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Computational Mechanics of Damage and Fracture in Fluid-Saturated Porous Media

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Since the pioneering work of Terzaghi and Biot the flow of fluids in deforming porous media has been given considerable attention. Nevertheless, flow in fractured or fracturing porous media has received less attention, although the physics of the flow within such discontinuities can be very different from that of the interstitial fluid in the surrounding deforming bulk.

Herein we develop a general model for flow in progressively fracturing porous media. Since the cross-sectional dimension of the fracture is small compared to its length, the flow in the crack can be averaged over the width. A two-scale model results, including momentum and mass couplings between the subgrid scale and the macroscopic scale. Numerically, the two-scale model imposes some requirements on the interpolation of the displacement and pressure fields.

Advanced discretisation methods are needed to model a crack, which is essentially an internal free boundary. Interface elements are an option, but have restrictions in terms of flexibility. Exploiting the partition-of-unity property allows the crack path to be decoupled from the underlying discretisation. Another possibility is isogeometric analysis. We develop an isogeometric formulation for porous media, including stationary and propagating cracks, such that it is possible to have fluid transport in the cracks. Crack initation and propagation can be modelled in two ways: either via lowering the order of the interpolation, or by using isogeometric interface elements.

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