A phase-field model with an extended hydrostatic-deviatoric strain energy density splitting scheme

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The interest in using phase-field theories to numerically model fracture has exploded during the last decade. Perhaps the most attractive characteristic of phase-field theories is that the crack mechanics is inherently obtained from a minimization scheme that couples the total strain and fracture energies. This enables the treatment of complex crack scenarios such as crack initiation, growth, merging, and branching without any need of e.g., complicated re-meshing or virtual crack closure algorithms, which remarkably distinguishes the method from traditional modelling techniques that rely on discrete representations of cracks.

However, decompositions, or splits, of the strain energy density into tensile and compressive parts are necessary to avoid interpenetration of crack surfaces and to select physically trustworthy crack paths. The by far most popular methods to decompose the strain energy density are a spectral decomposition [1] or a hydrostatic-deviatoric decomposition [2] based on the present strain state. Both decompositions have some disadvantages where the single most important is that none of them can handle crack growth in compression adequately [3].

To address this issue, several attempts have been made to develop alternative splitting schemes to simulate fracture under compression, cf. [4-5]. However, a drawback of those models is that stiffness may remain with a fully developed crack subject to shear load. An increased number of fitting parameters also poses difficulty to practical application of the models.

To circumvent this, we present a modified strain energy split that essentially is a combination of the spectral and hydrostatic-deviatoric splits. The split is inspired by the classical Mohr-Coulomb fracture criterion and needs few parameters to determine whether or not the present mechanical state will drive a shear crack. The model is judged against reported fracture experiment on concrete subject to combined shear and uniaxial compression. The model is then further employed to simulate a flattened Brazilian disk experiment, providing mechanistic insight into fracture of rock-like materials.

REFERENCES