Fractures in materials with microrotations: rational approach

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Engineering and geological applications often encounter materials exhibiting rotations of microstructural elements. These include granular and fragmented materials (sand, some clays, powders, blocky rock mass) as well as rocks, concrete and ceramics at developed stage of damage when the constituents are sufficiently separated to permit mutual rotation. Such materials support in-plane fracture propagation under shear and compressive loads. Also propagating compaction bands are observed, which are similar to Mode I anti-cracks, i.e. cracks with compressive stress singularity.

Continuum mechanics of materials with microrotations requires, in the simplest case, the use of the Cosserat theory. In this talk we will cover the basics of the Cosserat theory and the (already) traditional way of modelling fracture propagation using this approach. We then analyse real materials with rotating constituents and demonstrate that formulating fracture propagation criteria requires the use of an intermediate asymptotics in which the stress singularity at the crack tip is considered in the range of distances large compared to the Cosserat characteristic lengths but still smaller than the fracture length. While the stress distributions at the crack tip are the same as for the classical cracks, the moment stress has a stronger singularity. A universal mechanism of fracture propagation is formulated based on mutual rotations of the constituents caused by the moment stress concentration and leading to bond/particle breakage and re-compaction. Furthermore the tensile microstress induced by bending dominates the stress associated with conventional stress singularities and thus controls this type of fracture propagation. The distribution of the moment stress concentration is symmetrical, which supports the observed in-plane fracture propagation.

Biography

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Arcady Dyskin is a Winthrop Professor at School of Civil and Resource Engineering. Arcady graduated in 1975 from Moscow Oil & Gas Institute and in 1980 from Moscow State University. In 1986 he has obtained PhD in Mechanics of Solids from The Institute for Problems in Mechanics, USSR Academy of Sciences. In 1991 he joined the Department of Civil Engineering of the University of Western Australia. His areas of expertise include fracture mechanics, mechanics of materials with multiscale and fractal microstructure, rock mechanics and topological interlocking.