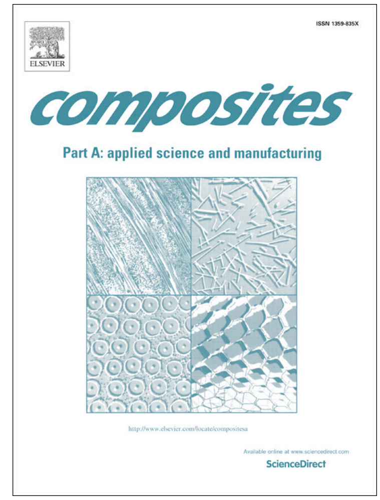
Accepted Manuscript



Theory of Variational Stress Transfer in General Symmetric Composite Laminates Containing Non-Uniformly Spaced Ply Cracks

M. Hajikazemi, L.N. McCartney, W. Van Paepegem, M.H. Sadr

PII: S1359-835X(18)30021-6
DOI: https://doi.org/10.1016/j.compositesa.2018.01.021
Reference: JCOMA 4902

To appear in: *Composites: Part A*

Received Date: 16 June 2017
Revised Date: 11 January 2018
Accepted Date: 18 January 2018

Theory of Variational Stress Transfer in General Symmetric Composite Laminates Containing Non-Uniformly Spaced Ply Cracks

M. Hajikazemi[1*], L.N. McCartney[2], W. Van Paepegem[1], M.H. Sadr[3]

[1]*Department of Materials, Textiles and Chemical Engineering, Faculty of Engineering and Architecture, Ghent University, Technologiepark Zwijnaarde 903, Ghent, Belgium*

[2]*Department of Engineering, Materials & Electrical Science, National Physical Laboratory, Teddington, Middlesex, TW11 0LW, UK*

[3]*Aerospace Engineering Department, Amirkabir University of Technology, Tehran, Iran*

Abstract

Ply cracking is an inherently stochastic process due to the random variability of local material properties of the plies. Such randomness in microstructure and in failure evolution generally leads to non-uniform distributions of ply cracks. Modeling this non-uniformity is a crucial factor in predicting the initiation and propagation of matrix cracks. Therefore, a novel stress-based variational model is developed to accurately predict stress transfer and stiffness reduction in general symmetric laminates containing non-uniformly spaced ply cracks. In contrast to available approaches for uniformly spaced ply cracks based on the unit cell, the analysis is carried out for the entire laminate. Results derived from the developed method for thermo-elastic properties of the cracked laminates show an excellent agreement with finite element results. Moreover, the accuracy of predictions based on an approximate approach is discussed using a comprehensive analysis of various laminates and crack patterns for both carbon and glass fibre systems.

Keywords

A. Laminates; B. Transverse cracking; C. Semi-analytical modelling; C. Micro-mechanics

1. Introduction

Ply cracking in laminates subject to static or fatigue mechanical and thermal loading, is the initial and most typical ply-level failure phenomenon resulting from the coalescence of micro-damage. Ply cracks (also known as matrix cracks, transverse cracks, intra-laminar cracks, inclined cracks, etc.) are orthogonal to the laminate mid-plane, run parallel to fibers in the ply and usually cover the whole thickness and width of the ply in the specimen. In both standard and thin-ply composite laminates subject to fatigue loading, damage tolerance can be assured only if

*Corresponding author. Tell: +32 479 65 98 75, E-mail address: Mohammad.Hajikazemi@ugent.be