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A comparative study on dynamic fracture with finite element methods

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ABSTRACT

This study addresses the question: how well can we predict dynamic fracture with current methods. Dynamic crack propagation is a difficult area in which to benchmark different methods because there are no analytical solutions which can readily be compared to numerical results. Therefore, we will make comparisons to experimental results and examine how well three of current methods reproduce various aspects of selected experiments. The three methods are:

The extended finite element method (XFEM): a methodology which can model arbitrary crack geometries in a finite element method without remeshing. It originated in Moes *et al.* [1]. The method can be viewed as a partition of unity method, but in fact, in the treatment of discontinuities by this method, a partition of unity is never constructed. Instead, a discontinuous function that only spans one element and vanishes at the edges is constructed.

The interelement crack method: a crack is modeled by separation along the element edges. Two approaches are used in the interelement crack method. In the original formulation of Xu and Needleman [2], all elements are separated from the beginning of the simulation. The edges are mechanically joined by cohesive laws. In the Ortiz and Camacho [3] approach, the cohesive zones are injected along edges only when a criterion is met or the element edges are contiguous to a crack tip.

The element deletion method: the one of the simplest methods which can simulate fracture problems within the framework of the conventional FEM without complicate modifications. There is no need to explicitly represent strong discontinuities in displacement fields since fractured elements are generically reflected by a set of elements in which the stress is set to zero.

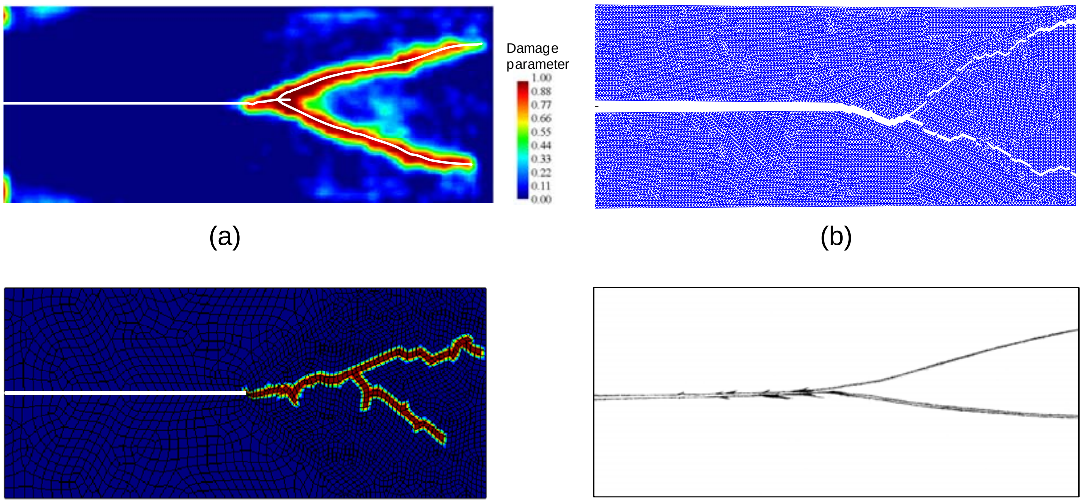

Figure 1. Comparison of the crack branching results with the experiment: results of (a) XFEM , (b) the interelement crack model, (c) the element deletion, and (d) a sketch of the experiment crack paths reported by Ramulu and Kobayashi [4].

We will show the prediction of dynamic fracture behavior even for the modest range of problems is still somewhat beyond current capabilities. The reasons for this do not lie only in the numerics, but in important gaps in our understanding of dynamic fracture processes and how to model them. In particular, it has become clear through the work of Ravi-Chandar and Knauss [5], and Sharon and Fineberg [6] that subscale processes play an important role in brittle fracture. These subscale processes are not modeled in any existing methods, so crack speed prediction is still not very accurate.

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