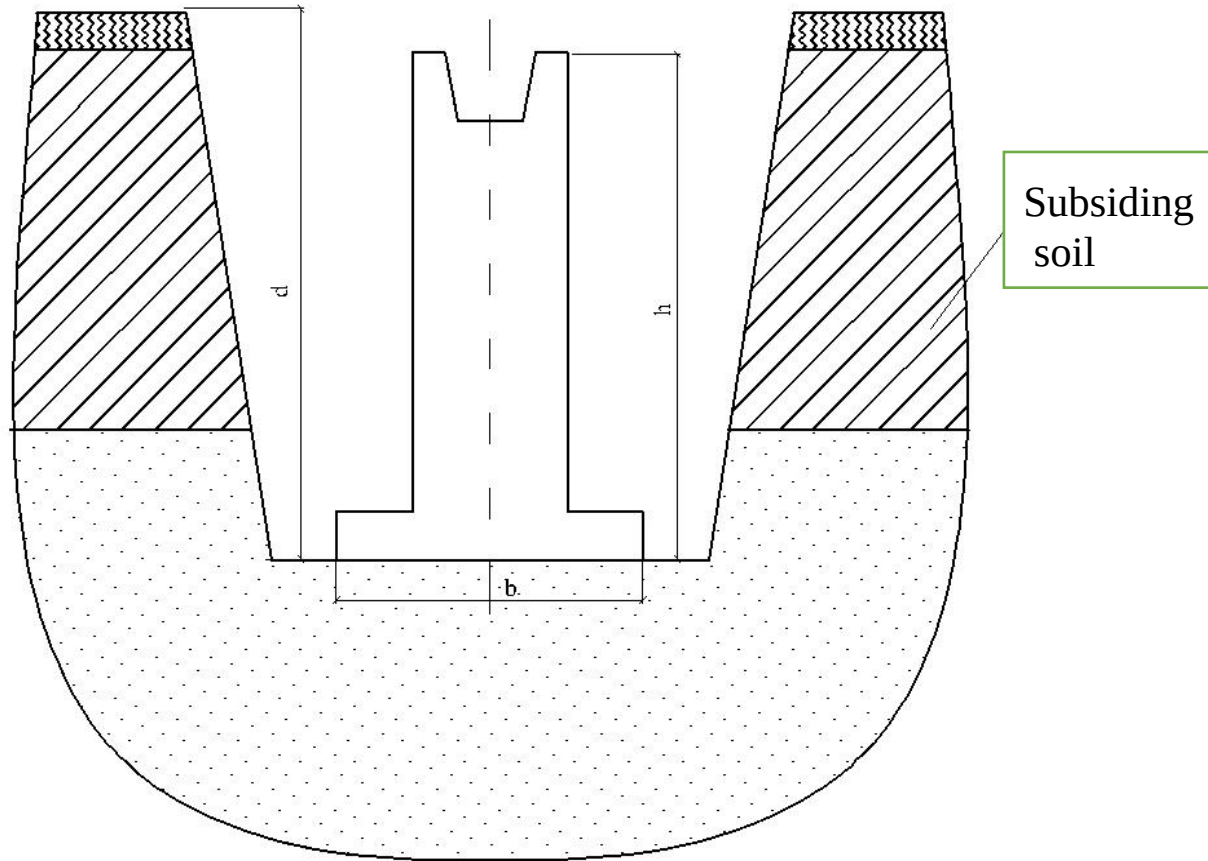


Foundation cutting through the subsidence layer



If there is a layer of subsiding soil of a small capacity, it is possible to arrange a foundation on a natural basis, which cuts through the subsiding soils and rests on non-subsiding soils.

The calculation is performed similarly to the calculation of the foundation on a natural basis, only the depth of laying the foundation changes, and, accordingly, the characteristics of the soils

Example

Geological structure and hydrogeological conditions of the construction site

№ layer	Soil	Well number and the depth of the sole of each soil layer from the surface of the earth, m				
		1	2	3	4	5
1.	plant layer	0,3	0,3	0,3	0,3	
2.	Subsidence soil	4,8	4,6	4,9	4,8	
3.	Sand medium-sized	3,4	3,6	3,5	3,3	
4.	sandy loam	3,5	3,6	3,7	3,6	
5.	Clay gray	8,7	8,9	8,8	8,7	
	The depth of underground water	8,2	8,0	8,3	8,1	
	Well mark, m					

Variant	Cross section of the column , mm	Combination			
		I		II	
		N,MN	M, MNm	N,MN	M,MNm
	600x400	2,1	0,26	1,2	0,41

Characteristics of soil properties

Name	Legend	Units of measurement	Layer number				
			1	2	3	4	5
Density	ρ_{II}	t/m ³	1,39	1,72	2,01	1,98	2,06
Solid Particle density	ρ_s	t/m ³		2,73	2,68	2,69	2,70
Water content	W			0,15	0,24	0,26	0,22
Liquid limit	W _L			0,35		0,28	0,40
Plastic limit	W _p			0,19		0,22	0,20
Angle of internal friction	φ_{II}	degree		21	33	20	15
Specific cohesion	C _{II}	kPa		25	1	12	80
Modulus of Deformation	E	MPa		20	30	15	50
Relative subsidence under pressure p, MПа	ϵ_{SL}	p=0,1		0,04			
		p=0,2		0,073			
		p=0,3		0,082			
Angle of internal friction water-saturated soil	$\varphi_{II,sat}$	degree		19			
Specific cohesion water-saturated soil	C _{II,sat}	kPa		5			
Modulus of Deformation water-saturated soil	E _{sat}	MPa		6			

Soil classification indicators

№ Layer	e	S_r	I_p	I_l	Soil properties
1					plant layer
2	0.825		0.16	-1.25	Subsiding soil loam solid
3	0.653	0.389			Sand medium-sized low moisture Medium density
4			0.06	0.667	sandy loam nplastic
5			0.2	0.1	Clay semi-solid

$$\rho_{sat} = \frac{\rho}{1+W} \cdot \left(1 + \frac{S_{r,sat} \cdot e \cdot \rho_w}{\rho_s} \right) = \frac{1,72}{1+0,15} \left(1 + \frac{0,9 \cdot 0,825 \cdot 1}{2,73} \right) = 1,93 \text{ t/m}^3$$

Psl=46 kPa

First, accept $R_0 = 400 \text{ kPa}$ according to the tables. DBN

The depth of laying the foundation $d = 0,3 + 4,6 + 0,3 = 5,2 \text{ m}$

$$b_0 = \sqrt{\frac{2100}{1,4 (400 - 20 \times 5,2 - 20)}} = 2,3 \text{ м}$$

We determine R_1 by the formula:

$$R = \frac{\gamma_{c1} \cdot \gamma_{c2}}{k} \cdot (M_\gamma \cdot k_z \cdot b \cdot \gamma_{II} + M_q \cdot d_1 \cdot \gamma'_{II} + (M_q - 1) \cdot d_b \cdot \gamma'_{II} + M_c \cdot c)$$

$$\gamma_{c2} = k = k_z = 1 \quad d_b = 0 \quad \gamma_{c1} = 1,4 \quad c = 1 \text{ kPa}$$

$$\text{For } \varphi_2 = 33 \quad M_\gamma = 1,44 \quad M_q = 6,76 \quad M_c = 8,88$$

$$\gamma = 20,1 \text{ kN/m}^3$$

$$\gamma' = 10 \frac{1,39 \cdot 0,3 + 1,72 \cdot 4,6 + 2,01 \cdot 0,3}{5,2} = 17,16 \text{ kN/m}^3.$$

$$R_1 = \frac{1,4 \cdot 1}{1} (1,44 \cdot 1 \cdot 2,3 \cdot 20,1 + 6,76 \cdot 5,2 \cdot 17,16 + 8,88 \cdot 1) = 966,4 \text{ kPa}$$

We clarify the value of b_1 for R_1

We clarify the value of b1 for R1

$$b_1 = \sqrt{\frac{2100}{1,4 (966,4 - 20 \times 5,2 - 20)}} = 1,33 \text{ m}$$

5. We specify R2 according to the formula :

$$R_2 = \frac{1,4 \cdot 1}{1} (1,44 \cdot 1 \cdot 1,33 \cdot 20,1 + 6,76 \cdot 5,2 \cdot 17,16 + 8,88 \cdot 1) = 927,1 \text{ kPa}$$

6. We clarify the value of b2 for R2

$$b_2 = \sqrt{\frac{2100}{1,4 (927,1 - 20 \times 5,2 - 20)}} = 1,37 \text{ m}$$

7 . We find the difference between b2 and b1

$$\frac{1,37 - 1,33}{1,37} 100\% = 2,9\% < 10\%$$

Since the difference is less than 10%, we accept:

We finally accept b=1,4 m and l=2 m

8. We perform checks of the ultimate stresses, kPa:

$$P_{\max} = \frac{N}{b \cdot l} + \gamma_{mf} \cdot d + q + \frac{M}{W} \leq 1.2R$$

$$P_{\min} = \frac{N}{b \cdot l} + \gamma_{mf} \cdot d + q - \frac{M}{W} > 0$$

$$W = \frac{b \cdot l^2}{6} = \frac{1,4 \cdot 2^2}{6} = 0,933 \text{ m}^3$$

$$P_{cp} = \frac{N}{b \cdot l} + \gamma_{mf} \cdot d + q \leq R$$

1. $N=2100 \text{ kN}$ $M=260 \text{ kNm}$

$$P_{\max} = \frac{2100}{1,4 \cdot 2} + 20 \cdot 5,2 + 20 + \frac{260}{0,933} = 1152,7 \text{ kPa} \not\leq 1112,52 \text{ kPa}$$

We accept constructively $b=1.6 \text{ m}$ $l=2.2 \text{ m}$

$$W = \frac{b \cdot l^2}{6} = \frac{1,6 \cdot 2,2^2}{6} = 1,29 \text{ m}^3$$

$$R_{1,6} = \frac{1,4 \cdot 1}{1} (1,44 \cdot 1 \cdot 1,6 \cdot 20,1 + 6,76 \cdot 5,2 \cdot 17,16 + 8,88 \cdot 1) = 938 \text{ kPa}$$

1. $N=2100 \text{ kN}$ $M=260 \text{ kNm}$

$$P_{max} = \frac{2100}{1,6 \cdot 2,2} + 20 \cdot 5,2 + 20 + \frac{260}{1,29} = 922,1 \text{ kPa} < 1125,6 \text{ kPa}$$

$$P_{min} = \frac{2100}{1,4 \cdot 2} + 20 \cdot 5,2 + 20 - \frac{260}{1,29} = 519 \text{ kPa} > 0 \text{ kPa}$$

$$P_{cp} = \frac{2100}{1,6 \cdot 2,2} + 20 \cdot 5,2 + 20 = 720,6 \text{ kPa} < 938 \text{ kPa}$$

1. $N=1200 \text{ kN}$ $M=410 \text{ kNm}$

$$P_{max} = \frac{1200}{1,6 \cdot 2,2} + 20 \cdot 5,2 + 20 + \frac{410}{1,29} = 782,7 \text{ kPa} < 1125,6 \text{ kPa}$$

$$P_{min} = \frac{1200}{1,6 \cdot 2,2} + 20 \cdot 5,2 + 20 - \frac{410}{1,29} = 147,1 \text{ kPa} > 0 \text{ kPa}$$

$$P_{cp} = \frac{1200}{1,6 \cdot 2,2} + 20 \cdot 5,2 + 20 = 464,9 \text{ kPa} < 938 \text{ kPa}$$

We finally accept $b = 1,6 \text{ m}$, $l = 2,2 \text{ m}$.

Estimated soil resistance R₀ of sandy soils

Sands	R ₀ values, kPa (kgf/cm ²), depending on the density of the sands	
	dense	Medium density
Coarse	600(6)	500(5)
Medium	500(5)	400(4)
fine:		
low moisture	400(4)	300(3)
wet and saturated with water	300(3)	200(2,0)
Dusty:		
low moisture	300(3)	250(2,5)
wet	200(2)	150(1,5)
saturated with water	150(1,5)	100(1)

Estimated soil resistance R₀ of clayey (non-subsidence) soils

clayey soils	Void ratio e	Values of R ₀ , kPa (kgf/cm ²), at liquidity index	
		$I_L = 0$	$I_L = 1$
sandy loams	0,5	300(3)	300(3)
	0,7	250(2,5)	200(2)
loams	0,5	300(3)	250(2,5)
	0,7	250(2,5)	180(1,8)
	1,0	200(2)	100(1)
clays	0,5	600(6)	400(4)
	0,6	500(5)	300(3)
	0,8	300(3)	200(2)
	1,1	250(2,5)	100(1)

Table 1– Coefficients of working conditions γ_{c2} , γ_{c2}

soils	Coefficient γ_{c1}	Coefficient for structures with a rigid structural scheme when the ratio of the length of the structure or its section to the height L/H is equal to	
		4 and more	1,5 and less
Large-clastic with sandy aggregate and sand, except small and dusty	1,4	1,2	1,4
The sands are fine	1,3	1,1	1,3
Dusty sands:			
- low moisture and wet,	1,25	1,0	1,2
- saturated with water	1,1	1,0	1,2
Clay, as well as large-fragmented with clay aggregate with a Liquidity index of the soil or aggregate $I_L \leq 0,25$	1,25	1,0	1,1
The same with $0,25 < I_L \leq 0,5$	1,2	1,0	1,1
The same with $I_L > 0,5$	1,0	1,0	1,0

Notes:

1 Buildings with a rigid structural scheme include buildings whose structures are specially adapted to absorb forces from deformation of the foundations, including due to the measures specified in Appendix K [1].

2 For buildings with a flexible structural scheme, the value of the coefficient γ_{c2} is assumed to be equal to one.

3 At intermediate L/H values, the γ_{c2} coefficient is determined by interpolation.

4 For loose sands γ_{c1} and γ_{c2} taken equal to 1.

Table 2 - Coefficients M_γ , M_q , M_c

Angle of internal friction , deg. φ_{II}	Coefficients			Angle of internal friction φ_{II} , deg.	Coefficients		
	M_γ	M_q	M_c		M_γ	M_q	M_c
0	0	1,00	3,14	23	0,69	3,65	6,24
1	0,01	1,06	3,23	24	0,72	3,87	6,45
2	0,03	1,12	3,32	25	0,78	4,11	6,67
3	0,04	1,18	3,41	26	0,84	4,37	6,90
4	0,06	1,25	3,51	27	0,91	4,64	7,14
5	0,08	1,32	3,61	28	0,98	4,93	7,40
6	0,10	1,39	3,71	29	1,06	5,25	7,67
7	0,12	1,47	3,82	30	1,15	5,59	7,95
8	0,14	1,55	3,93	31	1,24	5,95	8,24
9	0,16	1,64	4,05	32	1,34	6,34	8,55
10	0,18	1,73	4,17	33	1,44	6,76	8,88
11	0,21	1,83	4,29	34	1,55	7,22	9,22
12	0,23	1,94	4,42	35	1,68	7,71	9,58
13	0,26	2,05	4,55	36	1,81	8,24	9,97
14	0,29	2,17	4,69	37	1,95	8,81	10,37
15	0,32	2,30	4,84	38	2,11	9,44	10,80
16	0,36	2,43	4,99	39	2,28	10,11	11,25
17	0,39	2,57	5,15	40	2,46	10,85	11,73
18	0,43	2,73	5,31	41	2,66	11,64	12,24
19	0,47	2,89	5,48	42	2,88	12,51	12,79
20	0,51	3,06	5,66	43	3,12	13,46	13,37
21	0,56	3,24	5,84	44	3,38	14,50	13,98
22	0,61	3,44	6,04	45	3,66	15,64	14,64