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Title: Cohesive Fracture of Multilayered Beams Through a Homogenized Structural Theory

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Laminated and sandwich beams are being used frequently as structural components for applications in aggressive environments and under severe mechanical loadings. Due to the high interfacial tractions, multilayered systems are prone to delaminate. Delamination fracture in composite laminates may be studied through numerical tools by discretizing the domain in the in-plane and thickness directions and using cohesive-interface elements. The computational cost of this method depends on the discretization and may be very high for systems with many layers. This work proposes a novel homogenized approach for studying cohesive delamination fracture which avoids the through thickness discretization. The approach uses the multiscale structural model formulated in [1] for beams and plates with damaged interfaces which is based on the original theory in [2] for fully bonded plates. The model assumes a two-length scales zigzag displacement field described by global variables (first-order shear deformation theory) and local perturbations to account for discontinuities of the properties and interfacial displacement jumps. A homogenization technique is used to define the local variables as functions of the global variables so that the number of unknowns becomes independent of the number of layers and equal to that of the global model. Homogenized equilibrium equations and boundary conditions are obtained in terms of the global variables only, using the Principle of Virtual Work. In this work, the capabilities of the homogenized model to efficiently study mode II delamination cohesive fracture in delamination specimens are investigated. Different cohesive-traction laws are considered to examine different nonlinear fracture mechanisms. For bilinear cohesive laws, the structure is discretized only through the length, into regions separated by the cross sections at the traction-free and cohesive zone tips. These sections are initially unknown and are determined through an iterative solution process. The homogenized governing equations for the different regions are solved in closed-form and continuity and boundary conditions are imposed to obtain the solution. The fracture parameters are calculated and compared with solutions in the literature to assess the accuracy and reveal advantages and limitations of the approach. Acknowledgment Support by the U.S. Office of Naval Research no. N00014-14-1-0254 is acknowledged.
References [1] Massabò R., Campi F. An efficient approach for multilayered beams and wide plates with imperfect interfaces and delaminations, Compos. Struct. 2014;116:311-324. [2] Di Sciuva M. Bending, vibration and buckling of simply supported thick multilayered orthotropic plates: an evaluation of a new displacement model, J. Sound Vibration 1986;105:425–442.