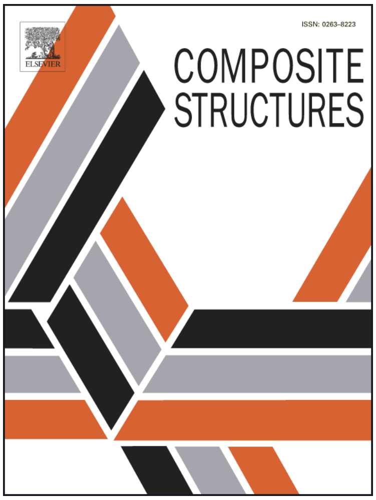

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Formulation of a Consistent Pressure-Dependent Damage Model with Fracture Energy as Input

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Abstract

Micromechanical simulation of composite material failure requires a pressure-dependent failure model for the polymeric matrix. Available pressure-dependent damage formulations assume a certain shape of the stress-strain law under uniaxial loading. However, upon close inspection none of the available formulations is able to reproduce the assumed shape. This implies that input values for the fracture energy cannot be recovered exactly.

In this paper, a new methodology for developing consistent pressure-dependent damage models for polymeric materials is presented. Using this method the predefined shape of the stress-strain relation of an element with localized deformation under uniaxial tension can be exactly reproduced which enables further to recover the exact amount of energy dissipation consistent with the input toughness. The methodology is demonstrated for two different softening laws, namely linear and exponential softening. These models are applied to the damage analysis of unidirectional continuous fiber-reinforced composites. The formulation is validated by simulation of a test for Mode-I fracture energy characterization and comparing the load-displacement response with that obtained with cohesive elements.

Keywords: pressure-dependent damage, fracture energy, micromechanics, composites, polymers.

1. Introduction

Progressive failure of composite structures is a multi-scale phenomenon which can be investigated in various length scales from micro-scale to macro-scale. The appeal of micromechanical analysis lies in the concept that the complex behavior of the composites is characterized based on the behavior of the relatively simple constituents and the interaction between these phases in the microstructural geometry. This approach relies on the accuracy of the constitutive models assigned to each constituent and the representativeness of the chosen microstructure. Consequently, it is necessary to develop realistic constitutive models for fiber, matrix and interface. The polymer matrix material is particularly relevant, because