Simulation of the dynamics of blocky media based on the Cosserat continuum theory using high-performance computations

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The method of numerical simulation based on the theory of an orthotropic elastic-plastic Cosserat continuum with a plasticity condition, that takes into account both the shear and rotational nature of irreversible deformation, is applied to the analysis of plastic deformation of structurally inhomogeneous materials. Within the assumption of a blocky structure of a material with elastic blocks interacting through compliant plastic interlayers, this condition limits the tangential components of the asymmetric stress tensor, which characterize shears, as well as the couple stresses, which limit values lead to an irreversible change in the curvature of deformed state of the continuum. The equations of translational and rotational motion together with the constitutive relations of the model are formulated as a variational inequality that correctly describes both the state of elastic-plastic deformation under active loading and the state of elastic unloading, [1]. For numerical implementation of mathematical model, the parallel computational algorithm and author’s software package for multiprocessor computer systems of the cluster architecture are used. With the help of the developed computational technology, [2], the problem of squeezing a rectangular block-type rock massif of a masonry by a rough non-deformable plate making a uniformly accelerated rotation is analysed. The influence of the yield strengths of compliant interlayers during shear and bending on the stress-strain state of the massif is investigated. The fields of displacements, stresses, couple stresses, angle of rotation, plastic energy dissipation of the structural elements are studied numerically. A detailed analysis of numerical solutions shows that the couple stresses and the associated curvatures have small effect on the final macroscale deformed state of the massif, which is characterized by the main quantities – displacements and corresponding stresses. The distribution of couple stresses takes a cellular structure, reflecting the heterogeneity of a material and the change in heterogeneity in the process of loading. Therefore, unlike conventional stresses, they should be associated with a mesoscale level of deformation of a structurally inhomogeneous material. Chaotic distribution of the energy of plastic dissipation due to a change in curvature in the entire volume of a medium confirms the hypothesis that the plasticization of a material at the meso-level is due to the rotational degrees of freedom of the particles.

This work was supported by the Russian Foundation for Basic Research, Government of Krasnoyarsk Territory, Krasnoyarsk Regional Fund of Science to the research project No. 18-41-242001.
References