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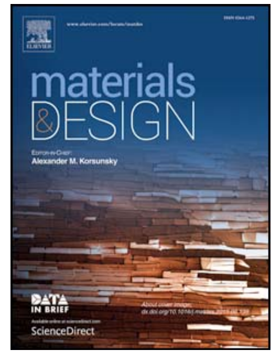

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Bijan Mohammadi, Hamed Pakdel

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Fatigue driven matrix crack propagation in laminated composites

Bijan Mohammadi*, Hamed Pakdel

School of Mechanical Engineering, Iran University of Science and Technology, Tehran, Iran

Abstract

An energy based evolution rule is developed to predict the propagation of mid and outer-ply matrix cracks in laminates with the layups of $[0_n/\theta_m]_s$ and $[\theta_m/0_n]_s$ subject to tensile fatigue loading from initiation up to saturation. A unit cell based variational approach is developed to model the damage state considering both crack density and distribution pattern. Crack densities for different layups are then predicted using only two unit effective material properties which are independent from geometry of laminate. Numerous specimens with 8 different layups are tested and during tensile fatigue loading, matrix cracks multiplication are monitored on site using an appropriate optical microscopy setup. Both material properties of Paris like evolution equation are derived based on experimental observations of crack density in two general layups. Analytically predicted crack densities of tested specimens are shown to be in agreement with experimental observations which confirms empirical parameters to be independent from layup in the tested carbon-epoxy specimens. The independence of the empirical parameters from layup and loading must be validated using extensive experimental results of different layups and materials considering different modes of damage.

Keywords: Matrix cracking, Fatigue, Critical energy release rate, Characteristic damage state, Matrix crack detection

*Corresponding author, Associate Professor
Email address: Bijan_Mohammadi@iust.ac.ir (Bijan Mohammadi)