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Prediction of the crack density evolution in multidirectional laminates under fatigue loading

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Abstract

An innovative procedure is proposed for the prediction of the crack density evolution in multidirectional laminates subjected to cyclic loading. The crack initiation and propagation phases are treated separately and described by means of a master S-N curve and a Paris-like curve, respectively. A damage-based multiscale strategy is adopted for the prediction of multiple crack initiation, accounting for the statistical distribution of fatigue strength and crack propagation resistance within a ply. The procedure has been implemented in a Matlab[®] code for the simulation of the fatigue damage evolution in multi-directional symmetric laminates. Comparisons with experimental results taken from previous works show a very good agreement.

List of symbols

a	Exponent of S-N curve equation
a_{LHS}	Exponent of the S-N curve under LHS-driven stress state
a_{LMPS}	Exponent of the S-N curve under LMPS-driven stress state
c	Crack length
C, C_{tot}, C_I	Coefficients of the CGR-ERR curve
c_0	Length of crack initiation process zone
CGR	Crack Growth Rate
D	Damage parameter
d, d_I, d_{tot}	Exponent of the Paris-like curve
E_1, E_2, E_3	Ply elastic moduli
ERR	Energy Release Rate
G_{12}, G_{23}, G_{31}	Ply shear moduli
G_{eq}	Equivalent ERR
$G_{eq,c}$	Critical value of G_{eq}
$G_{eq,th}$	Threshold value of G_{eq}
G_I	Mode I component of ERR
G_{II}	Mode II component of ERR
G_{ss}	Steady state ERR
G_{tot}	Total ERR (G_I+G_{II})

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