Failure of the heavy ground mass with the vertical cavity

La destruction du massif de sol lourd avec la cavité verticale

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ABSTRACT: On the base of conception of damage accumulation the process of scattered failure of the heavy transversal isotropic ground mass around the vertical cylindric cavity filled with the liquid is investigated .The formula for the incubation (period) during of which the ground mass does not get any noticeable changes and the equation for the law of expansion of the failed zone around the cavity are obtained. Numerical realization has been carried out for different correlations of the mechanical properties of the ground along the day-light surface and by depth.

RÉSUMÉ: A la base de la conception de l'accumulation des endommagements on étudie le procès de la destruction dispersée lourd trasversal-izotropique du massif de sol autour de la cavité verticale cylindrique le liquide rempli. Sont reçus es formule de la période incubation, dans le courant de qui le massif ne de sol subit pas des changements considérables, et l'équation pour la loi de l'élargissement de la zone détruite autour de la cavité. La réalisation numérique est produite pour les rapports divers des propriétés mécaniques du sol le long de la surface de jour et selon la profondeur.

The wells 2nd vertical mines passable in ground mass change its natural stress state. And under definite conditions this can reduce to the developing failure process of a mass. In view of not homogeneous stress state around the vertical cavity in a massif, its failure will be continuous both in time and space. Continuous, scattered failure process is explained by the formation and growth of different disturbances of continuity and structure, that in its turn influences to the stress-strain state of a ground mass, its strength characteristics. This leads to the failure of some part of mass that implies the stress redistribution. Then the damageability intensively increases in more stressed places and it is accompanied by a further lowering of strength characteristics and failure stage. This cyclically repeated process leads either to continuous sloughing of mass around the cavity, or to sudden cave of sufficiently, large volume of ground mass. The knowing of the law on expansion of external bound of a collapsed mass of the failure front is important to determinate the solid mass stability around the cavity. To determinate the prolonged ground mass strength near the ground mass doesn't endure changes. In this paper, this process studied on the basis of the known solid damageability model (Suvorova and Akhundov 1986) and corresponding mathematical problem is constructed.

Ground foundation is a homogeneous transversally isotropic mass whose isotropy plane is parallel to a day-light area. In this mass, a well in the form of semi-intinite circular cavity filled with fluid is passed (figure 1).

Dimensionless elastic stresses have the form (Lekhnitsky 1977):

$$\left.\begin{matrix}\sigma_r \\ \sigma_\theta\end{matrix}\right\} = -n \pm (n-m)\left(\frac{R_0}{r}\right)^2; \; \sigma_z = -1 \qquad (1)$$

where γz is a demeasuring parameter, γ is ground's specific weight: $m = q/\gamma$, qz is fluid pressure interior to the cavity in the depth z;

$$n = \frac{E}{E'} \cdot \frac{\nu'}{1-\nu} \qquad (2)$$

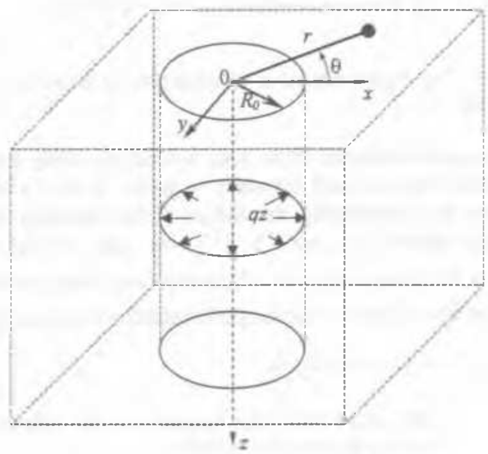

Figure 1. The investigated element of the domain.

Here E, E' are Young modulus in isotropy plane and along the axis z respectively; ν and ν' are also corresponding Poisson coefficients. Assuming the damageability process to be isotropic, and isotropy appears only through instantaneous values of mechanical characteristics, for stresses in a ground mass we'll have the same expression of (1) with only difference that instantaneous values of elastic modules will appear there. We take the greatest stress test as a base strength criterion. Analyze one of possible cases, when $n > m$, i.e. for small alternations of fluid pressure in a cavity with depth. Then it follows from (1) that σ_θ is the greatest contrastive tangential stress, and the failure test (Suvorova and Akhundov 1986) has the form .

$$(1+M^k)\sigma_\theta = \sigma_0. \qquad (3)$$

Here M^* - is an integral operator of damageability, σ_0 - i.e. dimensionless bound of instantaneous strength.

First the failure will occur near the cavity, where the stress σ_θ achieves its maximal value. The initial time is determined from (3) with to the expression σ_0 (1) for $r = R_0$;

$$\int_0^{t_0} M(\tau)d\tau = \frac{\sigma_0}{2n-m} - 1 . \quad (4)$$

For example, for a damageability operator kernel $M(t) = t^{-a}$; $\lambda > 0$; $0 \le a < 1$ have (here time t is demeasured in proportionality coefficient of kernel):

$$t_0 = \left[(1-\alpha)(\frac{\sigma_0}{2n-m} - 1) \right]^{\frac{1}{1-\alpha}} \quad (5)$$

The conditions under which incubational failure period exists follow from the positivity of the right hand side (4). The dependence curve of incubation period t_0 depending on the anisotropy parameter n for $a = 0.15$ is in figure 2.

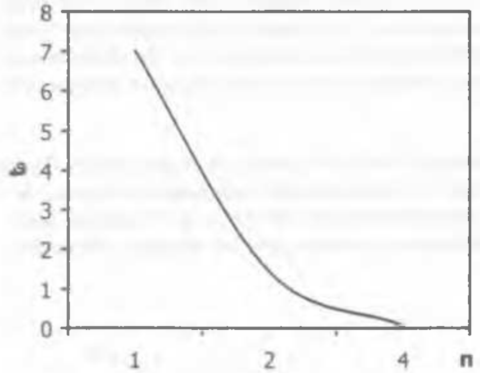

Figure 2. The dependence curve of initial time of failure of anisotropy parameter.

The destroyed parts of the mass around the cavity form a circular area with external boundary – failure front. To obtain an equation for determining the failure front extension law with moving radius R_1 and b (1) we put $R/R_0 = \beta(\tau)$; $v/R_0 = \beta(t)$ where $\beta(t)$ is a dimensionless radial coordinate of a failure front. Then for the tangential stress module we get:

$$\sigma_0(t,\tau) = n + (n-m)\frac{\beta^2(\tau)}{\beta^2(t)} \quad (6)$$

Taking this expression into account in the criteria (3) we have the following failure front equation:

$$\frac{1}{2n-m}\int_0^t M(t-\tau)\left[n - (n-m)\frac{\beta^2(\tau)}{\beta^2(t)} \right] d\tau = \frac{\sigma_0}{2n-m} - 1 \quad (7)$$

where $\beta(t) = 1$ for $0 \le t \le t_0$.

For a simple form of the kernel $M(t) = 1$ we get:

$$\beta(t) = \left(\frac{1-\omega}{1-\omega t / t_0} \right)^{\delta}; \; \sigma = \frac{2n}{2n-m}; \; \varpi = \frac{m}{2n} \quad (8)$$

Catastrophic failure time of the ground mass corresponds to (8) the conversion function $\beta(t)$ to infinity where $t_{kp} = t_0 / \omega$.

For example for $n = 2m$ we have $t_{kp} = 1.5 t_0$, i.e. obvious failure period is of 50% from incubation, Latent failure period.

For complicated forms of damageability kernels the equation (7) is realized numerically. The curves of a failure front for some values of anisotropy parameter n and for the kernel $M(t) = t^{-a}$, for the values of parameters: $\alpha = 0.15$; $m = 0.5$; $n = 1; 2; 4$; $\sigma_0 = 8$ are given in figure 3.

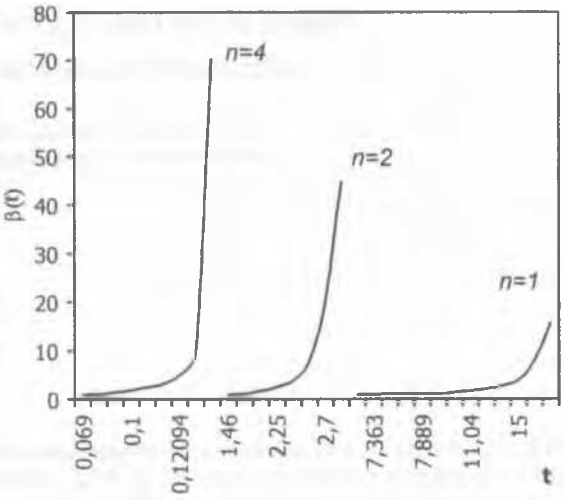

Figure 3. The curves of failure front extension.

CONCLUSIONS. It is shown that for the horizontal flatbed transversal isotropic ground masses with large relation of rigidity of the ground mass along the seam and transverse (rigidity by depth) the incubation (period) of absence of noticeable changes of the condition of the mass around the vertical cavity is filled with water less, moreover this decrease it has two characteristic areas with almost linear dependence: the first area of sharp decrease of incubation (period), the second area of its slower changing. Failure of the ground mass around the cavity happens with the increasing velocity and since some moment of time it has catastrophic avalanche form character. Excess of the rigidity along the seam over transverse rigidity decreases significantly the time of avalanchic propagation of the failure zone around the cavity.

REFERENCES

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