

Construction on subsidence 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					

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	Subsidence 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

Determination of the type of soil conditions by subsidence

1. Characteristics of the subsidence soil saturated with water to a degree $S_{r,sat} = 0.9$

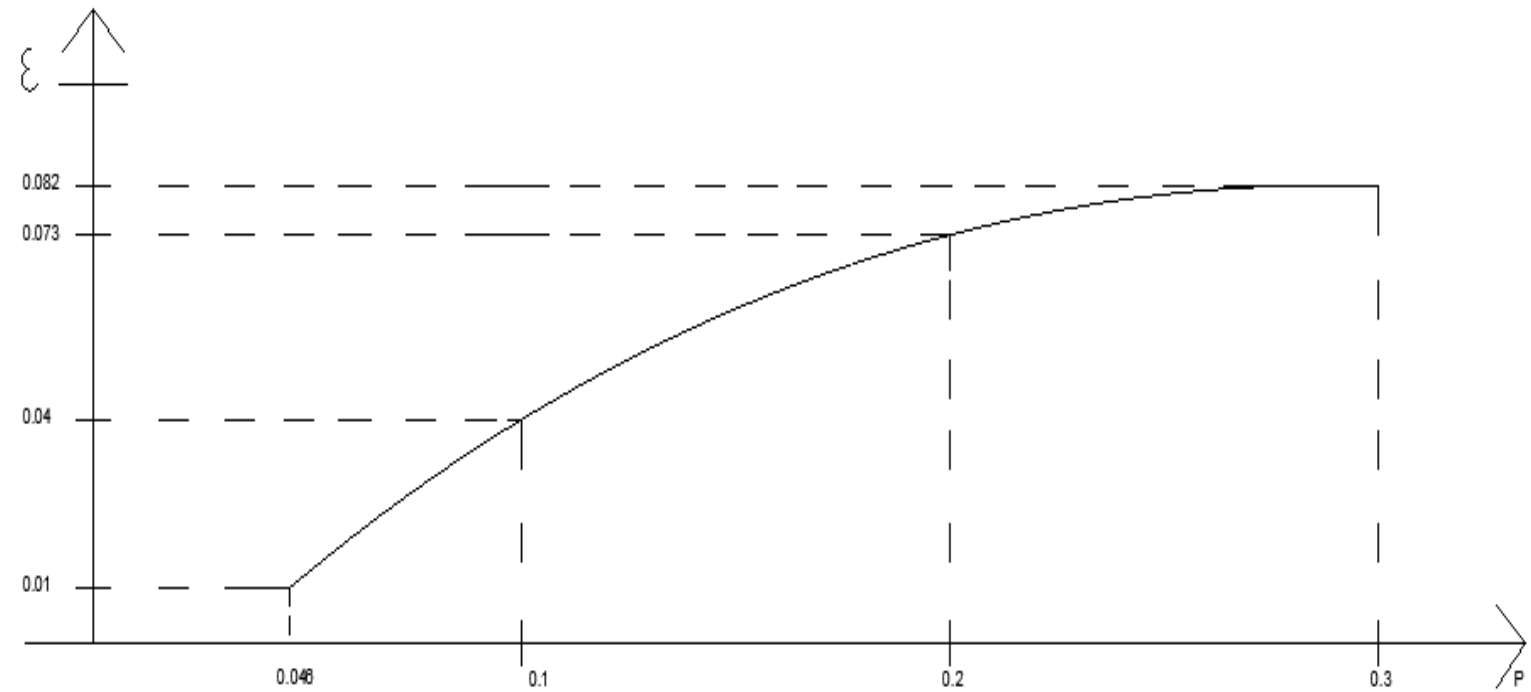
$$\rho_{sat} = \frac{\rho}{1+W} \cdot \left(1 + \frac{S_{r,sat} \cdot e \cdot \rho_w}{\rho_s} \right) = \frac{1,72}{1+0,15} \left(1 + \frac{0,9 \cdot 0,825 \cdot 1}{2,73} \right) = 1,93 \text{ t/m}^3$$

$$W_{sat} = \frac{S_{r,sat} \cdot e \cdot \rho_w}{\rho_s} = \frac{0,9 \cdot 0,825 \cdot 1}{2,73} = 0,273$$

2. We build a dependency graph $\varepsilon_{sl.i}$ from P_i

At the same time, we determine the initial subsidence pressure P_{sl} to which corresponds $\varepsilon_{sl.i} = 0.01$

P, MPa	$\varepsilon_{sl.i}$
0.1	0,04
0.2	0,073
0.3	0,082



$P_{sl}=0.046 \text{ MPa}=46 \text{ kPa}$

3. We calculate the value and build a graph of the stress in the layer of subsidence soil from its own weight when it is fully saturated with water, taking into account the possible cutting or backfilling when planning the territory. On the graph, mark the point corresponding to the value. The layer of subsiding soil below this point is divided into calculated strips, the thickness of which h_i should be no more than 2 m, and the number of which should be no less than 2.

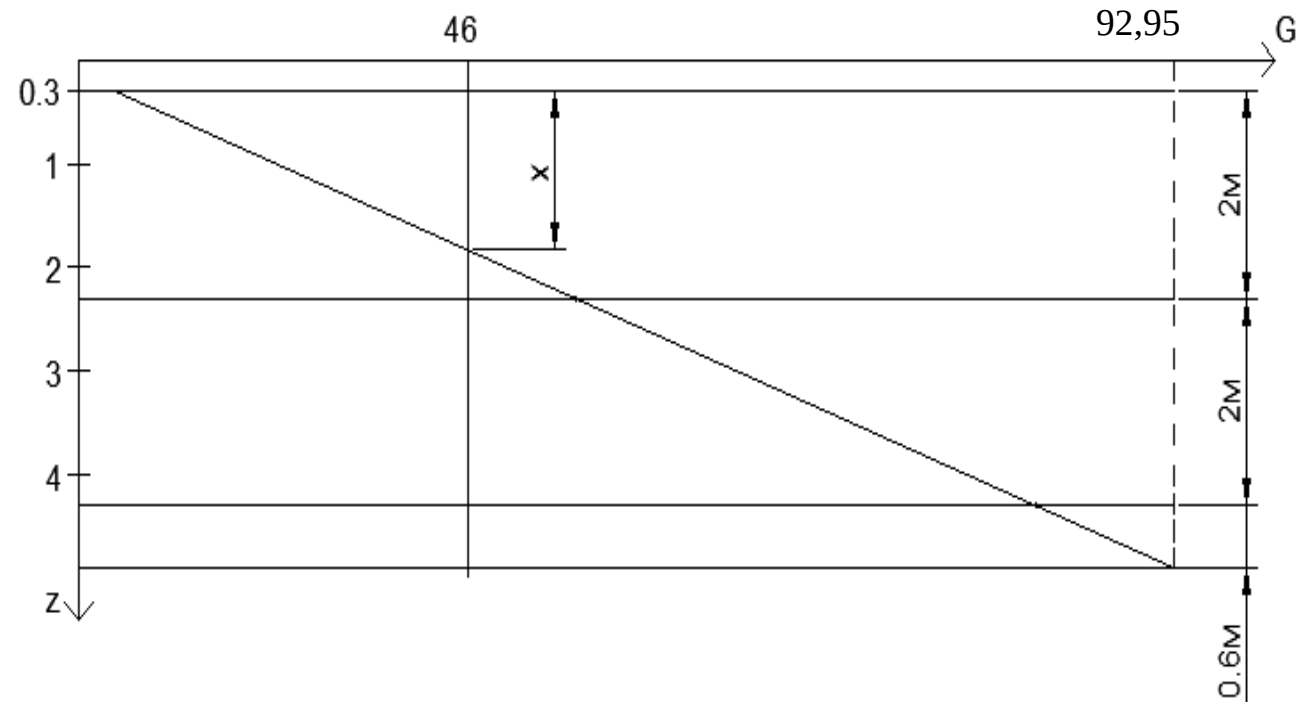
$$\sigma_{zg1} = 10 \cdot \rho_1 \cdot h_1 = 4.17 \text{ kPa}$$

$$\sigma_{zg2} = \sigma_{zg1} + 10 \cdot \rho_{\text{sat}} \cdot h_2 = 92.95 \text{ kPa}$$

$$\sigma_{zg1} + 10 \cdot \rho_{\text{sat}} \cdot x = P_{sl}$$

$$4.17 + 19.3 \cdot x = 46$$

$$x = 2.1 \text{ m}$$



We calculate the subsidence according to the formula $S_{sl.g} = \sum \varepsilon_{sl.g} \cdot h \cdot k_{sl.i}$, here we accept $k_{sl,i} = 1$.

h_i	Z, m	$\sigma_{zg} = 10 \cdot \rho \cdot h_i, \kappa Pa$	Average $\sigma_{zg, sat}$	$\varepsilon_{sl,g}$	$S_{sl,g}, m$
0.3	0.3	4.17		0	0
2	2.3	47.97	26.07	0	0
2	4.3	91.72	69.8	0.0361	0.0952
0,6	6.3	92,95	92,34	0.0526	0.2

$$\sum S = 0,0295 \text{ m}$$

Conclusion:

1. The construction site belongs to II type of subsidence soils
2. All layers of the soil layer, except the first, can be load-bearing. When using the 2nd layer, it is necessary to take into account the possibility of subsidence when the groundwater level rises to the critical level of Hc.

I type of subsidence soil:

- The initial subsidence pressure is greater than the stresses from the self-weight of the soil $p_{sl} > \sigma_{zg}$ within the entire subsidence layer
- The initial subsidence pressure is less than the stress from the soil's own weight $p_{sl} > \sigma_{zg}$ within a layer with a thickness of no more than 2 m along the dove.
- Estimated subsidence from the soil's own weight, determined by the formula $S_{sl.g} = \sum \varepsilon_{sl.g} \cdot h \cdot k_{sl.i}$, when $k_{sl.i} = 1$ taking into account the change in depth ε_{sl} is less than 5 cm).

If none of the conditions are met, then the soils belong to the II type of soil conditions in terms of permeability.