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A THREE DIMENSIONAL DISCRETE APPROACH FOR MODELLING STRESS INDUCED PERMABILITY CHANGES IN ROCKS

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Understanding permeability evolution due to microcracking is crucial for predicting fluid flow in the vicinity of underground excavations, boreholes or reservoirs. A three-dimensional approach combining a discrete element method (DEM) and a pore scale finite volume method (FVM) is proposed to investigate stress induced permeability changes in brittle porous materials. The solid phase is represented by an assembly of bonded particles interacting through elastic-brittle force-displacement laws [1]. The poral space is discretized based on a regular triangulation of the particle assembly so that a pore network is established following the dual Voronoi graph [2]. Locally, the interporal permeability is computed as a function of the pore throat geometry for the intact part of the rock matrix or as a function of the aperture of the induced or pre-existing cracks [3]. As an illustration of the method capability, synthetic rock samples representative of an argillaceous rock (i.e. claystone) are subjected to triaxial compression tests. During the tests, the macroscopic permeability is sequentially computed by simulating water flowing across the specimen and by applying Darcy's law. The numerical results show that the simulated effect of microcracking on the overall permeability is in reasonably good qualitative and quantitative agreement with the stress-dependent behaviors observed in laboratory experiments. In particular, the predicted stress-strain-permeability relationship shows that the permeability does not change significantly before reaching the crack damage threshold. At failure, the permeability has increased by several orders of magnitude and is directly related to the presence of discrete macrofractures which traverse the sample. It is demonstrated that the proposed approach allows to simulate stress-induced permeability change in argillaceous rocks as a result of the initiation, propagation, and coalescence of cracks. Elaborating on these results, a discussion is provided to assess the relevance of the approach when applied to different rock types.

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