UNDERGROUND STRUCTURES

CALCULATION OF SECTIONAL LININGS FOR COLLECTOR TUNNELS IN AN UNDERWORKED SOIL MASS

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Existing methods of calculating underground structures in the zone influenced by mining operations do not fully reflect the characteristic features of the performance of collector tunnels built by the shield method at a shallow depth. Thus, methods of calculating the bracing for mine workings [1, 2] fail to account for the effect of the closeness of the ground surface, while the method of calculating structures embedded in the ground [3] fails to account for the stress state of the soil mass that embeds the lining. Moreover, these methods address the calculation of the lining only for the compression modulus of the mass.

The method of calculation, which is proposed below in the development of [4], is based on approximate solution of the contact problem of the interaction between the lining and soil both in the zones of tensile (+εx) and compressive (−εx) strains. Modeling with respect to a discrete computational scheme (Fig. 1) of the stress state of the mass being underworked is a characteristic feature of the method.

In zones of tensile deformations, the lining is calculated for the total stresses in the mass, which is equal to the sum of the initial stresses dictated by its own weight, and additional stresses caused by mining operations. At a shallow depth H, which can be characterized by the ratio of the displacement of the ground surface to the length L of the mold H/L < L/8, deformations in the direction of the z axis under additional vertical stresses ozC = 0 can be freely accomplished for assigned strains εC in the mass. The additional stresses σx, σy, which are determined from Hooke's generalized law as a result of substituting the conditions εz = 0 and εy = 0 in it (for plane strain), are:

$$
σ_x' = 2G_o \varepsilon_x \frac{1}{1 - ν_o},
$$

$$
σ_y' = 2G_o \varepsilon_y \frac{1}{1 - ν_o},
$$

where G₀ and ν₀ are the shear modulus (MPa) and Poisson's ratio of the soil, respectively, and εx is the computed value of the relative horizontal tensile strains of the mass, which are caused by the underworking.

Using (1) and (2), the total stresses in the mass will be:

$$
σ_z = \frac{1}{1 - ν_o} (2G_o \varepsilon_x - ν_o \sigma_y H),
$$

$$
σ_x = \frac{1}{1 - ν_o} (2G_o \varepsilon_x - ν_o \sigma_y H),
$$

$$
σ_y = \frac{1}{1 - ν_o} (2G_o \varepsilon_y - ν_o \sigma_x H),
$$

where α is a coefficient that takes into account the lag in the construction of the lining due to the formation of the working, γ is the specific gravity of the soil in MN/m³, and H is the embedment depth of the tunnel in m.

In a polar coordinate system, stresses (3) are written as

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Fig. 1. Computational diagram of interaction between lining and soil mass: a) modeling of initial stresses in mass; b) deformation of "lining-mass" system on removal of contact restraints.

Fig. 2. Results of computation of lining in zone of tensile deformations in underworked mass: a) contact stresses and forces in lining; b) normal tangential stresses in section $\theta = 0^\circ$; 1) due to natural weight and tensile deformations of mass; 2) due to weight of mass itself outside zone influenced by cleaning operations.