Initiation and crack growth with the Thick Level Set damage model coupled to the eXtended Finite Element Method

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ABSTRACT

Crack initiation relies mainly on damage mechanics whereas crack propagation relies on fracture mechanics involving displacement discontinuity across a propagating crack. We propose a new model bridging these two mechanisms. Damage is expressed in terms of an evolving level set. In the wake of the front (iso-zero of the level set) damage is directly related to the distance of the front with a function considered as a material data. The new model is coined Thick Level Set because not only the location of the iso-zero is useful but all values up to the critical distance (lc) beyond which the material is considered fully damaged (d=1). In the TLS model, the crack location is defined as the set of points located further than the critical distance to the front. The crack placement in the damage band is thus part of the model.

From a numerical point of view, once a crack appears in the simulation (appearance of an iso-lc), it is taken into account with the eXtended Finite Element Method: displacement are allowed to be discontinuous across the iso-lc through the use of an Heaviside enrichment (or several Heaviside enrichments in the case where the support is cut into several pieces). Because of this enrichment, the mesh may be coarsen away from the evolving damage zones.

Several numerical experiments in 2D and 3D quasi-static simulation of quasi-brittle failure will demonstrate the capabilities of the TLS regarding initiation, branching and propagation of cracks over long distances.

References

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