A Unified Model for Tensile- and Shear-driven Dynamic Crack Propagation in Rocks

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Abstract

Transitions between separation, contact–stick, and contact–slip modes generate sharp discontinuities in stress and velocity fields. Capturing these sharp contact-mode transitions and response discontinuities presents a significant challenge to the numerical analyst. Any point on a fracture surface may undergo mode-I, mode-II, or mixed-mode crack propagation when dynamic fracture is incorporated, and many commonly used failure criteria are unsuitable for modeling all these propagation modes. For example, while the Mohr-Coulomb model is appropriate for mode-II crack propagation under a compressive stress state, it greatly overestimates the tensile strength of rocks.

We present an interfacial damage model for simulating dynamic contact-fracture in rock. In [1], we formulated an effective-stress model based on a Mohr-Coulomb failure criterion. Using a Weibull model for fracture strength [2], we were able to predict fracture patterns and crack angles observed in rock under dynamic compressive loading. However, the Mohr-Coulomb model predicts unrealistic results for hydraulic fracturing applications because it overestimates the tensile strength of rock. Therefore, we were forced to use a different failure criterion for modeling mode-I hydraulic fracture in our previous work; *e.g.*, [3]. In this work, we formulate a new effective-stress model that is consistent with more advanced failure criteria that accurately models both mode-I and mode-II fracture. We also describe how the new model captures contact-fracture mode transitions in hydraulic refracturing applications; *cf.* [3].

KEY WORDS: Mohr-Coulomb, failure criterion, rock, mixed-mode, dynamic, contact, stick–slip transition.

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