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ALTERNATIVE ASPECTS OF COHESIVE CRACK MODELING WITH MPM

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ABSTRACT

Recently, a decohesive model [1] has been developed with special attributes appropriate for modeling the initiation of failure for quasibrittle materials such as concrete and ice. In particular, the model provides a prediction for the orientation of the plane of failure that varies smoothly with the state of stress at failure and is in agreement with experimental data including splitting under uniaxial compression. This model has been used successfully with a smeared-crack algorithm in the material point method (MPM) with one recent application being that of large-scale lead (crack) formation in Arctic ice [2,3].

A limitation of the method is that cracks are represented only weakly in the sense that neither the crack path nor displacement discontinuity is continuous. However, in addition to computational simplicity, there are other important advantages of the model and the computational scheme. These advantages include: (1) a method involving rotation for choosing one orientation over another when the model predicts two orientations for planes of material failure, and (2) the capability to handle simultaneously two or more cracks with different orientations at a single material point.

The importance of the latter attribute is particularly appropriate in the study of the size effect related to the experimental determination of fracture energy as exhibited by the compact tension and three-point beam specimens. For each of these cases, it appears that states of equal biaxial tension may develop. Classical fracture criteria ignore the normal stress tangential to the failure plane. If compressive, such a stress is the dominant term causing axial splitting. The effect of a tensile contribution from such a term has either been ignored or incorporated through a “rotating crack” formulation.

However, there is another possibility that forms the core of this investigation and that is the second principal tensile stress may cause a distributed series of additional cracks to initiate that are oriented transversely to the primary crack. These secondary cracks do not develop to the point of complete opening but, rather, exist as short microcracks. The microcracks would close up when the stress reduces to zero and therefore may not be readily observable. The effect of such microcracks would be to provide an additional contribution to the fracture energy and to prevent unlimited growth of the tangential

tensile stress. Since the tensile stress is less than the fracture stress when the crack initiates and when the crack approaches a boundary, it is possible that these transverse microcracks might be viewed as the source of a size effect. Numerical results will be presented to explore the implications of this viewpoint.

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