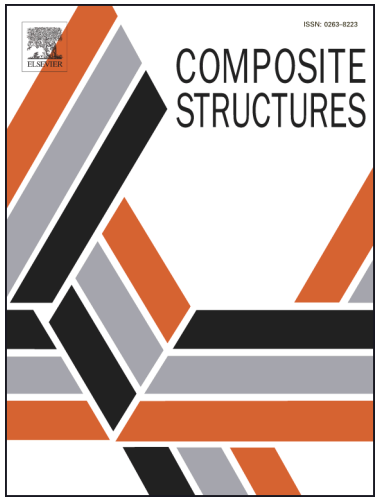

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Fang Jiang, Wenbin Yu

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Damage Analysis by Physically Nonlinear Composite Beam Theory

Fang Jiang[1,*], Wenbin Yu[2]

Purdue University, West Lafayette, IN 47907-2045, USA

Abstract

Damaging constitutive models are incorporated into the variational asymptotic beam sectional analysis method (VABS). Under the governing of the virtual work principle, Newton's method is applied to solve for the finite cross-sectional warping field and the damage variables according to continuum damage mechanics models from the literature. These solutions result in mesh-insensitive predictions of the damaged beam stiffness and three-dimensional stress and strain fields in the damaged state. The present theory is implemented using the finite element method to capture the high-fidelity elastic-to-damaged beam constitutive behaviors by the cross-sectional analyses. The predicted beam constitutive relations and local fields are compared with results from finite element analyses (FEA) using solid elements and plate elements, and experiments.

Keywords: Composite beam, Continuum damage mechanics, Free-edge effect, Laminate, Variational asymptotic method, VABS

1. Introduction

Beams possess a unique geometric feature, the slenderness, that is, one of its dimensions is much larger than the other two. Such type of structures historically found board applications (an early example dates back to the 16th

*Corresponding author

Email address: f.fang.jiang@gmail.com (Fang Jiang)

[1]Graduate Research Assistant, School of Aeronautics and Astronautics. Currently, Engineer at the Cooper Tire and Rubber Company.

[2]Associate Professor, School of Aeronautics and Astronautics.