
Settlement for 10 t/m2 (mm)	17.00
Total Settlement (mm)	17.00
Depth Correction	0.67
Rigidity Correction	0.8
Corrected Total Settlement (mm)	9.1

Footing Depth (m)	4.50
SBC (t/m2)	11.00
Average N value	17
Settlement for 10 t/m2 (mm)	17.00
Total Settlement (mm)	18.70
Depth Correction	0.63
Rigidity Correction	0.8
Corrected Total Settlement (mm)	9.4

Footing Depth (m)	6.00
SBC (t/m2)	12.00
Average N value	17
Settlement for 10 t/m2 (mm)	17.00
Total Settlement (mm)	20.40
Depth Correction	0.57
Rigidity Correction	0.8
Corrected Total Settlement (mm)	9.3

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Major Bridge No. 359 (P2)
Chainage	316/22-24
Bore Hole No.	P2

Footing Depth (m)	3.00
SBC (t/m2)	9.50
Average N value	15
Settlement for 10 t/m2 (mm)	19.00
Total Settlement (mm)	18.05
Depth Correction	0.67
Rigidity Correction	0.8
Corrected Total Settlement (mm)	9.7

Footing Depth (m)	4.50
SBC (t/m2)	10.50
Average N value	15
Settlement for 10 t/m2 (mm)	19.00
Total Settlement (mm)	19.95
Depth Correction	0.63
Rigidity Correction	0.8
Corrected Total Settlement (mm)	10.1

Footing Depth (m)	6.00
SBC (t/m2)	11.00
Average N value	16
Settlement for 10 t/m2 (mm)	18.00
Total Settlement (mm)	19.80
Depth Correction	0.57
Rigidity Correction	0.8
Corrected Total Settlement (mm)	9.0

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ANNEXURE - IV

Settlement Calculation for Cohesionless Soil As per IS 8009 (Part 1)	
Location	Major Bridge No. 359 (A2)
Chainage	316/22-24
Bore Hole No.	A2

Footing Depth (m)	1.50
SBC (t/m2)	16.00
Average N value	17
Settlement for 10 t/m2 (mm)	17.00
Total Settlement (mm)	27.20
Depth Correction	0.78
Rigidity Correction	0.8
Corrected Total Settlement (mm)	17.0

Footing Depth (m)	3.00
SBC (t/m2)	20.00
Average N value	18
Settlement for 10 t/m2 (mm)	16.00
Total Settlement (mm)	32.00
Depth Correction	0.67
Rigidity Correction	0.8
Corrected Total Settlement (mm)	17.2

Footing Depth (m)	4.50
SBC (t/m2)	20.50
Average N value	18
Settlement for 10 t/m2 (mm)	16.00
Total Settlement (mm)	32.80
Depth Correction	0.63
Rigidity Correction	0.8
Corrected Total Settlement (mm)	16.5

Footing Depth (m)	6.00
SBC (t/m2)	21.00
Average N value	19
Settlement for 10 t/m2 (mm)	15.00
Total Settlement (mm)	31.50
Depth Correction	0.57
Rigidity Correction	0.8
Corrected Total Settlement (mm)	14.4

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'ALIGNMENT'

CHAPTER – 28

"Alignment",

Location – Existing Km. – 358/1