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NUMERICAL APPLICATIONS OF DISTRIBUTED DAMAGE IN CONFINED BRITTLE MATERIALS

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ABSTRACT

A multiscale distributed damage model suitable to describe the overall compressive behavior of brittle materials was presented in [1]. The macroscopic (effective) behavior arises from elastic and fracture properties of the material, and the microscopic behavior is related to the presence microstructures, consisting of parallel faults separated by a matrix. The distributed faulting model is based on the assumption that the displacement field jumps discontinuously across a singular set and that the material energy density is composed of two terms: the elastic strain energy obtained by volume integration outside the singular set; and the cohesive fracture energy obtained by surface integration over the singular set. The work presented in [1] elucidated the conditions under which damage occurs in a distributed fashion, and therefore can be described by a damage model. As opposed to fracture, distributed damage is a compressive phenomenon that occurs only in present of sufficient confinement, i.e. thus it may be activated only by conditions of triaxial compression resulting in a distributed singular set. This result is in contrast to recent work on free-discontinuity problems in fracture mechanics, that has emphasized tensile conditions leading to the formation of isolated dominant cracks. In the context of fault microstructures, a recursive crack pattern may be derived by introducing into the solid a family of parallel planar cohesive faults, and applying such construction recursively to the matrix between the faults.

The damage model has been implemented in a finite element model within a concurrent multiscale framework. The validation of the model was done against the experimental data pertaining to compressive damage in confined ceramics. A significant application concerns the simulation of a shock wave test on a gypsum cylinder immersed in a fluid, in view of subsequent extensions to the simulation of kidney stone lithotripsy [2].

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