Transverse shear modulus of unidirectional composites with voids estimated by the multiple-cells model

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Transverse shear modulus of unidirectional composites with voids estimated by the multiple-cells model

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Abstract

Voids are inevitably formed as a by-product during manufacturing processes of composite materials and affect many of its mechanical properties including the transverse shear modulus. Although several analytical and empirical models are available for transverse shear modulus, they are based on simple assumptions, and none of them consider the effect of voids. In this work, we estimate transverse shear modulus through a finite element model that uses multiple-cells and three-dimensional analysis. The effect of voids on the transverse shear modulus is studied through a design of experiment approach via three primary parameters: fiber-to-matrix Young's moduli ratio, fiber volume fraction, and void volume fraction. The results indicate that for allowable void volume fractions, the transverse shear modulus can decrease by as much as 15%, while the fiber volume fraction is the most dominating factor of the three in influencing its value.

Keywords

A. Polymer-matrix composites (PMCs)

B. Defects

B. Mechanical properties

C. Finite element analysis (FEA)

1. Introduction

Composite materials are becoming ubiquitous in the world of materials where weight reduction is paramount in decreasing capital and maintenance costs. To analyze and design structures made of composites, one needs to accurately estimate the nine independent elastic moduli (orthotropic) of the unidirectional composite lamina. Theoretically, when the fiber distribution is random with a uniform probability distribution, one can assume that the lamina is transversely isotropic and hence needing only five independent elastic moduli [1]. One of the five elastic moduli is the transverse shear modulus,