NEGATIVE STIFFNESS EFECT OF ROTATING NON-SPHERICAL PARTICLES

Dyskin, A.V.[(1)] and Pasternak, E.[(1)]

(1) University of Western Australia, Perth, Australia
ph. +61-864883987 ; email arcady@civil.uwa.edu.au

Sliding over faults is, in many cases, affected by the presence of particles between the sliding surfaces, either pre-existing as in fault gouge or in granular materials, or produced by the wear. Traditionally, the micromechanical modelling of the effect of rotating particles is based on either the continuum or discrete modelling with the gouge particles being treated as spheres. The shapes of real grains are different from spherical and this difference can be profound. We demonstrate that rotation of a non-spherical grain under combined action of shear and compressive forces can produce an effect of negative (shear) stiffness. The value of negative stiffness is controlled by the magnitude of the compressive force.

Non-sphericity of grains also impedes their rotations. Therefore the concentrations of zones of apparent negative stiffness can be low. In order to investigate the effect of low concentration of negative stiffness zones on the overall stiffness we consider an example of conventional isotropic material (matrix) with negative stiffness cylindrical inclusions in the anti-plane strain approximation. We show that when the modulus of inclusions is close to negative of the matrix modulus, the interaction between the inclusions cannot be neglected even at low concentrations. We model the interaction using the differential self-consistent method. We found that at low concentrations the effective shear modulus becomes higher than that of the matrix. However there exists a critical concentration at which the effective stiffness abruptly changes its sign from positive to negative. This corresponds to a sudden release of the stored elastic energy and instantaneous localisation. The critical concentration depends upon the magnitude of compressive force; high enough compression can make the critical concentration arbitrary low. Thus, rotation of non-spherical particles can constitute a mechanism of abrupt development of negative stiffness and subsequent strain localisation.