Topology optimization for maximizing the fracture resistance of quasi-brittle composites

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We propose a topology optimization framework for optimizing the fracture resistance of two-phase composites through a redistribution of the inclusion phases [1,2]. A phase field method [3] for fracture able to take into account initiation, propagation and interactions of complex microcracks networks is adopted. This formulation avoids the burden of remeshing problems during crack propagation and is well adapted to topology optimization purpose. An efficient design sensitivity analysis is performed by using the adjoint method, and the optimization problem is solved by an extended bi-directional evolutionary structural optimization (BESO) method. The sensitivity formulation accounts for the whole fracturing process involving cracks nucleation, propagation and interaction, either from the interfaces and then through the solid phases, or the opposite. The spatial distribution of material phases are optimally designed using the extended BESO method to improve the fractural resistance. We demonstrate through several examples that the fracture resistance of the composite can be significantly increased at constant volume fraction of inclusions by the topology optimization process.

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