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Abstract

This work is focused on an adaptation of a continuum mixed mode I + II damage model which allows to simulate different paths of crack propagation as well as two-dimensional fracture process zone (FPZ) in adhesively bonded joints. A continuum mixed mode I + II damage model based on the exponential damage evolution with the B - K law is proposed in order to account for the nonlinear property of damage evolution in adhesively bonded joints and the elastic-plastic hardnening inherent to ductile adhesives. The current model is validated by comparison of simulation results of several types of single lap joint (SLJ) predicted using ABAQUS UMAT with the experimental and numerical results published in previous literature. Furthermore, the performance of the proposed model is examined by comparison with some previous models including the ABAQUS cohesive zone model, the virtual crack closure technique and the extended finite element method. Moreover, the effect of adhesive end fillet on the load carrying capacity and the fracture mode of the single lap joints are studied. It should be noted that two-dimensional plane stress and plane strain finite element analysis is preformed throughout this work. The application of the proposed model enables the simulation of a non-symmetric crack propagation path and the fracture process zone in adhesive bonded joints.

Key words: Adhesively bonded joint; Single lap joint; Continuum damage model; Mixed mode damage model; B - K law

Nomenclature

T_n	cohesive normal traction
T_s	cohesive shear traction
$\mathbf{K},\mathbf{C}$	linear elastic stiffness matrix
E	Young's modulus
G	shear modulus
h	adhesive thickness
δ_n	normal separation
δ_s	shear separation
i	subscript/ I, II mode
m	subscript/ I + II mixed - mode
$\sigma_{\max}$	maximum normal stress
σ_i	stress $(i = I, II)$
$\sigma_{u,i}$	material critical stress $(i = I, II)$
σ_{eI} , σ_{eII}	stress at damage onset
$\varepsilon_{u,i}$	failure strain $(i = I, II)$
l_c	element characteristic length
d_i	pure mode damage parameter
d_m	mixed mode damage parameter
n	material parameter
α	material parameter
β_d , β_s	mixity ratio parameter
η	B - K law parameter
δ	separation/displacement
$\delta_i^{\max}$	current maximum separation $(i = I, II)$