UDC 624.151.2

Irina Mosicheva, Ph.D., Associate Professor
Nick Stetsenko, student
Odessa State Academy of Civil Engineering and Architecture, imosicheva@gmail.com

DEVELOPMENT IN TIME OF SETTLEMENTS IN A WATER-SATURATED SOIL BASE HAVING CREEP PROPERTIES DURING ITS PRE-CONSTRUCTION COMPACTION WITH DRAINS

Modern methods of calculating the subsidence of the "vertical drains - loading on the day surface of the water-saturated base" systems during the pre-construction compaction of the bases made of weak water-saturated soils do not allow taking into account such properties of the soils that make up the base, such as the anisotropy of filtration and deformation properties; irreversibility of deformations during loading and unloading of the foundation, and correspond to the stress-deformed state of the soil during compression. At the same time, the foundations of structures, including port ones, can be in a state of compression, as well as in a state of plane deformation and spatial deformation. The course of the theoretical study of ground subsidence was carried out in two stages.

At the first stage, displacements in the under drained zone of the base at the calculated depth z were determined (Fig. 1). First, the stress-strain state of the half-space at the instant of time was determined. The algorithm described in [1, 2] was used to construct the asymptotic approximation.

According to [1, 2], in this case, the model of the soil base in the form of an elastic isotropic medium should be used and Lamé's elastic constant should be applied.

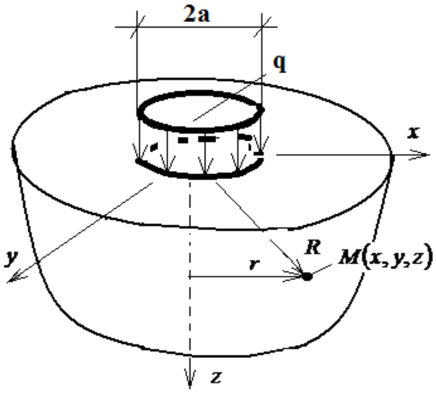

Fig. 1 – To calculate the settlement of a water-saturated half-space

To determine the settlement of the day surface, which is under the influence of an arbitrary load distributed over the plane of the circle, the approximate solution of the problem was obtained by Yu.K. Zaretsky [3], and the exact one - by V.G. Shapoval [2]. There are no analytical solutions to the problem for base movements below the day surface.

The problem was solved under the assumption of homogeneity of the base. That is, it was assumed that there were no sand drains in it. Due to the longer path of filtration of the pore fluid from the subdrain zone - not to the heel of the drain, but to the day surface - this is the most unfavorable case.

This solution, using the Dugamel formulas, was generalized to the case of a time-varying quasi-static load and further to the case of a base with aftereffect properties [4].

In the course of verification of the obtained approximate solution, a comparison was made at z = 0 (base settlement) with a similar exact solution. It turned out that over the entire range, the maximum relative error between the exact and approximate solution does not exceed 8%, and the average relative error does not exceed 3%. It was concluded that this result may well be used for the development of a methodology for determining base subsidence in the under-drained area of the base.

In the case of a stepwise increase in load, to determine the actual settlement, the dimensionless relative settlement should be multiplied by the corresponding design depth z of the settlement:

$$S(t) = S^y \cdot S^* = S^y \cdot \left[1 - A\left(\frac{z}{b}\right) \cdot exp\left(-\frac{c_v}{b^2} \cdot t\right)\right], \quad (1)$$

where S^y – settlement at the calculated depth z.

If the load on the base, and hence its elastic settlement, changes with time, then the Dugamel principle should be used to determine the settlement [4].

Required: Multiply by the corresponding design depth z of the draft:

$$S^{\Phi}(t) = S^y(t) + A\left(\frac{z}{b}\right) \cdot \frac{c_v}{b^2} \cdot \int_0^t S^y(\tau) \cdot exp\left[-\frac{c_v}{b^2} \cdot (t - \tau)\right] \cdot d\tau, \quad (2)$$

where $S^y(t)$ – elastic component of settlement at the calculated depth z.

Finally, if the base has the property of creep, settlement at the calculated depth should be determined as follows [1, 2, 5]:

$$S(t) = S^{\Phi}(t) + \int_0^t K(t,\tau) \cdot S^{\Phi}(\tau) \cdot d\tau. \quad (3)$$

At the second stage of theoretical studies, the settlements of the near-drained area of the base were calculated taking into account the filtration anisotropy of the soil for various boundary conditions. This solution was generalized with the help of Duhamel's formulas [4] for the case of time-varying quasi-static load and for the case of a base that has aftereffect properties.

In general, in the course of the research, for the first time, a solution was obtained for the problem of determining the displacements of an elastic water-saturated base, to the surface of which a load that is constant in time and distributed over the plane of a circle is applied at the calculated depth z. These results are generalized to the case of a time-varying load on the foundation. The obtained solutions can be used for the base, the soil skeleton of which has the creep property. The accumulated material makes it possible to calculate the settlement of the base in the under-drained zone.

References

1. Mosicheva I.I. Konsolidatsiya vodonasyshchennogo poluprostranstva, k verkhney granitse kotorogo prilozhena vertikal'naya sosredotochennaya sila / I.I. Mosicheva, A.V. Shapoval // XXÍ Mezhdunarodnaya zaochnaya konferentsiya «Razvitiye nauki v XXI veke». – Khar'kov: 2017. – pp. 69-78.

2. Shapoval A.V. Alhorytm pobudovy asymptotychnykh rishenʹ zadach dlya osidannya vodonasychenykh osnov / A.V. Shapoval, V.G. Shapoval // Resursoekonomni materialy, konstruktsiyi, sporudy ta sporudy: zbirnyk naukovykh pratsʹ. – Rivne: 2014 – Vol. 28. - pp. 463-469.

3. Zaretskiy YU.K. Vyazkoplastichnost' g̀runtov i raschety sooruzheniy / Zaretskiy YU.K. – M.: Stroyizdat, 1988. – 352 p.

4. Korn G., Korn T. Spravochnik po matematike / G. Korn, T. Korn. – M.: Nauka, 1974. – 840 p.

5. Shapoval A.V. Teoriya vzaimosvyazannoy fil'tratsionnoy konsolidatsii: monografiya / A.V. Shapoval, V.G. Shapoval. – Dnepropetrovsk: Porogi, 2009. – 311 p.