COMPUTATION OF SPRING COMPENSATORS FOR GROUND ANCHORS

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Ground anchors [1, 2] have come into increasingly widespread use for securing slide-prone slopes, and in retaining-wall structures. A typical slide-retaining installation consisting of a slab pressed against a slope using a ground anchor is shown in Fig. 1. The effective operation of this installation, which consists of a surcharge on the soil mass, is possible only in cases where the pressing force $P$ of the slab does not diminish with time. The latter may occur due to disturbance of the contact between the slab and soil (as a result of soil erosion, forst heaving and thawing, and consolidation with time) and "creep" of the anchor due to the appearance of rheological properties of the soil in which it is embedded. In connection with the high stiffness of the surcharged slab, even minor disturbances in the zone of contact between these slabs and the soils inevitably lead to virtually complete release of forces in the anchors.

For example, field observations conducted at the construction site of one of the stations in the Moscow Subway [3] indicated that the forces in ground anchors protecting the trench diminished to 46% of the initial force after two months. Similar data also exist from a number of foreign construction projects [2, 4].

The reliable performance of devices of the type under consideration can be achieved only by installing in the support unit between the slab and tensioning nut on the anchor elastic compensators in the form of different types of springs, or sets of springs, which provide for stability of the anchor force within a prescribed range.

In the absence of compensators, the bearing capacity of structures with ground anchors inevitably diminishes with time, and they gradually cease to fulfill their intended function. Available experience enables us to state with certainty that in the majority of cases, ground anchors are not effective in cohesive soils without elastic compensators [4].

The design of the compensator reduces to determination of its stiffness coefficient $K$. Equations for calculating $K$ for cases when axial displacement of the ground anchor results from the appearance of rheologic properties of the soil in which its effective portion is embedded are derived below (Fig. 2). As experiments have established, displacement of the anchor $e(t)$ in a creeping soil is related to the effective anchor force $P(t)$ by the relationship

$$P'(t) - P_c = \frac{\eta}{\bar{\eta}} \frac{de(t)}{dt},$$

where $P_c$ is the creep threshold of the anchor (the axial force below which displacement of the anchor does not take place), $\eta$ is a proportionality factor in N·day/m, and $t$ is time.

In the process of long-term experimental investigations [5] conducted under laboratory and field conditions, the interaction between the stressed state of ground anchors and their axial displacement with time in cohesive soils under constant and variable loads was studied in detail. Analysis of data obtained indicated that the experimental "strain-time" and "anchor-force/time" relationships correspond well to relationship (1) over the entire range of possible loads.

The constant $P_c$ is determined from the results of full-scale tests of ground anchors, the method of which is entirely similar to Vyalov's method for the dynamometric testing of piles [6], while the constant $\eta$ is determined from results of full-scale tests conducted under a constant load [7].

The accumulation of deformation $f(t)$ of the spring compensator with time, which functions in accordance with Hooke's law, is determined by the relationship
Fig. 1. Examples of use of ground anchors. a) For securing slide-prone slopes; b) for retaining walls; 1) slab; 2) prestressed anchor; 3) clayey soil; 4) retaining wall.

Fig. 2. Diagram showing stiff anti-slide surcharged slab with spring compensator. 1) Ground anchor; 2) slab; 3) spring compensator; 4) stop-tensioning device.

\[ P(t) - P(0) = -K_f(t), \]  

where \( P(0) \) is the initial anchor force.

Considering that condition \( e(t) = f(t) \) is observed in the "anchor–compensator" system, we can, on the basis of (1) and (2), obtain the differential equation