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Stochastic Characterization for Micromechanical Properties of Polymer Matrix

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Abstract

A stochastic characterization method was presented that can micromechanically derive stochastic information about spatially varying local matrix properties of fiber-reinforced composite lamina. The statistical information (mean, variance, covariance and correlation length) of the random matrix properties was used to generate statistically equivalent distributions of matrix properties. For reliable design and use of materials, accurate characterization of materials and structures are required. Traditionally, averaged effective properties with considerations of constituent volume fractions, properties of different material constituents and a simplification of the microstructure have been assumed for large selection of macro-scale material samples. However, initiations and evolutions of many critical damage phenomena in materials are closely linked to local stresses that can be associated with local variations and features in the material microstructure. Close observations of microscopic material features reveal significant heterogeneities in various forms such as inclusions, pores, local flaws, microcracks, and in random variations of local residual stresses and diffusivities for moisture ingress. For fiber reinforced polymer matrix composites and ceramic matrix composites, these heterogeneities are mainly caused by random fiber distributions, manufacturing process and damaging process of material properties under uncertain loadings. Therefore, under different potential combinations of these causes of heterogeneities, the matrix material has spatially varying gradients of local stiffness, strength properties and physical damage variables. The effects of the microstructure variability on transverse strength of the lamina can be evaluated by using sophisticated damage models.