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The effect of sheet pile wall on stress-strain state high-rise building foundations

The degree of influence of the distance from the sheet-pile wall to the edge of the slab, the depth of the wall into the soil below the bottom of the pit, the contact conditions of the soil massif from the side of the pit with the surface of the fence (soil-concrete), the deformation characteristics of the base and the load on the average settlements and tilts of high-rise buildings on slab foundations were studied.

Numerical modeling of the impact of a pit fence in the form of a monolithic reinforced concrete sheet-pile wall in soil on settlements and tilts of high-rise buildings on slab foundations in sandy soils was performed using the finite element method (FEM), which, on the contrary analytical methods, allows solving complex problems in a more correct formulation taking into account the peculiarities of the shape and properties of the geological environment and many factors that affect the behavior of the object under study. The research was conducted using the LIRA CAD software complex, which is widely used to solve many geotechnical problems and to study the interaction of foundation structures with the soil base [1, 2, 3].

The study of the influence of the sheet-pile wall on the settlement of high-rise buildings on slab foundations was carried out for the option of the building location in the center of the construction site.

A buried structure interacting with the soil massif is a complex geotechnical system. In this regard, the modeling process is proposed to be carried out in three stages:

stage 1: creation of a calculation model of a sheet-pile wall;

stage 2: creation of the calculation model of the soil massif;

stage 3: modeling of the "buried structure - soil" contact surface.

In order to determine the main principles and identify the features of modeling, the task of interaction of the sheet-pile wall with the soil massif was considered (Fig. 1). At the same time, the geometric dimensions of the structures and their rigidity characteristics varied. The calculation scheme included the enclosure of the pit with its two-sided location relative to the building and immersion in the soil to a depth h_{bur} below the bottom of the pit, a reinforced concrete foundation slab with a width of B_{pl} and a soil.

The calculation scheme of the task for the case of the location of the building in the center of the construction site is shown in fig. 1, the cutting of the finite-element mesh and boundary conditions (fixed supports on the sides and bottom of the calculation area) in fig. 2.

The influence of the sheet-pile wall in the soil on the average settlement of the building was investigated depending on the following factors and their change ranges:

- factor $m = B_{pit}/B_{pl}$, ∈ [1.2; 1.5; 1.8] - relative width of the pit;
- factor $t = h_{bur}/B_{pl}$, ∈ [0.5; 0.66; 0.8] - relative depth of the sheet-pile wall below the bottom of the pit;

- factor E_0, ∈ [15MPa; 20MPa; 25MPa] - deformation modulus of the soil massif;

- factor q, ∈ [300 kPa; 350 kPa; 400 kPa] - evenly distributed load on the foundation slab, where: B_{pl} – width of foundation slab, B_{pl} = 10 м; h_{bur} - the depth of the sheet-pile wall embedding in the soil below the bottom of the pit; B_{pit} - width of the pit.

The average settlement of a high-rise building was determined by the formula:

$$S_{aver}=(S_0+S_1)/2, \qquad (1)$$

where S_0, S_1 – settlement of the central and corner points of the foundation slab, respectively.

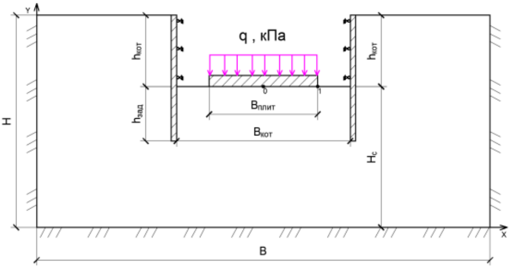

Fig. 1. The calculation scheme when the building is located in the centre of the construction site

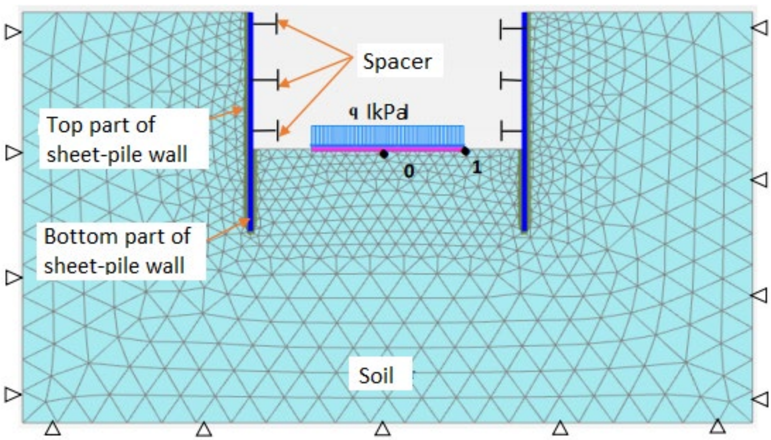

Fig. 2. Finite element model scheme, boundary conditions

Mosaics of deformations of the soil massif at a value E=15 MPa and q=300 kPa at different widths of the pit and depth of immersion of the wall in the soil are shown in fig. 3.

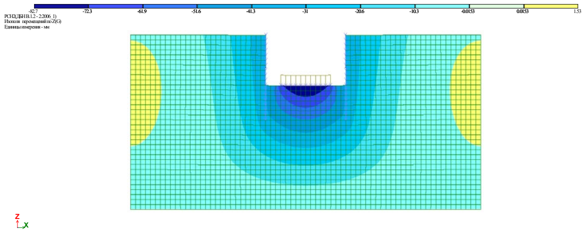

Fig. 3. Mosaic of deformations E=15 MPa and q=300 kPa at different pit width and embedment depth of the sheet-pile wall in the soil

Mosaics of deformations of the soil massif at the value of E=20 MPa, q=350 kPa and mosaics of deformations of the soil massif at the value of E=25 MPa, q=400 kPa were also obtained at different width of the pit and depth of embedment of the sheet-pile wall in the soil.

Summary data on the value of the average settlement of the foundation slab depending on the considered factors are shown in Table 1.

Table 1.

Average settlement of the foundation slab, mm

E=15 MPa та *q*=300 kPa								
t=0.5			*t*=0.66			*t*=0.88		
m=1.2	*m*=1.5	*m*=1.8	*m*=1.2	*m*=1.5	*m*=1.8	*m*=1.2	*m*=1.5	*m*=1.8
85,13	88,56	90,83	82,84	85,80	89,81	81,33	84,90	88,79
E=15 MPa та *q*=400 kPa								
t=0.5			*t*=0.66			*t*=0.88		
m=1.2	*m*=1.5	*m*=1.8	*m*=1.2	*m*=1.5	*m*=1.8	*m*=1.2	*m*=1.5	*m*=1.8
120,68	125,50	132,03	113,84	121,10	130,40	106,31	116,18	126,92
E=25 MPa та *q*=300 kPa								
t=0.5			*t*=0.66			*t*=0.88		
m=1.2	*m*=1.5	*m*=1.8	*m*=1.2	*m*=1.5	*m*=1.8	*m*=1.2	*m*=1.5	*m*=1.8
67,23	67,84	73,09	61,58	67,13	71,93	58,37	63,42	68,53
E=25 MPa та *q*=400 kPa								
t=0.5			*t*=0.66			*t*=0.88		
m=1.2	*m*=1.5	*m*=1.8	*m*=1.2	*m*=1.5	*m*=1.8	*m*=1.2	*m*=1.5	*m*=1.8
91,48	95,54	100,10	85,79	91,12	98,77	79,84	87,70	94,83

The graphs show that the average settlement of high-rise buildings decreases with an increase in the relative depth of the sheet-pile wall below the bottom of the pit *t* below the bottom of the pit, the coefficient of soil friction on the surface of the wall in the soil R_{int} and the modulus of deformation of the soil E and increases with an increase in the relative width of the pit *m* and an increase in the intensity of uniform loading on the foundation slab *q*.

References

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