

Microstructure-informed fracture modeling of open porous materials

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Abstract

The fracture behavior of open-porous materials is strongly influenced by the interaction between microstructural architecture and crack propagation mechanism, requiring systematic analysis for reliable use in structural, biomedical, and thermal insulation applications. This work presents a computational framework based on Laguerre–Voronoi tessellation to model the cellular morphology of open-porous solids. Predicted fracture toughness values agree well with experimental data reported in the literature, confirming the ability of Voronoi-based microstructures to capture established power laws while reflecting microstructural heterogeneity. A parametric study varying solid fraction, pore-size, pore-wall thickness, and crack geometry reveals a strong sensitivity of crack propagation and energy dissipation to microstructural features. These results highlight the potential of microstructure-informed design strategies to tailor fracture resistance in porous materials.

Keywords:

Open porous materials Pore size distribution Solid fraction Voronoi tessellation Fracture toughness Crack geometry