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A 3D two-scale multiplane cohesive-zone model for mixed-mode fracture with finite dilation

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Abstract

A 3D multi-scale cohesive-zone model (CZM) combining friction and finite dilation by a multi-plane approach (M-CZM), based on the concept of Representative Multiplane Element (RME), is developed within the mechanics of generalized continua for the analysis of mixed-mode fracture.

The proposed M-CZM formulation captures the increase of measured fracture energy in mode II as a natural effect of multi-scale coupling between cohesion, friction and interlocking, employing a reduced set of micromechanical parameters characterized by a well-defined micromechanical interpretation. This permits to devise clear calibration and identification procedures for 3D fracture problems.

Upon assessing the retrieval, by a regular 5-plane RME, of a quasi-isotropic response for fracture resistance and for dilation the M-CZM is employed in FEM simulations of Double-Cantilever Beam (DCB) tests to obtain predictions of mixed mode I-II and mixed mode I-III fracture resistance.

The DCB analyses show the key role of the characteristic height of asperities in determining the macroscopic fracture resistance in both mixed mode I-II and I-III interactions. Numerical results also show the independence of the mode-I fracture resistance on the geometry of the beam section and a marked dependence of the measured mixed-mode fracture resistance on the section aspect ratio.

Keywords: three-dimensional cohesive-zone model; interlocking; finite dilation; mixed-mode delamination; damage-friction coupling.

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