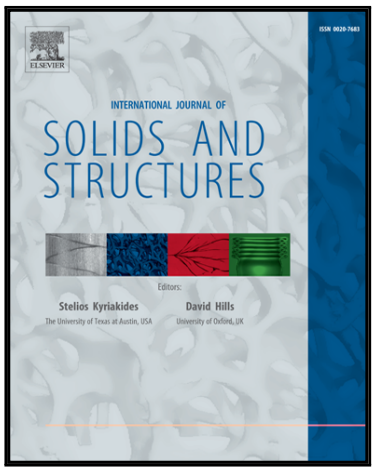

Closed-form Solutions for Cohesive Zone Modeling of Delamination Toughness Tests

Jiawen Xie, Anthony M. Waas, Mostafa Rassaian

PII: S0020-7683(15)00525-9
DOI: 10.1016/j.ijsolstr.2015.12.025
Reference: SAS 9006

To appear in: *International Journal of Solids and Structures*

Received date: 21 July 2015
Revised date: 3 December 2015
Accepted date: 19 December 2015

Please cite this article as: Jiawen Xie, Anthony M. Waas, Mostafa Rassaian, Closed-form Solutions for Cohesive Zone Modeling of Delamination Toughness Tests, *International Journal of Solids and Structures* (2015), doi: 10.1016/j.ijsolstr.2015.12.025

Closed-form Solutions for Cohesive Zone Modeling of Delamination Toughness Tests

Jiawen Xie[a], Anthony M. Waas[b,*], Mostafa Rassaian[c]

[a] *Dept. of Aerospace Engineering, University of Michigan, Ann Arbor, MI 48109-2140*
[b] *William E. Boeing Dept. of Aeronautics and Astronautics, University of Washington, Seattle, WA 98195-2400*
[c] *Boeing Company, Seattle, WA, 98124*

Abstract

Closed-form solutions for cohesive zone modeling within the framework of classical lamination theory (CLT), for the popular mode I double cantilever beam (DCB) test, the mode II end notched flexure (ENF) test and mixed-mode I/II bending (MMB) test are provided in this paper. Zero-thickness virtual multi-linear traction-separation laws are introduced to simulate the cohesive interactions between potential crack surfaces. The problem is formulated by solution forms corresponding to each segment of the cohesive laws and using appropriate boundary and continuity conditions. Detailed algorithms for each case are provided to clearly show the influence of the cohesive zone law on the ensuing crack growth. The superposition method used for mixed-mode growth in the MMB test for homogenous material or mid-plane symmetric laminates is proved both theoretically and numerically. Comprehensive parametric studies are performed on the crack growth response and the process zone length, revealing their relations to the delamination length, cohesive parameters, the shape of the traction-separation laws and the mode mixity. With applicability to general multilayered structures, and the capability to incorporate arbitrary, piecewise linear cohesive constitutive laws, the closed-form solutions can serve as a tool to determine the accuracy of numerical solutions used in conjunction

*Corresponding author
Email addresses: jwxie@umich.edu (Jiawen Xie), awaas@aa.washington.edu (Anthony M. Waas), mostafa.rassaian@boeing.com (Mostafa Rassaian)