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THE RESULTS OF MODELING AND FIELD STUDIES OF THE INTERACTION OF LARGE PILES WITH GROUND SUBSIDENCE

Abstract. The problems of modern geotechnical construction in the region of southern Kazakhstan are considered in this article. Engineering geological conditions in most of the territory are represented by ground subsidence. In conditions of tight urban and industrial buildings, as well as when it is necessary to transfer significant loads from high-rise buildings to the basement, the use of pile foundations is the only solution.

The aim of the work is to study the interaction of pile foundations with ground subsidence.

The article describes the principles of modelling the joint work of a long-bored pile with ground subsidence. The use of tensometry tools for studying the physical processes occurring on the contact surface between the pile and the soil is considered. The basis for obtaining information on the development of negative friction forces has been developed using model tests to pull piles out of the ground.

The results of tests of model piles and piles in full-scale conditions are presented. The tests were carried out on the action of a vertical pressing load, as well as on a pulling load. Experimental studies on models were carried out by the method of equivalent materials. The soil model was a mixture of sand, rubber chips and autoclave in a proportion by weight of 2: 0.1: 0.2. Strength and deformation properties of the soil model were determined by the degree of compaction. For comparison, the results of studying the work of field piles, obtained by the Association "Seismic Protection" are taken. Tests of piles were carried out during the construction of the METRO shopping complex in Shymkent. Due to the application of the modelling theory, the qualitative convergence of model and full-scale tests is achieved, including the receipt of "sediment-load" test schedules for models of piles and field piles.

The obtained experimental studies will make it possible to successfully use pile foundations in ground subsidence in the future. This will ensure the reliability of erected buildings and structures.

Modelling of joint work of long bored pile with ground subsidence allows us to make informed decisions on a wide range of tasks in production situations. Due to the observance of the postulates of the theory of modelling, the qualitative convergence of model and corresponding full-scale tests has been achieved in the studies carried out. Sufficient qualitative convergence of the "load-sediment" schedules of model and full-scale tests of piles has been achieved. The use of tensometry tools made it possible to detail the study of physical processes occurring on the contact surface between the pile and the ground.

Keywords: pile, pile model, tensometry pile, ground subsidence, "load-sediment" schedule, negative friction force.

Introduction. Summing up the experience of many years of base preparation and foundation construction in south region of Kazakhstan and analysing the current modern geotechnical situation it should be noted that the local geological conditions are very complex and specific. They are characterized by the proliferation of sharp inhomogeneous soils, in most of the territory - subsidence, the properties of which are heavily influenced by underground water, the level of which is constantly changing upwards and the seismicity of the region. In addition, current construction conditions characterized by crowded urban and industrial developments need a huge stress on the base of high-rise construction and need to use areas with problematic soil conditions [1-3]. The underestimation of even one of these factors or a flippant attitude to base preparation and foundation construction can lead to unacceptable deformation of buildings and structures, elimination of it at the stage of construction of the object, or after the completion is almost impossible. If it is necessary to restore the deformed emergency buildings or structures, the cost is very high.

With the implementation of mega projects in major cities around the world, through the use of advanced high-precision technology, it was possible to solve many problems of geotechnical construction, similar to the above. One of these methods is an arrangement of deep-laid foundations. As noted by leading domestic and foreign scientists, only the use of pile foundations make possible the perception of carrying loads of soil layer of about 4,000 - 25,000 kH of high-rise buildings. This dramatically reduces the volume of work "zero" cycle, for example, compared with the device of artificial bases that during the construction of a number of objects in the region associated with the necessity of excavation volume from passages 100,000 cubic meters of soil and delivery and seal of gravel-sand mixture of approximately equal to half of this amount.

Among the existing methods pile foundation construction device is fundamentally different in the nature of the load transfer on the ground [4, 5]. Therefore, in some cases, for example, for the rapid construction of foundations in the ground subsiding, they are regarded as the only possible option. However, even if the pile "cut" filler primer, cannot be guaranteed their full operational reliability [6, 7]. This is due to the fact that the side surface impact strength piles "negative" or biasing the friction [8-10], that can be so large that the load capacity decreases drastically and piles can be minimized. This complex, ambiguous process is poorly understood and requires both experimental research and analytical studies.

In this paper an attempt is made on the basis of pilot studies to identify the actual physical processes occurring in the soil, to make comparisons test piles on models and in natural conditions. This will later be successfully used in pile foundations subsiding soils, ensuring the reliability of constructed ground building constructions.

Methods of research. At the first stage the experimental studies carried out on models by equivalent materials [11-16]. Fundamentals of the method of equivalent materials were developed by G.N. Kuznetsov and et al. [13], and modelling systems "pile foundation-ground" with this method was developed in [14] and is as follows:

- from some artificially selected materials in compliance with the geometric similarity model and the nature of the soil and made a model of the pile;
- materials of which must be made the model chosen with such physical and mechanical properties, which would be in certain ratios with mechanical and physical constants of nature;
- these relations are based on the general law of dynamic similarity considering the simultaneous action of the forces of gravity and internal pressure;
- material that meets the above requirements, given the properties of the simulated soil and given a linear scale model, gets the name of the equivalent to this ground material;
- model of the foundation must also satisfy the requirements of the equivalent mechanical similarity of nature;
- in compliance with the requirements described, as well as the necessary initial and boundary conditions, the processes occurring in the model should be developed in a form close to nature. Just as in nature, the development of these processes will take place taking into account the influence of gravity of the model itself without any external additional loading. "

The general law of Newton's dynamic similarity is the basis of the method [15]

$$\frac{N_M}{\gamma_M i} = \frac{N_H}{\gamma_H J} = K = inv, \tag{1}$$

where K is "determining criterion of similarity" processes of deformation and destruction of the soil under the action of gravity and the stresses in the ground; $\gamma_M;\gamma_H$ are specific gravity of modelling and full-scale soil; $i;J$ are linear dimensions of model piles and full-scale piles; $N_M;N_H$ are value corresponding to different power characteristics of the model and nature state, dimension of which is force/area.

Equation (1) reduces to the form (2), in which selects mechanical properties of equivalent materials

$$N_M = \frac{i}{J} \cdot \frac{\gamma_M}{\gamma_H} \cdot N_H. \tag{2}$$

To do this, knowing the characteristics of the simulated rock expressed by some numerical parameters N_H, set the scale simulation $\frac{i}{j}$ and attitude $\frac{\gamma_M}{\gamma_H}$, with the equivalent materials in the elastic stage, the following dependencies must be followed

$$E_M = \frac{i}{j} \cdot \frac{\gamma_M}{\gamma_H} \cdot E_H; \tag{3}$$

$$C_M = \frac{i}{J} \cdot \frac{\gamma_M}{\gamma_H} \cdot C_H; \tag{4}$$

$$\mu_M = \mu_H; \tag{5}$$

$$\varphi_M = \varphi_H. \tag{6}$$

To carry out comprehensive studies of the interaction of piles and soil of the array, the selected scale simulation of 1/40, using the formulas 3-6, the calculated values of deformation and strength characteristics of the model piles and soil were obtained. Model soil was a mixture of sand, rubber crumb and avtol in a proportion by weight of 2:0.1:0.2, strength and deformation properties of which are determined by the degree of compaction. Table 1 summarizes the characteristics of the equivalent mixture with a density adopted in the experiments placing it in the tray, and the appropriate nature of soil.

Features of equivalent mixture

Feature name	Symbol	Measure	Model grounds	Nature grounds
Deformation module	E	МПа	1.628-2.035	40.7
Specific adhesion	c	МПа	0.000575	0.0115
Angle of internal friction	φ	°	29	29

For a system of "pile foundation-soil" according to the formula (7) was calculated modulus of elasticity of the pile material model $E_{M.CB.} = 1500 МПа$. The tubes used for simulation of reinforced concrete piles were made of vinyl plastic with the elasticity module of $E_B = 1450 МПа$.

$$E_{M.CB.} = E_{M.ГР.} \frac{E_{H.CB.}}{E_{H.ГР.}}, \tag{7}$$

Results of the study. In this procedure, the work of piles was studied on the action of a vertical load pressed and the dependence of "sediment-load". Piles model was loaded increasingly pressed load steps ΔP = 20 H. At each step, after stabilization, rainfall was measured. General view of the test tray is shown in Figure 1.

Figure 3 shows a similar dependence obtained by 'Seism protection' Association [16] during the test piles great lengths to ground subsidence during the construction of the shopping centre "Metro" in Shymkent. Comparing the graphics test piles *S=f(P)* model piles (Figure 2), made with all the parameters as geometric dimensions, soil conditions, the nature of the load and etc. real-pile foundation, with these static tests on the construction site (Figure 3), we can say that they have the same character. Both comparable graphics have smooth character, without any fracture points expressions (breakdown). In the initial stages of loading the model and the actual pile had not any movement. The model received the first movement with a load of 20 H, a full-scale pile at P=1705 kH. This is primarily due to the significant dimensions of the full-scale pile: a length of 23 m and 1 m in diameter that allows the perception of large loads. Then, as the loading steps, the model and full-scale pile gently pressed into the soil, reaching move of 1 mm at 100 H and 2.94 mm at 3751 kH respectively.

Figure 1 – General view of the static tests of model pile vertical load pressure.

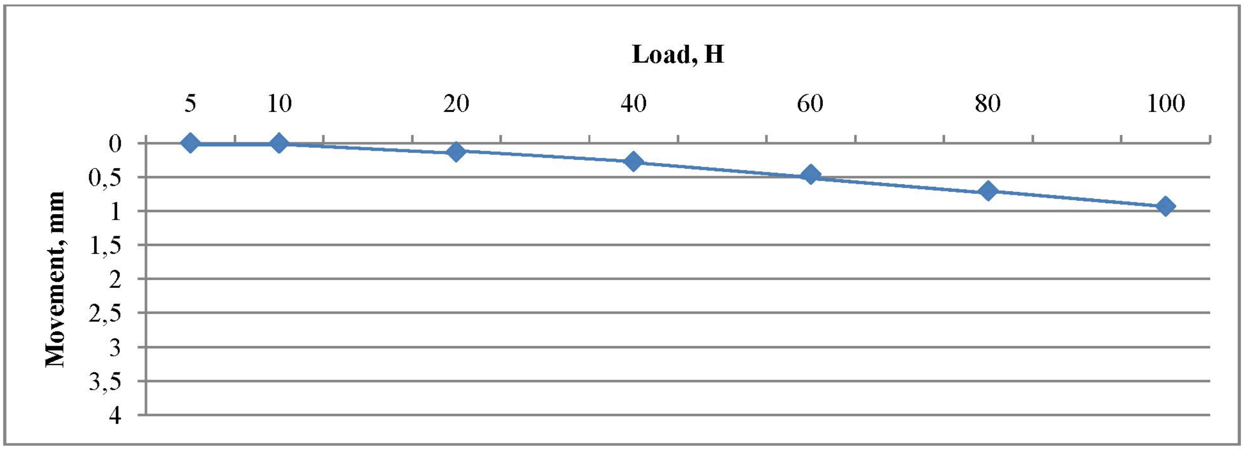

Figure 2 – Graph of S = f (P) relation in the test of model pile vertical load pressure

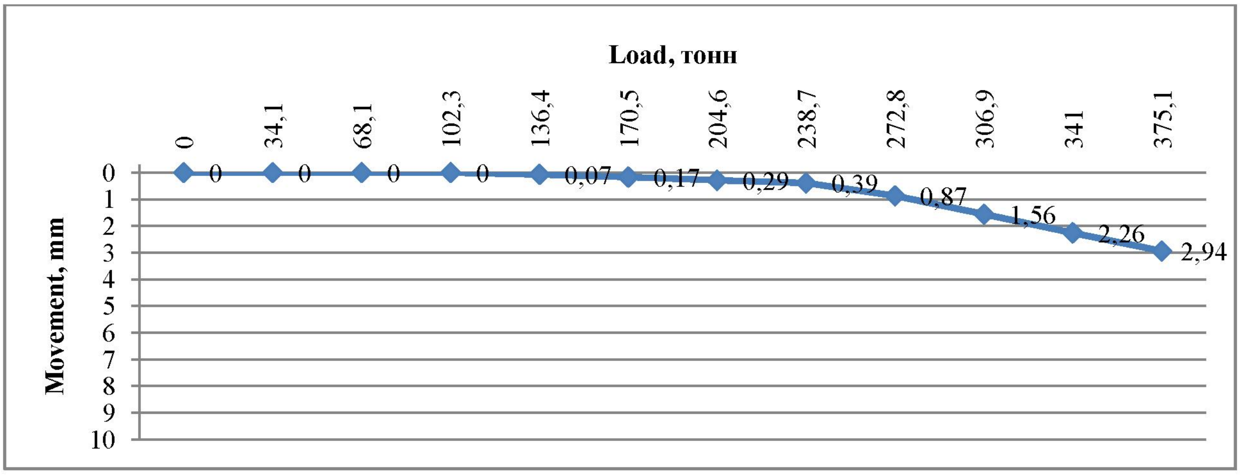

Figure 3 – Graph of S = f (P) relation in the test of full-scale pile vertical load pressure