Ultimate Limit States

1. Selection of design method

In order to determine required foundation dimensions an analytical method provided by attachement D.4 (Eurocode 7 – Geotechnical design. Part I) was used. Calculations were carried out with use of Design Approach 2.

2. Geotechnical parameters

In order to calculate dimensions of the pad footing and to check bearing capacity of soil, a set of factors (shape factors, bearing capacity factors etc.), as well as, geotechnical parameters must have been worked out (angel of internal friction, unit weight of a soil).

2.1 Characteristic values of geotechnical parameters

2.1.1 Angle of internal friction

Angel of internal friction was determined with use of representative profile of q_c. All CPT soundings were taken into account to create a representative profile of soil conditions. However, CPT4 sounding was treated as a leading test (the lowest distance to the foundation). Thereby, by using weighted average method it was possible to obtain a representative profile of q_c (Table 1 and Fig.2).

CPT	Distance [m]	Wright factor
1	13,2	0,48
2	9,0	0,7
3	10,0	0,63
4	6,3	1,0

Angle of internal friction φ' was determined by using equation $\varphi' = 13{,}5\log q_c + 23$ (attachement D.2 Eurocode 7- Part 2). It was assumed that angle of internal friction is determined up to depth which corresponds to width of a pad footing B (Fig.1).

From a set of these values (up to depth B below foundation level) an arithmetic value of φ', as well as, standard deviation σ were assesed. Afterwards, Schnaider's method ($X_k=X_m-0{,}5\sigma$) was used to calculate characteristic value of φ' (Fig.1).

z [m]	q_c [MPa]	φ' [°]	$\tan\varphi'$
0,8	13,20	38,13	0,78
0,9	11,45	37,29	0,76
1	11,70	37,42	0,77
1,1	11,39	37,26	0,76
1,2	11,89	37,51	0,77
1,3	12,63	37,87	0,78
1,4	13,22	38,14	0,79
1,5	13,05	38,06	0,78
1,6	14,57	38,71	0,80
1,7	15,76	39,17	0,81
1,8	14,59	38,72	0,80
1,9	14,47	38,67	0,80
2	14,85	38,82	0,80
2,1	15,90	39,22	0,82
2,2	16,01	39,26	0,82

$$X_m = \frac{\Sigma x_i}{n} = 0{,}79$$

$$\sigma = \sqrt{\frac{\Sigma(x_i - X_m)^2}{n-1}} = 0{,}02$$

$X_k = X_m - 0{,}5\sigma = 0{,}79 - 0{,}5 \text{ x } 0{,}02 = 0{,}78$

$\tan\varphi' = 0{,}78 \rightarrow \varphi' = 37{,}9°$

The characteristic value of angle of internal friction was determined as equal to $\varphi_k' = 37{,}9°$.

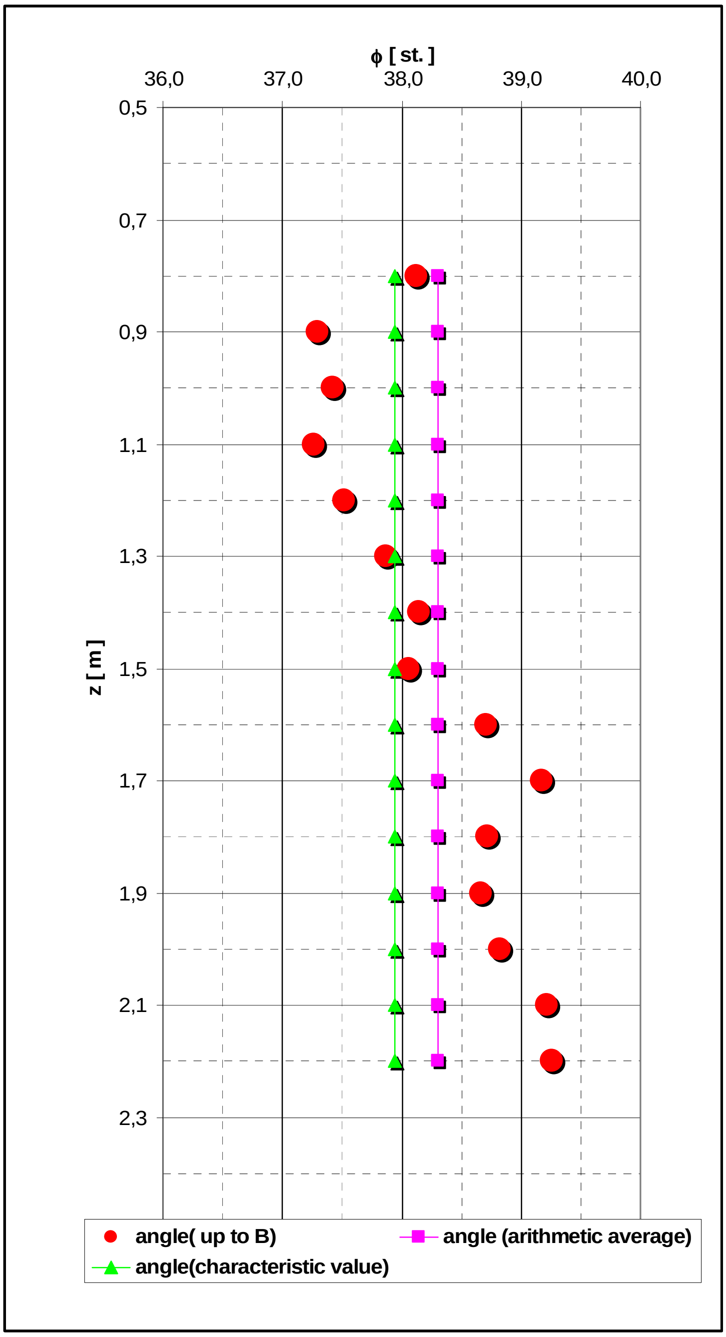


Fig.1 Characteristic value of angel of internal friction

2.1.2 Unit weight of soil

The characteristic values of unit weight of soil was taken as equal to γ_κ = 20 kN/m^3.

2.2 Design values of geotechnical parameters

Design values of geotechnical parameters were obtained by using partial factors from Table A.4 – M1 set (Eurocode 7 – Geotechnical design. Part I).

Partial factors on soil parameters γ_M

Soil properties	Symbol	M1 set
Angle of internal friction	$\gamma_{\varphi'}$	1,0
Unit weight of soil	γ_γ	1,0

3. Loads

3.1 Characteristic value of loads

The characteristic value of loads were determined according to information given in the description of the example. Additionally, weight of foundation was implemented into calculations.

Vertical loads

$G_{v,k}$ – permanent vertical load

$G_{v,k}$ = 1000 kN

$G_{p,k}$ – weight of foundation (B=L=1,4 m was assumed)

$G_{p,k}$ = 1,4 x 1,4 x 0,8 x 25 = 39 kN

$Q_{v,k}$ – variable vertical load

$Q_{v,k}$ = 750 kN

Horizontal loads

$G_{h,k}$ – permanent horizontal load

$G_{h,k}$ = 0 kN

$Q_{h,k}$ – variable horizontal load

$Q_{h,k}$ = 0 kN

Total characteristic value of vertical loads

$V_k = G_{v,k} + G_{p,k} + Q_{v,k}$ = 1000 + 39 + 750 = 1789 kN

3.2 Design value of loads

Design values of loads were obtained by using partial factors from Table A.3 – A1 set (Eurocode 7 – Geotechnical design. Part I).

Partial factors on actions or the effects of actions γ_F

Actions		Symbol	A1 set
Permanent	Unfavourable	γ_G	1,35
	Favourable		1,0
Variable	Unfavourable	γ_Q	1,5
	Favourable		0

$V_d = (G_{v,k} + G_{p,k})\,\gamma_G + Q_{v,k}\,\gamma_Q$ = (1000 + 39) x 1,35 + 750 x 1,5 = 2528 kN

4. Results of calculations

The formula supplied by annex D from EN 1997-1 was used so as to determine dimensions of shallow foundation. The analysis showed that required dimensions are as follows: B=L= 1,4 m.

Partial factors on soil resistance γ_R

Resistance	Symbol	R2 set
Bearing capacity	$\gamma_{R,v}$	1,4

$R_k = (c' \cdot N_c \cdot s_c \cdot b_c \cdot i_c + q' \cdot N_q \cdot s_q \cdot b_q \cdot i_q + 0{,}5 \cdot \gamma' B' \cdot N_\gamma \cdot s_\gamma \cdot b_\gamma \cdot i_\gamma)A'$

Foundation dimensions
$B' = L' = 1{,}4$ m
Bearing capacity factors
$N_q = 48{,}29$
$N_\gamma = 73{,}63$
Shape factors
$s_q = 1{,}61$
$s_\gamma = 0{,}7$
Inclination factors
$i_q = i_\gamma = 1$
$b_q = b_\gamma = 1$
Unit weight of soil
$\gamma' = 20$ kN/m^3
Angle of internal friction
$\Phi' = 37{,}9\,°$
Effective overburden pressure at foundation level
$q' = 16$ kPa
Design value of vertical loads
$V_d = (1000 + 1{,}4 \times 1{,}4 \times 0{,}8 \times 25) \times 1{,}35 + 750 \times 1{,}5 = 2528$ kN

$R_k = (c' \cdot N_c \cdot s_c \cdot b_c \cdot i_c + q' \cdot N_q \cdot s_q \cdot b_q \cdot i_q + 0{,}5 \cdot \gamma' B' \cdot N_\gamma \cdot s_\gamma \cdot b_\gamma \cdot i_\gamma)A' = (0 + 16 \times 48{,}29 \times 1{,}61 \times 1 \times 1 + 0{,}5 \times 20 \times 1{,}4 \times 73{,}63 \times 0{,}7 \times 1 \times 1)\ 1{,}4 \times 1{,}4 = (0 + 1243{,}95 + 721{,}57)\ 1{,}96 = 3852$ kN

The characteristic vertical bearing resistance $R_k = 3852$ kN

The requirement $V_d < R_d$ is fulfilled as

$V_d = 2528$ kN $< R_d = R_k / \gamma_{R,v} = 3852/ 1{,}4 = 2751$ kN

The degree of utilization Λ is equal to
$\Lambda = V_d/R_d = 2528/2751 = 0{,}92$

The overall factor of safety OFS is equal to
$OFS = R_k/V_k = 3852/1789 = 2{,}15$

Table 1

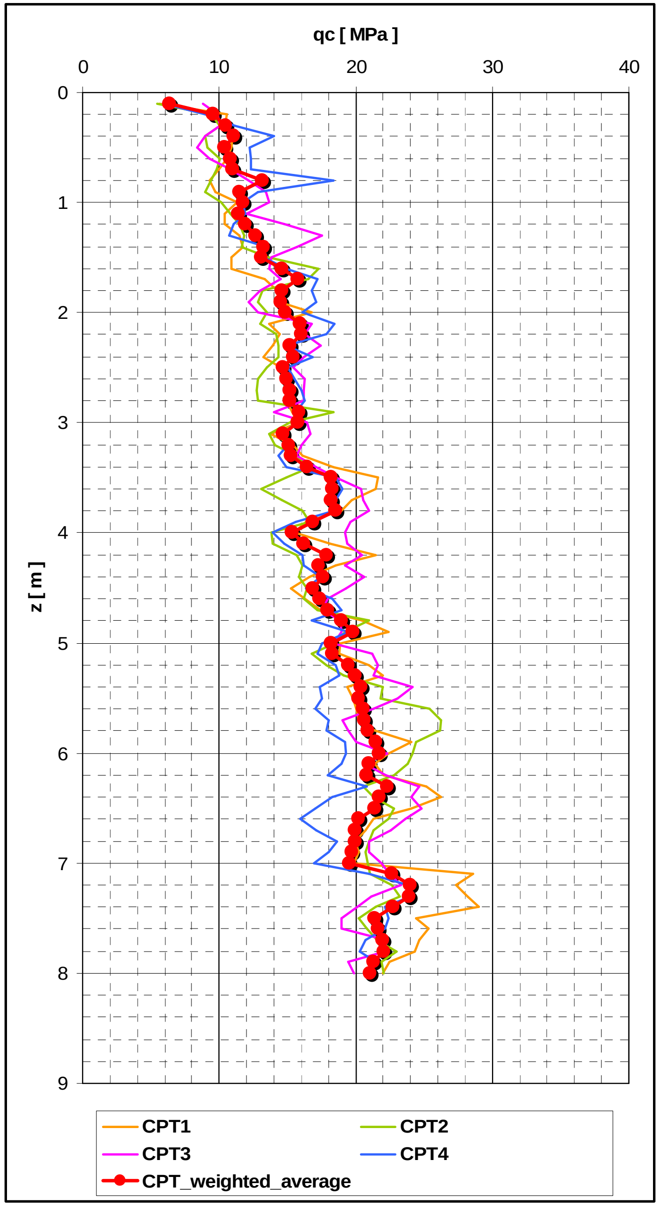
			CPT 1		CPT 2		CPT 3		CPT 4		Arithmetic average		Weighted average	
Depth (m)	γ (kN/m3)	σ'_{vo} (kPa)	qc (MPa)	fs (kPa)	qc (MPa)	fs (kPa)	qc (MPa)	fs (kPa)	qc (MPa)	fs (kPa)	qc (MPa)	fs (kPa)	qc (MPa)	fs (kPa)
0,1	20	2	5,62	23,6	5,41	18	8,78	9,1	5,99	5,7	6,45	14,1	6,41	12,58
0,2	20	4	10,56	56,5	9,37	45,6	9,89	25,6	9	6,1	9,71	33,5	9,56	28,92
0,3	20	6	10,4	83,5	10,1	92,8	10,05	45,3	11,14	44	10,42	66,4	10,51	63,20
0,4	20	8	10,95	61,9	8,94	95,9	8,96	61,6	14,01	64,8	10,72	71,1	11,09	71,33
0,5	20	10	10,92	68	9,14	75,1	8,38	63,3	12,23	110,7	10,17	79,3	10,37	83,91
0,6	20	12	10,6	76,3	10,1	67,9	9,27	38	12,36	106,4	10,58	72,2	10,80	76,33
0,7	20	14	10,01	80,5	9,78	82,9	10,78	53,3	12,36	111,7	10,73	82,1	10,96	86,10
0,8	20	16	9,34	87	9,38	81,1	12,17	88,3	18,37	139,2	12,32	98,9	13,20	104,40
0,9	20	18	9,72	107,1	8,95	100,3	13,42	122,2	12,79	121,1	11,22	112,7	11,45	113,77
1	20	20	11,35	127	10,18	109,8	13,63	160,3	11,72	105,6	11,72	125,7	11,70	122,57
1,1	20	22	10,36	128,7	10,82	115,6	12,03	136,2	11,89	119,8	11,28	125,1	11,39	123,95
1,2	20	24	10,4	102,4	11,48	123,9	14,79	136,6	11,06	122,8	11,93	121,4	11,89	122,68
1,3	20	26	11,46	85,8	11,81	126,6	17,5	167	10,71	115,2	12,87	123,7	12,63	124,63
1,4	20	28	11,73	100,5	11,69	130,9	15,68	178,9	13,47	126,7	13,14	134,3	13,22	134,97
1,5	20	30	10,9	119,8	13,58	136,3	13,83	132,6	13,23	140,7	12,89	132,4	13,05	134,22
1,6	20	32	10,9	128,5	17,3	159,6	13,7	122,4	14,96	153,9	14,22	141,1	14,57	143,92
1,7	20	34	13,32	134,4	16,51	157	14,51	121,4	17,2	149,7	15,39	140,6	15,76	142,56
1,8	20	36	14,27	128,3	13,15	180,6	13,03	127,2	16,74	204,2	14,30	160,1	14,59	168,09
1,9	20	38	14,45	159,4	12,81	186	12,15	125,6	17,11	252	14,13	180,8	14,47	191,40
2	20	40	16,74	189,5	13,49	180,5	12,87	125,2	16,14	244,9	14,81	185,0	14,85	192,56
2,1	20	42	13,68	196,3	12,98	186,3	16,76	138,4	18,47	221,8	15,47	185,7	15,90	189,90
2,2	20	44	14,45	181,2	14,21	197,3	16,24	145,2	17,88	257,5	15,70	195,3	16,01	204,29
2,3	20	46	13,91	186,3	14,36	190,2	17,48	268,9	14,89	232,8	15,16	219,6	15,17	222,34
2,4	20	48	13,24	199,7	14,38	181,9	16,16	262,8	16,82	228,7	15,15	218,3	15,45	219,73
2,5	20	50	14,49	189,1	13,46	184,3	15,45	239,9	15,02	233,6	14,61	211,7	14,64	215,13
2,6	20	52	14,82	203,4	12,83	183,9	16,26	219,6	15,51	236,2	14,86	210,8	14,89	213,85
2,7	20	54	15,52	215,5	12,76	133,3	16,19	217,2	16,03	195,8	15,13	190,5	15,16	188,39

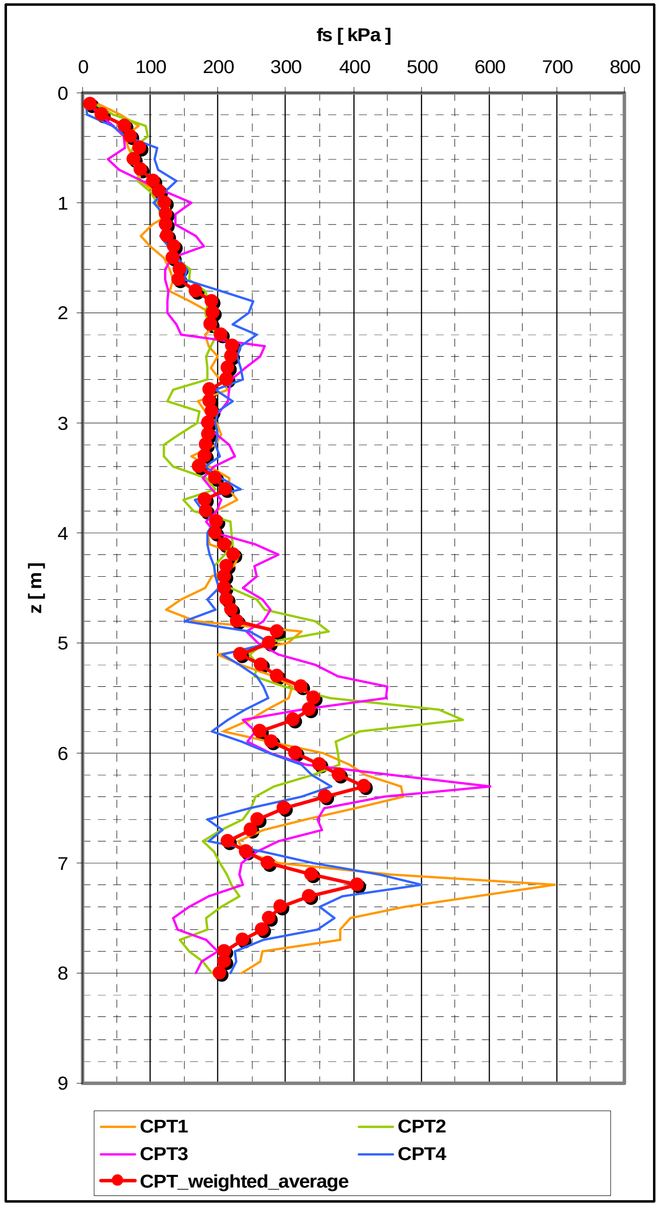
Table 1

			CPT 1		CPT 2		CPT 3		CPT 4		Arithmetic average		Weighted average	
Depth (m)	γ (kN/m3)	σ'_{vo} (kPa)	qc (MPa)	fs (kPa)	qc (MPa)	fs (kPa)	qc (MPa)	fs (kPa)	qc (MPa)	fs (kPa)	qc (MPa)	fs (kPa)	qc (MPa)	fs (kPa)
2,8	20	56	14,9	170,3	12,84	125,1	16,2	214,6	16,26	221	15,05	182,8	15,16	187,01
2,9	20	58	15,32	180,4	18,39	172,7	13,98	203,6	15,61	199,7	15,83	189,1	15,89	190,55
3	20	60	15,83	198,1	15,14	169,7	16,4	176,6	15,7	195,7	15,77	185,0	15,74	185,35
3,1	20	62	13,77	204,6	13,66	142,5	16,69	197,1	14,57	198,9	14,67	185,8	14,68	185,42
3,2	20	64	15,46	196,8	14,07	120,5	16,03	217,3	15,03	196,8	15,15	182,9	15,09	182,39
3,3	20	66	16,06	161,4	15,58	120,5	15,66	225,6	14,38	202,5	15,42	177,5	15,25	180,23
3,4	20	68	18,37	187,3	16,65	133,7	17,1	194,5	14,89	180,4	16,75	174,0	16,42	173,11
3,5	20	70	21,66	216,1	14,96	183,3	18,51	178,2	18,51	205,1	18,41	195,7	18,16	195,52
3,6	20	72	21,45	216,7	13,09	195,7	20,37	191	19	232,7	18,48	209,0	18,25	211,40
3,7	20	74	19,73	228,6	14,6	148,1	20,58	204,3	18,57	165,2	18,37	186,6	18,23	180,54
3,8	20	76	18,97	196	16,14	164,1	20,97	198,1	18,43	178,3	18,63	184,1	18,52	182,23
3,9	20	78	16,32	200,3	16,64	218	19,59	182,9	15,58	193,9	17,03	198,8	16,87	198,53
4	20	80	15,52	184,5	13,87	219,5	19,24	195,5	13,94	184,1	15,64	195,9	15,38	195,54
4,1	20	82	18,12	187,8	13,88	221,2	19,37	254,8	14,76	183,9	16,53	211,9	16,15	209,75
4,2	20	84	21,49	231,4	15,71	209,9	20,49	289,6	16,08	188,3	18,44	229,8	17,90	223,75
4,3	20	86	18,51	224,1	16,12	194,7	19,2	253,5	16,18	194,6	17,50	216,7	17,24	212,87
4,4	20	88	16,59	191,1	15,82	195,6	20,67	257,5	17,46	196,7	17,64	210,2	17,62	209,10
4,5	20	90	15,23	181	16,44	218,4	19,29	237,1	16,37	200,6	16,83	209,3	16,85	209,87
4,6	20	92	16,24	146,2	16,17	256,5	17,94	264,7	18,26	183,6	17,15	212,8	17,32	213,55
4,7	20	94	17,48	123,3	17,15	268,8	17,52	277,8	18,99	195,9	17,79	216,5	17,94	220,02
4,8	20	96	20,49	166,6	20,97	343,5	18,88	266,6	16,76	150,9	19,28	231,9	18,92	227,50
4,9	20	98	22,4	322,6	19,19	363,8	18,99	241,7	19,42	247,2	20,00	293,8	19,78	287,89
5	20	100	18,86	302,2	18,44	268,5	18,39	258,9	17,49	278,1	18,30	276,9	18,16	275,52
5,1	20	102	18,79	199,5	16,77	247	21,25	289,6	17,22	205,7	18,51	235,5	18,28	233,74
5,2	20	104	20,95	233,1	17,83	259,3	21,63	343,1	18,56	232	19,74	266,9	19,47	263,90
5,3	20	106	21,94	282,6	19,13	253,9	21,26	377	18,82	256,8	20,29	292,6	19,98	287,43
5,4	20	108	19,34	309,8	21,96	298,4	24,18	449,9	17,37	267,4	20,71	331,4	20,38	323,28

Table 1

			CPT 1		CPT 2		CPT 3		CPT 4		Arithmetic average		Weighted average	
Depth	γ	σ'vo	qc	fs	qc	fs	qc	fs	qc	fs	qc	fs	qc	fs
(m)	(kN/m3)	(kPa)	(MPa)	(kPa)	(MPa)	(kPa)	(MPa)	(kPa)	(MPa)	(kPa)	(MPa)	(kPa)	(MPa)	(kPa)
5,5	20	110	19,79	303,7	21,79	364,6	23,1	448,3	17,5	274,5	20,55	347,8	20,22	340,90
5,6	20	112	20,06	272	25,37	525,6	21,26	322,3	17,03	239,4	20,93	339,8	20,57	334,85
5,7	20	114	20,21	246,9	26,23	561,3	19,04	237,4	18,02	214,1	20,88	314,9	20,67	311,42
5,8	20	116	21,38	207,9	26,15	409,1	19,49	255	17,86	190,6	21,22	265,7	20,89	262,42
5,9	20	118	24,07	275,9	24,37	373,6	20,01	243,2	19,2	235,7	21,91	282,1	21,50	278,60
6	20	120	22,39	355,3	24,16	377,8	22,3	277	19,3	275,5	22,04	321,4	21,71	314,95
6,1	10	121	21,4	394,8	23,8	379,4	20,67	330,2	18,95	322,5	21,21	356,7	20,96	350,75
6,2	10	122	22,06	417,1	22,8	339,7	22,23	456,7	17,92	337,5	21,25	387,8	20,81	378,37
6,3	10	123	25,15	470,9	20,55	282,3	24,64	602,8	20,81	366,5	22,79	430,6	22,35	416,34
6,4	10	124	26,22	474	21,33	255,2	24,05	445,6	18,32	322,7	22,48	374,4	21,70	359,28
6,5	10	125	24,08	401,7	22,85	248,6	24,78	356,1	17,01	247,3	22,18	313,4	21,41	298,39
6,6	10	126	21,27	330,2	22,4	236,4	23,66	346,8	15,9	183,9	20,81	274,3	20,18	258,49
6,7	10	127	20,71	268	21,32	204,5	22,54	353	17,08	206,3	20,41	258,0	19,98	249,28
6,8	10	128	19,95	229,4	20,93	178,4	21	288,7	18,61	186,7	20,12	220,8	19,95	214,79
6,9	10	129	20,17	238,2	20,75	194,5	20,99	257,3	18	266,9	19,98	239,2	19,73	241,81
7	10	130	19,91	289,8	20,87	202,8	21,9	235,4	16,93	340,6	19,90	267,2	19,53	274,01
7,1	10	131	28,56	454,5	21,03	212,7	22,5	231,9	20,94	438,8	23,26	334,5	22,61	338,77
7,2	10	132	27,3	696,8	22,68	219,6	23,28	237,6	23,82	501,2	24,27	413,8	24,01	405,36
7,3	10	133	28,15	582,4	23,21	231,2	21,13	185,8	24,02	383,2	24,13	345,7	23,88	335,11
7,4	10	134	29	475,8	21,44	204,5	20,11	157	22,17	349,5	23,18	296,7	22,69	291,80
7,5	10	135	24,37	395,8	20,23	183,3	18,98	134,1	22,38	371,8	21,49	271,3	21,42	275,65
7,6	10	136	25,31	381,1	20,76	183,9	18,99	140,3	22,16	346,6	21,81	263,0	21,64	265,71
7,7	10	137	24,62	380	21,58	143,3	22,24	183,2	20,69	267	22,28	243,4	21,93	236,70
7,8	10	138	24,3	264,7	23,01	157,4	22,11	200,3	20,28	224,6	22,43	211,8	22,06	209,26
7,9	10	139	22,44	261,5	21,88	177,9	19,49	175,4	21,43	226,4	21,31	210,3	21,28	208,88
8	10	140	21,99	234,8	22,02	190,3	19,85	166,7	20,72	218,4	21,15	202,6	21,07	202,61





Rys. 2 Representative profile q_c and f_s

Serviceability Limit States

1. Selection of design method

As it was stated in the description of the example, settlements of a soil mass should not exceed 25 mm. Furthermore, foundation's design working life is around 50 years.

To find out what dimensions of pad footing must be designed to satisfy both requirements Schmertmann's method (annex D.3 from EN 1997-2) was used.

In this method soil mass beneath foundation base is divided on a finite number of layers up to 2B (square foundations L/B=1) or 4B (strip foundations L/B>10). Every layer represents a soil stiffness consistent with test results (in this case q_c – Fig. 4). Cone resistance and Young's modulus are determined for every calculation layer, however, it is assumed that q_c and E' values are constant in layers. In this example thickness of layers is equal to 0,4 m.

Calculations of settlements were carried out with use of the following equation:

$$s = C_1 \cdot C_2 \cdot (q - \sigma'_o) \cdot \int_0^z \frac{I_z}{C_3 \cdot E'} dz ;$$

a) C_1 - correction factor for the depth of foundation;

$$C_1 = 1 - 0{,}5 \frac{\sigma'_0}{q_n}$$

σ'_0 - effective overburden pressure at foundation level;

q_n - net foundation base pressure;

$$q_n = q - \sigma'_0$$

b) C_2 - correction factor for creep;

$$C_2 = 1 + 0{,}2 \log(\frac{t}{0{,}1})$$

t – time in years after the application of foundation for which the settlement value is required

c) C_3 - correction factor for foundation shape;;

C_3 =1,25 (for square foundation);

C_3 = 1,75 (for strip foundation);

d) I_z -strain influence factor which is determined with use of Fig. 3 for each soil layer in Schmertmann method;

$$I_{z\max} = 0{,}5 + 0{,}1\sqrt{\frac{q_n}{\sigma'_p}}$$

σ'_p - effective overburden pressure at depth 0,5 B (for square foundations) or B (for strip foundation);

e) dz - thickness of calculation layer ;

f) E'- Young's modulus in particular layer. It is recommended to use

E'= 2,5q_c (for square foundations);

E'= 3,5q_c (for strip foundations);

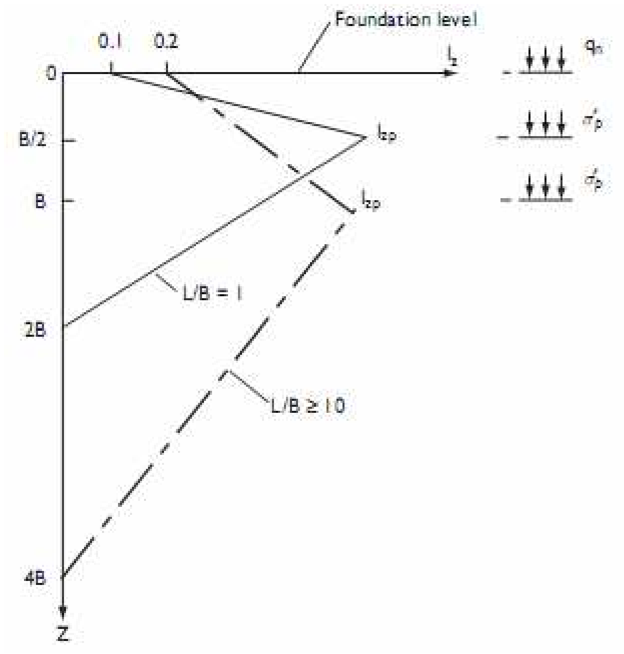


Fig.. 3 Distribution of strain influence factor I_z

2. Geotechnical parameters

Young's modulus was taken into account during calculations of settlements. To obtain total value of settlements it was necessary to sum up settlements of each soil layer.

2.1 Characteristic values of geotechnical parameters

2.1.1 Young's modulus

The characteristic values of Young's modulus (E') were derived from following equation: E'=2,5q_c (as suggested by Schmertmann for axisymmetric conditions). The representative profile of q_c was used to calculate E'.

2.2 Design values of geotechnical parameters

The calculations were carried out with design values of geotechnical parameters equal to characteristic values.

3. Loads

3.1 Characteristic value of loads

The characteristic value of loads were determined according to information given in the description of the example. Additionally, weight of foundation was implemented into calculations.

Vertical loads

$G_{v,k}$ – permanent vertical load

$G_{v,k}$ = 1000 kN

$G_{p,k}$ – weight of foundation (B=L=2,0 m was assumed)

$G_{p,k}$ = 2,0 x 2,0 x 0,8 x 25 = 80 kN

$Q_{v,k}$ – variable vertical load

$Q_{v,k}$ = 750 kN

Horizontal loads

$G_{h,k}$ – permanent horizontal load

$G_{h,k}$ = 0 kN

$Q_{h,k}$ – variable horizontal load
$Q_{h,k}$ = 0 kN
Total characteristic value of vertical loads
$V_k = G_{v,k} + G_{p,k} + Q_{v,k} = 1000 + 80 + 750 = 1830$ kN

3.2 Design value of loads

The calculations were carried out with using characteristic values of loads.

4. Results of calculations

It was pointed out that the minimum dimensions of foundation are B=L= 2,0 m. In such case settlements of pad footing are roughly about 25 mm. Input data, as well as, results of calculations are presented below.

Table 3 Input data for settlements analysis using Schmertmann's method

Foundation dimensions			
Width	B	2	[m]
Length	L	2	[m]
Depth	D	0,8	[m]
Loads			
Point load	V	1830	[kN]
Total foundation pressure	q	457,5	[kPa]
Net foundation base pressure	q_n	441,5	[kPa]
Soil conditions & correction factors			
Water table depth	d	6	[m]
Unit weight	γ	20	[kN/m^3]
Time	t	50	[years]
Effective overburden pressure at foundation level	σ'_o	16	[kPa]
Effective overburden pressure at depth B/2	σ'_p	36	[kPa]
Depth correction factor	C_1	0,982	[-]
Creep factor	C_2	1,540	[-]
Foundation shape correction factor	C_3	1,25	[-]
Vertical strain influence factor	Iz_{max}	0,850	[-]
Elastic modulus used in calculations	$Es = 2,5\ q_c$	-	[kPa]

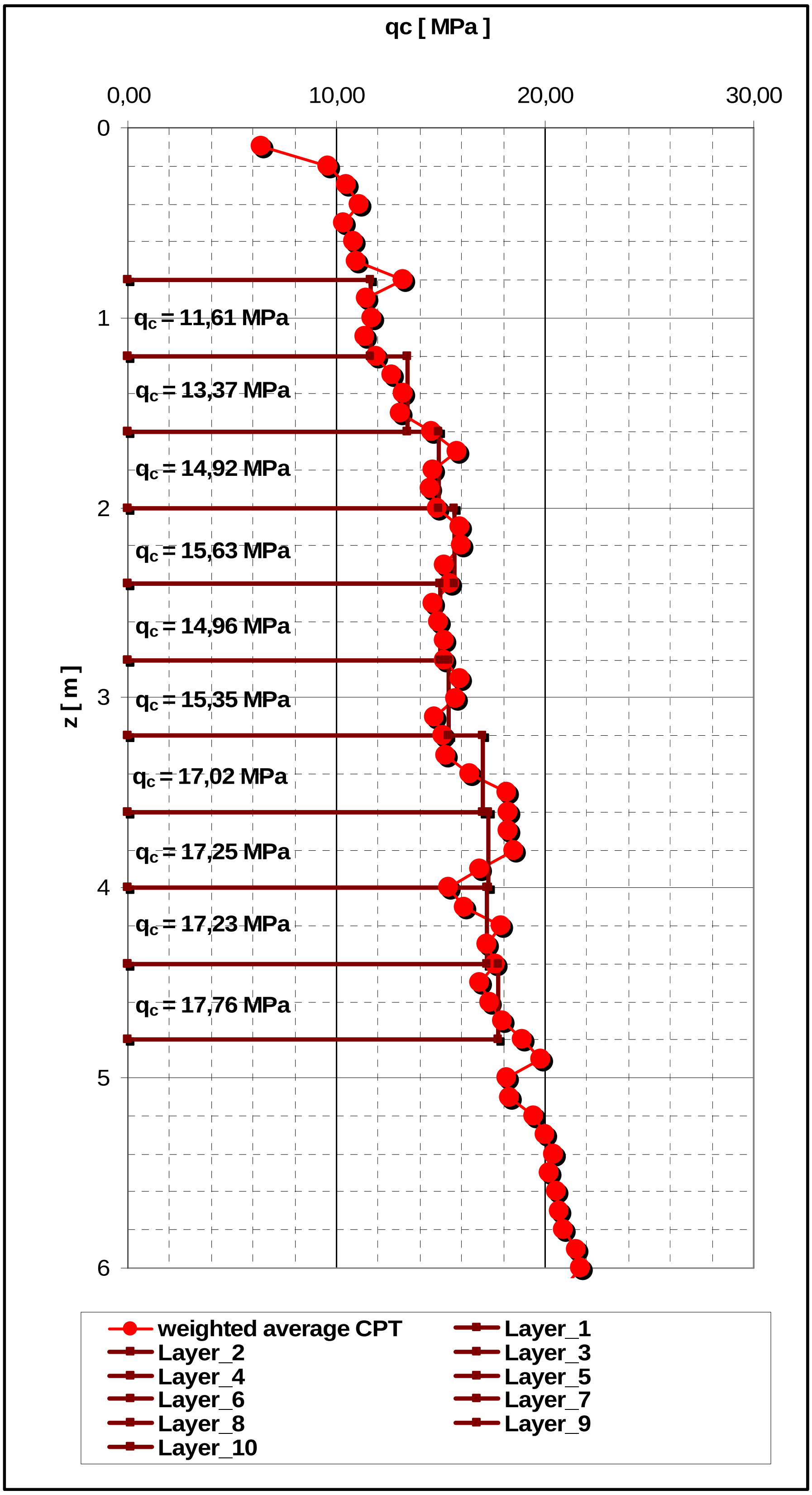


Fig. 4 Calculation layer used in settlement analysis

Table 4 Results of settlements calculations

Layer	Top	Bottom	Depth	Δz	qc	E'	Iz	(Iz x Δz)/C_3Es	s
[-]	[m]	[m]	[m]	[m]	[kPa]	[kPa]	[-]	[mm/kPa]	[mm]
1	0	-0,4	-0,2	0,4	11610	29025	0,2490	0,003	1,833
2	-0,4	-0,8	-0,6	0,4	13370	33425	0,5471	0,005	3,496
3	-0,8	-1,2	-1	0,4	14920	37300	0,8452	0,007	4,840
4	-1,2	-1,6	-1,4	0,4	15630	39075	0,7325	0,006	4,004
5	-1,6	-2	-1,8	0,4	14960	37400	0,6198	0,005	3,540
6	-2	-2,4	-2,2	0,4	15350	38375	0,5072	0,004	2,823
7	-2,4	-2,8	-2,6	0,4	17020	42550	0,3945	0,003	1,980
8	-2,8	-3,2	-3	0,4	17250	43125	0,2818	0,002	1,396
9	-3,2	-3,6	-3,4	0,4	17230	43075	0,1691	0,001	0,839
10	-3,6	-4	-3,8	0,4	17760	44400	0,0564	0,000	0,272
Total	-	-	-	4	-	-	-	-	**25,0**

Total value of settlements is equal to 25 mm.