Numerical solution of the stress-strain state of ground dams under the action of seismic loads

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Abstract: The aim of the work is to develop new effective methods for calculating the seismic resistance of ground dams, quarry sides, dams, slopes, dumps, taking into account the wave processes that occur during seismic impacts in the ground mass, i.e. in the body and base of the ground structure. The paper modifies the finite difference method for solving problems by the method of continuum mechanics and the engineering method for calculating slope stability. In the course of the stage, the algorithm and programs for solving problems by the MSS method and assessing the stability of slopes are developed and the reliability of the methodology, algorithm and program of the solution is shown. The developed calculation method and the obtained numerical results are the novelty of this stage of research.

Keywords: Ground structures, ground dams, quarry sides, railway embankments, deformation, stresses.

Consider the dynamics of the dam, taking into account its own weight. In this case, the equation of motion for the dam equation [1] takes into account the last terms, and the remaining equations and boundary conditions remain unchanged.

$$\rho\frac{dv_x}{dt}=\frac{\partial\sigma_{xx}}{\partial x}+\frac{\partial\tau_{xy}}{\partial y}+\rho F_x,$$
$$\rho\frac{dv_y}{dt}=\frac{\partial\tau_{xy}}{\partial x}+\frac{\partial\sigma_{yy}}{\partial y}+\rho F_y; \quad [1]$$

For the initial conditions, we take the state of the dam, which satisfies the equilibrium position under the action of its own weight. Thus, to obtain the initial condition, a static problem is solved. Now, using the obtained solution as an initial condition with the beginning of the time reference, we apply a dynamic load to the lower surface of the dam.

Here are the results obtained. Figure [1.1] shows the changes in vertical and horizontal stresses over time at the same fixed points of the dam. From this it can be seen that both components of the stress have negative values, which corresponds to the compression of the ground. The voltage values at time t=0 correspond to the initial state. It follows from the results that the greatest stresses both under the action of their own weight and during the action of the dynamic load occur at the bottom of the dam. At the same time, the value of the vertical stress of the dam sole exceeds the horizontal one. On the slope and near-ridge zones closer to the free boundaries, these stresses become commensurate and insignificant.

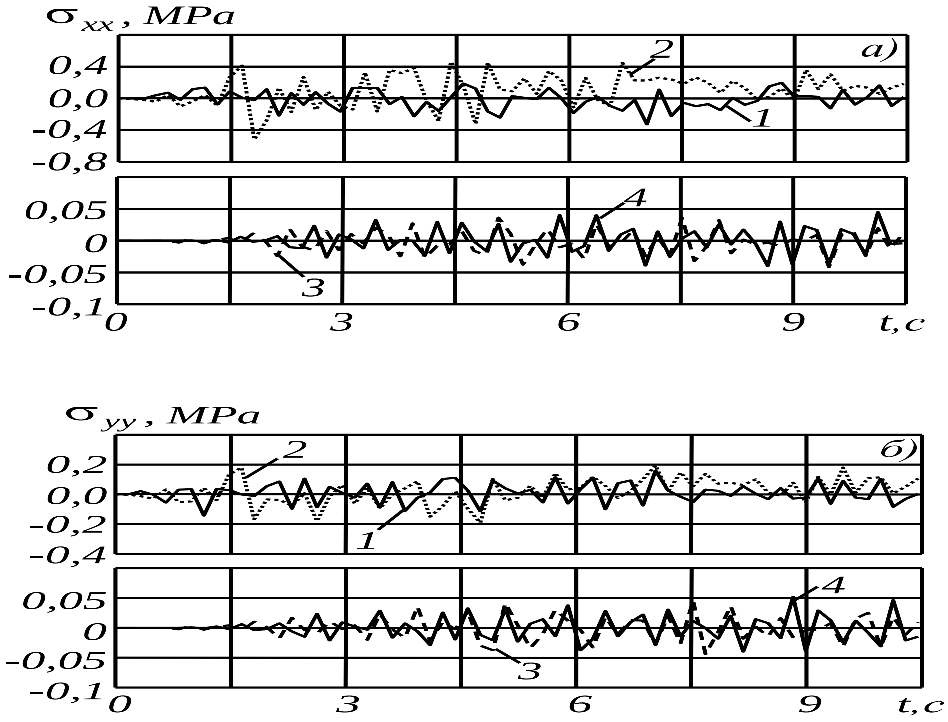

Figure 1.1-Time variation of stresses at fixed points

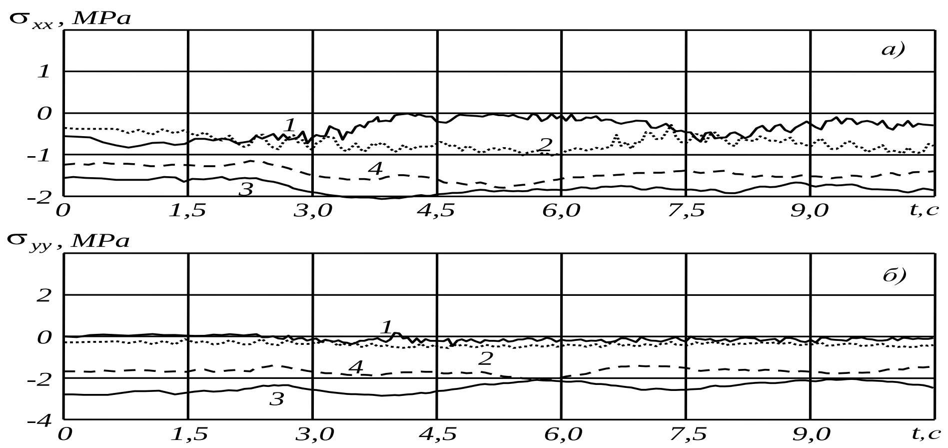

Figure 1.2-Time variation of stresses when taking into account their own weight

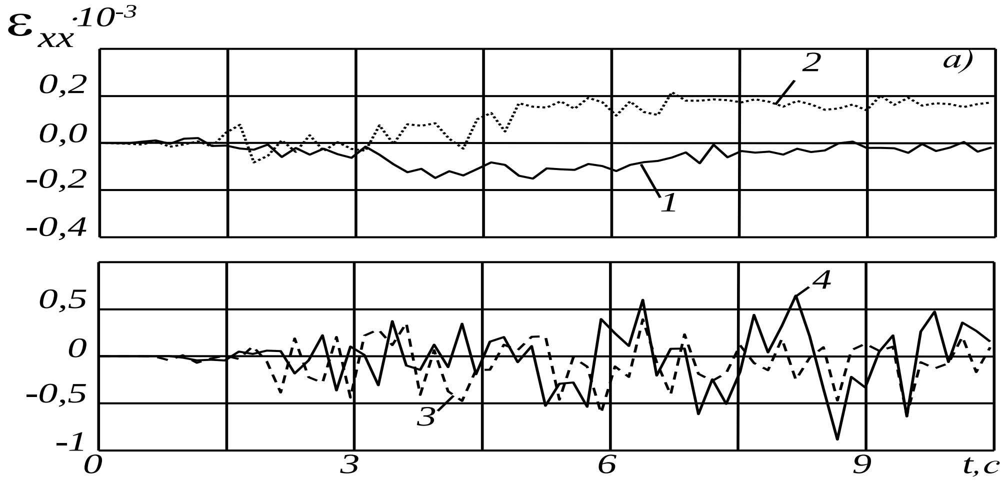

Figure 1.3 - Time variation of deformations at fixed points of the dam

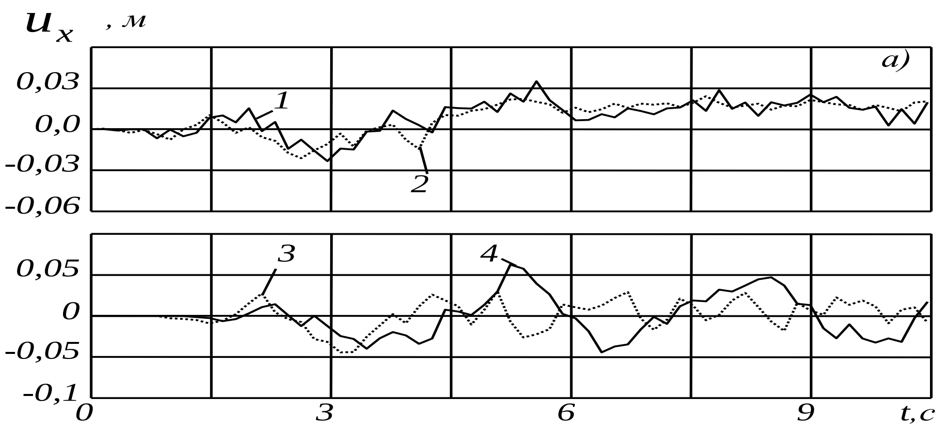

Figure 1.4-Change in time offsets at fixed points of dams

Figure [1.3] shows the change in horizontal and vertical deformations over time at the same points under consideration. Here, from Figure [1.3], it can be seen that the state of the dam slopes goes beyond the limit, and in the slope and near-ridge zones of the dam, residual deformations occur. The residual deformations in the prirebnevoy zone are negative, which leads to compaction of the dam material. Positive residual deformations in the slope zone curve 1, Figure [1.3, a] in the horizontal direction mean the decompression of the material, which may be due to the structural destruction (change) of the soil during deformation. The greatest vertical compaction is achieved in the prirebnevye particles of the dam. The pattern of deformation changes in the core of the dam is non-stationary. Figure [1.4] shows the changes in time displacements at the same points under consideration, they show a slight non-stationary displacement of the points of the prirebnevoy and slope zones (up to 3 cm along the Ox axis, and even less in the perpendicular direction); since the displacement of the points of the dam core is 2 times higher than their values. Thus, the analysis of the obtained results shows the need to take into account its own weight in the dynamic calculation, as well as the use of structural changes in the soil both during deformation and during wetting (water saturation)

The statement of the general problem of determining the stress-strain state (VAT) of ground structures taking into account wave processes in the ground mass is given, and the method and algorithm for solving the problem are developed. A brief review of methods for solving dynamic problems of continuum mechanics is made. It is shown that the chosen method of finite differences and the method of its implementation in problems allows us to apply more complex equations of state for soils, taking into account structural changes and moisture content of the environment, which is not possible in other methods and programs. On the example of the Charvak dam, the stress state under the action of its own weight is determined. Taking the stress state under the action of its own weight as the initial conditions, the problem of the dynamic behavior and stress-strain state of a ground dam under the influence of seismic loads is numerically solved, taking into account structural changes in the deformation of stone outlines and the dam core moisture content. The obtained results are presented in the form of graphs and analyzed.

Literatures

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