Phase-field modeling of brittle fracture in heterogeneous bars.

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Phase-field modeling of brittle fracture, first proposed by Bourdin et al. [1] as regularization of Francfort and Marigos variational approach to fracture mechanics [2], provides a remarkably flexible variational framework to describe the nucleation and propagation of cracks with arbitrarily complex geometries and topologies in two and three dimensions.

The approach is based on the assumption that the brittle material exhibits homogeneous elastic and fracture properties (fracture toughness). On the other hand, many brittle materials are characterized by strongly heterogeneous properties, one important category being biological tissues such as bones. Phase-field modeling of fracture in these tissues is particularly attractive due to their typically complex crack patterns, yet it requires the extension of the approach to the case of heterogeneous mechanical properties.

Previous studies addressing fracture in heterogenous materials have adopted a pragmatic approach, by simply substituting the constant fracture toughness of the original model with a fracture toughness depending on the material point [3]. However, the implications of heterogeneous material properties on the key predictions of the phase-field model have not been thoroughly investigated yet.

In this contribution, we perform such investigation for the one-dimensional case. We revisit the fundamental mathematical analysis in [3] by assuming that the material properties are heterogeneous with different possible profile shapes. Our main goal is to quantitatively assess how the heterogeneity in material properties influences the fracture toughness and the tensile strength of a one-dimensional bar.

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