

## Author's Accepted Manuscript

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PREDICTION OF FRACTURE  
CHARACTERISTICS IN ADHESIVELY  
BONDED JOINT

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PII: S0143-7496(17)30192-6  
DOI: <https://doi.org/10.1016/j.ijadhadh.2017.10.008>  
Reference: JAAD2074

To appear in: *International Journal of Adhesion and Adhesives*

Received date: 22 December 2016

Accepted date: 15 October 2017

Cite this article as: Myong-Ho Kim and Hyon-Sik Hong, AN ADAPTATION OF MIXED-MODE I + II CONTINUUM DAMAGE MODEL FOR PREDICTION OF FRACTURE CHARACTERISTICS IN ADHESIVELY BONDED JOINT, *International Journal of Adhesion and Adhesives*, <https://doi.org/10.1016/j.ijadhadh.2017.10.008>

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# AN ADAPTATION OF MIXED-MODE I + II CONTINUUM DAMAGE MODEL FOR PREDICTION OF FRACTURE CHARACTERISTICS IN ADHESIVELY BONDED JOINT

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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 hardening 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 performed 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	$\sigma_{u,i}$	material critical stress ( $i = I, II$ )
$T_s$	cohesive shear traction	$\sigma_{el}, \sigma_{ell}$	stress at damage onset
$\mathbf{K}, \mathbf{C}$	linear elastic stiffness matrix	$\varepsilon_{u,i}$	failure strain ( $i = I, II$ )
$E$	Young's modulus	$l_c$	element characteristic length
$G$	shear modulus	$d_i$	pure mode damage parameter
$h$	adhesive thickness	$d_m$	mixed mode damage parameter
$\delta_n$	normal separation	$n$	material parameter
$\delta_s$	shear separation	$\alpha$	material parameter
$i$	subscript/ I, II mode	$\beta_d, \beta_s$	mixity ratio parameter
$m$	subscript/ I + II mixed - mode	$\eta$	B - K law parameter
$\sigma_{\max}$	maximum normal stress	$\delta$	separation/displacement
$\sigma_i$	stress ( $i = I, II$ )	$\delta_i^{\max}$	current maximum separation ( $i = I, II$ )

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