

# EFFICIENT MODELLING OF DELAMINATION INITIATION AND PROPAGATION IN LARGE STRUCTURES

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It is well known that the mechanical response of laminated composite materials is greatly affected by out-of-plane failures. The traditional numerical modelling of these interface cracks, where each ply is discretized separately, leads to an unbearable computational cost for large structures. The present work outlines a method for the efficient modelling of delamination initiation and propagation under dynamic loading conditions. The crack initiation is detected, in an unrefined state, by the mean of a Stress Recovery method for arbitrarily curved laminates [1]. Where necessary, the model is refined through an adaptive strategy to kinematically describe the interface discontinuity [2, 3]. The delamination propagation is determined by the Virtual Crack Closure Technique to which an energy dissipation mechanism has been added. The resulting model is efficient as it allows the use of large elements and therefore also a large stable time step in explicit analysis. It also demonstrates similar accuracy compared to the traditional cohesive approach.

## References

- [1] P.M. Daniel, J. Främby, M. Fagerström and P. Maimí (2020) Complete transverse stress recovery model for linear shell elements in arbitrarily curved laminates. *Composite Structures*, **252**, 112675.
- [2] J. Främby, M. Fagerström and J. Karlsson (2020) An adaptive shell element for explicit dynamic analysis of failure in laminated composites Part 1: Adaptive kinematics and numerical implementation. *Engineering Fracture Mechanics*, **240**, 107288.
- [3] J. Främby and M. Fagerström (2021) An adaptive shell element for explicit dynamic analysis of failure in laminated composites Part 2: Progressive failure and model validation. *Engineering Fracture Mechanics*, **244**, 107364.