Mixed FE formulation for modelling incompressible damage with thermo-mechanical coupling

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ABSTRACT

Cracking in quasi-brittle materials has been intensively studied in computational solid mechanics over the last five decades. In most of the analyses performed with standard irreducible elements, attempts of predicting the crack path fail because the computed solution suffers from spurious bias mesh dependency.

Mixed finite elements have been applied by the authors to the solution of many nonlinear solid mechanics problems. In strain localization problems, they have shown to produce results with an enhanced accuracy in the computed strains and stress fields and predict reliable crack trajectories without spurious mesh-dependency issues [1-2]. They have also been used in incompressible problems to produce stable results and avoid volumetric locking [3].

In this work, a mixed stress/displacement formulation is considered to solve cracking problems in incompressible situations. The incompressibility constrain is fulfilled by splitting the flexibility tensor into volumetric and deviatoric components and setting the volumetric part to zero. The effect of temperature is introduced in the model through a thermal coupling following the method in reference [4]. In this way, the influence of temperature gradients in the development of cracks is investigated. For this, an enhanced version of the FE code COMET [5] has been developed.

The feasibility and performance of the method is assessed through numerical benchmarks showing the aptness of the formulation to produce results with enhanced accuracy and avoid volumetric locking in incompressible situations. The model is able of accurately simulating the phenomena related to cracking in incompressible situations while considering the influence of temperature. The mixed formulation has the necessary capability to produce reliable results in terms of structural response, damage patterns, crack trajectories and force-displacement curves without the need of auxiliary crack-tracking techniques.

REFERENCES