DEM-modeling of shear localization and transition of geomedium to unstable modes of deformation

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The discrete element shear deformation of the granular material samples in constrained conditions is considered.

Various algorithms for the formation of initial samples (packages of particles) of a cubic shape with a given relative density are proposed. It is shown that algorithms that use the motion equations based on Aristotelian mechanics are effective - the force is proportional to the velocity, but not to acceleration, as is the case in Newtonian mechanics. The main thing is the fact that in the stationary state the Aristotle equations and Newton's equations give the same result - the sum of forces and moments acting on each particle are equal to zero [1].

A series of numerical calculations on shear loading of granular material samples was carried out, taking into account dry and rolling friction and viscosity at the contacts between particles. The initial density of samples was considered, as well as various boundary conditions provided both soft (force) loading and hard (kinematic) loading included suppression of dilatancy by maintaining a constant sample volume as well.

It is shown that for all considered samples there are critical values of shear deformation. Upon reaching the critical value the stability of the deformation is failed. Isolated sliding surfaces are formed in the material, dividing it into separate blocks. Further deformation is reduced to the relative displacement of these blocks almost as rigid wholes. In the shear diagram, the transition to an unstable deformation regime is accompanied by softening. At the level of discrete elements (particles) a redistribution of acting stresses and the formation of new power chains are observed. An analysis of the kinematics shows that there is a redistribution of the velocities of particles assigned to different blocks, which is consistent with the data of laboratory experiments [2] obtained earlier. Diagrams of shear and distribution patterns of particle velocities at the moment of block structure formation are presented.

The results obtained can be used to model unstable deformation modes leading to disintegration and loosening of large geological objects. There is evidence that these phenomena can play a significant role in the formation of the structure and rheology of rocks [3].

The calculations were carried out on the basis of the original software developed by authors, as well as using the Altair EDEM software (academic license).

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