Discrete element modelling of the compressive failure of porous rocks

Ferenc Kun

Department of Theoretical Physics, University of Debrecen

ferenc.kun@science.unideb.hu

Understanding the processes that lead to catastrophic failure of porous granular media is an important problem in a wide variety of applications, notably in Earth science and engineering. Such failure is often preceded by detectable acoustic emissions which may be used to forecast the impending catastrophic event. Under compressive loading in the vicinity of failure localization emerges such that cracking events get concentrated in a damage band where eventually a macroscopic crack develops and the system falls apart. For a comprehensive understanding of the spatial structure of damage and of the statistics and dynamical features of acoustic emissions computer simulation of realistic models is indispensible.

Here we investigate the scaling properties of the sources of crackling noise and the spatial structure of damage in a discrete element model of porous granular materials [1, 2, 3]. Simulations are performed to investigate the strain controlled uniaxial compression of cylindrical sand stone samples. We show that in our DEM framework cracking avalanches can be identified and the source size, energy, and duration can all be quantified for an individual event. The statistics of single event quantities are all characterized by power law distributions over a broad range of scales. The waiting time also depends on event size: after large events one has to wait longer for the next one [1, 2].

Close to failure damage localizes in a narrow shear band containing a large number of poorly-sorted fragments with properties similar to those of natural and experimental faults. We determined the position and orientation of the central fault plane, the width of the shear band and the spatial and mass distribution of fragments. The relative width of the shear band decreases as a power law of the system size and the probability distribution of the angle of the central fault plane converges to around 30 degrees. The mass of fragments is power law distributed, with an exponent close to that inferred for experimental and natural fault gouges. The fragments are in general angular, with a clear self-affine geometry [3].

References

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