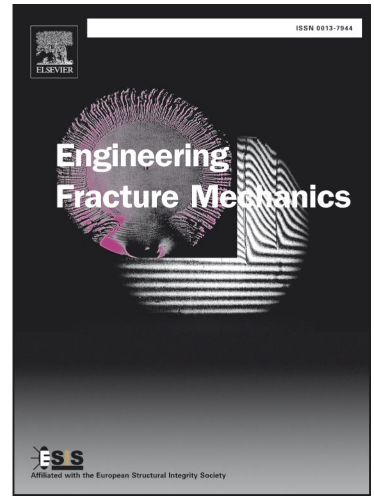

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A Modified Phase-Field Model for Quantitative Simulation of Crack Propagation in Single-Phase and Multi-Phase Materials

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Abstract

A quantitative phase-field model based on the regularized formulation of Griffith's theory is presented for crack propagation in homogenous and heterogeneous brittle materials. This model utilizes correction parameters in the total free energy functional and mechanical equilibrium equation in the diffusive crack area to ensure that the maximum stress in front of the crack tip is equal to the stress predicted by classical fracture mechanics. Also, unlike other phase-field models, the effect of material strength on crack nucleation and propagation was considered independent of the regularization parameter. The accuracy of the model was benchmarked in two ways. First, the stress and strain fields around the crack tip in single-phase ZrB_2 were compared with the analytical solutions in classical linear elastic fracture mechanics. Second, the crack path and force-displacement responses were examined against experimental results for concrete in the form of fracture of L-shaped plates and wedge splitting tests. To demonstrate the capability of the model in multi-phase materials, crack propagation was simulated for laminates composed of alternating layers of ZrB_2 and carbon plus ZrB_2. The results showed that the proposed modifications in the phase-field model were necessary to predict crack deflection along carbon layers similar to the experimental observations.

Keywords Phase-field model, brittle fracture, crack propagation, multi-phase materials, ZrB_2-C composite ceramics.

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