

ANNEXURE - I

Geotechnical Report

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (A1) OF MAJOR BRIDGE No. 294 AT CHAINAGE 257 5-17

Project :	Chainage 257.300 Bridge No. 294		Date of Testing 13.12.2009 to 15.12.2009	Location at A1	B.H. No. 1	Depth of Water Table 08.00 m.	Termination Depth 30.00mtr	Surface Elevation 270.196												
	Observed	Correction						Corrected	B.D.	M.C.	D.D.	Specific Gravity	Shear Strength							
Depth from GL (m)	N	C _n	N _n	Soil Description (Soil Group)	Grain Size Distribution % wt retained						φ degree									
					Clay	Silt	Sand			Gravel										
							Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc			
0.00	-	-	-	Silty Sand	3.26	29.87	65.29	0.22	1.36	0.00	0.00	22	NIL	NP	-	-	-	-	-	-
1.50	8	1.46	11.68	Silty Sand	3.65	32.93	63.25	0.17	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	3.55	34.31	60.52	0.52	1.10	0.00	0.00	24	NIL	NP	1.70	6.68	1.59	2.66	0.00	28.0
4.50	10	1.09	10.90	Silty Sand	4.25	42.08	51.94	0.68	1.05	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
6.00	UDS	-	-	Silty Sand	2.52	36.49	59.48	0.86	0.65	0.00	0.00	22	NIL	NP	1.79	14.56	1.74	2.67	0.00	28.0
7.50	12	0.91	10.92	Silty Sand	2.89	22.07	72.11	1.85	0.66	0.42	0.00	23	NIL	NP	-	-	-	-	-	-
10.50	15	0.80	12.00	Silty Sand	3.84	28.20	57.53	5.54	1.32	3.57	0.00	24	NIL	NP	-	-	-	-	-	-
12.00	UDS	-	-	Clayey Silt with Sand	12.25	76.67	3.26	4.26	1.20	2.36	0.00	31	21	10	2.06	19.68	1.72	2.65	0.11	20.0
13.50	23	0.70	15.55	Clayey Silt with Sand	16.22	75.43	4.16	3.25	0.36	0.58	0.00	34	20	14	-	-	-	-	-	-
16.50	28	0.63	16.32	Clayey Silt with Sand	18.45	72.57	5.26	1.68	0.52	1.52	0.00	37	21	16	-	-	-	-	-	-
19.50	32	0.56	16.46	Clayey Silt with Sand	21.65	69.44	4.25	2.36	1.65	0.65	0.00	39	20	19	-	-	-	-	-	-
22.50	41	0.51	17.96	Clayey Silt with Sand	19.95	70.22	3.65	4.58	0.45	1.15	0.00	36	19	17	-	-	-	-	-	-
24.00	UDS	-	-	Clayey Silt with Sand	22.88	66.59	3.25	5.67	1.25	0.36	0.00	41	21	20	2.06	21.26	1.70	2.64	0.23	14.0
25.50	45	0.47	18.08	Clayey Silt with Sand	17.53	70.03	4.52	4.98	1.64	1.30	0.00	35	20	15	-	-	-	-	-	-
28.50	50	0.43	18.25	Clayey Silt with Sand	14.67	70.75	6.35	6.25	1.41	0.57	0.00	33	21	12	-	-	-	-	-	-
30.00	60	0.41	19.80	Clayey Silt with Sand	15.98	75.56	4.15	2.69	0.68	0.94	0.00	35	21	14	-	-	-	-	-	-

SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (IN BETWEEN P1 & P2) OF MAJOR BRIDGE No. 294 AT CHAINAGE 257.5-17

Project :	Chainage 257.300 Bridge No. 294		Date of Testing 16.12.2009 to 16.12.2009	Location at In Between P1 & P2	B.H. No. 2	Depth of Water Table 10.00 m.	Termination Depth 30.00mtr			Surface Elevation 267.561										
	Depth	from					GL (m)	B.D.	M.C.	D.D.	Specific Gravity	Shear Strength	φ degree							
Depth	Observed	Correction Factor	Corrected	Soil Description (Soil Group)	Grain Size Distribution % wt retained						Atterberg Limits %	P.L.	P.I.	B.D.	M.C.	D.D.	Specific Gravity	Shear Strength	φ degree	
					Clay	Silt	Fine	Medium	Coarse	Fine										Coarse
0.00	-	-	-	Silty Sand	2.65	8.36	80.35	8.22	0.42	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-
1.50	6	1.43	8.58	Silty Sand	3.55	6.36	82.07	7.65	0.37	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	4.28	2.80	91.67	1.15	0.10	0.00	0.00	28	NIL	NP	1.85	13.62	1.63	2.62	0.00	28.0
4.50	8	1.06	8.48	Silty Sand	3.85	8.70	85.51	1.58	0.21	0.15	0.00	26	NIL	NP	-	-	-	-	-	-
7.50	15	0.88	13.20	Silty Sand	0.00	8.12	91.34	0.54	0.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Sandy Silt with Clay	12.18	61.18	26.21	0.20	0.23	0.00	0.00	30	19	11	1.95	15.66	1.69	2.63	0.11	20.0
10.50	20	0.77	15.20	Clayey Silt with Sand	21.52	72.94	3.95	1.20	0.23	0.16	0.00	37	18	19	-	-	-	-	-	-
12.00	UDS	-	-	Clayey Silt with Sand	19.92	73.90	4.25	1.42	0.26	0.25	0.00	37	19	18	2.07	20.24	1.72	2.68	0.21	16.0
13.50	24	0.68	15.66	Clayey Silt with Sand	22.85	70.64	5.52	0.65	0.34	0.00	0.00	42	22	20	-	-	-	-	-	-
16.50	29	0.61	16.35	Clayey Silt with Sand	17.68	76.05	3.45	2.25	0.42	0.15	0.00	37	21	16	-	-	-	-	-	-
19.50	33	0.55	16.58	Clayey Silt with Sand	20.64	71.89	4.25	2.35	0.52	0.35	0.00	37	19	18	-	-	-	-	-	-
21.00	UDS	-	-	Clayey Silt with Sand	22.35	71.04	5.25	0.68	0.68	0.00	0.00	41	21	20	2.09	20.82	1.73	2.67	0.27	12.0
22.50	40	0.50	17.50	Clayey Silt with Sand	17.68	74.46	6.15	1.15	0.41	0.15	0.00	36	21	15	-	-	-	-	-	-
25.50	45	0.45	17.63	Clayey Silt with Sand	18.44	73.13	7.25	0.25	0.68	0.25	0.00	37	21	16	-	-	-	-	-	-
28.50	48	0.42	17.58	Clayey Silt with Sand	20.45	71.58	6.14	1.39	0.44	0.00	0.00	38	20	18	-	-	-	-	-	-
30.00	53	0.40	18.10	Clayey Silt with Sand	15.85	75.35	6.26	1.65	0.56	0.33	0.00	33	19	14	-	-	-	-	-	-



**CONSULTING
Engineers Group Ltd.**
10, Park Road, Sector 17, Gurgaon, Haryana
India. Phone: 01299-421111, 421112

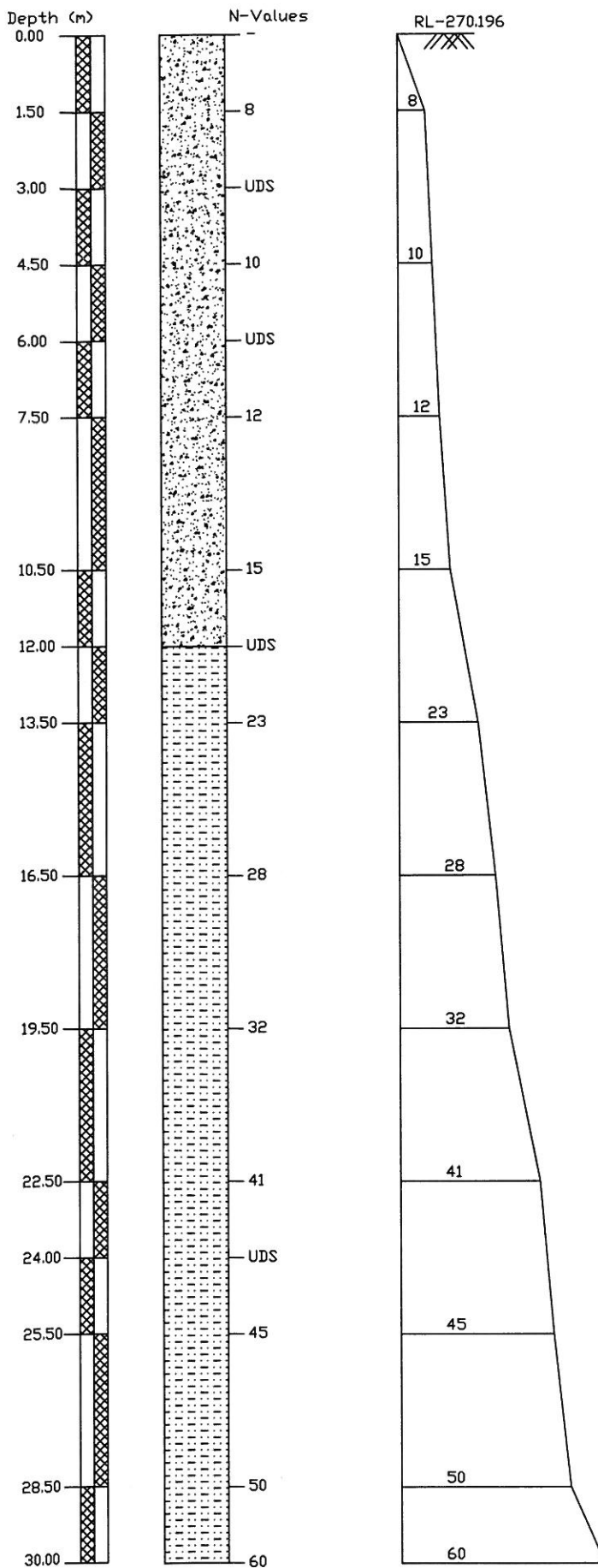
1072

SOIL CHARACTERISTICS OF BORE HOLE AT BH-3 (A2) OF MAJOR BRIDGE No.294 AT CHAINAGE 257.5-17																				
Project :	Chainage 257.300 Bridge No. 294		Date of Testing 09.12.2009 to 09.12.2009	Location at A2	B.H. No. 3	Depth of Water Table 09.50 m.	Termination Depth 30.00mtr	Surface Elevation												
	Depth from	Observed						Correction Factor	Corrected	Clay	Silt	Sand	Gravel	B.D.	M.C.	D.D.	Specific Gravity	Shear Strength		
GL (m)	N	C _n	N _n	Description (Soil Group)	Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc	c kg/cm ²	φ degree	
0.00	-	-	-	Sandy Silt	2.26	60.93	36.58	0.23	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
1.50	7	1.46	10.22	Sandy Silt	3.89	61.71	34.30	0.10	0.00	0.00	0.00	26	NIL	NP	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	4.28	1.81	93.60	0.31	0.00	0.00	0.00	27	NIL	NP	1.70	8.54	1.57	2.69	0.00	28.0
4.50	9	1.09	9.81	Silty Sand	3.14	12.31	83.73	0.82	0.00	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
7.50	12	0.92	11.04	Silty Sand	3.26	44.34	47.00	1.25	0.74	3.41	0.00	24	NIL	NP	-	-	-	-	-	-
10.50	15	0.81	12.15	Silty Sand	3.72	10.17	83.63	1.41	0.44	0.63	0.00	24	NIL	NP	-	-	-	-	-	-
12.00	UDS	-	-	Clayey Silt	18.45	79.02	2.53	0.00	0.00	0.00	0.00	38	22	16	2.00	22.78	1.63	2.67	0.19	16.0
13.50	21	0.71	14.91	Clayey Silt	21.52	70.68	3.69	0.63	0.70	2.78	0.00	38	19	19	-	-	-	-	-	-
16.50	27	0.64	16.14	Clayey Silt with Sand	19.23	68.60	6.67	2.00	1.47	2.03	0.00	38	21	17	-	-	-	-	-	-
18.00	UDS	-	-	Clayey Silt with Sand	20.91	70.62	7.20	0.19	0.08	1.00	0.00	38	19	19	2.04	22.28	1.67	2.64	0.22	14.0
19.50	35	0.57	17.48	Clayey Silt with Sand	27.18	67.84	3.22	1.39	0.37	0.00	0.00	48	24	24	-	-	-	-	-	-
22.50	39	0.52	17.64	Clayey Silt with Sand	14.26	73.66	7.92	1.55	0.77	1.84	0.00	29	17	12	-	-	-	-	-	-
24.00	UDS	-	-	Clayey Silt with Sand	15.22	74.52	4.57	4.85	0.67	0.17	0.00	31	18	13	2.08	18.98	1.75	2.66	0.13	17.0
25.50	45	0.47	18.08	Clayey Silt with Sand	18.65	75.44	4.07	1.25	0.59	0.00	0.00	36	19	17	-	-	-	-	-	-
28.50	48	0.43	17.82	Clayey Silt with Sand	10.15	81.10	3.32	2.54	2.20	0.69	0.00	28	19	9	-	-	-	-	-	-
30.00	54	0.42	18.84	Clayey Silt with Sand	8.26	81.68	3.87	3.70	1.79	0.70	0.00	26	18	8	-	-	-	-	-	-



**CONSULTING
Engineers Group Ltd.**
117, 119, 121, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173, 175, 177, 179, 181, 183, 185, 187, 189, 191, 193, 195, 197, 199, 201, 203, 205, 207, 209, 211, 213, 215, 217, 219, 221, 223, 225, 227, 229, 231, 233, 235, 237, 239, 241, 243, 245, 247, 249, 251, 253, 255, 257, 259, 261, 263, 265, 267, 269, 271, 273, 275, 277, 279, 281, 283, 285, 287, 289, 291, 293, 295, 297, 299, 301, 303, 305, 307, 309, 311, 313, 315, 317, 319, 321, 323, 325, 327, 329, 331, 333, 335, 337, 339, 341, 343, 345, 347, 349, 351, 353, 355, 357, 359, 361, 363, 365, 367, 369, 371, 373, 375, 377, 379, 381, 383, 385, 387, 389, 391, 393, 395, 397, 399, 401, 403, 405, 407, 409, 411, 413, 415, 417, 419, 421, 423, 425, 427, 429, 431, 433, 435, 437, 439, 441, 443, 445, 447, 449, 451, 453, 455, 457, 459, 461, 463, 465, 467, 469, 471, 473, 475, 477, 479, 481, 483, 485, 487, 489, 491, 493, 495, 497, 499, 501, 503, 505, 507, 509, 511, 513, 515, 517, 519, 521, 523, 525, 527, 529, 531, 533, 535, 537, 539, 541, 543, 545, 547, 549, 551, 553, 555, 557, 559, 561, 563, 565, 567, 569, 571, 573, 575, 577, 579, 581, 583, 585, 587, 589, 591, 593, 595, 597, 599, 601, 603, 605, 607, 609, 611, 613, 615, 617, 619, 621, 623, 625, 627, 629, 631, 633, 635, 637, 639, 641, 643, 645, 647, 649, 651, 653, 655, 657, 659, 661, 663, 665, 667, 669, 671, 673, 675, 677, 679, 681, 683, 685, 687, 689, 691, 693, 695, 697, 699, 701, 703, 705, 707, 709, 711, 713, 715, 717, 719, 721, 723, 725, 727, 729, 731, 733, 735, 737, 739, 741, 743, 745, 747, 749, 751, 753, 755, 757, 759, 761, 763, 765, 767, 769, 771, 773, 775, 777, 779, 781, 783, 785, 787, 789, 791, 793, 795, 797, 799, 801, 803, 805, 807, 809, 811, 813, 815, 817, 819, 821, 823, 825, 827, 829, 831, 833, 835, 837, 839, 841, 843, 845, 847, 849, 851, 853, 855, 857, 859, 861, 863, 865, 867, 869, 871, 873, 875, 877, 879, 881, 883, 885, 887, 889, 891, 893, 895, 897, 899, 901, 903, 905, 907, 909, 911, 913, 915, 917, 919, 921, 923, 925, 927, 929, 931, 933, 935, 937, 939, 941, 943, 945, 947, 949, 951, 953, 955, 957, 959, 961, 963, 965, 967, 969, 971, 973, 975, 977, 979, 981, 983, 985, 987, 989, 991, 993, 995, 997, 999, 1001, 1003, 1005, 1007, 1009, 1011, 1013, 1015, 1017, 1019, 1021, 1023, 1025, 1027, 1029, 1031, 1033, 1035, 1037, 1039, 1041, 1043, 1045, 1047, 1049, 1051, 1053, 1055, 1057, 1059, 1061, 1063, 1065, 1067, 1069, 1071, 1073, 1075, 1077, 1079, 1081, 1083, 1085, 1087, 1089, 1091, 1093, 1095, 1097, 1099, 1101, 1103, 1105, 1107, 1109, 1111, 1113, 1115, 1117, 1119, 1121, 1123, 1125, 1127, 1129, 1131, 1133, 1135, 1137, 1139, 1141, 1143, 1145, 1147, 1149, 1151, 1153, 1155, 1157, 1159, 1161, 1163, 1165, 1167, 1169, 1171, 1173, 1175, 1177, 1179, 1181, 1183, 1185, 1187, 1189, 1191, 1193, 1195, 1197, 1199, 1201, 1203, 1205, 1207, 1209, 1211, 1213, 1215, 1217, 1219, 1221, 1223, 1225, 1227, 1229, 1231, 1233, 1235, 1237, 1239, 1241, 1243, 1245, 1247, 1249, 1251, 1253, 1255, 1257, 1259, 1261, 1263, 1265, 1267, 1269, 1271, 1273, 1275, 1277, 1279, 1281, 1283, 1285, 1287, 1289, 1291, 1293, 1295, 1297, 1299, 1301, 1303, 1305, 1307, 1309, 1311, 1313, 1315, 1317, 1319, 1321, 1323, 1325, 1327, 1329, 1331, 1333, 1335, 1337, 1339, 1341, 1343, 1345, 1347, 1349, 1351, 1353, 1355, 1357, 1359, 1361, 1363, 1365, 1367, 1369, 1371, 1373, 1375, 1377, 1379, 1381, 1383, 1385, 1387, 1389, 1391, 1393, 1395, 1397, 1399, 1401, 1403, 1405, 1407, 1409, 1411, 1413, 1415, 1417, 1419, 1421, 1423, 1425, 1427, 1429, 1431, 1433, 1435, 1437, 1439, 1441, 1443, 1445, 1447, 1449, 1451, 1453, 1455, 1457, 1459, 1461, 1463, 1465, 1467, 1469, 1471, 1473, 1475, 1477, 1479, 1481, 1483, 1485, 1487, 1489, 1491, 1493, 1495, 1497, 1499, 1501, 1503, 1505, 1507, 1509, 1511, 1513, 1515, 1517, 1519, 1521, 1523, 1525, 1527, 1529, 1531, 1533, 1535, 1537, 1539, 1541, 1543, 1545, 1547, 1549, 1551, 1553, 1555, 1557, 1559, 1561, 1563, 1565, 1567, 1569, 1571, 1573, 1575, 1577, 1579, 1581, 1583, 1585, 1587, 1589, 1591, 1593, 1595, 1597, 1599, 1601, 1603, 1605, 1607, 1609, 1611, 1613, 1615, 1617, 1619, 1621, 1623, 1625, 1627, 1629, 1631, 1633, 1635, 1637, 1639, 1641, 1643, 1645, 1647, 1649, 1651, 1653, 1655, 1657, 1659, 1661, 1663, 1665, 1667, 1669, 1671, 1673, 1675, 1677, 1679, 1681, 1683, 1685, 1687, 1689, 1691, 1693, 1695, 1697, 1699, 1701, 1703, 1705, 1707, 1709, 1711, 1713, 1715, 1717, 1719, 1721, 1723, 1725, 1727, 1729, 1731, 1733, 1735, 1737, 1739, 1741, 1743, 1745, 1747, 1749, 1751, 1753, 1755, 1757, 1759, 1761, 1763, 1765, 1767, 1769, 1771, 1773, 1775, 1777, 1779, 1781, 1783, 1785, 1787, 1789, 1791, 1793, 1795, 1797, 1799, 1801, 1803, 1805, 1807, 1809, 1811, 1813, 1815, 1817, 1819, 1821, 1823, 1825, 1827, 1829, 1831, 1833, 1835, 1837, 1839, 1841, 1843, 1845, 1847, 1849, 1851, 1853, 1855, 1857, 1859, 1861, 1863, 1865, 1867, 1869, 1871, 1873, 1875, 1877, 1879, 1881, 1883, 1885, 1887, 1889, 1891, 1893, 1895, 1897, 1899, 1901, 1903, 1905, 1907, 1909, 1911, 1913, 1915, 1917, 1919, 1921, 1923, 1925, 1927, 1929, 1931, 1933, 1935, 1937, 1939, 1941, 1943, 1945, 1947, 1949, 1951, 1953, 1955, 1957, 1959, 1961, 1963, 1965, 1967, 1969, 1971, 1973, 1975, 1977, 1979, 1981, 1983, 1985, 1987, 1989, 1991, 1993, 1995, 1997, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013, 2015, 2017, 2019, 2021, 2023, 2025, 2027, 2029, 2031, 2033, 2035, 2037, 2039, 2041, 2043, 2045, 2047, 2049, 2051, 2053, 2055, 2057, 2059, 2061, 2063, 2065, 2067, 2069, 2071, 2073, 2075, 2077, 2079, 2081, 2083, 2085, 2087, 2089, 2091, 2093, 2095, 2097, 2099, 2101, 2103, 2105, 2107, 2109, 2111, 2113, 2115, 2117, 2119, 2121, 2123, 2125, 2127, 2129, 2131, 2133, 2135, 2137, 2139, 2141, 2143, 2145, 2147, 2149, 2151, 2153, 2155, 2157, 2159, 2161, 2163, 2165, 2167, 2169, 2171, 2173, 2175, 2177, 2179, 2181, 2183, 2185, 2187, 2189, 2191, 2193, 2195, 2197, 2199, 2201, 2203, 2205, 2207, 2209, 2211, 2213, 2215, 2217, 2219, 2221, 2223, 2225, 2227, 2229, 2231, 2233, 2235, 2237, 2239, 2241, 2243, 2245, 2247, 2249, 2251, 2253, 2255, 2257, 2259, 2261, 2263, 2265, 2267, 2269, 2271, 2273, 2275, 2277, 2279, 2281, 2283, 2285, 2287, 2289, 2291, 2293, 2295, 2297, 2299, 2301, 2303, 2305, 2307, 2309, 2311, 2313, 2315, 2317, 2319, 2321, 2323, 2325, 2327, 2329, 2331, 2333, 2335, 2337, 2339, 2341, 2343, 2345, 2347, 2349, 2351, 2353, 2355, 2357, 2359, 2361, 2363, 2365, 2367, 2369, 2371, 2373, 2375, 2377, 2379, 2381, 2383, 2385, 2387, 2389, 2391, 2393, 2395, 2397, 2399, 2401, 2403, 2405, 2407, 2409, 2411, 2413, 2415, 2417, 2419, 2421, 2423, 2425, 2427, 2429, 2431, 2433, 2435, 2437, 2439, 2441, 2443, 2445, 2447, 2449, 2451, 2453, 2455, 2457, 2459, 2461, 2463, 2465, 2467, 2469, 2471, 2473, 2475, 2477, 2479, 2481, 2483, 2485, 2487, 2489, 2491, 2493, 2495, 2497, 2499, 2501, 2503, 2505, 2507, 2509, 2511, 2513, 2515, 2517, 2519, 2521, 2523, 2525, 2527, 2529, 2531, 2533, 2535, 2537, 2539, 2541, 2543, 2545, 2547, 2549, 2551, 2553, 2555, 2557, 2559, 2561, 2563, 2565, 2567, 2569, 2571, 2573, 2575, 2577, 2579, 2581, 2583, 2585, 2587, 2589, 2591, 2593, 2595, 2597, 2599, 2601, 2603, 2605, 2607, 2609, 2611, 2613, 2615, 2617, 2619, 2621, 2623, 2625, 2627, 2629, 2631, 2633, 2635, 2637, 2639, 2641, 2643, 2645, 2647, 2649, 2651, 2653, 2655, 2657, 2659, 2661, 2663, 2665, 2667, 2669, 2671, 2673, 2675, 2677, 2679, 2681, 2683, 2685, 2687, 2689, 2691, 2693, 2695, 2697, 2699, 2701, 2703, 2705, 2707, 2709, 2711, 2713, 2715, 2717, 2719, 2721, 2723, 2725, 2727, 2729, 2731, 2733, 2735, 2737, 2739, 2741, 2743, 2745, 2747, 2749, 2751, 2753, 2755, 2757, 2759, 2761, 2763, 2765, 2767, 2769, 2771, 2773, 2775, 2777, 2779, 2781, 2783, 2785, 2787, 2789, 2791, 2793, 2795, 2797, 2799, 2801, 2803, 2805, 2807, 2809, 2811, 2813, 2815, 2817, 2819, 2821, 2823, 2825, 2827, 2829, 2831, 2833, 2835, 2837, 2839, 2841, 2843, 2845, 2847, 2849, 2851, 2853, 2855, 2857, 2859, 2861, 2863, 2865, 2867, 2869, 2871, 2873, 2875, 2877, 2879, 2881, 2883, 2885, 2887, 2889, 2891, 2893, 2895, 2897, 2899, 2901, 2903, 2905, 2907, 2909, 2911, 2913, 2915, 2917, 2919, 2921, 2923, 2925, 2927, 2929, 2931, 2933, 2935, 2937, 2939, 2941, 2943, 2945, 2947, 2949, 2951, 2953, 2955, 2957, 2959, 2961, 2963, 2965, 2967, 2969, 2971, 2973, 2975, 2977, 2979, 2981, 2983, 2985, 2987, 2989, 2991, 2993, 2995, 2997, 2999, 3001, 3003, 3005, 3007, 3009, 3011, 3013, 3015, 3017, 3019, 3021, 3023, 3025, 3027, 3029, 3031, 3033, 3035, 3037, 3039, 3041, 3043, 3045, 3047, 3049, 3051, 3053, 3055, 3057, 3059, 3061, 3063, 3065, 3067, 3069, 3071, 3073, 3075, 3077, 3079, 3081, 3083, 3085, 3087, 3089, 3091, 3093, 3095, 3097, 3099, 3101, 3103, 3105, 3107, 3109, 3111, 31

BORELOG OF BH-1(A1) AT EXISTING KM-257/5-17 FOR IMPORTANT MAJOR BRIDGE NO.-294,
ON KESARI TO SANEHWAL, LUDHIANA

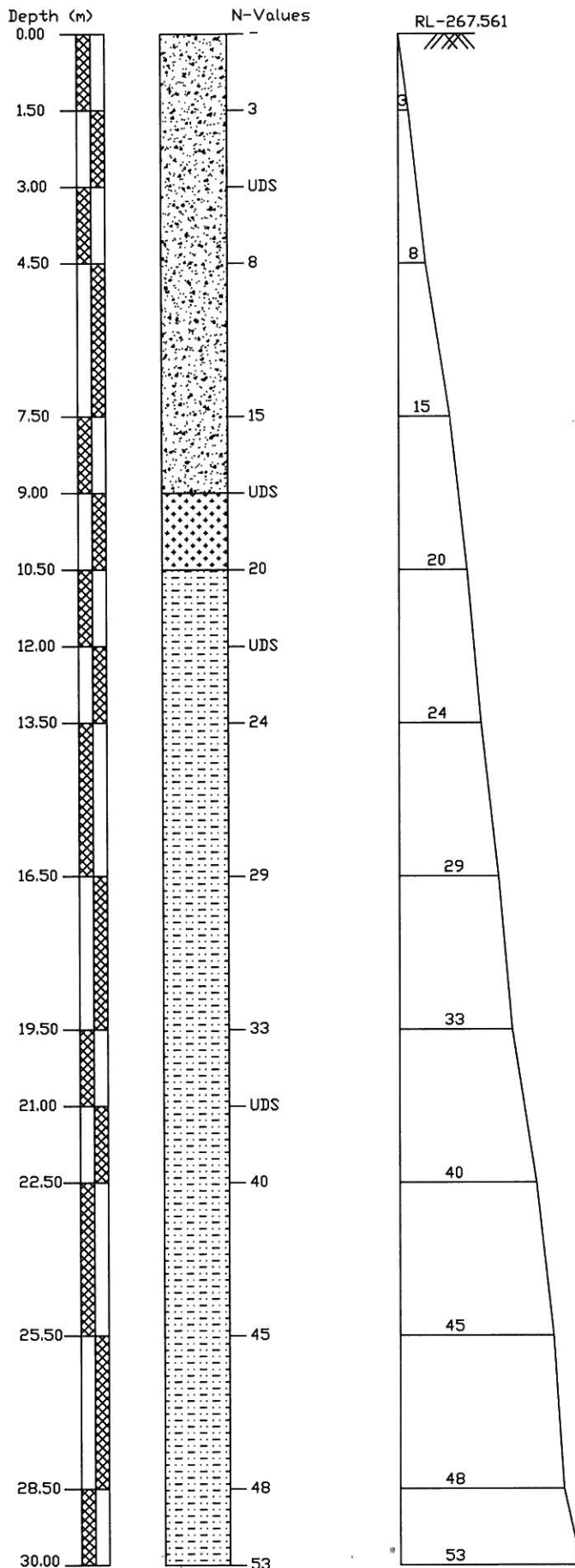


LEGEND

SYMBOL	DESCRIPTION
	SILTY SAND
	CLAYEY SILT WITH SAND

1074

BORELOG OF BH-2(P1&P2) AT EXISTING KM-257/5-17 FOR IMPORTANT MAJOR BRIDGE NO.-294,
ON KESARI TO SANEHWAL, LUDHIANA

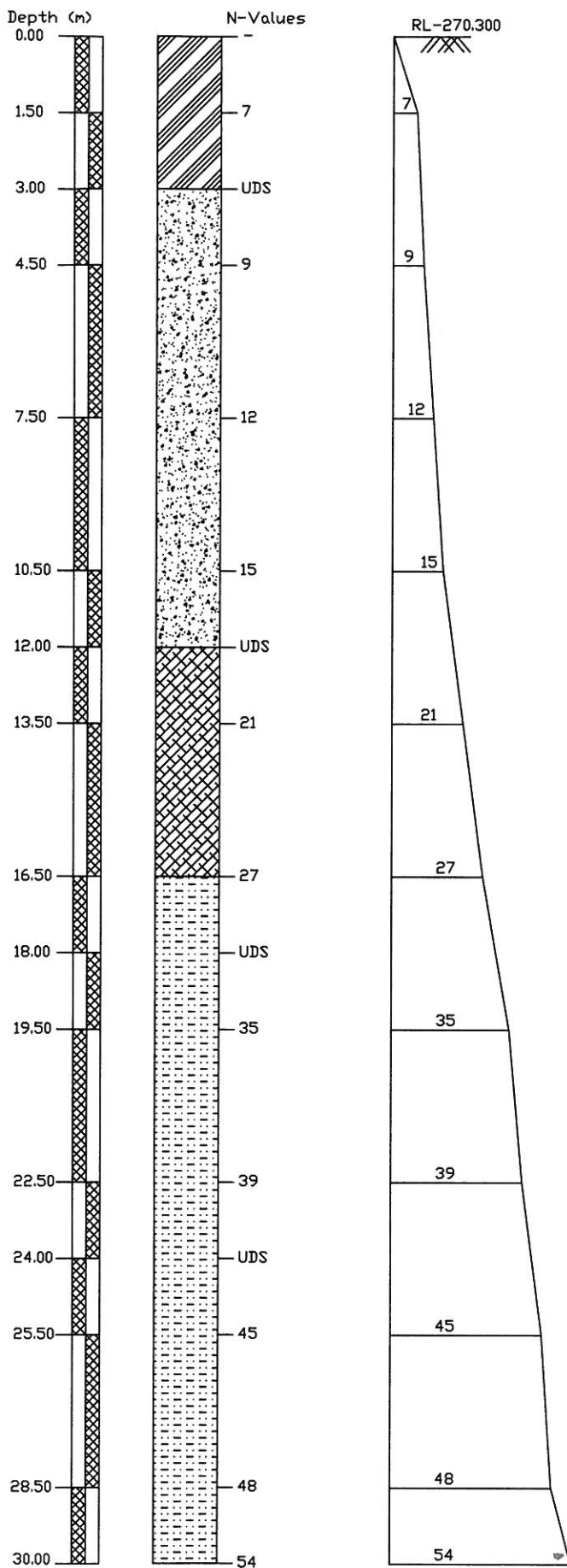


LEGEND

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

1075

BORELOG OF BH-3(A2) AT EXISTING KM-257/5-17 FOR MAJOR BRIDGE NO.-294,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

ANNEXURE - III

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

INPUT DATA

	Ch 257 5-17	BH-A1
<i>Type of footing</i>		Rectangular
1 Continuous Strip		2
2 Rectangular		
3 Square		
4 Circular		
Angle of internal friction (ϕ°)		28.00
Cohesion (c in t/m ²)		0.00
Void ratio (e)		0.67
Direction of load with vertical ($^\circ$)		0.00
Density of surcharge (t/m ³)		1.70
Density of foundation soil (t/m ³)		1.70
Depth of water table(m)		1.50
Factor of safety		3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

$$q'_d = (2/3) c N'_c s'_c d'_c i'_c + q (N'_q - 1) s'_q d'_q i'_q + (1/2) B \gamma N'_\gamma s'_\gamma d'_\gamma i'_\gamma W'$$

Where,

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

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

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

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

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

OUTPUT

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

ANNEXURE - III

Bearing capacity factors :

ϕ	28.00
N_c	26.37
N_q	15.30
N_γ	17.79

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	d_c	d_q	d_γ
1	1.50	3.00	1.17	1.08	1.08
2	3.00	3.00	1.33	1.17	1.17
3	4.50	3.00	1.50	1.25	1.25
4	6.00	3.00	1.67	1.33	1.33

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m ²)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	21.12	7.18	12.76
2	3.00	3.00	8.00	37.99	13.28	23.16
3	4.50	3.00	8.00	40.70	14.23	24.82
4	6.00	3.00	8.00	43.41	15.18	26.47

0804.1

1078

ANNEXURE - III

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

INPUT DATA

	Ch 257 5-17	BH-A2	
<i>Type of footing</i>			
1 Continuous Strip			
2 Rectangular		Rectangular	2
3 Square			
4 Circular			
Angle of internal friction (ϕ°)			28.00
Cohesion (c in t/m ²)			0.00
Void ratio (e)			0.72
Direction of load with vertical ($^\circ$)			0.00
Density of surcharge (t/m ³)			1.70
Density of foundation soil (t/m ³)			1.70
Depth of water table(m)			1.50
Factor of safety			3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

$$q'_d = (2/3) c N'_c s'_c d'_c i'_c + q (N'_q - 1) s'_q d'_q i'_q + (1/2) B \gamma N'_\gamma s'_\gamma d'_\gamma i'_\gamma W'$$

Where,

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

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

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

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

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

OUTPUT

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

ANNEXURE - III

Bearing capacity factors :

ϕ	28.00
N_c	26.37
N_q	15.30
N_γ	17.79

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	d_c	d_q	d_γ
1	1.50	3.00	1.17	1.08	1.08
2	3.00	3.00	1.33	1.17	1.17
3	4.50	3.00	1.50	1.25	1.25
4	6.00	3.00	1.67	1.33	1.33

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	21.12	7.18	9.27
2	3.00	3.00	8.00	37.99	13.28	16.99
3	4.50	3.00	8.00	40.70	14.23	18.20
4	6.00	3.00	8.00	43.41	15.18	19.41

1080

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Major Bridge
Chainage	257/05-17
Bore Hole No.	A1

Footing Depth (m)	1.50
SBC (t/m ²)	10.00
Average N value	11
Settlement for 10 t/m ² (mm)	31.00
Settlement (mm) for SBC	31.00
Depth Correction	0.91
Regidity Factor	0.80
Corrected Settlement (mm)	22.6

Footing Depth (m)	3.00
SBC (t/m ²)	11.00
Average N value	11
Settlement for 10 t/m ² (mm)	31.00
Settlement (mm) for SBC	34.10
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	22.6

Footing Depth (m)	4.50
SBC (t/m ²)	11.50
Average N value	11
Settlement for 10 t/m ² (mm)	31.00
Settlement (mm) for SBC	35.65
Depth Correction	0.74
Regidity Factor	0.80
Corrected Settlement (mm)	21.1

Footing Depth (m)	6.00
SBC (t/m ²)	12.00
Average N value	11
Settlement for 10 t/m ² (mm)	31.00
Settlement (mm) for SBC	37.20
Depth Correction	0.68
Regidity Factor	0.80
Corrected Settlement (mm)	20.2

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Major Bridge
Chainage	257/05-17
Bore Hole No.	A2

Footing Depth (m)	1.50
SBC (t/m ²)	9.00
Average N value	10
Settlement for 10 t/m ² (mm)	36.00
Settlement (mm) for SBC	32.40
Depth Correction	0.91
Regidity Factor	0.80
Corrected Settlement (mm)	23.6

Footing Depth (m)	3.00
SBC (t/m ²)	10.50
Average N value	10
Settlement for 10 t/m ² (mm)	36.00
Settlement (mm) for SBC	37.80
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	25

Footing Depth (m)	4.50
SBC (t/m ²)	11.00
Average N value	10
Settlement for 10 t/m ² (mm)	36.00
Settlement (mm) for SBC	39.60
Depth Correction	0.74
Regidity Factor	0.80
Corrected Settlement (mm)	23.4

Footing Depth (m)	6.00
SBC (t/m ²)	11.50
Average N value	11
Settlement for 10 t/m ² (mm)	31.00
Settlement (mm) for SBC	35.65
Depth Correction	0.68
Regidity Factor	0.80
Corrected Settlement (mm)	19.4

CHAPTER - 131

"Major Bridge No. 293",

Location - Existing Km. - 256/05-07

131.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 1x30.50

131.2 BOREHOLE DESCRIPTIONS:

- (a) Location of Structure, Boreholes with RL shown in **FIGURE-1**.
- (b) Subsurface Characteristic of Soil/Rock shown in **ANNEXURE-I**.
- (c) Borelogs and sub soil profile shown in **ANNEXURE-II**.
- (d) Calculations of Safe Bearing Capacities in **ANNEXURE-III**.
- (e) Calculations of Probable Settlement in **ANNEXURE-IV**.
- (f) Depth of water Table 07.50m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1(A1)	0.00 to 6.00	Silty Sand	Loose
	6.00 to 7.50	Clayey Silt with Sand	Loose
	7.50 to 10.50	Silty Sand	Medium Dense
	10.50 to 25.50	Clayey Silt with Sand	Medium Dense
	25.50 to 30.00	Clayey Silt	Medium Dense
	Below 30.00	Clayey Silt with Sand	Medium Dense
BH-2(A2)	0.00 to 4.50	Silty Sand	Loose
	4.50 to 16.50	Silty Sand	Medium Dense
	16.50 to 24.00	Clayey Silt with Sand	Medium Dense
	24.00 to 30.00	Clayey Silt	Medium Dense

131.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.10	0.010	0.0022	NIL	0.0010	0.082
	9.00	8.50	0.006	0.0024	NIL	0.0011	0.062
	12.00	8.20	0.010	0.0023	NIL	0.0014	0.060
	21.00	8.70	0.008	0.0025	NIL	0.0012	0.049
BH-2 (A2)	3.00	8.40	0.008	0.0020	NIL	0.0012	0.085
	9.00	8.20	0.011	0.0028	NIL	0.0011	0.098
	24.00	9.20	0.015	0.0021	NIL	0.0012	0.097

131.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1(A1)	3.00	NIL
	6.00	15.00
	12.00	19.00
	21.00	NIL

BH-2 (A2)

24.00

131.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BORE HOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (μ S/cm)
Test Result	7.6	81	98	177	788	0.1	2.0	1003	668
Requirement as per IS: 456 / Mosrths	Not less than 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 ₂ SO ₄	-	-

131.6 PILE LOAD CARRYING CAPACITY

131.6.1 Normal Bored Cast in-situ Pile Foundations:

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

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

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

Safe bearing capacity in t/m²

BH -NO.	DEPTH (mtr)	Net Allowable Bearing Pressure (t/m ²)
BH-1 (A1)	1.50m	09.00
	3.00m	09.50
	4.50m	10.00
	6.00m	11.00
BH-3 (A2)	1.50m	11.00
	3.00m	12.00
	4.50m	13.00
	6.00m	14.00

1085

Pile load carrying capacity in t

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE
		Pile Diameter= 1.0 m
BH-1 (A1)	17.00	100.00
	20.00	135.00
	23.00	180.00
BH-2 (A2)	17.00	130.00
	20.00	160.00
	23.00	200.00

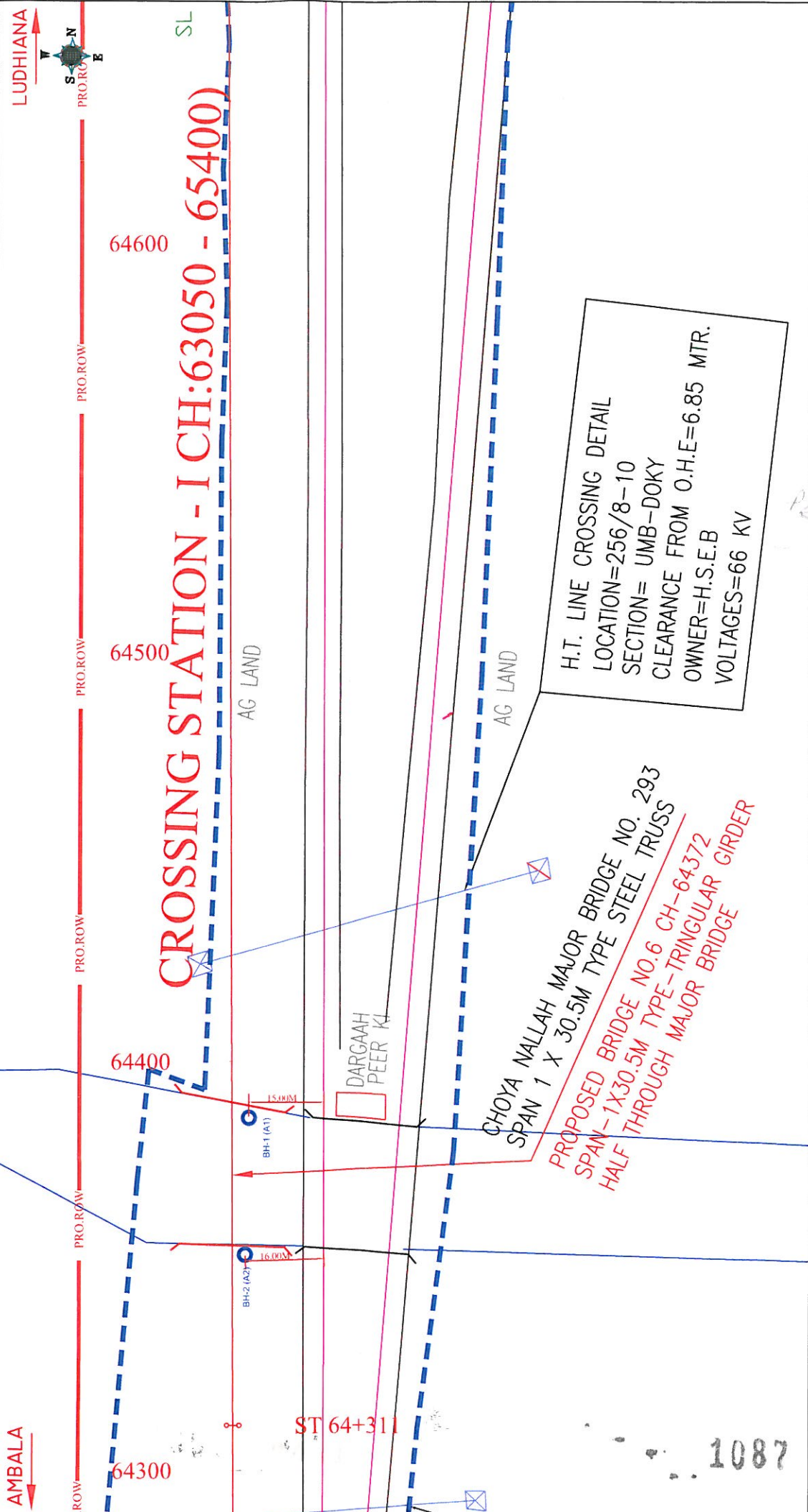
131.7 CONCLUSIONS

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

131.8 RECOMMENDATIONS

(i)	<i>Type of foundation</i>	File 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.



H.T. LINE CROSSING DETAIL
 LOCATION=256/8-10
 SECTION= UMB-DOKY
 CLEARANCE FROM O.H.E=6.85 MTR.
 OWNER=H.S.E.B
 VOLTAGES=66 KV

<p>FIG.-1 LOCATION PLAN OF PROPOSED MAJOR BRIDGE CH. 256/5-7</p>	<p>ALL DIMENSIONS IN METER</p> <p>RL OF BH (A1) = 270.315 RL OF BH (A2) = 268.532</p>	<p>PROJECT :- LUDHIANA-AMBALA (DFCCIL)</p>	<p>DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12, Meji Colony, Malviya Nagar, Jaipur-17 Tel: +91-141- 2520899, 2521899, 2520556 Fax: 2521348, E-Mail: cegeg@cegindia.com</p>
--	--	--	---

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (A1) OF MAJOR BRIDGE No. 293 AT CHAINAGE 256/5-7

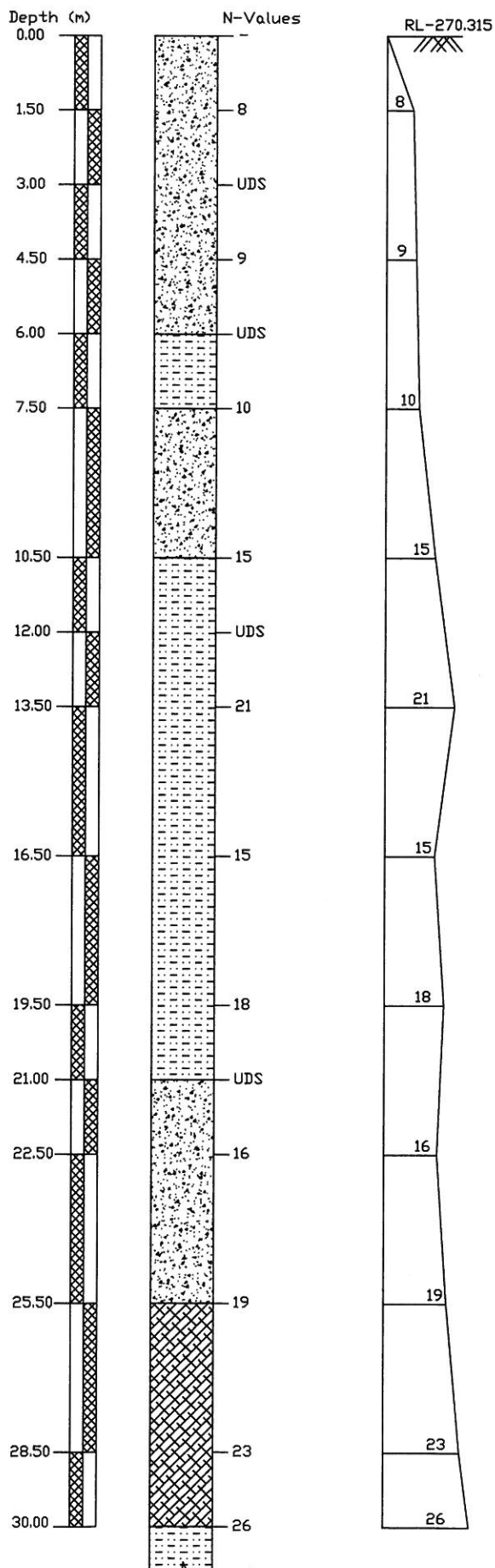
Project :	Chainage 256/5-7 Bridge No. 293		Date of Testing	Location at	B.H. No.	Depth of Water Table	Termination Depth	Surface Elevation									
	Observed	Correction	Corrected	Soil	Description	Clay	Silt	Grain Size Distribution % wt retained									
Depth from GL (m)	N	C _n	N _n					Atterberg Limits %			φ						
								L.L.	P.L.	P.I.	B.D.	M.C.	D.D.	Specific Gravity	Shear Strength c kg/cm ²	Shear Strength φ degree	
0.00	-	-	-	Silty Sand	3.25	16.19	80.44	0.12	0.00	0.00	0.00	-	-	-	-	-	
1.50	8	1.46	11.68	Silty Sand	3.82	20.27	75.87	0.04	0.00	0.00	0.00	-	-	-	-	-	
3.00	UDS	-	-	Silty Sand	2.41	20.51	75.98	0.45	0.65	0.00	0.00	1.70	8.15	1.57	2.67	0.00	28.0
4.50	9	1.09	9.81	Silty Sand	3.22	19.38	76.73	0.37	0.30	0.00	0.00	-	-	-	-	-	
6.00	UDS	-	-	Clayey Silt with Sand	14.25	71.36	10.90	0.94	1.10	1.45	0.00	1.77	12.32	1.58	2.68	0.13	18.0
7.50	10	0.92	9.20	Silty Sand	2.15	47.81	49.56	0.35	0.13	0.00	0.00	-	-	-	-	-	
10.50	15	0.80	12.00	Clayey Silt with Sand	18.95	64.62	13.50	1.05	0.87	1.01	0.00	-	-	-	-	-	
12.00	UDS	-	-	Clayey Silt with Sand	18.21	70.22	10.42	1.15	0.00	0.00	0.00	2.01	20.21	1.67	2.66	0.20	15.0
13.50	21	0.70	14.70	Clayey Silt with Sand	17.82	76.77	5.01	0.40	0.00	0.00	0.00	-	-	-	-	-	
16.50	15	0.63	9.45	Clayey Silt with Sand	14.15	71.98	10.11	1.11	0.97	1.68	0.00	-	-	-	-	-	
19.50	18	0.57	10.26	Clayey Silt with Sand	9.10	77.61	8.20	1.11	1.20	2.78	0.00	-	-	-	-	-	
21.00	UDS	-	-	Silty Sand	10.59	77.03	8.65	0.74	0.85	2.14	0.00	2.07	18.13	1.75	2.68	0.00	20.0
22.50	16	0.52	8.32	Silty Sand	15.48	69.84	6.59	2.43	2.40	3.26	0.00	-	-	-	-	-	
25.50	19	0.47	8.93	Clayey Silt	13.24	85.12	1.39	0.25	0.00	0.00	0.00	-	-	-	-	-	
28.50	23	0.43	9.89	Clayey Silt	20.14	78.79	0.99	0.08	0.00	0.00	0.00	-	-	-	-	-	
30.00	26	0.41	10.66	Clayey Silt with Sand	15.43	69.58	9.56	1.54	1.57	2.32	0.00	-	-	-	-	-	

ANNEXURE - I

Geotechnical Report

SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (A2) OF MAJOR BRIDGE No. 293 AT CHAINAGE 256/5-7																				
Project :	Chainage 256/5-7 Bridge No. 293			Date of Testing 10.12.2009 to 10.12.2009	Location at A2	B.H. No. 2	Depth of Water Table		Termination Depth 30.00mtr	Surface Elevation										
	Observed	Correction	Corrected				Clay	Silt		Gravel	B.D.	M.C.	D.D.	Specific Gravity	Shear Strength					
Depth from G.L. (m)	N	C _n	N _n	Soil Description (Soil Group)	Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	L.L.	P.L.	P.I.	gm/cc	%	gm/cc	φ degree		
0.00	-	-	-	Silty Sand	3.49	15.12	80.26	0.55	0.00	0.58	0.00	23	NIL	NP	-	-	-	-		
1.50	7	1.46	10.22	Silty Sand	3.58	18.16	77.76	0.14	0.05	0.31	0.00	24	NIL	NP	-	-	-	-		
3.00	UDS	-	-	Silty Sand	4.14	18.65	76.52	0.63	0.06	0.00	0.00	24	NIL	NP	1.69	9.45	1.54	2.67	0.00	28.0
4.50	12	1.09	13.08	Silty Sand	3.89	18.78	77.01	0.32	0.00	0.00	0.00	25	NIL	NP	-	-	-	-	-	-
7.50	11	0.92	10.12	Silty Sand	3.69	5.88	89.87	0.26	0.30	0.00	0.00	24	NIL	NP	-	-	-	-	-	-
9.00	UDS	-	-	Silty Sand	2.86	14.70	80.66	0.68	1.10	0.00	0.00	23	NIL	NP	2.00	18.22	1.69	2.67	0.00	28.0
10.50	22	0.79	16.19	Silty Sand	3.68	20.30	74.37	0.72	0.93	0.00	0.00	23	NIL	NP	-	-	-	-	-	-
13.50	27	0.70	16.95	Silty Sand	3.25	84.46	8.65	0.53	0.85	2.26	0.00	22	NIL	NP	-	-	-	-	-	-
16.50	13	0.63	8.19	Clayey Silt with Sand	13.68	79.23	5.02	0.36	0.45	1.26	0.00	33	21	12	-	-	-	-	-	-
19.50	16	0.57	9.12	Clayey Silt with Sand	16.22	75.07	7.48	0.43	0.15	0.65	0.00	35	21	14	-	-	-	-	-	-
22.50	15	0.52	7.80	Clayey Silt with Sand	17.65	75.26	6.35	0.32	0.42	0.00	0.00	36	21	15	-	-	-	-	-	-
24.00	UDS	-	-	Clayey Silt	12.48	83.29	3.87	0.26	0.10	0.00	0.00	30	19	11	2.09	18.65	1.76	2.69	0.12	19.0
25.50	19	0.47	8.93	Clayey Silt	15.22	81.25	2.52	0.68	0.33	0.00	0.00	34	21	13	-	-	-	-	-	-
28.50	21	0.43	9.03	Clayey Silt	18.45	77.72	2.25	0.75	0.41	0.42	0.00	38	22	16	-	-	-	-	-	-
30.00	23	0.41	9.43	Clayey Silt	13.58	84.20	1.65	0.33	0.24	0.00	0.00	31	19	12	-	-	-	-	-	-

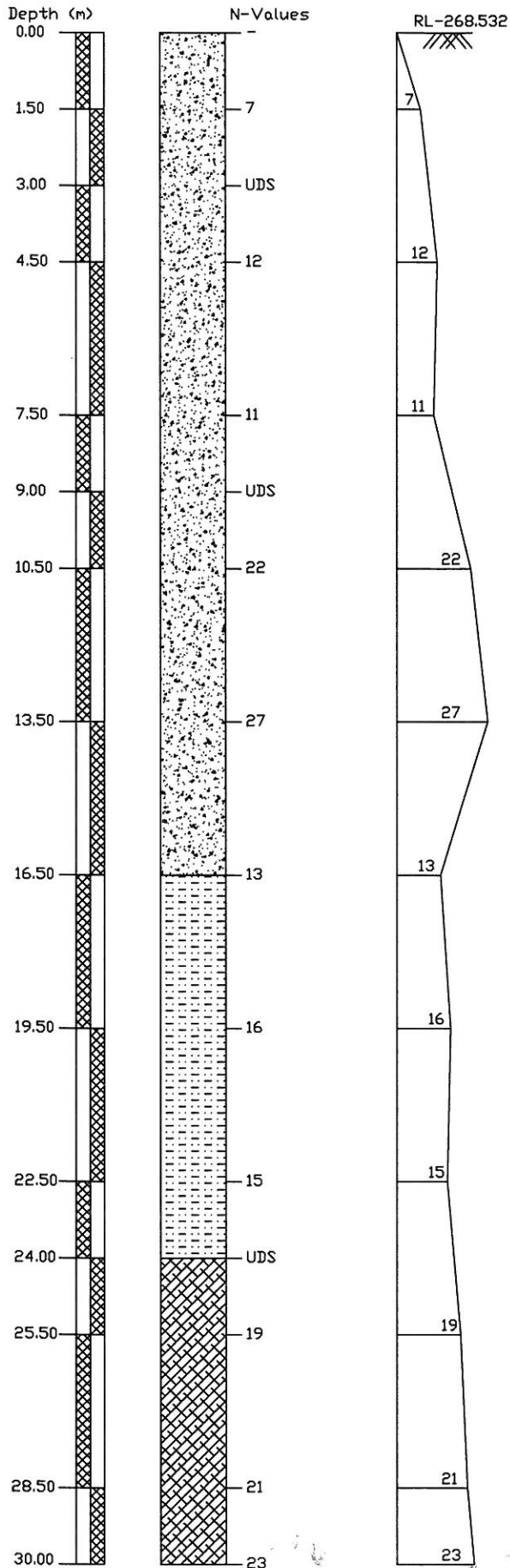
BORELOG OF BH-1(A1) AT EXISTING KM-256/5-7 FOR MAJOR BRIDGE NO.-293,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SILTY SAND
	CLAYEY SILT WITH SAND
	CLAYEY SILT

BORELOG OF BH-2(A2) AT EXISTING KM-256/5-7 FOR MAJOR BRIDGE NO.-293,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	SILTY SAND
	CLAYEY SILT WITH SAND
	CLAYEY SILT

1091

ANNEXURE - III

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

INPUT DATA

Ch. 256 5-7

BH-A1

Type of footing

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

Rectangular

2

Angle of internal friction (ϕ°)	28.00
Cohesion (c in t/m ²)	0.00
Void ratio (e)	0.70
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m ³)	1.70
Density of foundation soil (t/m ³)	1.70
Depth of water table(m)	1.50
Factor of safety	3.00

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

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,

$$d_c = 1 + 0.2 (D_f/B) \cdot \text{SQRT}(N_\phi)$$

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

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

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

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

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.

1092

ANNEXURE - III

Bearing capacity factors :

ϕ	28.00
N_c	26.37
N_q	15.30
N_γ	17.79

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	d_c	d_q	d_γ
1	1.50	3.00	1.17	1.08	1.08
2	3.00	3.00	1.33	1.17	1.17
3	4.50	3.00	1.50	1.25	1.25

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	35.28	12.33	18.07
2	3.00	3.00	8.00	37.99	13.28	19.46
3	4.50	3.00	8.00	40.70	14.23	20.85

ANNEXURE - III

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

INPUT DATA

Ch. 256 5-7

BH-A1

Type of footing

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

Rectangular

2

Angle of internal friction (ϕ°)	18.00
Cohesion (c in t/m ²)	1.30
Void ratio (e)	0.70
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m ³)	1.70
Density of foundation soil (t/m ³)	1.70
Depth of water table(m)	1.50
Factor of safety	3.00

S.no.	Depth (m)	Width (m)	
1	6.00	3.00	

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,

$$d_c = 1 + 0.2 (D_f/B) \cdot \text{SQRT}(N_\phi)$$

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

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

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

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

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.

1094

ANNEXURE - III

Bearing capacity factors :

<table style="width: 100%; border-collapse: collapse;"> <tr><td style="width: 30%;">ϕ</td><td style="text-align: right;">18.00</td></tr> <tr><td>N_c</td><td style="text-align: right;">13.29</td></tr> <tr><td>N_q</td><td style="text-align: right;">5.42</td></tr> <tr><td>N_γ</td><td style="text-align: right;">4.29</td></tr> </table>	ϕ	18.00	N_c	13.29	N_q	5.42	N_γ	4.29	<table style="width: 100%; border-collapse: collapse;"> <tr><td style="width: 30%;">ϕ'</td><td style="text-align: right;">12.28</td></tr> <tr><td>N'_c</td><td style="text-align: right;">9.55</td></tr> <tr><td>N'_q</td><td style="text-align: right;">3.14</td></tr> <tr><td>N'_γ</td><td style="text-align: right;">1.87</td></tr> </table>	ϕ'	12.28	N'_c	9.55	N'_q	3.14	N'_γ	1.87
ϕ	18.00																
N_c	13.29																
N_q	5.42																
N_γ	4.29																
ϕ'	12.28																
N'_c	9.55																
N'_q	3.14																
N'_γ	1.87																

Shape factors :

S.no.	Width(m)	Length (m)	S _c	S _q	S _γ
1	3.00	8.00	1.08	1.08	0.85

Depth factors :

S.no.	Depth(m)	Width(m)	d _c	d _q	d _γ
1	6.00	3.00	1.55	1.28	1.28

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m ²)		
				General shear	Local shear	Actual
1	6.00	3.00	8.00	21.87	10.45	13.31

- 1095

ANNEXURE - III

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

INPUT DATA

Ch. 256 5-7

BH-A2

Type of footing

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

Rectangular

2

Angle of internal friction (ϕ°)	28.00
Cohesion (c in t/m ²)	0.00
Void ratio (e)	0.73
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m ³)	1.69
Density of foundation soil (t/m ³)	1.69
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

$$q'_d = (2/3) c N'_c s'_c d'_c i'_c + q (N'_q - 1) s'_q d'_q i'_q + (1/2) B \gamma N'_\gamma s'_\gamma d'_\gamma i'_\gamma W'$$

Where,

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

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

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

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

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

OUTPUT

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

ANNEXURE - III

Bearing capacity factors :

ϕ	28.00
N_c	26.37
N_q	15.30
N_γ	17.79

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

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	d_c	d_q	d_γ
1	1.50	3.00	1.17	1.08	1.08
2	3.00	3.00	1.33	1.17	1.17
3	4.50	3.00	1.50	1.25	1.25
4	6.00	3.00	1.67	1.33	1.33

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m ²)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	35.07	12.26	14.54
2	3.00	3.00	8.00	37.76	13.20	15.66
3	4.50	3.00	8.00	40.46	14.14	16.78
4	6.00	3.00	8.00	43.15	15.09	17.89

1097

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Major Bridge
Chainage	256/05-7
Bore Hole No.	A1

Footing Depth (m)	1.50
SBC (t/m ²)	9.00
Average N value	10
Settlement for 10 t/m ² (mm)	36.00
Settlement (mm) for SBC	32.40
Depth Correction	0.91
Regidity Factor	0.80
Corrected Settlement (mm)	23.6

Footing Depth (m)	3.00
SBC (t/m ²)	9.50
Average N value	10
Settlement for 10 t/m ² (mm)	36.00
Settlement (mm) for SBC	34.20
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	22.7

Footing Depth (m)	4.50
SBC (t/m ²)	10.00
Average N value	9
Settlement for 10 t/m ² (mm)	42.00
Settlement (mm) for SBC	42.00
Depth Correction	0.74
Regidity Factor	0.80
Corrected Settlement (mm)	24.9

Footing Depth (m)	6.00
SBC (t/m ²)	11.00
Average N value	9
Settlement for 10 t/m ² (mm)	42.00
Settlement (mm) for SBC	46.20
Depth Correction	0.68
Regidity Factor	0.80
Corrected Settlement (mm)	25

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Major Bridge
Chainage	256/05-7
Bore Hole No.	A2

Footing Depth (m)	1.50
SBC (t/m ²)	11.00
Average N value	11
Settlement for 10 t/m ² (mm)	31.00
Settlement (mm) for SBC	34.10
Depth Correction	0.91
Regidity Factor	0.80
Corrected Settlement (mm)	24.8

Footing Depth (m)	3.00
SBC (t/m ²)	12.00
Average N value	11
Settlement for 10 t/m ² (mm)	31.00
Settlement (mm) for SBC	37.20
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	24.7

Footing Depth (m)	4.50
SBC (t/m ²)	13.00
Average N value	12
Settlement for 10 t/m ² (mm)	29.00
Settlement (mm) for SBC	37.70
Depth Correction	0.74
Regidity Factor	0.80
Corrected Settlement (mm)	22.3

Footing Depth (m)	6.00
SBC (t/m ²)	14.00
Average N value	12
Settlement for 10 t/m ² (mm)	29.00
Settlement (mm) for SBC	40.60
Depth Correction	0.68
Regidity Factor	0.80
Corrected Settlement (mm)	22.1

CHAPTER - 132

"Major Bridge No. 291",

Location - Existing Km. - 253/23-25



132.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 1x24.40

132.2 BOREHOLE DESCRIPTIONS:

- (a) Location of Structure, Boreholes with RL shown in **FIGURE-1**.
- (b) Subsurface Characteristic of Soil/Rock shown in **ANNEXURE-I**.
- (c) Borelogs and sub soil profile shown in **ANNEXURE-II**.
- (d) Calculations of Safe Bearing Capacities in **ANNEXURE-III**.
- (e) Calculations of Probable Settlement in **ANNEXURE-IV**.
- (f) Depth of water Table 13.30m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1(A1)	0.00 to 3.00	Clayey Silt with Sand	Loose
	3.00 to 4.50	Clayey Silt	Loose
	4.50 to 22.50	Clayey Silt	Medium Dense
	22.50 to 24.00	Clayey Silt with Sand	Medium Dense
	24.00 to 25.50	Clayey Silt	Medium Dense
	25.50 to 30.00	Clayey Silt with Sand	Dense
BH-2(A2)	0.00 to 1.50	Silty Sand	Loose
	1.50 to 7.50	Silty Sand	Medium Dense
	7.50 to 10.50	Sandy Silt	Medium Dense
	10.50 to 12.00	Clayey Silt	Medium Dense
	12.00 to 25.50	Clayey Silt with Sand	Medium Dense
	25.50 to 28.50	Clayey Silt	Medium Dense
	28.50 to 30.00	Clayey Silt	Dense

132.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.80	0.007	0.0032	NIL	0.0014	0.082
	9.00	8.80	0.007	0.0011	NIL	0.0011	0.033
	18.00	9.10	0.010	0.0021	NIL	0.0013	0.056
	24.00	8.80	0.007	0.0025	NIL	0.0013	0.049
BH-2 (A2)	12.00	8.50	NIL	0.0021	NIL	0.0013	0.055

132.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1(A1)	3.00	28.00
	9.00	21.00
	18.00	26.00
	24.00	29.00
BH-2 (A2)	3.00	NIL
	12.00	28.00
	21.00	25.00

132.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BORE HOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (μ S/cm)
Test Result	7.2	90	90	169	812	0.2	2.5	1020	650
Requirement as per IS:456 / Mosths	Not less than 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 ₂ SO ₄	-	-

132.6 PILE LOAD CARRYING CAPACITY

132.6.1 Normal Bored Cast in- situ Pile Foundations:

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

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

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

Safe bearing capacity in t/m²

BH -NO.	DEPTH (mtr)	Net Allowable Bearing Pressure (t/m ²)
BH-1 (A1)	1.50m	07.00
	3.00m	09.00
	4.50m	10.00
	6.00m	10.50
BH-3 (A2)	1.50m	12.50
	3.00m	13.50
	4.50m	14.50
	6.00m	15.50

Pile load carrying capacity in t

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE	
		Pile Diameter= 1.0 m	Pile Diameter= 1.2 m
BH-1 (A1)	17.00	90.00	110.00
	20.00	110.00	140.00
	23.00	140.00	170.00
BH-2 (A2)	17.00	70.00	90.00
	20.00	90.00	110.00
	23.00	120.00	140.00

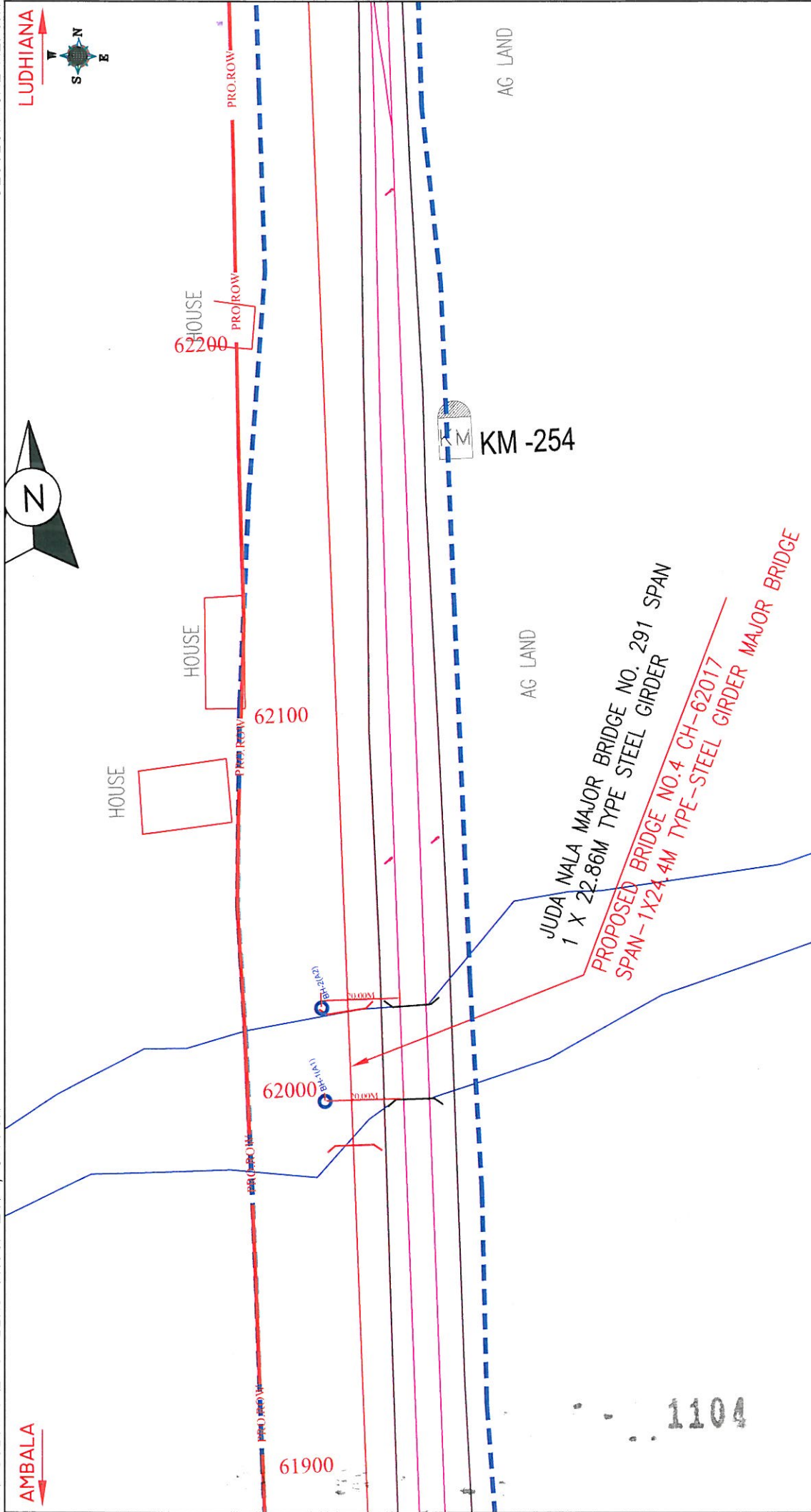
132.7 CONCLUSIONS

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

132.8 RECOMMENDATIONS

(i)	<i>Type of foundation</i>	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.



<p>FIG.-1 LOCATION PLAN OF PROPOSED MAJOR BRIDGE CH. 253/23-25</p>	<p>ALL DIMENSIONS IN METER</p> <p>RL OF BH (A1) = 267.507 RL OF BH (A2) = 264.485</p>	<p>PROJECT :- LUDHIANA-AMBALA (DFCCIL)</p>	<p>DESIGN :- CONSULTING ENGINEERS GROUP LTD. E-12, Meji Colony, Malviya Nagar, Jaipur-17 Tel: +91-141-2520899, 2521899, 2520556 Fax: 2521348, E-Mail: ceg@cegroupindia.com</p>
--	---	--	--

1104

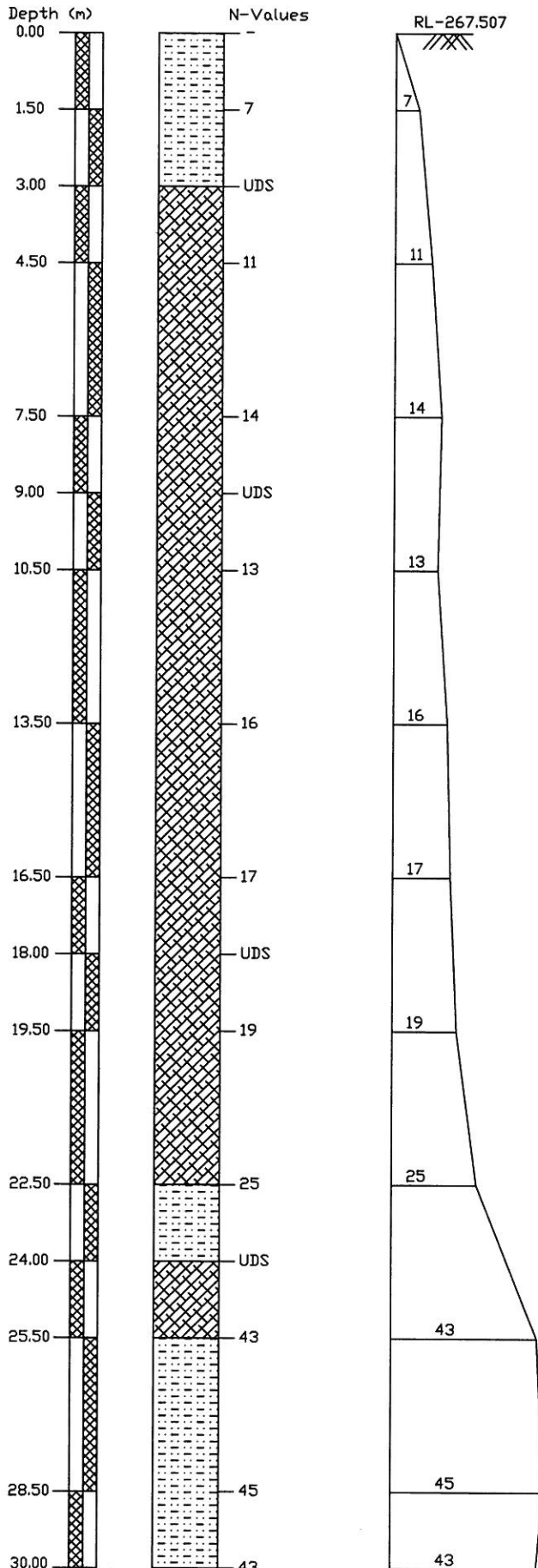
SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (A1) RHS OF MAJOR BRIDGE No. 291 AT CHAINAGE 253/23-25

Project : Depth from GL (m)	Chainage 253/23-25 Bridge No. 291		Date of Testing 25.07.2009 to 26.07.2009	Location at A1	B.H. No. 1(RHS)	Depth of Water Table 13.30 m.	Termination Depth 30.00mtr		Surface Elevation 267.507														
	Observed	Corrected					Soil Description (Soil Group)	Clay	Silt	Grain Size Distribution % wt retained	Atterberg Limits %	B.D.	M.C.	D.D.	Specific Gravity	Shear Strength c kg/cm ² φ degree							
	Factor	N _h																					
2.00	-	-	-	26.69	64.24	6.26	0.95	1.2	0	0	0.66	0.95	1.2	0	45	20	25	-	-	-	-	-	-
1.50	1.51	10.57	Clayey silt with sand	27.85	65.57	4.84	0.31	0.67	0.00	0.00	0.76	0.31	0.67	0.00	46	21	25	-	-	-	-	-	-
3.00	-	-	Clayey silt	32.22	62.78	3.14	0.85	0.52	0.00	0.00	0.49	0.85	0.52	0.00	52	23	29	1.63	1.53	2.68	0.34	10.00	
4.50	1.11	12.21	Clayey silt	23.26	73.15	1.54	0.32	0.00	0.00	0.00	1.73	0.32	0.00	0.00	41	20	21	-	-	-	-	-	-
7.50	0.93	13.02	Clayey silt	25.65	73.23	1.07	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	43	20	23	-	-	-	-	-	-
9.00	-	-	Clayey silt	13.25	85.99	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31	20	11	1.84	15.62	1.59	2.68	0.10	20.00
10.50	0.81	10.53	Clayey silt	24.59	74.23	1.06	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	41	19	22	-	-	-	-	-	-
13.50	0.72	11.52	Clayey silt	25.62	72.94	0.76	0.10	0.28	0.00	0.00	0.30	0.10	0.28	0.00	44	21	23	-	-	-	-	-	-
16.50	0.65	11.05	Clayey silt	23.12	74.32	2.14	0.14	0.00	0.00	0.00	0.28	0.14	0.00	0.00	40	19	21	-	-	-	-	-	-
18.00	-	-	Clayey silt	22.94	75.57	0.87	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	43	22	21	1.96	20.33	1.63	2.68	0.26	13.00
19.50	0.59	11.21	Clayey silt	24.10	72.17	1.79	0.13	0.00	0.00	0.00	1.81	0.13	0.00	0.00	42	20	22	-	-	-	-	-	-
22.50	0.53	13.25	Clayey silt with sand	20.59	59.66	19.33	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	37	19	18	-	-	-	-	-	-
24.00	-	-	Clayey silt	23.94	74.14	1.76	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	42	20	22	2.11	22.12	1.73	2.66	0.27	12.00
25.50	0.49	18.04	Clayey silt with sand	23.69	70.34	4.32	0.54	0.00	0.00	0.00	1.11	0.54	0.00	0.00	41	20	21	-	-	-	-	-	-
28.50	0.44	17.40	Clayey silt with sand	21.89	72.20	3.85	0.66	0.15	0.00	0.00	1.25	0.66	0.15	0.00	39	19	20	-	-	-	-	-	-
30.00	0.42	16.53	Clayey silt with sand	24.59	70.60	3.92	0.22	0.00	0.00	0.00	0.67	0.22	0.00	0.00	42	20	22	-	-	-	-	-	-



SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (A2) RHS OF MAJOR BRIDGE No. 291 AT CHAINAGE 253/23-25																												
Project :	Chainage 253/23-25 Bridge No. 291			Date of Testing 24.07.2009 to 25.07.2009	Location at A2	B.H. No. 2(RHS)	Depth of Water Table 14.00 m.	Termination Depth 30.00mtr	Surface Elevation																			
	Observed	Correction	Corrected						B.D.	M.C.	D.D.	Specific Gravity	Shear Strength															
Depth from GL (m)	N	Factor	N _n	Soil Description (Soil Group)	Clay	Silt	Grain Size Distribution % wt retained			Atterberg Limits %	B.D.	M.C.	D.D.	Specific Gravity	Shear Strength	φ degree												
		C _n					Fine	Medium	Coarse	Fine	Coarse	Gravel	L.L.	P.L.	P.I.	gm/cc	%	gm/cc										
0.00	-	-	-	Silty Sand	2.16	10.68	75.61	6.23	2.11	3.21	0.00		23	NIL	NP	-	-	-	-	-	-	-	-	-	-	-	-	-
1.50	14	1.46	20.44	Silty Sand	2.34	7.69	80.86	4.64	2.91	1.56	0.00		26	NIL	NP	-	-	-	-	-	-	-	-	-	-	-	-	-
3.00	UDS	-	-	Silty Sand	3.22	7.23	82.70	2.49	1.21	3.15	0.00		26	NIL	NP	1.69	8.56	1.56	2.68	0.00	26.00							
4.50	19	1.09	20.71	Silty Sand	2.68	6.34	87.27	3.30	0.41	0.00	0.00		25	NIL	NP	-	-	-	-	-	-							
7.50	16	0.92	14.72	Sandy Silt	4.52	77.19	15.37	0.51	0.25	2.16	0.00		28	NIL	NP	-	-	-	-	-	-							
10.50	14	0.81	11.34	Clayey silt	18.68	79.58	1.54	0.08	0.12	0.00	0.00		34	18	16	-	-	-	-	-	-							
12.00	UDS	-	-	Clayey silt with sand	25.62	67.54	4.61	0.73	0.94	0.56	0.00		45	22	23	1.80	10.33	1.63	2.68	0.27	11.00							
13.50	16	0.72	11.52	Clayey silt with sand	26.21	64.30	5.23	2.09	1.40	0.77	0.00		43	20	23	-	-	-	-	-	-							
16.50	16	0.65	10.40	Clayey silt with sand	23.88	61.12	8.63	2.25	1.82	2.30	0.00		41	19	22	-	-	-	-	-	-							
19.50	19	0.59	11.21	Clayey silt with sand	26.58	65.77	4.37	1.37	1.08	0.83	0.00		44	20	24	-	-	-	-	-	-							
21.00	UDS	-	-	Clayey silt with sand	23.11	68.03	5.23	2.11	0.83	0.69	0.00		41	21	20	2.03	19.65	1.70	2.67	0.22	14.00							
22.50	23	0.54	12.42	Clayey silt with sand	26.94	61.83	4.97	1.56	1.86	2.84	0.00		46	21	25	-	-	-	-	-	-							
25.50	26	0.49	12.74	Clayey silt	23.97	71.53	3.43	0.60	0.37	0.10	0.00		41	19	22	-	-	-	-	-	-							
28.50	33	0.45	14.85	Clayey silt	22.68	70.83	3.87	1.16	0.82	0.64	0.00		39	19	20	-	-	-	-	-	-							
30.00	41	0.43	16.32	Clayey silt	21.67	74.72	3.32	0.21	0.08	0.00	0.00		38	19	19	-	-	-	-	-	-							

BORELOG OF BH-1(A1) RHS AT EXISTING KM-253/23-25 FOR MAJOR BRIDGE NO.-291,
ON KESARI TO SANEHWAL, LUDHIANA

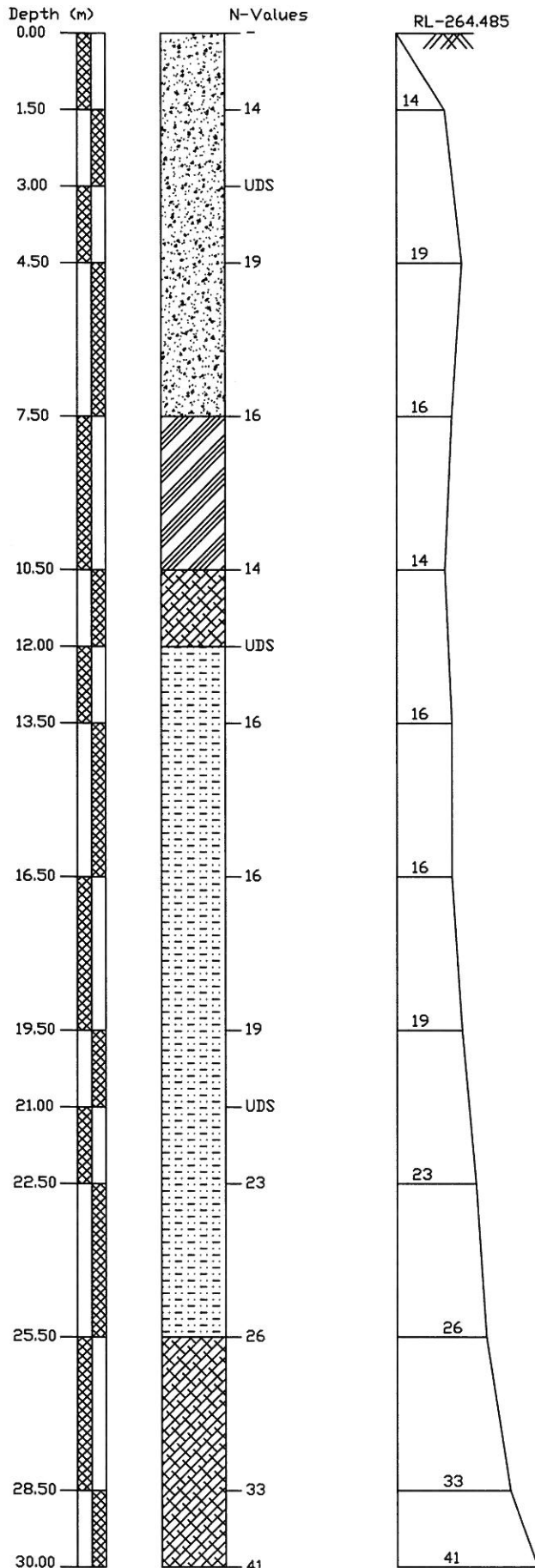


LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	CLAYEY SILT

1107

BORELOG OF BH-2(A2) RHS AT EXISTING KM-253/23-25 FOR MAJOR BRIDGE NO.-291,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

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

ANNEXURE - III

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

INPUT DATA

Ch. 253 23-25

BH-A1

Type of footing

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

Rectangular

2

Angle of internal friction (ϕ°)	10.00
Cohesion (c in t/m ²)	3.40
Void ratio (e)	0.75
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m ³)	1.63
Density of foundation soil (t/m ³)	1.63
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

$$q'_d = (2/3) c N'_c s'_c d'_c i'_c + q (N'_q - 1) s'_q d'_q i'_q + (1/2) B \gamma N'_\gamma s'_\gamma d'_\gamma i'_\gamma W'$$

Where,

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

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

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

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

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

OUTPUT

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

ANNEXURE - III

Bearing capacity factors :

ϕ	10.00
N_c	8.35
N_q	2.47
N_γ	1.22

ϕ'	6.74
N'_c	7.14
N'_q	1.88
N'_γ	0.72

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	d_c	d_q	d_γ
1	1.50	3.00	1.12	1.06	1.06
2	3.00	3.00	1.24	1.12	1.12
3	4.50	3.00	1.36	1.18	1.18
4	6.00	3.00	1.48	1.24	1.24

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	14.56	8.39	8.39
2	3.00	3.00	8.00	15.95	9.19	9.19
3	4.50	3.00	8.00	17.34	9.99	9.99
4	6.00	3.00	8.00	18.74	10.78	10.78

ANNEXURE - III

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

INPUT DATA

Ch. 253 23-25

BH-A2

Type of footing

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

Rectangular



Angle of internal friction (ϕ°)	26.00
Cohesion (c in t/m ²)	0.00
Void ratio (e)	0.72
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m ³)	1.69
Density of foundation soil (t/m ³)	1.69
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

$$q'_d = (2/3) c N'_c s'_c d'_c i'_c + q (N'_q - 1) s'_q d'_q i'_q + (1/2) B \gamma N'_\gamma s'_\gamma d'_\gamma i'_\gamma W'$$

Where,

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

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

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

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

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

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.

0111 1111

ANNEXURE - III

Bearing capacity factors :

ϕ	26.00
N_c	22.60
N_q	12.21
N_γ	13.18

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

Shape factors :

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

Depth factors :

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

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m ²)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	27.11	10.44	12.94
2	3.00	3.00	8.00	29.11	11.22	13.90
3	4.50	3.00	8.00	31.12	11.99	14.86
4	6.00	3.00	8.00	33.13	12.77	15.82

1112

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 23-25	
BH No. (A1)			
Depth of foundation	=	1.5	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer P_o	=	6.1	t/m ²
Concentrated load P	=	7.00	t/m ²
Increase in pressure at mid of layer ΔP	=	$P \times I_B$	
		$I_B = 0.21$	
	ΔP	=	1.5 t/m ²
Compression Index C_c	=	0.144	
Thickness of clay layer H	=	4.5	m
Initial Void ratio e_o	=	0.75	
	$\frac{P_o + \Delta p}{P_o}$	=	1.24049
Settlement of clay layer S_f	=	$\frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$	
	S_f	=	0.03466 m
		=	34.6564 mm
Correction for Depth, Rigidity of foundation and Pore Pr. on total settlement			
<u>Depth Factor Calculation</u>			
	$D/(LB)^{0.5}$	=	0.31
D = Depth of Foundation			
	L/B	=	2.67
Depth Factor	=	0.91	
Rigidity Factor	=	$\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$	
		=	0.8
Pore Pr. Correction = N.A.			
Corrected Total Settlement S_{f2}	=	$S_f \times D.F. \times R.F.$	
	S_{f2}	=	25 mm

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 23-25	
BH No. (A1)			
Depth of foundation	=	3.0	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer	P _o	=	8.5575 t/m ²
Concentrated load P	=	9.00	t/m ²
Increase in pressure at mid of layer	ΔP	=	P x I _B
	I _B	=	0.21
	ΔP	=	1.9 t/m ²
Compression Index	C _c	=	0.144
Thickness of clay layer	H	=	4.5 m
Initial Void ratio	e _o	=	0.75
	$\frac{P_o + \Delta p}{P_o}$	=	1.22086
Settlement of clay layer	S _f	=	$\frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$
	S _f	=	0.03209 m
		=	32.091 mm
Correction for Depth,Rigidity of foundation and Pore Pr. 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 Pr. Correction = N.A.			
Corrected Total Settlement		=	S _f x D.F.x R.F.
	S _{f2}	=	21.3 mm

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 23-25	
BH No. (A1)			
Depth of foundation		=	4.5 m
Length of footing (L)		=	8.0 m
Width of footing (B)		=	3.0 m
Initial effective stress at mid of layer	P _o	=	11.0025 t/m ²
Concentrated load P		=	10.00 t/m ²
Increase in pressure at mid of layer	ΔP	=	P × I _B
	I _B	=	0.21
	ΔP	=	2.1 t/m ²
Compression Index	C _c	=	0.144
Thickness of clay layer	H	=	4.5 m
Initial Void ratio	e _o	=	0.75
	$\frac{P_o + \Delta p}{P_o}$	=	1.19087
Settlement of clay layer	S _f	=	$\frac{C_c}{1 + e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$
	S _f	=	0.02809 m
		=	28.0909 mm
Correction for Depth, Rigidity of foundation and Pore Pr. on total settlement			
Depth Factor Calculation			
	D/(LB) ^{0.5}	=	0.92
D = Depth of Foundation			
	L/B	=	2.67
Depth Factor		=	0.74
Rigidity Factor	=	$\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$	
		=	0.8
Pore Pr. Correction = N.A.			
Corrected Total Settlement		=	S _f × D.F. × R.F.
	S _{f2}	=	16.6 mm

1115

1115

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 23-25	
BH No. (A1)			
Depth of foundation		=	6.0 m
Length of footing (L)		=	8.0 m
Width of footing (B)		=	3.0 m
Initial effective stress at mid of layer	P _o	=	13.4475 t/m ²
Concentrated load P		=	10.50 t/m ²
Increase in pressure at mid of layer	ΔP	=	P × I _B
		I _B	= 0.21
	ΔP	=	2.2 t/m ²
Compression Index	C _c	=	0.144
Thickness of clay layer	H	=	4.5 m
Initial Void ratio	e _o	=	0.75
	$\frac{P_o + \Delta p}{P_o}$	=	1.16397
Settlement of clay layer	S _f	=	$\frac{C_c}{1 + e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$
	S _f	=	0.02442 m
		=	24.4174 mm
Correction for Depth, Rigidity of foundation and Pore Pr. on total settlement			
Depth Factor Calculation			
	(LB) ^{0.5} /D	=	0.82
D = Depth of Foundation			
	L/B	=	2.67
Depth Factor		=	0.68
Rigidity Factor	=	$\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$	
		=	0.8
Pore Pr. Correction = N.A.			
Corrected Total Settlement		=	S _f × D.F. × R.F.
	S _{f2}	=	13.3 mm

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)	
Location	Major Bridge
Chainage	253/23-25
Bore Hole No.	A2

Footing Depth (m)	1.50
SBC (t/m ²)	12.50
Average N value	20
Settlement for 10 t/m ² (mm)	16.00
Settlement (mm) for SBC	20.00
Depth Correction	0.91
Regidity Factor	0.80
Corrected Settlement (mm)	14.6

Footing Depth (m)	3.00
SBC (t/m ²)	13.50
Average N value	19
Settlement for 10 t/m ² (mm)	17.00
Settlement (mm) for SBC	22.95
Depth Correction	0.83
Regidity Factor	0.80
Corrected Settlement (mm)	15.2

Footing Depth (m)	4.50
SBC (t/m ²)	14.50
Average N value	17
Settlement for 10 t/m ² (mm)	19.00
Settlement (mm) for SBC	27.55
Depth Correction	0.74
Regidity Factor	0.80
Corrected Settlement (mm)	16.3

Footing Depth (m)	6.00
SBC (t/m ²)	15.50
Average N value	15
Settlement for 10 t/m ² (mm)	21.00
Settlement (mm) for SBC	32.55
Depth Correction	0.68
Regidity Factor	0.80
Corrected Settlement (mm)	17.7

2010

1118

CHAPTER - 133

"Major Bridge No. 290",

Location - Existing Km. - 253/1-3



**CONSULTING
Engineers Group Ltd.**

E-72, Mid. Colony, Meera Nagar, Jalandhar-17, INDIA
Tel: +91-181-520888, 521889, 520554
Fax: 521549, E-Mail: info@cegindia.com

133.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 1x24.4

133.2 BOREHOLE DESCRIPTIONS:

- Location of Structure, Boreholes with RL shown in **FIGURE-1**.
- Subsurface Characteristic of Soil/Rock shown in **ANNEXURE-I**.
- Borelogs and sub soil profile shown in **ANNEXURE-II**.
- Calculations of Safe Bearing Capacities in **ANNEXURE-III**.
- Calculations of Probable Settlement in **ANNEXURE-IV**.
- 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 3.00	Clayey Silt with Sand	Loose
	3.00 to 4.50	Clayey Silt	Loose
	4.50 to 13.50	Clayey Silt	Medium Dense
	13.50 to 16.50	Clayey Silt with Sand	Medium Dense
	16.50 to 19.50	Clayey Silt	Medium Dense
	19.50 to 22.50	Clayey Silt with Sand	Dense
	22.50 to 28.50	Clayey Silt	Dense
	28.50 to 30.00	Clayey Silt with Sand	Dense
BH-2(A2)	0.00 to 3.00	Clayey Silt with Sand	Loose
	3.00 to 4.50	Clayey Silt	Loose
	4.50 to 7.50	Clayey Silt	Medium Dense
	7.50 to 10.50	Clayey Silt with Sand	Medium Dense
	10.50 to 19.50	Clayey Silt	Medium Dense
	19.50 to 30.00	Clayey Silt	Dense

133.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.00	NIL	0.0028	NIL	0.0013	0.054
	12.00	8.80	0.005	0.0018	NIL	0.0012	0.034
	18.00	8.70	0.005	0.0018	NIL	0.0012	0.037
	24.00	8.30	NIL	0.0021	NIL	0.0012	0.046
BH-2 (A2)	3.00	8.50	0.002	0.0021	NIL	0.0014	0.062
	12.00	8.40	NIL	0.0025	NIL	0.0012	0.045

133.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1 (A1)	3.00	40.00
	12.00	27.00
	18.00	21.00
	24.00	25.00

BH-2 (A2)	3.00	41.00
	12.00	26.00
	21.00	28.00

133.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BORE HOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (μ S/cm)
Test Result	7.5	110	102	150	810	0.1	2.5	980	625
Requirement as per IS:456 / Mosrths	Not less than 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 ₂ SO ₄	-	-

133.6 PILE LOAD CARRYING CAPACITY

133.6.1 Normal Bored Cast in- situ Pile Foundations:

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

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

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

Safe bearing capacity in t/m²

BH -NO.	DEPTH (mtr)	Net Allowable Bearing Pressure (t/m ²)
BH-1 (A1)	1.50m	07.00
	3.00m	08.00
	4.50m	08.50
	6.00m	09.50
BH-3 (A2)	1.50m	07.00
	3.00m	08.50
	4.50m	09.50
	6.00m	10.00

Pile load carrying capacity in t

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE	
		Pile Diameter= 1.0 m	Pile Diameter= 1.2 m
BH-1 (A1)	17.00	80.00	100.00
	20.00	110.00	130.00
	23.00	140.00	170.00
BH-2 (A2)	17.00	80.00	90.00
	20.00	100.00	120.00
	23.00	130.00	150.00

133.7 CONCLUSIONS

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

133.8 RECOMMENDATIONS

(i)	<i>Type of foundation</i>	Pile foundation
-----	---------------------------	-----------------

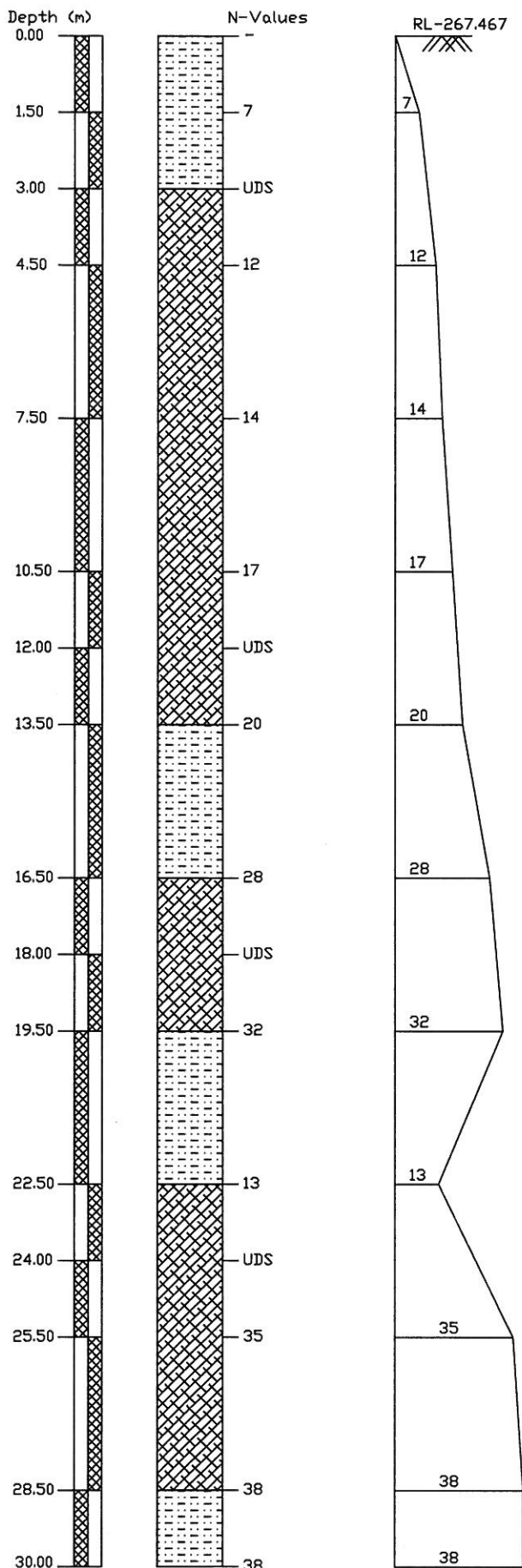
Note- The above recommendations are based on the field and laboratory tests conducted on the soil, and our experience in this regard. If the actual subsoil conditions during excavation for the foundation differ from the observations reported here, the design experts/consultants should be referred for 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.

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (A1) RHS OF MAJOR BRIDGE No. 290 AT CHAINAGE 253/1-3

Project :	Chainage 253/1-3 Bridge No. 290		Date of Testing 21.07.2009 to 22.07.2009	Location at A1	B.H. No. 1(RHS)	Depth of Water Table 13.50 m.	Termination Depth 30.00mtr	Surface Elevation											
	Observed	Corrected						B.D.	M.C.	D.D.	Specific Gravity								
Depth from GL (m)	N	Factor C _n	Soil Description (Soil Group)	Clay	Silt	Grain Size Distribution % wt retained						Atterberg Limits % L.L. P.L. P.I.	B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength c kg/cm ² φ degree		
						Fine	Medium	Coarse	Fine	Coarse	Gravel							Fine	Coarse
0.00	-	-	Clayey silt with sand	20.5	64.17	6.22	3.21	2.64	3.26	0.00	36	18	18	-	-	-	-	-	
1.50	7	1.51	Clayey silt with sand	22.69	63.18	6.20	2.32	2.53	3.08	0.00	36	16	20	-	-	-	-	-	
3.00	UDS	-	Clayey silt	32.69	65.99	1.11	0.16	0.05	0.00	0.00	55	25	30	1.63	6.65	1.53	2.67	0.38	7.00
4.50	12	1.11	Clayey silt	22.10	75.86	1.29	0.75	0.00	0.00	0.00	37	18	19	-	-	-	-	-	-
7.50	14	0.93	Clayey silt	18.95	79.59	1.08	0.26	0.12	0.00	0.00	34	18	16	-	-	-	-	-	-
10.50	17	0.82	Clayey silt	20.11	78.27	1.59	0.03	0.00	0.00	0.00	32	15	17	-	-	-	-	-	-
12.00	UDS	-	Clayey silt	21.65	76.49	1.25	0.30	0.12	0.19	0.00	39	21	19	1.69	6.55	1.59	2.66	0.25	13.00
13.50	20	0.74	Clayey silt with sand	16.65	76.49	5.61	0.80	0.30	0.15	0.00	30	16	14	-	-	-	-	-	-
16.50	28	0.67	Clayey silt	24.12	74.97	0.74	0.17	0.00	0.00	0.00	41	20	21	-	-	-	-	-	-
18.00	UDS	-	Clayey silt	18.95	79.72	1.33	0.00	0.00	0.00	0.00	38	22	16	2.00	20.59	1.66	2.68	0.19	17.00
19.50	32	0.60	Clayey silt with sand	16.82	68.62	12.33	0.35	0.10	1.78	0.00	31	17	14	-	-	-	-	-	-
22.50	13	0.54	Clayey silt	20.31	75.38	3.80	0.29	0.22	0.00	0.00	35	18	17	-	-	-	-	-	-
24.00	UDS	-	Clayey silt	22.19	74.30	2.14	0.76	0.33	0.28	0.00	39	20	19	2.09	20.85	1.73	2.67	0.23	14.00
25.50	35	0.49	Clayey silt	21.33	76.36	1.07	0.67	0.57	0.00	0.00	37	19	18	-	-	-	-	-	-
28.50	38	0.45	Clayey silt with sand	16.83	75.34	5.61	1.52	0.70	0.00	0.00	31	17	14	-	-	-	-	-	-
30.00	38	0.43	Clayey silt with sand	17.44	72.02	3.20	1.91	1.65	3.78	0.00	32	17	15	-	-	-	-	-	-

SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (A2) RHS OF MAJOR BRIDGE No. 290 AT CHAINAGE 253/1-3																				
Project :	Chainage 253/1-3 Bridge No. 290		Date of Testing 22.07.2009 to 23.07.2009	Location at A2	B.H. No. 2(RHS)	Depth of Water Table 13.50 m.	Termination Depth 30.00mtr	Surface Elevation												
								267.436												
Depth from GL (m)	Observed N	Correction Factor C _n	Corrected N _n	Soil Description (Soil Group)	Grain Size Distribution % wt retained						Atterberg Limits %			D.D. gm/cc	M.C. %	B.D. gm/cc	Specific Gravity	Shear Strength		
					Clay	Silt	Fine Medium Coarse	Gravel Fine Coarse	L.L.	P.L.	P.I.	c kg/cm ²	φ degree							
0.00	-	-	-	Clayey silt with sand	22.56	66.14	4.56	2.15	0.39	4.2	0.00	40	20	20	-	-	-	-	-	-
1.50	6	1.46	8.76	Clayey silt with sand	18.55	70.52	5.22	1.16	0.56	3.99	0.00	32	16	16	-	-	-	-	-	-
3.00	UDS	-	-	Clayey silt	33.42	64.35	0.69	0.26	0.28	1.00	0.00	55	25	30	1.70	9.64	1.55	2.69	0.36	8.00
4.50	14	1.09	15.26	Clayey silt	20.59	74.81	0.66	0.77	0.92	2.25	0.00	36	18	18	-	-	-	-	-	-
7.50	16	0.92	14.72	Clayey silt with sand	21.58	72.33	5.97	0.04	0.08	0.00	0.00	39	20	19	-	-	-	-	-	-
10.50	11	0.81	8.91	Clayey silt	23.15	76.10	0.68	0.07	0.00	0.00	0.00	40	20	20	-	-	-	-	-	-
12.00	UDS	-	-	Clayey silt	21.56	76.40	1.97	0.07	0.00	0.00	0.00	40	20	20	1.80	9.36	1.65	2.68	0.24	13.00
13.50	18	0.72	12.96	Clayey silt	26.59	72.57	0.76	0.08	0.00	0.00	0.00	50	26	24	-	-	-	-	-	-
16.50	25	0.65	15.63	Clayey silt	25.26	74.07	0.52	0.15	0.00	0.00	0.00	45	22	23	-	-	-	-	-	-
19.50	31	0.59	16.65	Clayey silt	23.58	74.99	0.53	0.58	0.32	0.00	0.00	41	20	21	-	-	-	-	-	-
21.00	UDS	-	-	Clayey silt	23.10	74.43	1.23	0.59	0.65	0.00	0.00	40	20	20	2.10	20.61	1.74	2.67	0.24	13.00
22.50	15	0.54	8.10	Clayey silt	23.58	75.56	0.49	0.37	0.00	0.00	0.00	40	20	20	-	-	-	-	-	-
25.50	25	0.49	12.25	Clayey silt	26.54	71.90	0.46	0.66	0.16	0.28	0.00	46	21	25	-	-	-	-	-	-
28.50	29	0.44	12.76	Clayey silt	23.15	75.98	0.79	0.08	0.00	0.00	0.00	39	19	20	-	-	-	-	-	-
30.00	36	0.43	15.24	Clayey silt	21.29	77.94	0.67	0.10	0.00	0.00	0.00	39	20	19	-	-	-	-	-	-

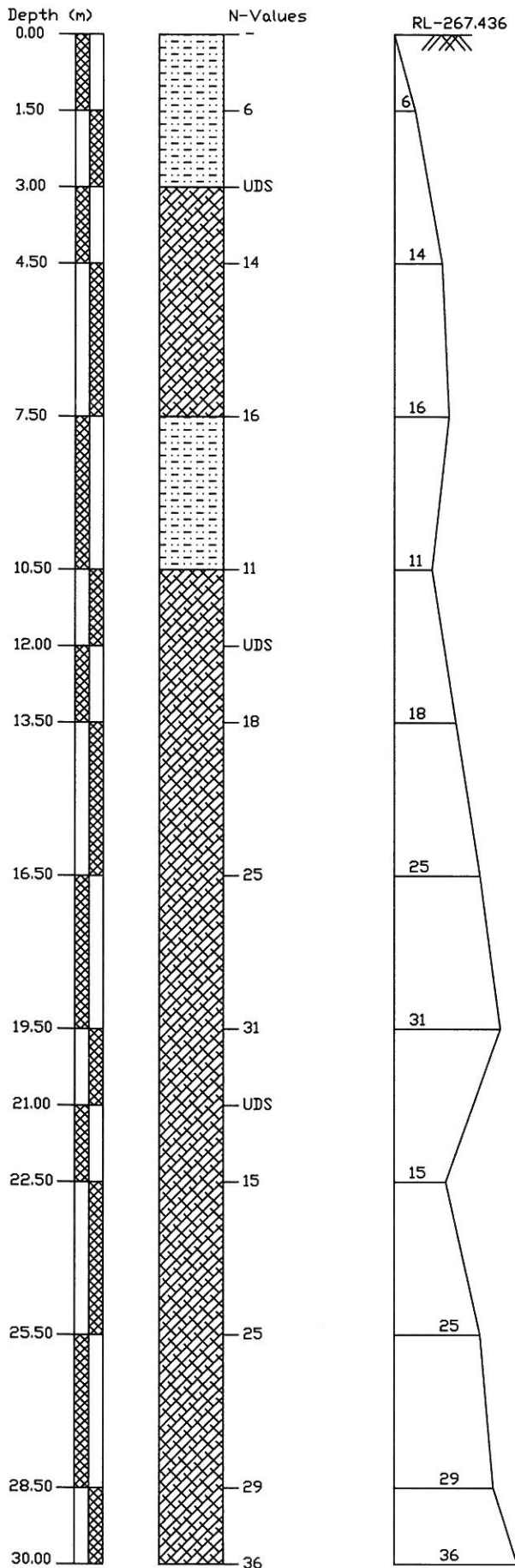
BORELOG OF BH-1(A1) RHS AT EXISTING KM-253/1-3 FOR MAJOR BRIDGE NO.-290,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	CLAYEY SILT

BORELOG OF BH-2(A2) RHS AT EXISTING KM-253/1-3 FOR MAJOR BRIDGE NO.-290,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	CLAYEY SILT

ANNEXURE - III

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

INPUT DATA

Ch. 253 1-3

BH-A1

Type of footing

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

Rectangular

2

Angle of internal friction (ϕ°)	7.00
Cohesion (c in t/m ²)	3.80
Void ratio (e)	0.75
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m ³)	1.63
Density of foundation soil (t/m ³)	1.63
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

$$q'_d = (2/3) c N'_c s'_c d'_c i'_c + q (N'_q - 1) s'_q d'_q i'_q + (1/2) B \gamma N'_\gamma s'_\gamma d'_\gamma i'_\gamma W'$$

Where,

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

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

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

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

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

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.

4511

1129

ANNEXURE - III

Bearing capacity factors :

ϕ	7.00
N_c	7.23
N_q	1.93
N_γ	0.76

ϕ'	4.70
N'_c	6.41
N'_q	1.54
N'_γ	0.42

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	d_c	d_q	d_γ
1	1.50	3.00	1.11	1.00	1.00
2	3.00	3.00	1.23	1.00	1.00
3	4.50	3.00	1.34	1.00	1.00
4	6.00	3.00	1.45	1.00	1.00

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m ²)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	12.86	7.56	7.56
2	3.00	3.00	8.00	13.97	8.22	8.22
3	4.50	3.00	8.00	15.08	8.88	8.88
4	6.00	3.00	8.00	16.20	9.54	9.54

1130

ANNEXURE - III

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

INPUT DATA

Ch. 253 1-3

BH-A2

Type of footing

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

Rectangular

2

Angle of internal friction (ϕ°)	8.00
Cohesion (c in t/m ²)	3.60
Void ratio (e)	0.74
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m ³)	1.70
Density of foundation soil (t/m ³)	1.70
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

$$q'_d = (2/3) c N'_c s'_c d'_c i'_c + q (N'_q - 1) s'_q d'_q i'_q + (1/2) B \gamma N'_\gamma s'_\gamma d'_\gamma i'_\gamma W'$$

Where,

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

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

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

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

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

OUTPUT

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

ANNEXURE - III

Bearing capacity factors :

ϕ	8.00
N_c	7.61
N_q	2.11
N_γ	0.91

ϕ'	5.38
N'_c	6.63
N'_q	1.64
N'_γ	0.51

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	d_c	d_q	d_γ
1	1.50	3.00	1.12	1.00	1.00
2	3.00	3.00	1.23	1.00	1.00
3	4.50	3.00	1.35	1.00	1.00
4	6.00	3.00	1.46	1.00	1.00

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	13.30	7.71	7.99
2	3.00	3.00	8.00	14.43	8.36	8.67
3	4.50	3.00	8.00	15.56	9.02	9.35
4	6.00	3.00	8.00	16.68	9.68	10.03

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 1-3	
BH No. (A1)			
Depth of foundation	=	1.5	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer	P _o	=	6.1 t/m ²
Concentrated load P	=	7.00	t/m ²
Increase in pressure at mid of layer	ΔP	=	$P \times I_B$
	I _B	=	0.21
	ΔP	=	1.5 t/m ²
Compression Index	C _c	=	0.144
Thickness of clay layer	H	=	4.5 m
Initial Void ratio	e _o	=	0.75
	$\frac{P_o + \Delta p}{P_o}$	=	1.24049
Settlement of clay layer	S _f	=	$\frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$
	S _f	=	0.03466 m
		=	34.6564 mm
Correction for Depth, Rigidity of foundation and Pore Pr. on total settlement			
Depth Factor Calculation			
	D/(LB) ^{0.5}	=	0.31
D = Depth of Foundation			
	L/B	=	2.67
Depth Factor	=	0.91	
Rigidity Factor	=	$\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$	
	=	0.8	
Pore pr. Correction = N.A.			
Corrected Total Settlement	=	S _f × D.F. × R.F.	
	S _{f2}	=	25 mm

9837

1133

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 1-3	
BH No. (A1)			
Depth of foundation	=	3.0	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer P_o	=	8.5575	t/m ²
Concentrated load P	=	8.00	t/m ²
Increase in pressure at mid of layer ΔP	=	$P \times I_B$	
		$I_B = 0.21$	
		$\Delta P = 1.7$	t/m ²
Compression Index C_c	=	0.144	
Thickness of clay layer H	=	4.5	m
Initial Void ratio e_o	=	0.75	
		$\frac{P_o + \Delta p}{P_o} = 1.19632$	
Settlement of clay layer S_f	=	$\frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$	
		$S_f = 0.02883$	m
		= 28.8256	mm
Correction for Depth,Rigidity of foundation and Pore Pr. 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 pr. Correction = N.A.			
Corrected Total Settlement S_{f2}	=	$S_f \times D.F. \times R.F.$	
		$S_{f2} = 19.1$	mm

1134

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 1-3	
BH No. (A1)			
Depth of foundation	=	4.5	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer	Po	=	11.0025 t/m ²
Concentrated load P	=	8.50	t/m ²
Increase in pressure at mid of layer	ΔP	=	P x I _B
	I _B	=	0.21
	ΔP	=	1.8 t/m ²
Compression Index	Cc	=	0.144
Thickness of clay layer	H	=	4.5 m
Initial Void ratio	e _o	=	0.75
	$\frac{Po + \Delta p}{Po}$	=	1.16224
Settlement of clay layer	S _f	=	$\frac{Cc}{1+e_o} H \log_{10} \frac{Po + \Delta P}{Po}$
	S _f	=	0.02418 m
		=	24.1775 mm
Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement			
<u>Depth Factor Calculation</u>			
	D/(LB) ^{0.5}	=	0.92
D = Depth of Foundation			
	L/B	=	2.67
Depth Factor		=	0.74
Rigidity Factor	=	$\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$	
	=	0.8	
Pore pr. Correction = N.A.			
Corrected Total Settlement	S _{f2}	=	S _f x D.F.x R.F.
	S _{f2}	=	14.3 mm

4811

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/1-3	
BH No. (A1)			
Depth of foundation	=	6.0	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer P_o	=	13.4475	t/m ²
Concentrated load P	=	9.50	t/m ²
Increase in pressure at mid of layer ΔP	=	$P \times I_B$	
		$I_B = 0.21$	
	ΔP	=	2.0 t/m ²
Compression Index C_c	=	0.144	
Thickness of clay layer H	=	4.5	m
Initial Void ratio e_o	=	0.75	
	$\frac{P_o + \Delta p}{P_o}$	=	1.14835
Settlement of clay layer S_f	=	$\frac{C_c}{1 + e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$	
	S_f	=	0.02225 m
		=	22.2453 mm
Correction for Depth, Rigidity of foundation and Pore Pr. on total settlement			
<u>Depth Factor Calculation</u>			
	$(LB)^{0.5}/D$	=	0.82
D = Depth of Foundation			
	L/B	=	2.67
Depth Factor	=	0.68	
Rigidity Factor	=	$\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$	
	=	0.8	
Pore pr. Correction = N.A.			
Corrected Total Settlement S_{f2}	=	$S_f \times D.F. \times R.F.$	
	S_{f2}	=	12.1 mm

1136

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 1-3	
BH No. (A2)			
Depth of foundation	=	1.5	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer P_o	=	6.4	t/m ²
Concentrated load P	=	7.00	t/m ²
Increase in pressure at mid of layer ΔP	=	$P \times I_B$	
		$I_B = 0.21$	
	ΔP	=	1.5 t/m ²
Compression Index C_c	=	0.141	
Thickness of clay layer H	=	4.5	m
Initial Void ratio e_o	=	0.74	
	$\frac{P_o + \Delta p}{P_o}$	=	1.23059
Settlement of clay layer S_f	=	$\frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$	
	S_f	=	0.03286 m
		=	32.8601 mm
Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement			
<u>Depth Factor Calculation</u>			
	$D/(LB)^{0.5}$	=	0.31
D = Depth of Foundation			
	L/B	=	2.67
Depth Factor	=	0.91	
Rigidity Factor	=	$\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$	
		=	0.8
Pore pr. Correction = N.A.			
Corrected Total Settlement S_{f2}	=	$S_f \times D.F. \times R.F.$	
	S_{f2}	=	23.9 mm

1137

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 1-3	
BH No. (A2)			
Depth of foundation	=	3.0	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer P_o	=	8.925	t/m ²
Concentrated load P	=	8.50	t/m ²
Increase in pressure at mid of layer ΔP	=	$P \times I_B$	
		$I_B = 0.21$	
	ΔP	=	1.8 t/m ²
Compression Index C_c	=	0.141	
Thickness of clay layer H	=	4.5	m
Initial Void ratio e_o	=	0.74	
	$\frac{P_o + \Delta p}{P_o}$	=	1.2
Settlement of clay layer S_f	=	$\frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$	
	S_f	=	0.02887 m
		=	28.8739 mm
Correction for Depth, Rigidity of foundation and Pore Pr. on total settlement			
<u>Depth Factor Calculation</u>			
	$D/(LB)^{0.5}$	=	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 pr. Correction = N.A.			
Corrected Total Settlement S_{f2}	=	$S_f \times D.F. \times R.F.$	
	S_{f2}	=	19.2 mm

1138

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 1-3	
BH No. (A2)			
Depth of foundation	=	4.5	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer	P _o	=	11.475 t/m ²
Concentrated load P	=	9.50	t/m ²
Increase in pressure at mid of layer	ΔP	=	P x I _B
	I _B	=	0.21
	ΔP	=	2.0 t/m ²
Compression Index	C _c	=	0.141
Thickness of clay layer	H	=	4.5 m
Initial Void ratio	e _o	=	0.74
	$\frac{P_o + \Delta p}{P_o}$	=	1.17386
Settlement of clay layer	S _f	=	$\frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$
	S _f	=	0.02539 m
		=	25.3854 mm
Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement			
Depth Factor Calculation			
	D/(LB) ^{0.5}	=	0.92
D = Depth of Foundation			
	L/B	=	2.67
Depth Factor	=	0.74	
Rigidity Factor	=	$\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$	
		=	0.8
Pore pr. Correction = N.A.			
Corrected Total Settlement	S _{f2}	=	S _f x D.F.x R.F.
	S _{f2}	=	15.0 mm

8023

1139

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 1-3	
BH No. (A2)			
Depth of foundation	=	6.0	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer	P _o	=	14.025 t/m ²
Concentrated load P	=	10.00	t/m ²
Increase in pressure at mid of layer	ΔP	=	P × I _B
	I _B	=	0.21
	ΔP	=	2.1 t/m ²
Compression Index	C _c	=	0.141
Thickness of clay layer	H	=	4.5 m
Initial Void ratio	e _o	=	0.74
	$\frac{P_o + \Delta p}{P_o}$	=	1.14973
Settlement of clay layer	S _f	=	$\frac{C_c}{1 + e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$
	S _f	=	0.0221 m
		=	22.097 mm
Correction for Depth, Rigidity of foundation and Pore Pr. on total settlement			
Depth Factor Calculation			
	(LB) ^{0.5} /D	=	0.82
D = Depth of Foundation			
	L/B	=	2.67
Depth Factor	=	0.68	
Rigidity Factor	=	$\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$	
	=	0.8	
Pore pr. Correction = N.A.			
Corrected Total Settlement	S _{f2}	=	S _f × D.F. × R.F.
	S _{f2}	=	12.0 mm

1140

133.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 1x24.4

133.2 BOREHOLE DESCRIPTIONS:

- Location of Structure, Boreholes with RL shown in **FIGURE-1**.
- Subsurface Characteristic of Soil/Rock shown in **ANNEXURE-I**.
- Borelogs and sub soil profile shown in **ANNEXURE-II**.
- Calculations of Safe Bearing Capacities in **ANNEXURE-III**.
- Calculations of Probable Settlement in **ANNEXURE-IV**.
- 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 3.00	Clayey Silt with Sand	Loose
	3.00 to 4.50	Clayey Silt	Loose
	4.50 to 13.50	Clayey Silt	Medium Dense
	13.50 to 16.50	Clayey Silt with Sand	Medium Dense
	16.50 to 19.50	Clayey Silt	Medium Dense
	19.50 to 22.50	Clayey Silt with Sand	Dense
	22.50 to 28.50	Clayey Silt	Dense
BH-2(A2)	28.50 to 30.00	Clayey Silt with Sand	Dense
	0.00 to 3.00	Clayey Silt with Sand	Loose
	3.00 to 4.50	Clayey Silt	Loose
	4.50 to 7.50	Clayey Silt	Medium Dense
	7.50 to 10.50	Clayey Silt with Sand	Medium Dense
	10.50 to 19.50	Clayey Silt	Medium Dense
	19.50 to 30.00	Clayey Silt	Dense

133.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.00	NIL	0.0028	NIL	0.0013	0.054
	12.00	8.80	0.005	0.0018	NIL	0.0012	0.034
	18.00	8.70	0.005	0.0018	NIL	0.0012	0.037
	24.00	8.30	NIL	0.0021	NIL	0.0012	0.046
BH-2 (A2)	3.00	8.50	0.002	0.0021	NIL	0.0014	0.062
	12.00	8.40	NIL	0.0025	NIL	0.0012	0.045

133.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1 (A1)	3.00	40.00
	12.00	27.00
	18.00	21.00
	24.00	25.00

BH-2 (A2)	3.00	41.00
	12.00	26.00
	21.00	28.00

133.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BORE HOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (μ S/cm)
Test Result	7.5	110	102	150	810	0.1	2.5	980	625
Requirement as per IS:456 / Mosrths	Not less than 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 ₂ SO ₄	-	-

133.6 PILE LOAD CARRYING CAPACITY

133.6.1 Normal Bored Cast in- situ Pile Foundations:

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

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

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

Safe bearing capacity in t/m²

BH -NO.	DEPTH (mtr)	Net Allowable Bearing Pressure (t/m ²)
BH-1 (A1)	1.50m	07.00
	3.00m	08.00
	4.50m	08.50
	6.00m	09.50
BH-3 (A2)	1.50m	07.00
	3.00m	08.50
	4.50m	09.50
	6.00m	10.00

Pile load carrying capacity in t

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE	
		Pile Diameter= 1.0 m	Pile Diameter= 1.2 m
BH-1 (A1)	17.00	80.00	100.00
	20.00	110.00	130.00
	23.00	140.00	170.00
BH-2 (A2)	17.00	80.00	90.00
	20.00	100.00	120.00
	23.00	130.00	150.00

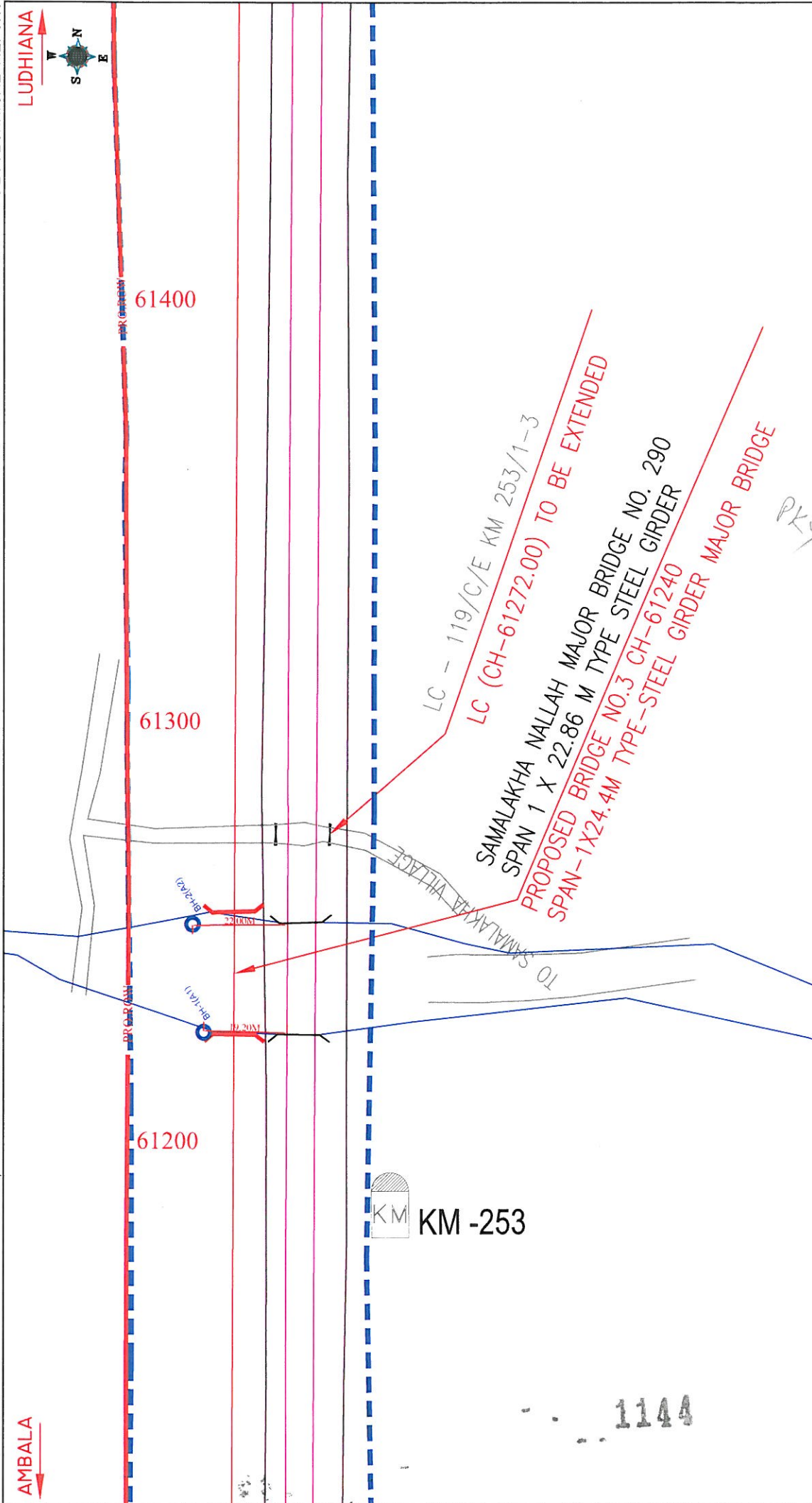
133.7 CONCLUSIONS

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

133.8 RECOMMENDATIONS

(i)	<i>Type of foundation</i>	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.



<p>ALL DIMENSIONS IN METER</p> <p>FIG.-1</p> <p>LOCATION PLAN OF PROPOSED MAJOR BRIDGE</p> <p>CH. 253/1-3</p>	<p>RL OF BH (A1) = 267.467</p> <p>RL OF BH (A2) = 267.436</p>	<p>PROJECT :-</p> <p>LUDHIANA-AMBALA (DFCCIL)</p>	<p>DESIGN :-</p> <p>CONSULTING ENGINEERS GROUP LTD.</p> <p>E-12, Meji Colony, Malviya Nagar, Jaipur-17</p> <p>Tel: +91-141-2520899, 2521899, 2520556</p> <p>Fax: 2521348, E-Mail: ceg@cegroupindia.com</p>
---	---	---	--

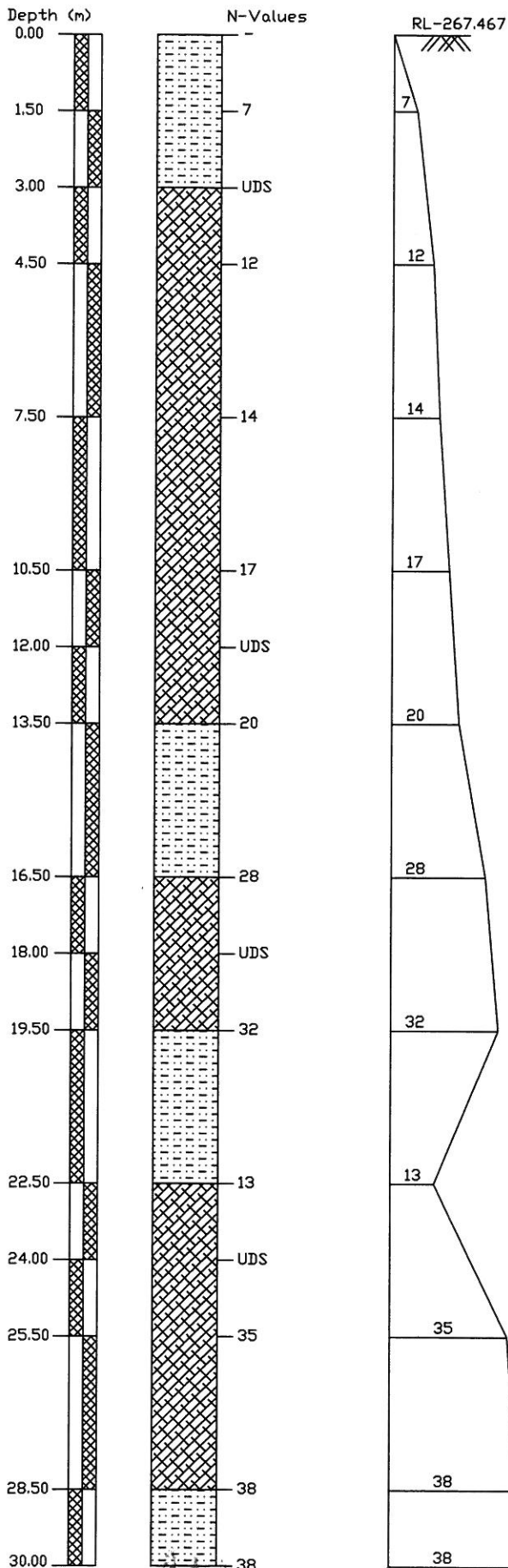
1144

SOIL CHARACTERISTICS OF BORE HOLE AT BH-1 (A1) RHS OF MAJOR BRIDGE No. 290 AT CHAINAGE 253/1-3

Project :	Chainage 253/1-3 Bridge No. 290		Date of Testing 21.07.2009 to 22.07.2009	Location at A1	B.H. No. 1(RHS)	Depth of Water Table 13.50 m.	Termination Depth 30.00mtr	Surface Elevation 267.467													
	Depth from GL (m)	Observed						Correction Factor	Corrected	Soil Description (Soil Group)	Clay	Silt	Grain Size Distribution % wt retained	Gravel	Atterberg Limits %	B.D. gm/cc	M.C. %	D.D. gm/cc	Specific Gravity	Shear Strength c kg/cm ²	φ degree
		N	C _n	N _n	Soil			Grain Size Distribution % wt retained			Atterberg Limits %			Shear Strength							
0.00	-	-	-	-	Clayey silt with sand	20.5	64.17	6.22	3.21	2.64	3.26	0.00	36	18	18	-	-	-			
1.50	7	1.51	10.57	-	Clayey silt with sand	22.69	63.18	6.20	2.32	2.53	3.08	0.00	36	16	20	-	-	-			
3.00	UDS	-	-	-	Clayey silt	32.69	65.99	1.11	0.16	0.05	0.00	0.00	55	25	30	1.63	6.65	1.53	2.67	0.38	7.00
4.50	12	1.11	13.32	-	Clayey silt	22.10	75.86	1.29	0.75	0.00	0.00	0.00	37	18	19	-	-	-	-	-	-
7.50	14	0.93	13.02	-	Clayey silt	18.95	79.59	1.08	0.26	0.12	0.00	0.00	34	18	16	-	-	-	-	-	-
10.50	17	0.82	13.94	-	Clayey silt	20.11	78.27	1.59	0.03	0.00	0.00	0.00	32	15	17	-	-	-	-	-	-
12.00	UDS	-	-	-	Clayey silt	21.65	76.49	1.25	0.30	0.12	0.19	0.00	39	21	19	1.69	6.55	1.59	2.66	0.25	13.00
13.50	20	0.74	14.80	-	Clayey silt with sand	16.65	76.49	5.61	0.80	0.30	0.15	0.00	30	16	14	-	-	-	-	-	-
16.50	28	0.67	16.88	-	Clayey silt	24.12	74.97	0.74	0.17	0.00	0.00	0.00	41	20	21	-	-	-	-	-	-
18.00	UDS	-	-	-	Clayey silt	18.95	79.72	1.33	0.00	0.00	0.00	0.00	38	22	16	2.00	20.59	1.66	2.68	0.19	17.00
19.50	32	0.60	17.10	-	Clayey silt with sand	16.82	68.62	12.33	0.35	0.10	1.78	0.00	31	17	14	-	-	-	-	-	-
22.50	13	0.54	7.02	-	Clayey silt	20.31	75.38	3.80	0.29	0.22	0.00	0.00	35	18	17	-	-	-	-	-	-
24.00	UDS	-	-	-	Clayey silt	22.19	74.30	2.14	0.76	0.33	0.28	0.00	39	20	19	2.09	20.85	1.73	2.67	0.23	14.00
25.50	35	0.49	16.08	-	Clayey silt	21.33	76.36	1.07	0.67	0.57	0.00	0.00	37	19	18	-	-	-	-	-	-
28.50	38	0.45	16.05	-	Clayey silt with sand	16.83	75.34	5.61	1.52	0.70	0.00	0.00	31	17	14	-	-	-	-	-	-
30.00	38	0.43	15.67	-	Clayey silt with sand	17.44	72.02	3.20	1.91	1.65	3.78	0.00	32	17	15	-	-	-	-	-	-

SOIL CHARACTERISTICS OF BORE HOLE AT BH-2 (A2) RHS OF MAJOR BRIDGE No. 290 AT CHAINAGE 253/1-3																			
Project :	Chainage 253/1-3 Bridge No. 290		Date of Testing 22.07.2009 to 23.07.2009	Location at A2	B.H. No. 2(RHS)	Depth of Water Table 13.50 m.	Termination Depth 30.00mtr	Surface Elevation											
								B.D.	M.C.	D.D.	Specific Gravity								
Depth from GL (m)	Observed N	Correction Factor C _n	Corrected N _c	Soil Description (Soil Group)				Grain Size Distribution % wt retained				Atterberg Limits %				Shear Strength c kg/cm ² φ degree			
				Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	Gravel	L.L.	P.L.	P.I.	gm/cc		%	gm/cc	
0.00	-	-	-	22.56	66.14	4.56	2.15	0.39	4.2	0.00	40	20	20	-	-	-	-	-	-
1.50	6	1.46	8.76	18.55	70.52	5.22	1.16	0.56	3.99	0.00	32	16	16	-	-	-	-	-	-
3.00	UDS	-	-	33.42	64.35	0.69	0.26	0.28	1.00	0.00	55	25	30	1.70	9.64	1.55	2.69	0.36	8.00
4.50	14	1.09	15.26	20.59	74.81	0.66	0.77	0.92	2.25	0.00	36	18	18	-	-	-	-	-	-
7.50	16	0.92	14.72	21.58	72.33	5.97	0.04	0.08	0.00	0.00	39	20	19	-	-	-	-	-	-
10.50	11	0.81	8.91	23.15	76.10	0.68	0.07	0.00	0.00	0.00	40	20	20	-	-	-	-	-	-
12.00	UDS	-	-	21.56	76.40	1.97	0.07	0.00	0.00	0.00	40	20	20	1.80	9.36	1.65	2.68	0.24	13.00
13.50	18	0.72	12.96	26.59	72.57	0.76	0.08	0.00	0.00	0.00	50	26	24	-	-	-	-	-	-
16.50	25	0.65	15.63	25.26	74.07	0.52	0.15	0.00	0.00	0.00	45	22	23	-	-	-	-	-	-
19.50	31	0.59	16.65	23.58	74.99	0.53	0.58	0.32	0.00	0.00	41	20	21	-	-	-	-	-	-
21.00	UDS	-	-	23.10	74.43	1.23	0.59	0.65	0.00	0.00	40	20	20	2.10	20.61	1.74	2.67	0.24	13.00
22.50	15	0.54	8.10	23.58	75.56	0.49	0.37	0.00	0.00	0.00	40	20	20	-	-	-	-	-	-
25.50	25	0.49	12.25	26.54	71.90	0.46	0.66	0.16	0.28	0.00	46	21	25	-	-	-	-	-	-
28.50	29	0.44	12.76	23.15	75.98	0.79	0.08	0.00	0.00	0.00	39	19	20	-	-	-	-	-	-
30.00	36	0.43	15.24	21.29	77.94	0.67	0.10	0.00	0.00	0.00	39	20	19	-	-	-	-	-	-

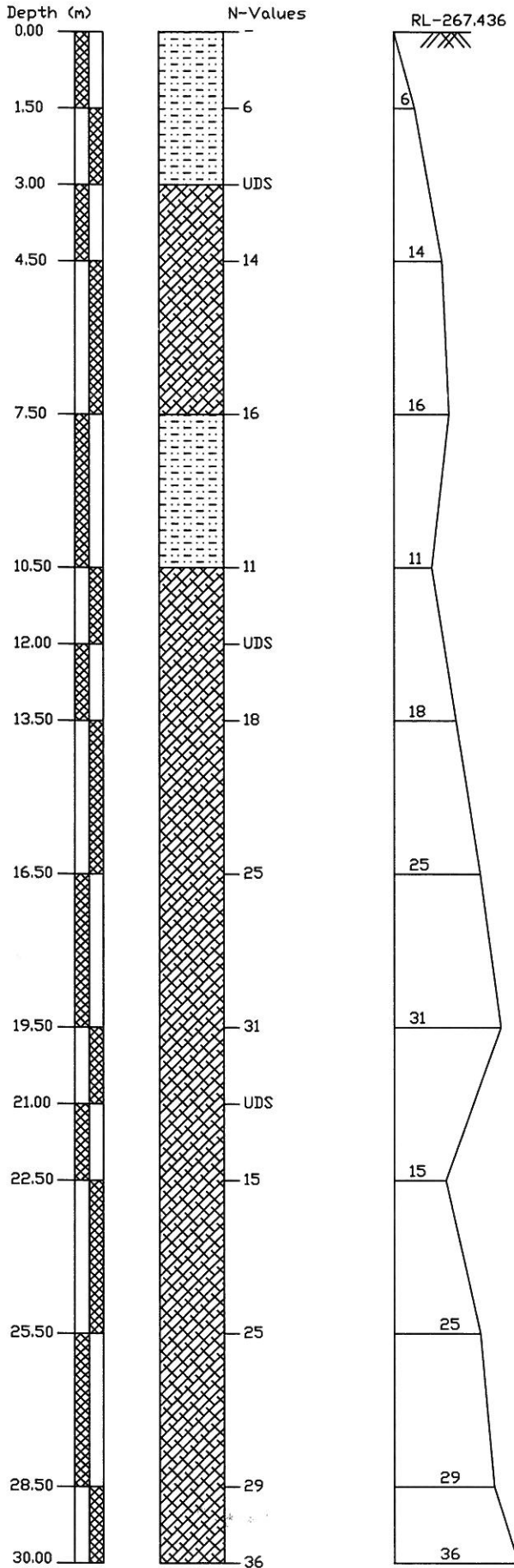
BORELOG OF BH-1(A1) RHS AT EXISTING KM-253/1-3 FOR MAJOR BRIDGE NO.-290,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	CLAYEY SILT

BORELOG OF BH-2(A2) RHS AT EXISTING KM-253/1-3 FOR MAJOR BRIDGE NO.-290,
ON KESARI TO SANEHWAL, LUDHIANA



LEGEND

SYMBOL	DESCRIPTION
	CLAYEY SILT WITH SAND
	CLAYEY SILT

ANNEXURE - III

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

INPUT DATA

Ch. 253 1-3

BH-A1

Type of footing

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

Rectangular

2

Angle of internal friction (ϕ°)	7.00
Cohesion (c in t/m ²)	3.80
Void ratio (e)	0.75
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m ³)	1.63
Density of foundation soil (t/m ³)	1.63
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

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

Where,

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

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

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

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

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

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.

1149

ANNEXURE - III

Bearing capacity factors :

ϕ	7.00
N_c	7.23
N_q	1.93
N_γ	0.76

ϕ'	4.70
N'_c	6.41
N'_q	1.54
N'_γ	0.42

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	d_c	d_q	d_γ
1	1.50	3.00	1.11	1.00	1.00
2	3.00	3.00	1.23	1.00	1.00
3	4.50	3.00	1.34	1.00	1.00
4	6.00	3.00	1.45	1.00	1.00

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m^2)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	12.86	7.56	7.56
2	3.00	3.00	8.00	13.97	8.22	8.22
3	4.50	3.00	8.00	15.08	8.88	8.88
4	6.00	3.00	8.00	16.20	9.54	9.54

1150

ANNEXURE - III

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

INPUT DATA

Ch. 253 1-3

BH-A2

Type of footing

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

Rectangular

2

Angle of internal friction (ϕ°)	8.00
Cohesion (c in t/m ²)	3.60
Void ratio (e)	0.74
Direction of load with vertical ($^\circ$)	0.00
Density of surcharge (t/m ³)	1.70
Density of foundation soil (t/m ³)	1.70
Depth of water table(m)	1.50
Factor of safety	3.00

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

SHEAR FAILURE CRITERIA

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

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

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

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

$$q'_d = (2/3) c N'_c s'_c d'_c i'_c + q (N'_q - 1) s'_q d'_q i'_q + (1/2) B \gamma N'_\gamma s'_\gamma d'_\gamma i'_\gamma W'$$

Where,

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

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

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

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

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

OUTPUT

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

ANNEXURE - III

Bearing capacity factors :

ϕ	8.00
N_c	7.61
N_q	2.11
N_y	0.91

ϕ'	5.38
N'_c	6.63
N'_q	1.64
N'_y	0.51

Shape factors :

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

Depth factors :

S.no.	Depth(m)	Width(m)	d_c	d_q	d_y
1	1.50	3.00	1.12	1.00	1.00
2	3.00	3.00	1.23	1.00	1.00
3	4.50	3.00	1.35	1.00	1.00
4	6.00	3.00	1.46	1.00	1.00

Inclination factors :

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

Water table factor :

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

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	Length (m)	SBC in (t/m ²)		
				General shear	Local shear	Actual
1	1.50	3.00	8.00	13.30	7.71	7.99
2	3.00	3.00	8.00	14.43	8.36	8.67
3	4.50	3.00	8.00	15.56	9.02	9.35
4	6.00	3.00	8.00	16.68	9.68	10.03

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 1-3	
BH No. (A1)			
Depth of foundation	=	1.5	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer	P _o	=	6.1 t/m ²
Concentrated load P	=	7.00	t/m ²
Increase in pressure at mid of layer	ΔP	=	$P \times I_B$
	I_B	=	0.21
	ΔP	=	1.5 t/m ²
Compression Index	C _c	=	0.144
Thickness of clay layer	H	=	4.5 m
Initial Void ratio	e _o	=	0.75
	$\frac{P_o + \Delta p}{P_o}$	=	1.24049
Settlement of clay layer	S _f	=	$\frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$
	S _f	=	0.03466 m
		=	34.6564 mm
Correction for Depth, Rigidity of foundation and Pore Pr. on total settlement			
Depth Factor Calculation			
	$D/(LB)^{0.5}$	=	0.31
D = Depth of Foundation			
	L/B	=	2.67
Depth Factor	=	0.91	
Rigidity Factor	=	$\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$	
	=	0.8	
Pore pr. Correction = N.A.			
Corrected Total Settlement	S _{f2}	=	S _f × D.F. × R.F.
	S _{f2}	=	25 mm

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/1-3	
<u>BH No. (A1)</u>			
<u>Depth of foundation</u>	=	3.0	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer P_o	=	8.5575	t/m ²
Concentrated load P	=	8.00	t/m ²
Increase in pressure at mid of layer ΔP	=	$P \times I_B$	
	I_B	=	0.21
	ΔP	=	1.7 t/m ²
Compression Index C_c	=	0.144	
Thickness of clay layer H	=	4.5	m
Initial Void ratio e_o	=	0.75	
	$\frac{P_o + \Delta p}{P_o}$	=	1.19632
Settlement of clay layer S_f	=	$\frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$	
	S_f	=	0.02883 m
		=	28.8256 mm
Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement			
<u>Depth Factor Calculation</u>			
	$D/(LB)^{0.5}$	=	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 pr. Correction = N.A.			
Corrected Total Settlement S_{f2}	=	$S_f \times D.F. \times R.F.$	
	S_{f2}	=	19.1 mm

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 1-3	
<u>BH No. (A1)</u>			
<u>Depth of foundation</u>	=	4.5	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer	P _o	=	11.0025 t/m ²
Concentrated load P	=	8.50	t/m ²
Increase in pressure at mid of layer	ΔP	=	$P \times I_B$
	I _B	=	0.21
	ΔP	=	1.8 t/m ²
Compression Index	C _c	=	0.144
Thickness of clay layer	H	=	4.5 m
Initial Void ratio	e _o	=	0.75
	$\frac{P_o + \Delta p}{P_o}$	=	1.16224
Settlement of clay layer	S _f	=	$\frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$
	S _f	=	0.02418 m
		=	24.1775 mm
Correction for Depth, Rigidity of foundation and Pore Pr. on total settlement			
<u>Depth Factor Calculation</u>			
	D/(LB) ^{0.5}	=	0.92
D = Depth of Foundation			
	L/B	=	2.67
Depth Factor	=	0.74	
Rigidity Factor	=	$\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$	
	=	0.8	
Pore pr. Correction = N.A.			
Corrected Total Settlement	S _{f2}	=	S _f × D.F. × R.F.
	S _{f2}	=	14.3 mm

1155

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 1-3	
BH No. (A1)			
Depth of foundation	=	6.0	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer	P _o	=	13.4475 t/m ²
Concentrated load P	=	9.50	t/m ²
Increase in pressure at mid of layer	ΔP	=	P × I _B
	I _B	=	0.21
	ΔP	=	2.0 t/m ²
Compression Index	C _c	=	0.144
Thickness of clay layer	H	=	4.5 m
Initial Void ratio	e _o	=	0.75
	$\frac{P_o + \Delta p}{P_o}$	=	1.14835
Settlement of clay layer	S _f	=	$\frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$
	S _f	=	0.02225 m
		=	22.2453 mm
Correction for Depth, Rigidity of foundation and Pore Pr. on total settlement			
Depth Factor Calculation			
	(LB) ^{0.5} /D	=	0.82
D = Depth of Foundation			
	L/B	=	2.67
Depth Factor	=	0.68	
Rigidity Factor	=	$\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$	
	=	0.8	
Pore pr. Correction = N.A.			
Corrected Total Settlement	=	S _f × D.F. × R.F.	
	S _{f2}	=	12.1 mm

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 1-3	
<u>BH No. (A2)</u>			
<u>Depth of foundation</u>	=	1.5	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer	P _o	=	6.4 t/m ²
Concentrated load P	=	7.00	t/m ²
Increase in pressure at mid of layer	ΔP	=	$P \times I_B$
		I_B	= 0.21
	ΔP	=	1.5 t/m ²
Compression Index	C _c	=	0.141
Thickness of clay layer	H	=	4.5 m
Initial Void ratio	e _o	=	0.74
	$\frac{P_o + \Delta p}{P_o}$	=	1.23059
Settlement of clay layer	S _f	=	$\frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$
	S _f	=	0.03286 m
		=	32.8601 mm
Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement			
<u>Depth Factor Calculation</u>			
	$D/(LB)^{0.5}$	=	0.31
D = Depth of Foundation			
	L/B	=	2.67
Depth Factor	=	0.91	
Rigidity Factor	=	$\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$	
	=	0.8	
Pore pr. Correction = N.A.			
Corrected Total Settlement	=	S _f × D.F. × R.F.	
	S _{f2}	=	23.9 mm

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 1-3	
<u>BH No. (A2)</u>			
<u>Depth of foundation</u>	=	3.0	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer	P_o	=	8.925 t/m^2
Concentrated load P	=	8.50	t/m^2
Increase in pressure at mid of layer	ΔP	=	$P \times I_B$
	I_B	=	0.21
	ΔP	=	1.8 t/m^2
Compression Index	C_c	=	0.141
Thickness of clay layer	H	=	4.5 m
Initial Void ratio	e_o	=	0.74
	$\frac{P_o + \Delta p}{P_o}$	=	1.2
Settlement of clay layer	S_f	=	$\frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$
	S_f	=	0.02887 m
		=	28.8739 mm
Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement			
<u>Depth Factor Calculation</u>			
	$D/(LB)^{0.5}$	=	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 pr. Correction = N.A.			
Corrected Total Settlement	=	$S_f \times D.F. \times R.F.$	
	S_{f2}	=	19.2 mm

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 1-3	
BH No. (A2)			
Depth of foundation	=	4.5	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer	P _o	=	11.475 t/m ²
Concentrated load P	=	9.50	t/m ²
Increase in pressure at mid of layer	ΔP	=	P × I _B
	I _B	=	0.21
	ΔP	=	2.0 t/m ²
Compression Index	C _c	=	0.141
Thickness of clay layer	H	=	4.5 m
Initial Void ratio	e _o	=	0.74
	$\frac{P_o + \Delta p}{P_o}$	=	1.17386
Settlement of clay layer	S _f	=	$\frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$
	S _f	=	0.02539 m
		=	25.3854 mm
Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement			
Depth Factor Calculation			
	D/(LB) ^{0.5}	=	0.92
D = Depth of Foundation			
	L/B	=	2.67
Depth Factor	=	0.74	
Rigidity Factor	=	$\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$	
	=	0.8	
Pore pr. Correction = N.A.			
Corrected Total Settlement	S _{f2}	=	S _f × D.F. × R.F.
	S _{f2}	=	15.0 mm

ANNEXURE - IV

Settlement Calculation As per IS 8009 (Part 1)		Major Bridge at Ch.253/ 1-3	
BH No. (A2)			
Depth of foundation	=	6.0	m
Length of footing (L)	=	8.0	m
Width of footing (B)	=	3.0	m
Initial effective stress at mid of layer P_o	=	14.025	t/m ²
Concentrated load P	=	10.00	t/m ²
Increase in pressure at mid of layer ΔP	=	$P \times I_B$	
		$I_B = 0.21$	
	ΔP	=	2.1 t/m ²
Compression Index C_c	=	0.141	
Thickness of clay layer H	=	4.5	m
Initial Void ratio e_o	=	0.74	
	$\frac{P_o + \Delta p}{P_o}$	=	1.14973
Settlement of clay layer S_f	=	$\frac{C_c}{1+e_o} H \log_{10} \frac{P_o + \Delta P}{P_o}$	
	S_f	=	0.0221 m
		=	22.097 mm
Correction for Depth,Rigidity of foundation and Pore Pr. on total settlement			
<u>Depth Factor Calculation</u>			
	$(LB)^{0.5}/D$	=	0.82
D = Depth of Foundation			
	L/B	=	2.67
Depth Factor	=	0.68	
Rigidity Factor	=	$\frac{\text{Total Settlement of Rigid foundation}}{\text{Total Settlement at the centre of Flexible foundation}}$	
		=	0.8
Pore pr. Correction = N.A.			
Corrected Total Settlement S_{f2}	=	$S_f \times D.F. \times R.F.$	
	S_{f2}	=	12.0 mm

CHAPTER - 134

"Major Bridge No. 289",

Location - Existing Km. - 251/05-07

134.1 LOCATION OF STRUCTURE:

Proposed Major Bridge of Span 5x6.10

134.2 BOREHOLE DESCRIPTIONS:

- Location of Structure, Boreholes with RL shown in **FIGURE-1**.
- Subsurface Characteristic of Soil/Rock shown in **ANNEXURE-I**.
- Borelogs and sub soil profile shown in **ANNEXURE-II**.
- Calculations of Safe Bearing Capacities in **ANNEXURE-III**.
- Calculations of Probable Settlement in **ANNEXURE-IV**.
- Depth of water Table 07.00m below EGL.

Subsurface profile at the site

BOREHOLE No.	Depth (m)	Type of Soil/Rock	Soil/Rock Characteristics
BH-1(A1)	0.00 to 3.00	Sandy Silt with Clay	Loose
	6.00 to 7.50	Clayey Silt with Sand	Loose
	7.50 to 10.50	Clayey Silt with Sand	Medium Dense
	10.50 to 12.00	Silty Sand	Medium Dense
	12.00 to 13.50	Clayey Silt with Sand	Medium Dense
	13.50 to 30.00	Clayey Silt	Medium Dense
BH-2(A2)	0.00 to 3.00	Clayey Silt with Sand	Loose
	3.00 to 4.50	Sandy Silt with Clay	Loose
	4.50 to 7.50	Silty Sand	Loose
	7.50 to 12.00	Silty Sand	Medium Dense
	12.00 to 19.50	Clayey Silt with Sand	Medium Dense
	19.50 to 30.00	Clayey Silt	Medium Dense

134.3 CHEMICAL ANALYSIS OF SOIL:

BOREHOLE		CHEMICAL PROPERTIES					
No.	Depth (m)	pH	Carbonate	Chlorides %	Sulphate %	Nitrate %	Salinity %
BH-1 (A1)	3.00	8.20	NIL	0.0021	NIL	0.0012	0.087
	12.00	8.70	0.005	0.0021	NIL	0.0011	0.059
	18.00	8.80	0.007	0.0017	NIL	0.0012	0.067
	21.00	8.70	0.005	0.018	NIL	0.0012	0.049
BH-2 (A2)	3.00	8.10	NIL	0.0021	NIL	0.0012	0.051
	12.00	8.40	NIL	0.0024	NIL	0.0012	0.055
	24.00	8.30	NIL	0.0028	NIL	0.0011	0.0065

134.4 DIFFERENTIAL FREE SWELL INDEX (DFS)

Bore Hole No.	Depth (m)	DFS Index in %
BH-1(A1)	3.00	16.00
	12.00	22.00
	18.00	27.00
	21.00	19.00

BH-2 (A2)	3.00	16.00
	12.00	13.00
	24.00	21.00

134.5 CHEMICAL ANALYSIS OF ENCOUNTERED WATER FROM BORE HOLE

Chemical Properties	pH Value	Chlorides mg/lit	Sulphate mg/lit	Organic Matter mg/lit	Inorganic Matter mg/lit	Acidity (ml)	Alkalinity (ml)	Total Disso. Solids (ppm)	Conductivity (μ S/cm)
Test Result	7.0	128	83	165	852	0.1	2.4	1043	672
Requirement as per IS:456 / Months	Not less than 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 ₂ SO ₄	-	-

134.6 PILE LOAD CARRYING CAPACITY

134.6.1 Normal Bored Cast in- situ Pile Foundations:

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

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

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

Safe bearing capacity in t/m²

BH -NO.	DEPTH (mtr)	Net Allowable Bearing Pressure (t/m ²)
BH-1 (A1)	1.50m	08.00
	3.00m	09.50
	4.50m	10.00
	6.00m	10.50
BH-2 (A2)	1.50m	08.50
	3.00m	09.50
	4.50m	10.50
	6.00m	11.50

Pile load carrying capacity in t

BH -NO.	PILE DEPTH (mtr)	PILE CARRYING CAPACITY IN TONNE
		Pile Diameter= 1.0 m
BH-1 (A1)	17.00	100.00
	20.00	135.00
	23.00	170.00
BH-2 (A2)	17.00	120.00
	20.00	150.00
	23.00	180.00

134.7 CONCLUSIONS

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

134.8 RECOMMENDATIONS

(i)	<i>Type of foundation</i>	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.