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Comprehensive study of the basses and foundations of furnaces No. 61, 63 of the melting shop No. 6 of the Aksu Ferroalloy Plant in connection with the renovation

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ABSTRACT: The work is devoted to a comprehensive study of the bases and foundations of electric furnaces No. 61 and 63 of the melting shop of the Aksu ferroalloy plant. Engineering-geological and hydrogeological surveys of souls, geophysical work, as well as studies of the technical condition of existing foundations were carried out.

Based on the conducted comprehensive scientific and technical studies of the mechanism of interaction of the foundation with the ground foundation, a fundamentally new calculation model has been developed that allows calculating the precipitation of buildings taking into account the long-term water saturation of the foundation soils and an assessment of the reliability of the existing foundations of electric furnaces No. 61 and 63 of smelting shop No. 6 with the possibility of their reconstruction in connection with the upcoming renovation.

1 INTRODUCTION

Aksu Ferroalloy Plant is located on the territory of Pavlodar region, 20 km southwest of Pavlodar and 2.5 km north of Aksu, on the left bank of the Irtysh river. The production infrastructure of the city is represented by two city-forming enterprises: the Aksu Ferroalloy Plant and the electric station of JSC "EEC". The object is connected by asphalt and railways with the cities of Nur-Sultan, Pavlodar, Ekibastuz, Semipalatinsk. Aksu Ferroalloy Plant is a ferrous metallurgy enterprise for the production of high-carbon ferrochrome, manganese and siliceous alloys.

The smelting building of shop No. 6 of the Aksu Ferroalloy Plant is designed for the production of high-carbon ferrochrome. Aksu Ferroalloy Plant is a two-span industrial building of complex shape in plan. This object has overall dimensions in plan in the axes "1-24, A-B" – 276x24 m, in the axes "1-20, B-C" – 228x24 m and one deformation seam in the axes "21, A-B". Gas treatment facilities are adjacent to the building of the smelting building in the axes "1-4, A". The rigidity of the building is ensured jointly by the work of foundations, metal frame elements, vertical and horizontal stiffness connections, coating and floor slabs.

Engineering and geological surveys revealed that clay serves as the bearing base for the foundations of electric furnaces No. 61 and No. 63 (CLAY N1 1-2 ar is opened everywhere at depths of 0.1–4.8 m). The exposed thickness of the clay thickness varies from 3.2 m to 26.7 m . With a relative swelling value of 0.005, the calculated swelling pressure is 3.0 kgf/cm2. The exposed

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thickness of the Neogene clays of the Aral formation is considered to be strongly swelling, according to the complexity of engineering and geological conditions according to the Joint Venture of the Republic of Kazakhstan 1.02-102-2014 the survey site belongs to the III category.

According to the field description, the clays are greenish-gray, light gray, dark gray, with the inclusion of gypsum, dense, having the following characteristics:

γ = 18, 1 kN/m^3; γ_s = 25,2 kN/m^3; γ_d = 13,9 kN/m^3; φ_{II} = 7^0; c_{II} = 10,8 kPa; E_0 = 10 MPa; S_r = 0,95; e = 0,816.

The foundation of Fo-37 for the electric furnace RKZ-63-I1 No. 61 is monolithic reinforced concrete, filled in the form of a disk with a diameter of 12.00 m and a depth of laying – 3.0 m from the level of the clean floor of the first floor of the melting shop No. 6. The foundation of Fo-1 for the electric furnace RKZ-63-I1 No. 63 is monolithic reinforced concrete, made in the form of a disk with a diameter of 14.26 m with rectangular protrusions, a depth of laying -2.30 m from the level of the clean floor of the first floor of the melting shop No. 6.

Based on the field visual description of engineering and geological workings, confirmed by the results of laboratory tests of soils, it was found that up to a depth of 8.0-30.0 m in the geological structure of the survey site, the following take part (up-down): • quaternary deposits, represented by large sands and coarse sands; Neogene clays Pavlodar suite. From the surface, these formations are covered with a layer of bulk soils.

Control calculations of the soil sediment of the foundations were carried out in accordance with the requirements of the current building regulations - SP RK 5.01-102-2013 The basis of buildings and structures [1, 2].

According to the requirements of the norms, the calculation of the sediment of the flooded bases is carried out taking into account the decrease in the modulus of deformation of the soils during their soaking and the change in the stress state of the compressible zone of the foundation base following hydrostatic and hydrodynamic weighing. At the same time, the main reason for the decrease in the modulus of deformation of soils subject to flooding is mainly due to the weakening of their structure due to water saturation. In this regard, when geotechnical design of buildings and structures in conditions of flooded soil bases, it will be advisable to adhere to the basic principles applied to subsidence soils based on the use of the results of compression tests [3, 4].

Construction practice shows that the operational reliability and durability of buildings and structures under construction mainly depend on the reliability of the results of engineering and geological surveys used as input data in geotechnical design. In particular, the calculation of foundation bases according to the second limit state imposes high requirements on the accuracy of determining the values of the soil deformation modulus, on which the risk of accidents of constructed objects directly depends. However, there is still uncertainty in the choice of this important characteristic of soil compressibility, which is due to a significant discrepancy between its values determined by laboratory (compression) and field (stamp) methods.

As is known, compression tests have found wide application in the practice of engineering and geological surveys as one of the main methods for determining the deformation characteristics of the soils of the bases of the projected foundations (GOST 12248-2010). Such tests are characterized by simplicity, low labor intensity and cost.

The compression dependence reflects one of the laws of porosity of dispersed bodies – the law of compaction and is used to solve the main problem of soil mechanics, determining the precipitation of the soil layer under continuous load.

However, at present, according to the current norms (SP 22.13330, 2016), the results of compression experiments are used in the design of foundations on structurally unstable soils and are not directly used in the calculations of deformations of foundations composed of ordinary soils. In accordance with the requirements of standards for buildings and structures of geotechnical category 2 and 3, the value of E according to compression tests for each soil layer should be adjusted based on their comparison with the results of parallel stamp, pressiometric tests, which have a high cost and high labor intensity.

To determine the precipitation of the flooded foundations of newly erected and existing buildings, it is necessary to have the actual dimensions of local sections of water-saturated soil within the active area of the foundation of the foundation under construction and inhomogeneously compacted zones of the foundation of existing foundations. However, the methods of the current norms based on the theory of linearly deformable bodies, the object of study of which, according to its basic prerequisites, is a conditional, idealized foundation soil as an isotropic solid, are not acceptable for solving such a complex geotech problem. Because this theory does not allow us to predict the actual dimensions of the parameters of the deformed zone of the base, allowing errors of more than 100%, but, as experiments show, its application to calculate stresses in real soils gives quite satisfactory results with an accuracy of 20% [5, 6].

2 METHODOLOGY

Calculation of the sediment of the existing foundations of furnaces No. 61 and No. 63 of the Aksu Ferroalloy Plant, taking into account the flooding of the foundation soils in the operational period by the modulless method.

The forecast of the development of foundation precipitation caused by flooding of previously compacted soils of its base during the operational period is an insufficiently studied complex task. To solve it, we will make assumptions, according to which we will assume that "the precipitation of the base from the prolonged action of loads is stabilized, and the soils are compacted inhomogeneously within the compressed zone in accordance with its stressed state, therefore, additional precipitation of the existing foundation in the process of flooding its base occurs by analogy with the phenomenon of subsidence due to weakening soil structures in the process of soaking".

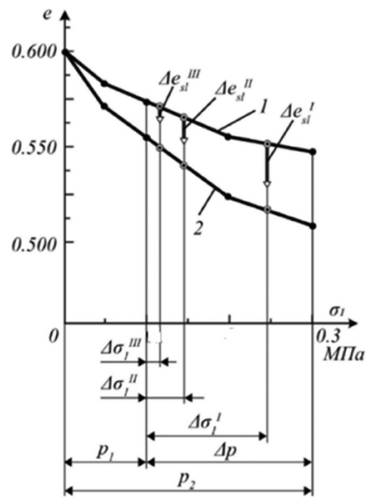

Figure 1. Compression curves of the soil of the foundation base: 1 и 2 – experimental soil compression curves with natural humidity and in a water-saturated state; ● - experimental points; ⊙ - points on the experimental curves used in the calculation of precipitation by the non-modular method; ▿ - prospective test points obtained as a result of soaking of long-compacted soils of the base of the existing foundation.

The following formula is used to determine precipitation without a modular method:

$$S = \frac{1}{A_\Phi} \cdot \sum_{i=1}^{i=n} \left[V_{i3} \cdot \left(1 - \frac{1 + e_2^{i3}}{1 + e_1} \right) \right], \tag{1}$$

where i and n – number and number of dedicated compacted base zones;

$A_ф$ – the area of the sole of the foundation;

$V_{iз}$ – volume of the i – th compacted zone of the base;

e_1 – the porosity coefficient of the soil of natural composition;

$e_2^{iз}$ - porosity coefficient of soil compacted under compressive stress $\Delta\sigma_1^{iз}$, arising in the i – th zone from an external load.

3 RESULTS

The proposed model-free method can also be used to calculate the sediment of foundations having the shape of a sole in the form of a circle, a square and a straight square.

As a result of modeling the behavior of the existing foundation during flooding of its base by conducting three parallel compression tests with soil samples pre-compacted under loads $\Delta\sigma_1^{I}$, $\Delta\sigma_1^{II}$ and $\Delta\sigma_1^{III}$ and subjected to soaking under the same loads, the corresponding values of reducing the porosity coefficient of the soil were obtained $\Delta e_{sl}^{I} = 0{,}024$; $\Delta e_{sl}^{II} = 0{,}018$; $\Delta e_{sl}^{III} = 0{,}012$.

At the same time, additional precipitation of the foundation of the existing building, taking into account the factors of soil compaction and subsequent flooding, amounted to: for position 2 (WL_1) $s_{sat.ex} = 1{,}40$ cm; for position 3 (WL_2) $s_{sat.ex} = 4{,}6$ cm; for position 4 (WL_3) $s_{sat.ex} = 7{,}5$ cm.

Thus, the proposed method, in comparison with the recommendations of the norms, makes it possible to more accurately and reliably predict the nature of the development of additional sediments of the flooded foundations of existing buildings, establish the permissible amount of groundwater level rise and determine the optimal depth of water reduction.

4 DISCUSSIONS

According to engineering and geological surveys, an uneven increase in the groundwater level was noted at the site, which indicates that water saturation of the foundation soils, including swelling clay, occurred for a long time, which usually leads to the development of unacceptable deformations of the foundation and reduces its operational reliability. In addition, with the continuous annual seasonal flooding of the territory (min to the level of 127.30 and max. up to the level of 128.00), the compressibility characteristics (modulus of deformation E_0) and strength (c, φ) of the soils of the base layers undergo significant changes, as a rule, a decrease of 2 or more times, and these changes in space are also uneven in the supporting area of the foundation and in the depth of the base.

Thus, loading of the flooded foundation, composed of swelling soils, in conditions of poor drainability can lead to a dangerous unstable condition of the foundations. In such a situation, as a result of the lag of the "water filtration process" from the "soil compaction process (pore reduction)", the excess pressure in the pore water sharply increases, which leads the foundation to an unstable state or is the cause of the development of excessive plastic deformations of the soil.

5 CONCLUSIONS

The periodically recurring (cyclically) process of flooding of the foundation soils does not favorably affect the nature of the development of foundation sediments, namely, it causes their unevenness, which can be seen from the following analysis of the results of control calculations:

a) when calculating by the method of layer-by-layer summation, an increase in foundation sediment due to the influence of the weighing action of ground water, as can be seen from the following comparison: 5.85 cm < 6.84 cm;
b) when calculating by the non-modular method, the additional precipitation of the foundation of the existing building, taking into account the factors of soil compaction and subsequent flooding, amounted to: 1.40 cm<4.6 cm<7.5 cm. What shows the real values of the precipitation of foundations caused by the flooding of the foundation soils, taking into account the additional change in the compressibility of soils: an increase during watering or a decrease during drying.

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