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Forecasting of Load - Carrying Ability of The Earth file Around of Horizontal Cavities

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Strictly as per the compliance and regulations of:

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I. Introduction

Necessity of stressed and deformed state definition of soil mass around tunnels appears while making underground tunnels and metro lines as well. This is actual as for unfixed tunnel-mine working so as for fixed tunnel. Complexity of this problem is in amount of reological properties of soil variety, nonhomogeneousness, structural changes, particularly connected with destroying process and underground water presence. The bad that metro lines are put in the places where surface construction are presented, also complicates this issue. Calculation method of stressed state of one or two horizontal cylindrical cavities in the soil mass is offered in this research. The problem is solved for the case wish surface deformation taking in to account soil mass stratification, underground water presence, process formation and damage accumulation.

The contour of the cavity is effected by the given pressure. The presence construction on the surface is modified according to the given on it power-pressure system.

Numerical algorithm of stressed state calculation and its changeability in time has been developed.

Based this algorithm not only stressed state definition in the area around cavities tunnels appears, but searching of appearing and extending destroying zones as well (fig.1).

II. Preliminary Notes

$$\sigma_u + M^* \sigma_u = \sigma_M$$

Here σ_M is instantaneous ultimate stress limit, σ_u is stress intensity

III. Main Results

For illustrating the process in the figure below specific picture of extending destroying zones around cavities for homogeneous soil masses (○, ●, △ -the areas of consequent destroying) is given.

From numerical experiment the influence of the factors soil mass weight, its stratification, damage tunnel location according to surface construction, underground water and others on the process if tension redistribution in round-tunnel space has been identified. The given calculation method is used while projecting of Baku metropoliten constructing area. It gives us chance to predict long stable soil mass characteristic around put tunnel. The importance of the suggested method is that it is applicable for tunnels of small put at over-constructed area of tunnel pass existence.

a) Properties

i. *The main defining correlation are*

$$\sigma = 3K_0\varepsilon; \quad S_{ij} = 2G_0\text{Э}_{ij}; \; \sigma = \sigma_{ii}; \quad \varepsilon = \varepsilon_{ii}; \; S_{ij} = \sigma_{ij} - \frac{1}{3}\sigma\delta_{ij}; \; \text{Э}_{ij} = \varepsilon_{ij} - \frac{1}{3}\varepsilon\delta_{ij}$$

Here Э_{ij} and S_{ij} are strain and stress deviators respectively, G_0 and K_0 are instantaneous coefficient of elasticity, M^* and N^* are destruction operators of hereditary type.

$$\varepsilon_{ij} = \frac{1}{2G_0}(1+M^*)\sigma_{ij} + \frac{1}{3}\left\{\left(\frac{1}{3K_0} - \frac{1}{2G_0}\right) + \left(\frac{1}{3K_0}N^* - \frac{1}{2G_0}M^*\right)\right\}\sigma\delta_{ij} \qquad 1$$

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ii. *The criterion of failure will be*

$$\sigma_u + M^* \sigma_u = \sigma_M \qquad 2$$

Here σ_M is instantaneous ultimate stress limit, σ_u is stress intensity

$$\sigma_u = \sqrt{\sigma_{11}^2 + \sigma_{22}^2 + \sigma_{33}^2 - \sigma_{11}\sigma_{22} - \sigma_{11}\sigma_{33} - \sigma_{22}\sigma_{33} + 3\sigma_{12}^2} \qquad 3$$

i. *Since, the problem is a plane one then equations of motion will be will have the following form*

$$\begin{cases} \dfrac{\partial \sigma_{11}}{\partial x_1} + \dfrac{\partial \sigma_{12}}{\partial x_2} = 0 \\ \dfrac{\partial \sigma_{12}}{\partial x_1} + \dfrac{\partial \sigma_{22}}{\partial x_2} - \gamma = 0 \end{cases} \qquad 4$$

Here γ is specific gravity of rock.

Equations of deformation compatibility,

$$\frac{\partial^2 \varepsilon_{11}}{\partial x_2^2} + \frac{\partial^2 \varepsilon_{22}}{\partial x_1^2} = 2\frac{\partial^2 \varepsilon_{12}}{\partial x_1 \partial x_2} \qquad 5$$

The criteria were given by means of stresses, therefore we express the problem trough the stresses. For that, taking into account (1) and (5), we obtain the following system

$$\begin{cases} \dfrac{1}{2G_0}(1+M^*)\left(\dfrac{\partial^2 \sigma_{11}}{\partial x_2^2} + \dfrac{\partial^2 \sigma_{22}}{\partial x_1^2}\right) + \dfrac{1}{3}\left\{\left(\dfrac{1}{3K_0} + \dfrac{1}{2G_0}\right) + \dfrac{1}{2G_0}M^*\right\} * \\ * \left(\dfrac{\partial^2 \sigma_{11}}{\partial x_2^2} + \dfrac{\partial^2 \sigma_{22}}{\partial x_2^2} + \dfrac{\partial^2 \sigma_{33}}{\partial x_2^2} + \dfrac{\partial^2 \sigma_{11}}{\partial x_1^2} + \dfrac{\partial^2 \sigma_{22}}{\partial x_1^2} + \dfrac{\partial^2 \sigma_{33}}{\partial x_1^2}\right) = \dfrac{1}{G_0}(1+M^*)\dfrac{\partial^2 \sigma_{12}}{\partial x_1 \partial x_2} \\ \dfrac{1}{2G_0}(1+M^*)\sigma_{33} + \dfrac{1}{3}\left\{\left(\dfrac{1}{3K_0} - \dfrac{1}{2G_0}\right) + \left(\dfrac{1}{3K_0}N^* - \dfrac{1}{2G_0}M^*\right)\right\}(\sigma_{11} + \sigma_{22} + \sigma_{33}) = 0 \\ \dfrac{\partial \sigma_{11}}{\partial x_1} + \dfrac{\partial \sigma_{12}}{\partial x_2} = 0 \\ \dfrac{\partial \sigma_{12}}{\partial x_1} + \dfrac{\partial \sigma_{22}}{\partial x_2} - \gamma \end{cases} \qquad 6$$

This system of equations with equilibrium equation (6) forms by stress component an isolated system of equations. As was noted, in the system N^* and M^* are integral operators of hereditary type, characterizing failure process. Since the amount of failure formed by volumetric deformation significantly smaller than the amount of failures formed due to volumetric friction, $N^* = 0$.

Since forces on segment [a, b] of rectilinear domain of half-plane are taken uniformly distributed, and out of the

segment all forces are taken equal to zero, then here boundary conditions will be as following:

$$\sigma_{xy} = 0; \sigma_{yy} = -p; \quad y = H, a \le x \le b \qquad 7$$

Because of uniform distribution of forces inside of circle, the boundary conditions on the contour of aperture will be the following:

$$\sigma_{rr}\Big|_{r=R} = -q\,; \quad \sigma_{r\varphi}\Big|_{r=R} = 0 \qquad 8$$

At the point at infinity stress tends to the natural stress, i.e. on a heavy half-plane, where aperture is absent

$$\sigma_{ij} \longrightarrow \sigma_{ij}^0; \;\; x^2 + y^2 \longrightarrow \infty \qquad 9$$

Here σ_{ij}^0 are stress corresponding to initial natural state, where

$$\begin{cases} \sigma_{yy} = -\gamma(H - y) \\ \sigma_{xx} = -\lambda\gamma(H - y) \end{cases} \qquad 10$$

Here $\lambda \; (0 < \lambda < 1)$ is the construction coefficient, in elastic state $\lambda = \nu/(1-\nu)$, ν is Poisson coefficient.

Analytical solving of (6) is very difficult therefore here numerical method and finite net method were applied. For that we pass from infinite half-plane onto finite rectangle. Its incremental dimensions are defined during the numerical computations. Damaging operator is of the form,

$$M^*\sigma_{ij} = \sum_{k=1}^{n} \int_{t_k^-}^{t_k^+} M(t-\tau)\sigma_{ij}(\tau)d\tau + \int_{t_{n+1}^-}^{t} M(t-\tau)\sigma_{ij}(\tau)d\tau \qquad 11$$

$$\sigma_{u_r} - \sigma_{u_{r-1}} \qquad 12$$

IV. Labels of Figures and Tables

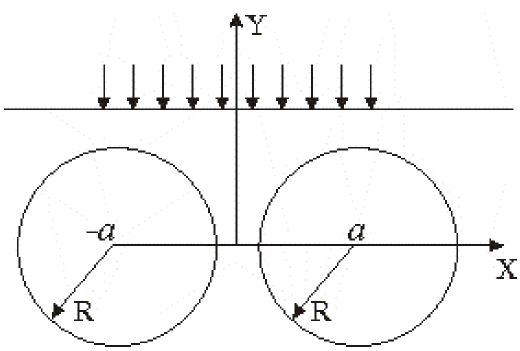

Figure 1

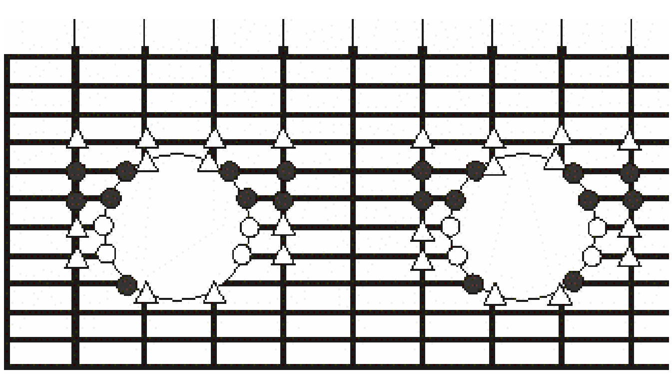

Figure 2.

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