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Damage Initiation in Unidirectional Fiber Composites with Different Degrees of Nonuniform Fiber Distribution

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Abstract

This paper reports a study of the initiation of the first failure event in unidirectional composites subjected to transverse tension. Two energy based point failure criteria – critical dilatational energy density and critical distortional energy density – are considered. The manufacturing induced disorder in the fiber distribution in the composite cross section is described in terms of the degree of nonuniformity, which is quantified and for which an algorithm is developed. The nonuniformity is captured in a representative volume element (RVE) whose minimum size is determined based on statistics of nearest fiber distance distribution. Several realizations of the RVE for three fiber volume fractions and three degrees of nonuniformity are analyzed using a finite element model. A parametric study of the effect of matrix/fiber stiffness ratio on the damage initiation is also conducted. Significant effects of the fiber distribution nonuniformity on the strain to onset of damage are found.

Keywords: Polymer-matrix composites (PMCs); Damage mechanics; Finite element analysis (FEA); Nonuniform fiber distribution.