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3D crack propagation with X-FEM cohesive elements

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ABSTRACT

In case of brittle failure of metallic components or reinforced concrete structures, trajectories are often unknown in case of mixed mode loading. The X-FEM cohesive model presented in this talk will address the issues of crack bifurcation and crack advance.

A procedure in four steps is adopted: computation of the equilibrium state in the presence of cohesive forces with a given potential crack surface, detection of the updated crack front on the surface from the computed cohesive state, determination of bifurcation angles along the front, and update of the potential crack surface accordingly.

The cohesive model that is used [1] allows initial perfect adherence. It relies on the use of an XFEM-suited reduced space of Lagrange multipliers [2, 3], on the use of a mortar formulation to write the cohesive law from quantities defined over this space in an appropriate manner, and finally on a lumping strategy leading to blockwise diagonal operators.

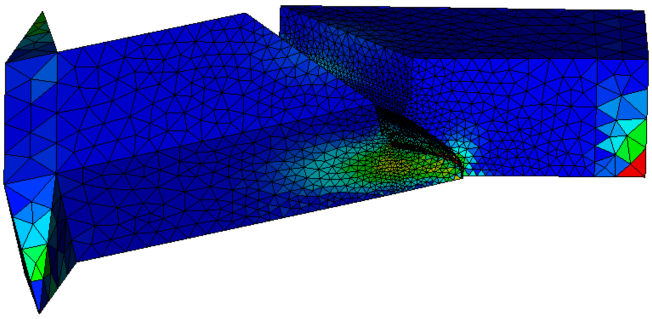

Figure 1: Complex crack propagation path for a concrete specimen under torsion.

The originality of the approach lies in the a posteriori computation of the crack advance speed that is naturally embedded in the cohesive model, while in most of the literature it is determined beforehand based on the stress state ahead of the front. A first rough updated crack front is computed from the internal variables of the cohesive law. This rough crack front is then converted into a smooth crack advance speed, itself converted back into a new smooth crack front location with the help of the level-set formalism.

The crack bifurcation angle is determined along the front, based on a criterion using the equivalent stress intensity factors. A new way of computing these equivalent stress intensity factors is suggested, from the cohesive fields exclusively. Then, the potential crack surface is updated accordingly based on an explicit level-set update algorithm [4].

Finally, several numerical tests have been carried out in mixed mode I and II to reproduce 3D non planar crack paths and showed good accordance with previous results from the literature.

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