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SIMULATING BRITTLE MATERIAL FAILURE WITH HIGH-ORDER FINITE ELEMENTS

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ABSTRACT

Prevention of failure of structures and structural components is a major concern in engineering. Among the many possible causes for structural failure, this paper focuses on the numerical simulation of material induced failure phenomena. In spite of considerable progress that has been achieved in application of the finite element method to this class of problems, an objective and efficient treatment is still a challenging goal.

With particular focus on large scale analyses, this paper adopts a macroscopic view of the failure process. For many materials used in practice, such as steel or concrete, this perspective motivates the introduction of strong discontinuities, i.e., jumps in the displacement field. Doing so, the pathological mesh sensitivity exhibited by classical continuum softening approaches is overcome. Discontinuities are incorporated into the finite element formulation in an embedded manner, avoiding the need of additional degrees of freedom and thus, giving rise to an efficient discretization and numerical treatment of the problem.

As opposed to previous concepts, the presented approach is consequently developed regarding its possible application in the context of high-order finite elements. Put forth by a novel reassessment of the strong discontinuity kinematics, an extended *p*-adaptive formulation is established. It is shown that the superior kinematics of these elements can be exploited in order to establish a formulation that minimizes potential locking effects – while at the same the algorithmic implementation efficiently preserves a high degree of locality. The latter aspect, in particular, incorporates additional potential for a computationally economical implementation.

The realization of the proposed concept is illustrated by means of a series of comparative three-dimensional numerical computations. To this end, a classical benchmark problem of a plain concrete specimen, loaded until failure under predominant mode-I conditions, is analyzed. Characteristics of the advocated method

are elaborated and – based on the available experimental data – a qualitative assessment of the computational results is performed.

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