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Extraction of rate-dependent traction–separation relations

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ABSTRACT

Methods for characterizing and predicting crack growth in linearly or nonlinearly elastic materials are well established both theoretically and experimentally. However, fundamental work relating to fracture in polymers and other time dependent materials is relatively limited. Complexity in characterizing crack development, growth, and propagation in viscoelastic media stems from two different yet unique challenges. Firstly, typical energy-based methods, widely used in characterizing traction separation relationships in elastic media, are not applicable anymore because of inherent bulk energy dissipation, a characteristic of viscoelastic media. Furthermore, the load dependent response of viscoelastic materials makes it difficult to quantify any independent parameters which would be indicative of fracture process. For example, loss of stiffness at particular load level in an elastic body can be very well attributed to crack development/propagation, whereas the same cannot be hypothesized for a viscoelastic material. The primary objective of this study is to establish a theoretical framework for developing a simple experimental procedure aimed at quantifying traction–separation relations, a vital fracture parameter used in numerical modeling of cohesive or interfacial cracks in viscoelastic media. The procedure combines the pseudo strain concepts of Schapery with the field projection method of Kim to extract traction–separation relationships for both cohesive and adhesive cracks, without making any assumptions on their form. It was found that test problems for the interaction integrals could be chosen so as to greatly reduce the number of measurements that are required. Numerical experiments were carried out on two strips of polyvinyl acetate bonded together and conclusive results produced demonstrate the efficiency of the framework developed in this study.