The base soil local sagging zones’ influence assessment on the water retaining structure’s operability

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Abstract. The base modeling using the elastic-ideal-plastic Mora-Coulomb model made it possible to evaluate the vertical displacements in the presence and absence of local subsidence. It was established that the influence of local sagging in the second and third zones does not significantly affect the vertical displacements recorded on the pile grillage’s surface.

Introduction

Computer modeling using modern packages of automated engineering analysis is today an effective calculation method for the study and analysis of building structures, including foundations and basements, and even at such complex physical processes as local sagging of foundation soils. At present, quite a lot of different models are known. These are: Elastic (elastic material), Mohr-Coulmb (Mohr-Coulomb model), Von Mises Nonlinear (non-linear Mises model), Jointed Rock Mass (fractured rock model) and others. Moreover, the calculations are mainly carried out in linear and elastoplastic formulations.

One of the possible damages to which waterworks are subjected, is local sagging. Moreover, the zone of local sagging can be significant [1, 2, 3, 4]. The objective of the study is to determine the effect of local sagging on the operability of a water retaining structure. The analysis for the condition when the investigated boundary of the base sagging is limited by the rock, which is an emphasis for piles of the water retaining structure, was performed. The analysis of damage to water retaining structures and their impact on operability is assessed in the base – foundation – over ground structure system [5, 6, 7, 8].

The modeling of the soil base local sagging with the base vertical displacements’ determination was carried out in a specialized geotechnical software package for modeling the interactions between the structure and the foundation based on the finite element method GTS NX.

Material and technology

Figure 1 shows the plan diagram with the designations of the base local sagging zones.

When modeling the base, the elastic-ideal-plastic Mora-Coulomb model is used, which contains five input parameters: E and ν – are the soil elasticity parameters, φ and c – are the soil plasticity parameters and ψ – is a dilatancy angle.
Figure 1. The stages plan

The design scheme corresponding to the base local sagging zone 1 is shown in Figure 2. The following materials were used in the calculation model:
- Isotropic (Isotropic).
  They are used to simulate the behavior of most linearly elastic, nonlinear elastic and elastoplastic materials.
- Interface / Pile.
  It is used in simulating the interaction (contact) behavior between the base and the structure.
  For the mathematical description of the structures’ operation with base soil, the following elements were used:
  - 1D element (One-dimensional element).
    A one-dimensional element is an element having 2 or 3 nodes and a geometric property of length.
  - 2D element (two-dimensional element).
    Two-dimensional elements are the elements of a triangular and quadrangular shape having a geometric area property.

Figure 2. Design scheme

The results of calculating vertical displacements in the absence of local sagging in zone 1 are presented in Figure 3.
Figure 3. Vertical movements in the absence of local sagging in zone 1

The results of calculating vertical displacements taking into account local sagging in zone 1 are presented in Figure 4.

Figure 4. Vertical movements in the absence of local, taking into account local sagging in zone 1

Based on the presented data, it should be noted that the influence of local sagging in the 1st zone does not significantly affect the vertical movements recorded on the surface of the pile grillage [9, 10].

The design scheme corresponding to the 2 zone of the base local sagging is shown in Figure 5.
The results of calculating vertical displacements in the absence of local sagging in zone 2 are presented in Figure 6.

The results of calculating vertical displacements taking into account local sagging in zone 2 are presented in Figure 7.
Based on the presented data, it should be noted that the influence of local sagging in zone 2 does not significantly affect the vertical displacements recorded on the surface of the pile grillage [11, 12]. The design scheme corresponding to zone 3 of the base local sagging is shown in Figure 8.

The results of calculating vertical displacements in the absence of local sagging in zone 3 are presented in Figure 9.
Figure 9. Vertical movements in the absence of local sagging in zone 2

The results of calculating vertical displacements taking into account local sagging in zone 3 are presented in Figure 10.

Figure 10. Vertical movements in the absence of local ones, taking into account local sagging in zone 3

Based on the presented data, it should be noted that the influence of local sagging in zone 3 does not significaantly affect the vertical movements recorded on the surface of the pile grillage [13, 14].

Summary
Based on the presented data, it should be noted that the influence of local sagging in the second and third zones does not significantly affect the vertical movements recorded on the surface of the pile grillage.

Thus, it has been established that the base local sagging does not significantly affect the operation safety of the water retaining structure. In case of their detection, the development of special measures is necessary, but this defect is temporarily not critical, but only requires monitoring and elimination during the operation.

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