Geometrically Nonlinear Materials as a Framework for Nonlinear Elastic Fracture Mechanics

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Abstract

Linear elastic fracture mechanics theory (LEFM) predicts that the speed of crack growth is limited by the Rayleigh wave speed. Although many experimental observations and numerical simulations have supported this prediction, some exceptions have raised questions about its validity. The underlying reasons for these discrepancies and the precise limiting speed of dynamic cracks remain unknown. Here we lay the foundations of a theory of nonlinear elastic fracture mechanics (NLEFM) to demonstrate that tensile (mode_˜I) cracks can exceed the Rayleigh wave speed and propagate at supershear speeds. We show that taking into account geometric non-linearities, inherent in most materials, is sufficient to enable such propagation modes. These geometric non-linearities modify the crack-tip singularity, resulting in different crack-tip opening displacements, cohesive zone behavior, and energy flows towards the crack tip.

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