Materials of Conferences

CONSOLIDATION OF TENSILE-CREEPING HETEROGENEOUS EARTH FOUNDATIONS

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Compaction of heterogeneous earth foundation having creeping property has been studied in the given work. The creeping property of compactible water-saturated heterogeneous soil is described by Maslov-Arutyunyan theory of tensile-creeping body in the interpretation of Florin V.A.

For theoretical research the process of soil compaction, its heterogeneity, are considered in the work by deformation module of the compactible mass. Mathematically it is expressed by power or exponential function which is changed by the depth of compactible soil body. Besides it is accepted here that for strongly compressible water-saturated heavy soil in the initial instant of time a part of load, suddenly applied load q to the soil, equal in value of structural compressive strength p_{str}, is immediately taken by the soil skeleton, i.e. $p\big|_{t=\tau_1} = q - p_{str}$.

Mathematical statement of this problem comes to the determination in this soil body of distribution of pressure in the porous fluid $p(x, z, t)$, tension in the soil skeleton $\sigma(z, t)$, and vertical movement of points of the upper surface $S(t)$ (setting). Pressure in the porous fluid is identified by solution of integral-differential equation at the initial and boundary conditions.

An outer crust of earth is usually characterized by a large-scale heterogeneity of earth and rocks composing it. It is due to the sufficiently complex geological-tectonic structure of rocks, where one or another construction project is built. Dropping of heterogeneity of geological structure of the outer crust of earth may lead in the future to damage of engineering constructions, due to the settlement, development in the subfoundation. As is known, nonrigid properties of heterogeneous soils, actually, are changed together with point positions, and assumption about their homogeneity represents idealization of real conditions. Certainly, providing the heterogeneity, the mathematical problem is incomparably complex and, therefore, in such cases we often apply for different simplification kinds of model, acceptable from one or another point of view. At that in one group of problems parameters characterizing properties of the material are sectionally constant. This means that the investigated body consists of several homogeneous bodies. In the other group of problems they represent continuous functions of point position. Moreover, the soil, which module of deformation continuously grows with a depth is called as a continuously heterogeneous. Such model of the soil was presented in the works of E.K. Klein [2] and Popov [3] for solution of some contact problems of the theory of elasticity. G.K. Klein at calculation of constructions laying on the solid base, for the module of deformation of the soil has following expression

$$E(z) = E_n z^n, \qquad (1)$$

where E_n is the module of deformation of the soil at a depth $z = 1$; the figure n in most cases is in the limit of $0 < n < 2$. In the works of Popov at solution of similar problems the module of deformation of the soil is in the following form

$$E(z) = E_0 e^{\alpha z}, \qquad (2)$$

where E_0, α are experimental data.

Furthermore, intrinsically the soils also relate to the rheologic bodies and deformations connected with creeping phenomenon, and find their reflection in compaction of the earth masses with rates which do not exceed several centimeters a year. Moreover the process of compaction of a construction foundation can be in a slow permanent motion without any features of its final stabilization. Notwithstanding such insignificant intensity of deformation, in some instances they can appear to be inadmissible for constructions located on the deformed foundation.

Mechanics of such soils under load and in time are usually described by rheologic equations of the soils state which connect between themselves its deformation, tension and their derivatives in time, and they had a form of linear differential equation. Later, integral relations were used for solution of the earth medium compaction problems. One of the first who used them for description of soil skeleton state was V.A. Florin [4]. At this, relationship between soil porosity factor $\varepsilon(t)$ and sum of the main tensions $\theta(t)$ in a skeleton of homogeneous soil can be presented as follows:

$$\varepsilon(t) = \varepsilon(\tau_1) - \frac{1}{1+(n-1)\xi}\left[\theta(\tau_1)\delta(M,t,\tau_1) - \int_{\tau_1}^{t} \frac{\partial\theta}{\partial\tau}\delta(M,t,\tau)\,d\tau\right], \qquad (3)$$

where $\varepsilon(\tau_1)$ and $\varepsilon(t)$ are relatively coefficients of porosity for initial and final time point; ξ is a coefficient of the lateral earth pressure; τ is a time of load application; t is a time for which creeping deformation is determined; n is a dimension of compaction which possesses values properly 1, 2, 3; $\delta(t, \tau)$ is a function throwing back changes in the soil porosity to the time point t from the unit load applied in the time point τ. For heterogeneous soil we take it in the form:

$$\delta(M,t,\tau)=\frac{1}{E(M)}+C(M,\tau,t);$$
$$C(M,\tau,t)=C(\tau,t)E^{-1}(M);$$
$$C(\tau,t)=a_1\left[1-e^{-\gamma_1(t-\tau)}\right]. \qquad (4)$$

Here a_0 is a coefficient of instantaneous compaction; a_1 and γ_1 are parameters of creeping determined from tests. M is a point of compactible body; $C(\tau, t)$ is a measure of creeping for homogeneous soil subjected to the compaction.

Therefore, let compactible medium contain not only fluid filling soil pores, but also some entrapped air or other gas; a soil skeleton is heterogeneous on the structure, i.e. some features reflecting physical-mathematical properties are functions from space coordinates. Particularly, the soil deformation module can be changed on the coordinate determining depth of the considered point position; in the large the soil can possess by ageing property; flow of a fluid filling soil pores is subject to the generalized filtration law of Darcy-Gersevanov; a soil skeleton is tensile-creeping porous medium is subject to the hereditary creep theory of G.N. Maslov – N.Kh. Arutyunyan [4]; in the initial instant of time a part of load, suddenly applied load q to the soil, equal in value of structural compressive strength p_{str}, is immediately taken by the soil skeleton, i.e. $p\big|_{t=\tau_1}=q-p_{str}$ At this, relationship between soil porosity factor and sum of the main tensions can be in the form (3); soil; according to impermeability soil is anisotropic. Therefore compaction of the earth masses taking into account (3), (4) relating to the pore pressure amounts to the study of following integral-differential equation with variable coefficients:

$$\left[na_0+\beta^1(1+\varepsilon_{sr})[1+(n-1)\zeta]\right]\frac{\partial p}{\partial t}+a_1\gamma_1\phi(t)p(t)-a_1\gamma_1\int_{\tau_1}^{t}p(\tau)\left[\phi^1(\tau)+\gamma_1\alpha(\tau)\right]\times$$
$$\times e^{-\gamma_1(t-\tau)}d\tau=\frac{k(1+\varepsilon_{sr})}{\gamma_b}\left[x^{-\alpha_1}\frac{\partial}{\partial x}\left(x^{\alpha_1}\frac{\partial p}{\partial x}\right)+\alpha_2\frac{\partial^2 p}{\partial y^2}+\alpha_3\frac{\partial^2 p}{\partial z^2}\right]+a_1\gamma_1\phi(t)n\cdot\left(\frac{\theta^*}{n}+p^*\right)+ \qquad (5)$$
$$+na_1\gamma_1\cdot\int_{\tau_1}^{t}\left(\frac{\theta^*}{n}+p^*\right)\cdot\left[\phi^1(\tau)+\gamma_1\phi(\tau)\right]\cdot e^{-\gamma_1(t-\tau)}d\tau.$$

Initial condition of equation (5) has the following form:

$$p_0(x,y,\tau_1)=\frac{1}{\omega_0^1}\left[\frac{\theta^*(x,y)}{n}+p^*(x,y)\right], \qquad (6)$$

where $\varphi(t)$ is a function of ageing; θ^*, p^* are relatively sum of the main tensions and pore pressure for stabilized condition of compactible body; p is a pressure in porous fluid; ω_0^1 is a factor considering volume compression.

In the given work the equation (5) at (6) for cases (1) and (2) are solved for one dimensional compaction of heterogeneous soil having creeping property. These solutions reflect distribution of pressure in the porous fluid, tension in the soil skeleton, and vertical movement of points of the upper surface of compactible foundation soils. They have been received in the form of Bessel's functions combination, equations in the form (5) for heterogeneous boundary conditions have been solved in the works [5, 6].

References

1. Arutyunyan N.Kh. Some questions of a creep theory. – M.: Gostechizdat, 1952. – 323 p.

2. Klein E.K. Consideration of heterogeneity, discontinuity of deformations and other mechanical properties of soil at proportioning of structures on solid base // Works of V.V. Kuibyshev Moscow State Builing Institute. – M., 1959. – P. 57–65.

3. Popov G.Ya. To the theory of flagstone bending on the elastic heterogeneous half-space // Cjnstructijn and archittctbre. – 1959. – № 12. – P. 11–19.

4. Florin V.A. Fundamentals of soil engineering. – M.: Gostechizdat, 1959. – V.1, 2. – 357 p.; 1961. – 543 p.

5. Shirinrulov T.T.Sh., Dasibekov A., Berdybayeva M.Zh. Two-dimensional compaction of tensile-creeping soils at their heterogeneous boundary conditions // Mechanics and modeling of engineering processes. – Taraz, 2006. – № 1. – P. 61–66.

6. Shirinrulov T.T.Sh., Dasibekov A., Berdybayeva M.Zh. On three – dimensional compaction of tensile-creeping heterogeneous soils with their heterogeneous boundary conditions). // Mechanics and modeling of engineering processes. – Taraz, 2006. – № 1. – P. 30–35.

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