Micro-scale progressive damage development in polymer composites under longitudinal loading

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Micro-scale progressive damage development in polymer composites under longitudinal loading

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Abstract

A detailed investigation of micro–scale damage development in uni-directional polymer composites under longitudinal loading (loading along the fiber-direction) has been presented in the current work. Three major damage modes have been considered, namely, matrix damage, fiber–matrix interface debonding and multiple fiber fragmentation. The development and progression of these damage modes and their effect on the overall stress–strain response of the uni-directional fiber reinforced plastic (UD-FRP) is of interest. From the study, it has been demonstrated that the dimensions of the three dimensional repeating unit cell (3D–RUC) needed to generate repeatable results are inherently dependent on the fiber volume fractions. The length of 3D-RUC is longer for a higher fiber volume fractions. In addition, the physics of fiber fragmentation is inherently linked to the proximity of other fibers triggering failure mechanics different from the single fiber fragmentation behavior. Stochastic fiber fragmentation characteristics have also been studied by quantifying the effect of Weibull parameters on overall response of the micro-structure.

Keywords: Damage analysis, longitudinal loading, UD-FRPs, Weibull statistics, 3D-RUCs

1. Introduction

Due to hierarchical material micro-structure and presence of multiple phases, composites exhibit complex failure mechanisms such as matrix cracking, fiber-matrix debonding, fiber breakage, fiber pull-outs, delaminations etc. that occur at multiple length scales [1–4] Additional complexities arise due to spatial randomness and stochastic strength of individual material phases in a composite

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