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FRACTURE MODELING OF COMPOSITE LAMINATES BASED ON PHASE FIELD DAMAGE EVOLUTION IN SHELL KINEMATICS

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Through-the-thickness crack formation in thin-walled composite structures is dealt with in this paper. The underlying shell model model to this problem comprises the representation of continuous deformation, represented by mid–surface placement, director and through–the–thickness inhomogeneous fields. Typically, through-the-thickness fracture is handled via XFEM enhancements combined with cohesive zone modeling of the shell model, cf. e.g. Larsson et al. [1]; however, in order to alleviate the complexity of the XFEM enhanced shell problem, the present formulation is based on a non–local damage evolution applied to a kinematically consistent shell model based on continuous kinematics. The actual shell model is implemented as a 7-parameter solid–shell element based on a 6-noded triangular element for implicit static analysis, along the lines set out in ref [1]. This element was recently extended to handle multiple delamination in the thickness shell direction, based on XFEM enrichment placed in context with polymeric composite laminate modeling, cf [2].

Upon introducing the damage phase field as a diffuse representation of a fracture surface, the formulation relates to the work of e.g. Miehe et al. [3]. The energy dissipation due to damage evolution is thereby directly related to standard fracture mechanical concepts of LEFM, Griffiths [4], and cohesive zone modeling, Barenblatt [5]. A central part in the present developments concerns the enhancement of the standard non–local damage model, cf. Peerlings et al. [6] and [3], in context of the presently adopted shell kinematics, where the damage field is considered as a Taylor series expansion in the thickness direction from the mid–surface. In this fashion we allow for a full 3D representation of the damage field in the shell, accounting for an inhomogeneous damage distribution through the shell thickness. This representation is necessary when considering layerwise anisotropic composite laminates in conjunction with failures of bending type.

Preliminary results are obtained for isotropic shell properties, cf. Fig 1. Layer-wise anisotropic shells representing a polymeric composite laminate are also considered.

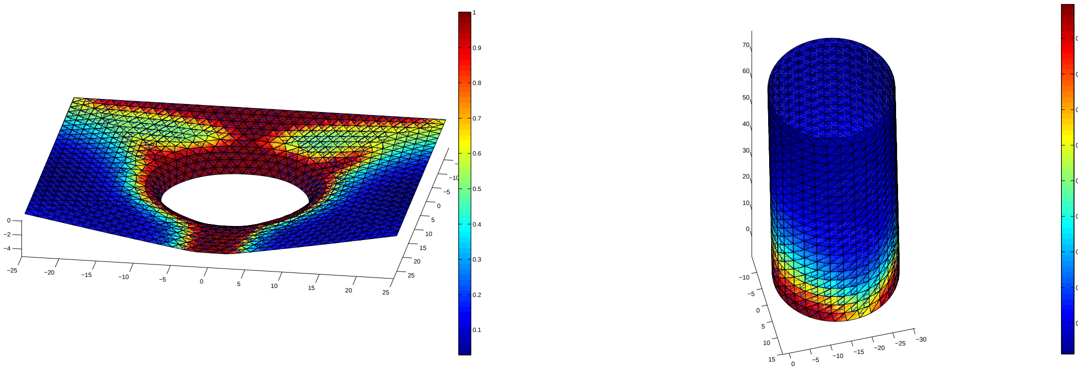

Figure 1: Deformed configurations along with damage field distributions of a) hollow plate subjected to prescribed vertical displacement and b) cylinder shell subjected to torque loading; the resulting damage induces through the thickness fracture of the thin-walled structures.

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