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APPLICATION OF THE STRONG DISCONTINUITY METHOD TO DUCTILE FAILURE WITH DAMAGE

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This work deals with a modeling tool aiming at representing without mesh dependency, ductile fracture phenomena considering a coupled damage-plasticity constitutive law. Ductile materials are characterized by a severe non-linear behavior that induces two distinct phases of the global response to failure analysis: the pre-peak phase in which plasticity and damage are evolving in the bulk, and the softening post-peak phase in which strain localization occurs and leads to a macro-crack growth responsible for the failure of the structure. This second phase, which is mostly a surfacic phenomenon, also induces a well-known mesh-dependency issue, due to the softening behavior. Many authors have worked on this topic by proposing different localization limiters, among them we can cite [11, 8] who worked on non-local techniques, or [9, 10] who use the rate-dependency as a regularizing effect via the use of a viscosity parameter, or other authors that linked the mesh size to the softening parameters to ensure the objectivity of the solution [4, 1].

In this work, a coupled damage-plasticity version of Lemaitre's phenomenological model [7] has been implemented along with the strong discontinuity method to tackle the mesh dependency issue. The damage-plasticity model allows the representation of volumic phenomena occuring during the ductile fracture pre-peak phase. A one equation return-mapping algorithm [3] was used to implement Lemaitre's model, in which the damage variable remains scalar. On the other hand, the strong discontinuity method allows the modeling of surfacic phenomena occuring during the post-peak phase, by introducing a surface of discontinuity of displacements mainly linked to the apparition of localization bands and cohesive cracks. This softening cohesive law is responsible for the softening of the global response, and is considered as rigid-damageable. This method, based on the incompatible modes method [6], has demonstrated its regularizing capabilities in the brittle fracture framework [2]. In this work, we intend to attest its regularizing effects in the ductile fracture framework, and the results presented are promising with this regard. Developments were undertaken in both plane strain and axisymmetric frameworks. A four-node quadriletral element with embedded linear displacement jump was formulated [5] and implemented in an academic Finite Element solver. These numerical developments will be outlined. Only mode I fracture is considered for the introduction of the discontinuity and two different types of criterion are taken into account, a maximal principal stress criterion and a damage criterion. Some numerical examples, including a three-point bending test and a tensile test on a cylindrical notched specimen, will be presented to attest the capabilities of the method in terms of mesh dependency regularization and fracture modeling.

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