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Phase-field modelling of brittle fracture in thin shell elements based on MITC4+ approach

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Numerical damage modelling of shells plays a crucial role in the overall design, manufacturing and ensuring safety of thin structures. An important challenge while modelling nonlinear phenomena, such as damage, in thin shell elements is that they exhibit membrane and transverse shear locking which may lead to erroneous crack paths and fracture energy estimations. To derive an accurate 3-D description of crack topology, especially in mixed-mode loading cases, it is primarily important to cure such shell locking issues.

The present work combines an assumed strain based MITC4+ approach which effectively alleviates both membrane and shear locking, and the well-known phase-field method which has already proved its prominence in efficiently predicting complex crack patterns. The formulation considers degenerated Mindlin quadrilateral shell elements with a scalar 2-D phase-field defined on the shell-midsurface, which governs full 3-D degradation of stresses. Furthermore, a tension-compression split is performed on the total strain for all integration points along the thickness, wherein only tensile part of elastic strain energy is degraded with the phase-field evolution. The accuracy of the proposed method in investigating crack patterns in shell elements is examined through a set of benchmarks.

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