On Crack Dynamics in Brittle Heterogeneous Materials

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Abstract

Natural variation, sub-structural features, heterogeneity and porosity make fracture modelling of wood and many other heterogeneous and cellular materials challenging. In this thesis, fracture in such complicated materials is simulated using phase field methods for fracture. Phase field methods have shown promise in simulations of complex geometries as well as dynamics and require few additional parameters; only the material toughness and a length parameter, determining the width of a regularised crack, are needed.

First, a dynamic phase field model is developed and validated against experiments performed on homogeneous brittle polymeric materials, wood fibre composites and polymeric materials with different hole patterns. Then, a high-resolution model of wood is developed and related to experiments, this time without considering fracture. Attention is finally focussed on high-resolution numerical analyses of fracture in wood and other cellular microstructures, considering both heterogeneity and relative density.

The phase field model is found to reproduce crack paths, velocities and energy release rates well in homogeneous samples both with and without holes. In more complicated heterogeneous and porous materials, the model is also able to simulate crack paths, but the interpretation of the length scale is complicated by the inherent lengths of the micro-structural geometry. In sum, the thesis points to possibilities with the proposed method, as well as limitations in our current understanding of both quasistatic and dynamic fracture of heterogeneous and cellular materials. The findings of this thesis can contribute to an improved understanding of fracture in such materials.

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