A homogenized approach for delamination fracture in layered beams

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Delamination fracture in layered structures is a major design concern which is typically modelled through discretization of the domain in the in-plane and through-thickness directions and using cohesive interfaces. Recently, an approach based on a homogenized treatment of the problem was proposed in [1]; the approach uses a multiscale structural model formulated in [2] for plates with imperfect interfaces, to avoid through thickness discretization. The model couples a first-order equivalent single-layer theory (global scale) and a discrete-layer cohesive-interface model (local scale) using a homogenization technique based on the imposition of the continuity of the interfacial tractions. The homogenized field equations then depend on a number of unknown variables which is independent of the number of layers and delaminations and equal to that of the equivalent single-layer theory.

For a preliminary validation of the homogenized approach for studying delamination problems, the brittle fracture of an edge-cracked homogeneous and orthotropic layer subjected to end forces and under mode II dominant conditions was considered in [1]. A cohesive interface was first introduced along the crack line which divides the geometry into two sub-layers. The multiscale structural theory was then used to homogenize and analyse the cracked and intact portions of the layer and the energy release rate was derived through an application of the J-integral using the local fields calculated by the multiscale model. It was shown that the explicit expression of the energy release rate, in terms of force and moment resultants and end rotations, coincides with the classical solution of the problem, where the relative rotations of the beam arms at the crack tip, or root-rotations, are neglected. The solution was then applied to study delamination growth in a mode II fracture specimen. In this work, to shed more light on the range of validity of the homogenized approach, we first extend the previous work in [1] to bi-material plates where zigzag enrichments of the displacements are included in the small-scale description of the problem and then apply the homogenized model to study mixed-mode fracture problems. The model will be applied to analyse delamination specimens and the results compared with accurate 2D solutions to assess the predictive capabilities and limitations of the homogenized approach. The accuracy of the multiscale structural model in predicting interfacial cohesive tractions and relative displacements, which could be important for cohesive crack modelling, is also under investigation and results will be presented at the meeting.

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References

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