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Dynamic modeling of interacting damage mechanisms in laminated composite plates using partition-of-unity

A. Ahmed[1,2*] **and L.J. Sluys**[2†]
[1] Department of Civil Engineering, N-W.F.P University of Engineering & Technology Peshawar, Pakistan
[2] Faculty of Civil Engineering and Geosciences, Delft University of Technology, The Netherlands
PO Box 5048, 2600 GA Delft, The Netherlands.
[*] A. Ahmed@tudelft.nl, [†] L.J.Sluys@tudelft.nl

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ABSTRACT

A mesoscopic, geometrically and physically nonlinear finite element model based on solid-like shell elements is presented for the simulation of impact damage in laminated composite plates. The impact on these structures causes significant damage in terms of matrix cracking (intraply damage) and delamination (interply damage). The aim of the manuscript is to highlight the numerical aspects of modeling the coupled response of interacting interply and intraply damage under dynamic loading conditions using the partition-of-unity method.

To model matrix cracking a discontinuous solid-like shell element (DSLS) [1] is utilized. A partition-of-unity approach is exploited to incorporate the discontinuity in the shell mid-surface, shell director and internal stretching field. This enables the element to model arbitrary propagating cracks through the finite element mesh of solid-like shell elements. To model delamination phenomena, a shell interface model is developed. The model allows computationally efficient simulation of delamination and evaluation of a consistently linearized tangent for large deformation problems.

In addition, the performance of partition-of-unity based methods such as the extended finite element method (XFEM) is discussed for the simulation of cohesive cracking using linear solid elements or solid-like shell elements. It is discussed that an XFEM approximation of the displacement jump across the crack may result in an error in the approximation of the displacement jump field and an un-desirable rotation of the interface. Moreover, the paper addresses computational issues related to rate-dependent cohesive crack propagation in laminated composite plates. Illustrative numerical examples are presented to simulate dynamic failure in laminated composite plates and to highlight the salient features of the model.

REFERENCES

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