Example 2.1 Pad foundation with vertical central load on dense sand

Note: this is a persistent design situation; for simplicity, accidental design situations do NOT need to be checked.

The square pad foundation shown in Figure 2.1a is made from concrete with a weight density of 25 kN/m^3 and has an embedment depth of 0.8 m. The ground surface shown can reliably be assumed to be below any topsoil and disturbed ground.

The foundation is required to support the following characteristic loads:

Permanent:	Vertical	$G_{v,k}$ = 1000 kN, excluding weight of foundation
	Horizontal	$G_{h,k}$ = 0
Variable:	Vertical	$Q_{v,k}$ = 750 kN
	Horizontal	$Q_{h,k}$ = 0

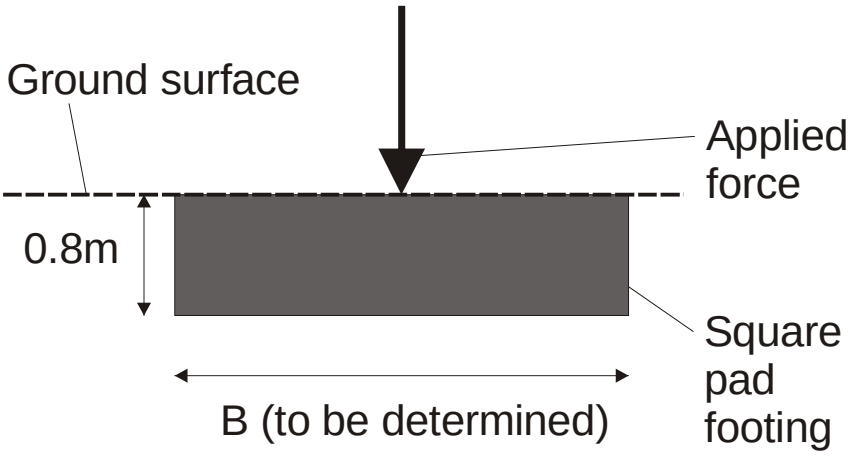

Figure 2.1a: Pad foundation (square on plan)

The soil consists of a very dense fine glacial outwash sand with a mean particle size of 0.14 mm. The soil has a bulk weight density of 20 kN/m^3 and close to 100% relative density. The ground water level is 6 m below ground level. The water content above the water table is 11% and the degree of saturation is 71%. Bedrock underlies the sand at 8m depth.

A plan of the site is given in Figure 2.1b showing the locations of four CPT tests carried out on the site with respect to the centre of the proposed foundation. The results of the four CPT tests are plotted separately in Figures 2.1c (1-4) and all the q_c values are plotted together in Figure 2.1d and listed in Table 2.1a.

The foundation is to be designed to Eurocode 7 to determine the foundation width when the maximum allowable settlement is 25 mm. There is no need to consider any effects due to frost or vegetation. The foundation's design working life is 50 years.

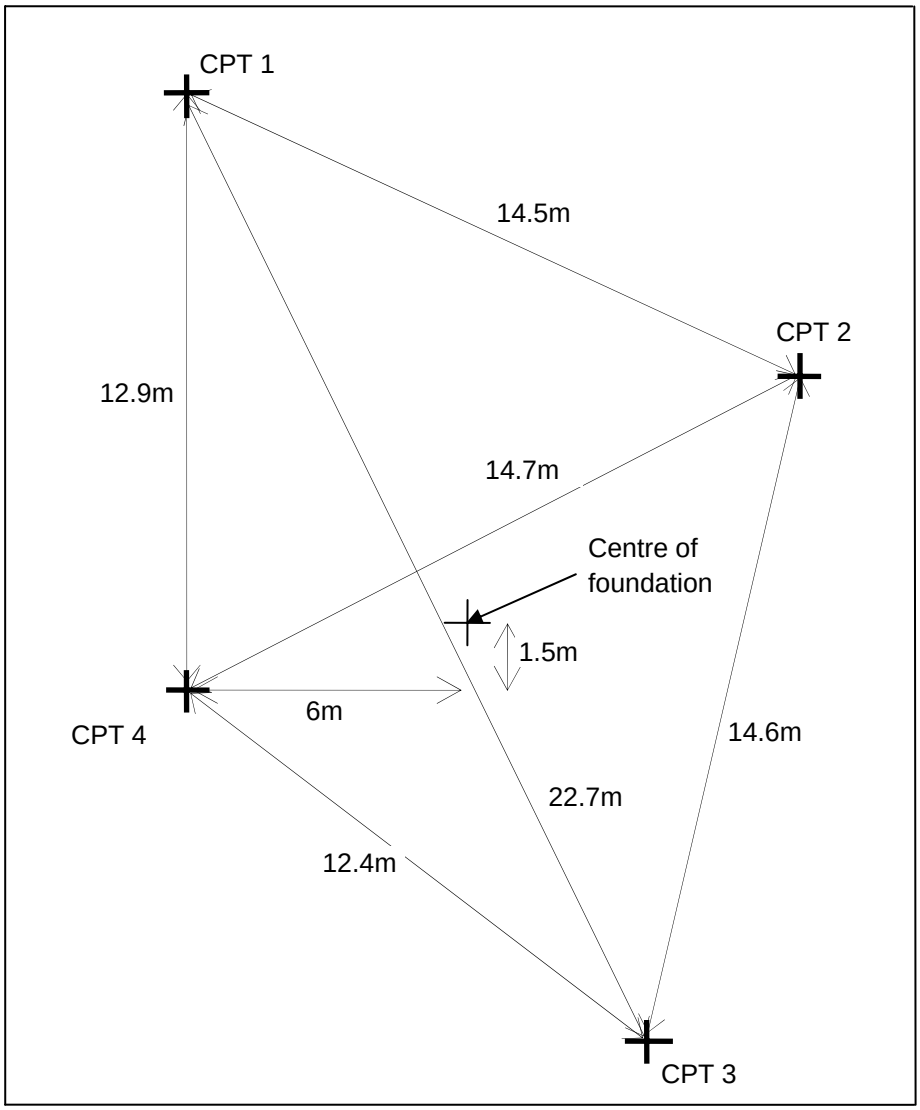

Figure 2.1b: Example 2.1 Site plan and location of CPT tests

Note: vertical axis on following diagram should read 'Depth below ground level (m)'

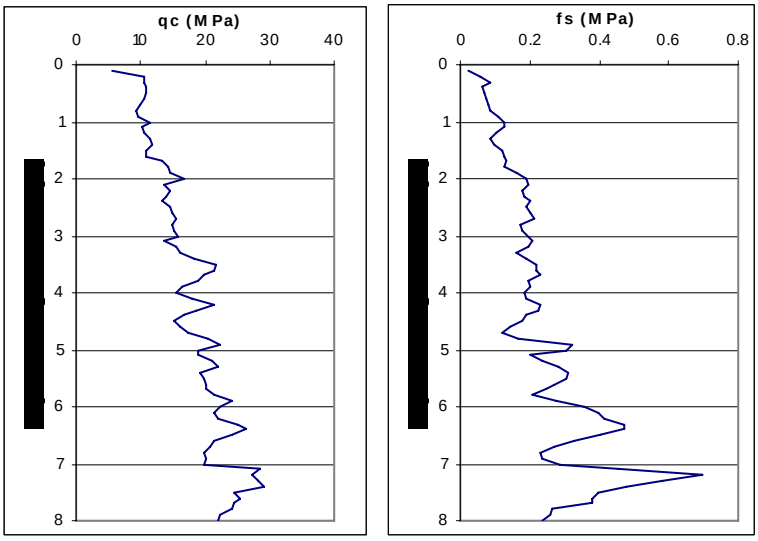

Figure 2.1c(1): CPT 1 test results - $q_{c \text{ and }} f_s$

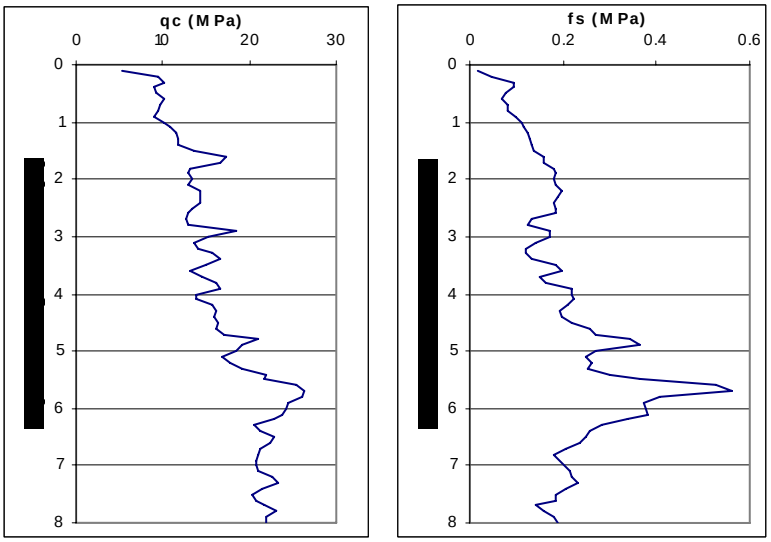

Figure 2.1c(2): CPT 2 test results - $q_{c\ and}$ f_s

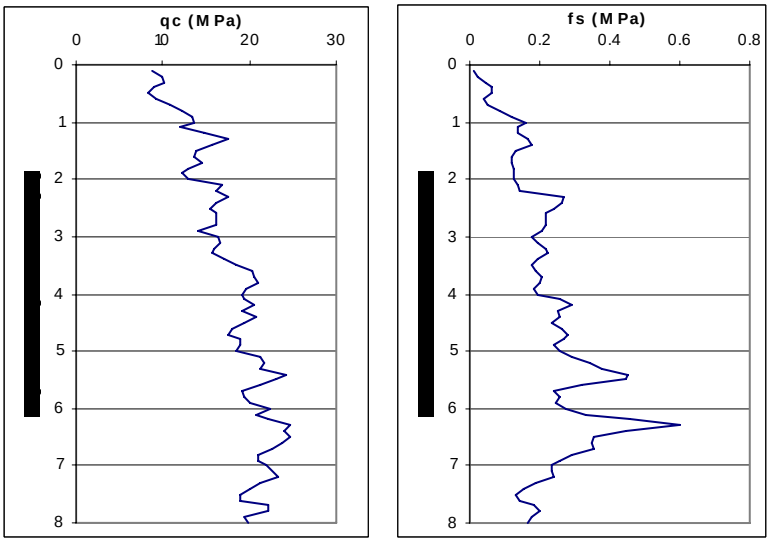

Figure 2.1c(3): CPT 3 test results - q_c and f_s

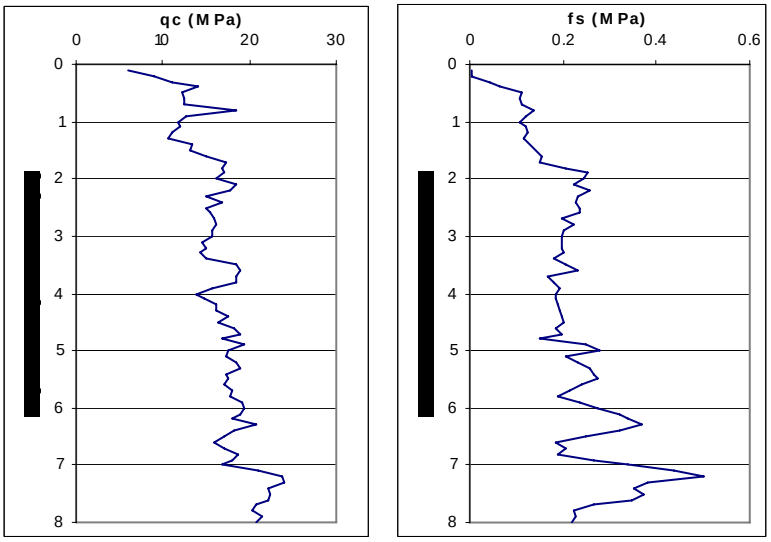

Figure 2.1c(4): CPT 4 test results - q_c and f_s

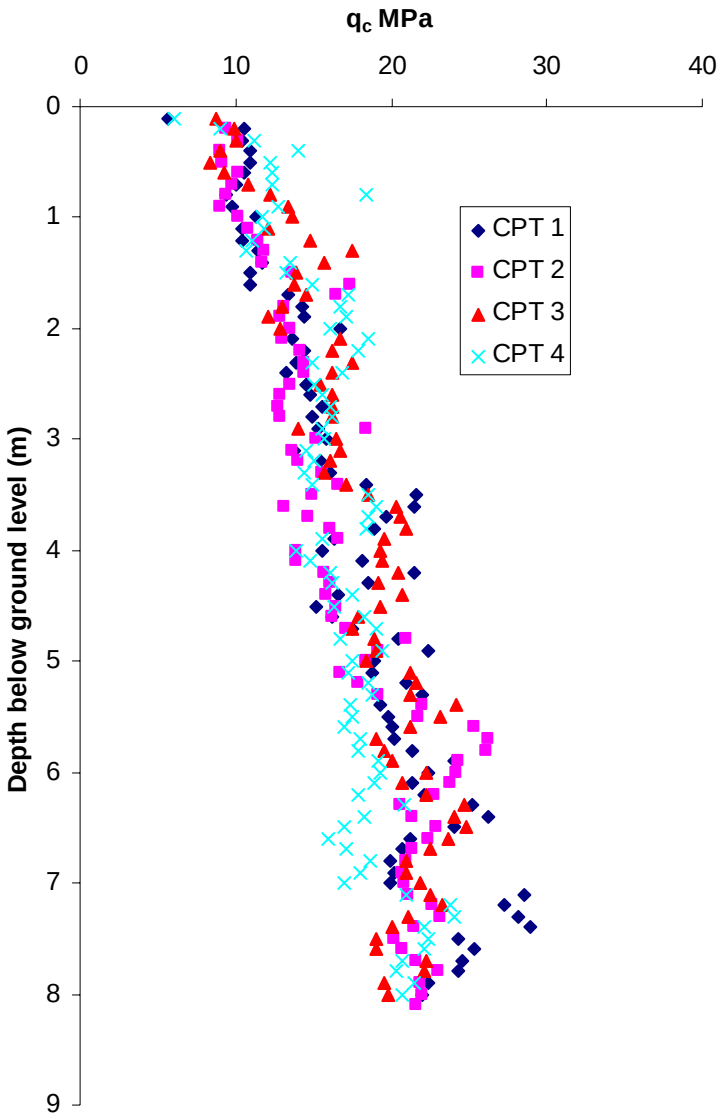

Figure 2.1d: Combined plot of CPT test results

Table 2.1a: CPT test results
(data available in separate Excel spreadsheet)

	CPT 1		CPT 2		CPT 3		CPT 4	
Depth (m)	qc (MPa)	fs (MPa)	qc (MPa)	fs (MPa)	qc (MPa)	fs (MPa)	qc (MPa)	fs (MPa)
0.1	5.62	0.0236	5.41	0.018	8.78	0.0091	5.99	0.0057
0.2	10.56	0.0565	9.37	0.0456	9.89	0.0256	9	0.0061
0.3	10.4	0.0835	10.1	0.0928	10.05	0.0453	11.14	0.044
0.4	10.95	0.0619	8.94	0.0959	8.96	0.0616	14.01	0.0648
0.5	10.92	0.068	9.14	0.0751	8.38	0.0633	12.23	0.1107
0.6	10.6	0.0763	10.1	0.0679	9.27	0.038	12.36	0.1064
0.7	10.01	0.0805	9.78	0.0829	10.78	0.0533	12.36	0.1117
0.8	9.34	0.087	9.38	0.0811	12.17	0.0883	18.37	0.1392
0.9	9.72	0.1071	8.95	0.1003	13.42	0.1222	12.79	0.1211
1	11.35	0.127	10.18	0.1098	13.63	0.1603	11.72	0.1056
1.1	10.36	0.1287	10.82	0.1156	12.03	0.1362	11.89	0.1198
1.2	10.4	0.1024	11.48	0.1239	14.79	0.1366	11.06	0.1228
1.3	11.46	0.0858	11.81	0.1266	17.5	0.167	10.71	0.1152
1.4	11.73	0.1005	11.69	0.1309	15.68	0.1789	13.47	0.1267
1.5	10.9	0.1198	13.58	0.1363	13.83	0.1326	13.23	0.1407
1.6	10.9	0.1285	17.3	0.1596	13.7	0.1224	14.96	0.1539
1.7	13.32	0.1344	16.51	0.157	14.51	0.1214	17.2	0.1497
1.8	14.27	0.1283	13.15	0.1806	13.03	0.1272	16.74	0.2042
1.9	14.45	0.1594	12.81	0.186	12.15	0.1256	17.11	0.252
2	16.74	0.1895	13.49	0.1805	12.87	0.1252	16.14	0.2449
2.1	13.68	0.1963	12.98	0.1863	16.76	0.1384	18.47	0.2218
2.2	14.45	0.1812	14.21	0.1973	16.24	0.1452	17.88	0.2575
2.3	13.91	0.1863	14.36	0.1902	17.48	0.2689	14.89	0.2328
2.4	13.24	0.1997	14.38	0.1819	16.16	0.2628	16.82	0.2287
2.5	14.49	0.1891	13.46	0.1843	15.45	0.2399	15.02	0.2336
2.6	14.82	0.2034	12.83	0.1839	16.26	0.2196	15.51	0.2362
2.7	15.52	0.2155	12.76	0.1333	16.19	0.2172	16.03	0.1958
2.8	14.9	0.1703	12.84	0.1251	16.2	0.2146	16.26	0.221
2.9	15.32	0.1804	18.39	0.1727	13.98	0.2036	15.61	0.1997
3	15.83	0.1981	15.14	0.1697	16.4	0.1766	15.7	0.1957
3.1	13.77	0.2046	13.66	0.1425	16.69	0.1971	14.57	0.1989
3.2	15.46	0.1968	14.07	0.1205	16.03	0.2173	15.03	0.1968
3.3	16.06	0.1614	15.58	0.1205	15.66	0.2256	14.38	0.2025
3.4	18.37	0.1873	16.65	0.1337	17.1	0.1945	14.89	0.1804
3.5	21.66	0.2161	14.96	0.1833	18.51	0.1782	18.51	0.2051
3.6	21.45	0.2167	13.09	0.1957	20.37	0.191	19	0.2327
3.7	19.73	0.2286	14.6	0.1481	20.58	0.2043	18.57	0.1652
3.8	18.97	0.196	16.14	0.1641	20.97	0.1981	18.43	0.1783
3.9	16.32	0.2003	16.64	0.218	19.59	0.1829	15.58	0.1939
4	15.52	0.1845	13.87	0.2195	19.24	0.1955	13.94	0.1841
4.1	18.12	0.1878	13.88	0.2212	19.37	0.2548	14.76	0.1839
4.2	21.49	0.2314	15.71	0.2099	20.49	0.2896	16.08	0.1883
4.3	18.51	0.2241	16.12	0.1947	19.2	0.2535	16.18	0.1946
4.4	16.59	0.1911	15.82	0.1956	20.67	0.2575	17.46	0.1967
4.5	15.23	0.181	16.44	0.2184	19.29	0.2371	16.37	0.2006
4.6	16.24	0.1462	16.17	0.2565	17.94	0.2647	18.26	0.1836
4.7	17.48	0.1233	17.15	0.2688	17.52	0.2778	18.99	0.1959
4.8	20.49	0.1666	20.97	0.3435	18.88	0.2666	16.76	0.1509
4.9	22.4	0.3226	19.19	0.3638	18.99	0.2417	19.42	0.2472
5	18.86	0.3022	18.44	0.2685	18.39	0.2589	17.49	0.2781
5.1	18.79	0.1995	16.77	0.247	21.25	0.2896	17.22	0.2057
5.2	20.95	0.2331	17.83	0.2593	21.63	0.3431	18.56	0.232
5.3	21.94	0.2826	19.13	0.2539	21.26	0.377	18.82	0.2568
5.4	19.34	0.3098	21.96	0.2984	24.18	0.4499	17.37	0.2674

5.5	19.79	0.3037	21.79	0.3646	23.1	0.4483	17.5	0.2745
5.6	20.06	0.272	25.37	0.5256	21.26	0.3223	17.03	0.2394
5.7	20.21	0.2469	26.23	0.5613	19.04	0.2374	18.02	0.2141
5.8	21.38	0.2079	26.15	0.4091	19.49	0.255	17.86	0.1906
5.9	24.07	0.2759	24.37	0.3736	20.01	0.2432	19.2	0.2357
6	22.39	0.3553	24.16	0.3778	22.3	0.277	19.3	0.2755
6.1	21.4	0.3948	23.8	0.3794	20.67	0.3302	18.95	0.3225
6.2	22.06	0.4171	22.8	0.3397	22.23	0.4567	17.92	0.3375
6.3	25.15	0.4709	20.55	0.2823	24.64	0.6028	20.81	0.3665
6.4	26.22	0.474	21.33	0.2552	24.05	0.4456	18.32	0.3227
6.5	24.08	0.4017	22.85	0.2486	24.78	0.3561	17.01	0.2473
6.6	21.27	0.3302	22.4	0.2364	23.66	0.3468	15.9	0.1839
6.7	20.71	0.268	21.32	0.2045	22.54	0.353	17.08	0.2063
6.8	19.95	0.2294	20.93	0.1784	21	0.2887	18.61	0.1867
6.9	20.17	0.2382	20.75	0.1945	20.99	0.2573	18	0.2669
7	19.91	0.2898	20.87	0.2028	21.9	0.2354	16.93	0.3406
7.1	28.56	0.4545	21.03	0.2127	22.5	0.2319	20.94	0.4388
7.2	27.3	0.6968	22.68	0.2196	23.28	0.2376	23.82	0.5012
7.3	28.15	0.5824	23.21	0.2312	21.13	0.1858	24.02	0.3832
7.4	29	0.4758	21.44	0.2045	20.11	0.157	22.17	0.3495
7.5	24.37	0.3958	20.23	0.1833	18.98	0.1341	22.38	0.3718
7.6	25.31	0.3811	20.76	0.1839	18.99	0.1403	22.16	0.3466
7.7	24.62	0.38	21.58	0.1433	22.24	0.1832	20.69	0.267
7.8	24.3	0.2647	23.01	0.1574	22.11	0.2003	20.28	0.2246
7.9	22.44	0.2615	21.88	0.1779	19.49	0.1754	21.43	0.2264
8	21.99	0.2348	22.02	0.1903	19.85	0.1667	20.72	0.2184