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The Influence of Through-Thickness Reinforcement Geometry and Pattern on Delamination of Fiber-Reinforced Composites: Part II - Modeling

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Abstract

This article reports modeling techniques and results based on experimental Mode I characterization of a layered woven GFRP material with tufting reinforcement. Standard tuft and loop-less geometries are investigated on three different areal patterns to evaluate their effects on fracture resistance. The experiments reveal that tow/ply and tuft bridging phenomena are present during delamination. The numerical modeling comprises cohesive elements for tow/ply bridging and 1D connector elements for discrete tufts. The traction separation relations for the cohesive model are acquired using an inverse scheme based on strain measurements and force-separation relations of tuft's failure mechanisms from uniaxial pulling tests on a reference tufting pattern. Results show that tuft's failure mechanism is strongly affected by tufting pattern while tow/ply bridging contributes 20-30% of the overall fracture energy. The energy absorbed by pull-out of loop-less tufts is approximately twice the fracture energy of standard ones with pull-out triggering much more extensive tow/ply bridging phenomena.

Keywords: Composite materials; Fracture resistance; Through-thickness reinforcement (TTR); Tufting; Traction Separation Relations; Cohesive zone modeling;

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