Phase field modeling of brittle fracture in large-deformation solid shells with the efficient quasi-Newton solution and global-local approach

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Abstract
To efficiently predict the crack propagation in thin-walled structures, a global-local approach for phase field modeling using large-deformation solid shell element formulation considering the enhanced assumed strain (EAS) and assumed natural strain (ANS) methods for the alleviation of locking effects is developed in this work. Aiming at tackling the poor convergence performance of standard Newton schemes, a quasi-Newton (QN) scheme is proposed for the solution of coupled governing equations with enhanced assumed strain shell formulation in a monolithic manner. The excellent convergence performance of this QN monolithic scheme for the multi-field shell formulation is demonstrated through several paradigmatic boundary value problems, including single edge notched tension and shear, fracture of cylindrical structure under mixed loading and fatigue induced crack growth. Compared with the popular alternating minimization (AM) or staggered solution scheme, it is also found that the QN monolithic solution scheme for the phase field modeling using enhanced strain shell formulation is very efficient without the loss of robustness, and significant computational gains are observed in all the numerical examples. In addition, to further reduce the computational cost in fracture modeling of large-scale thin-walled structures, a specific global-local phase field approach for solid shell elements in the 3D setting is proposed, in which the full displacement-phase field problem is considered at the local level, while addressing only elastic problem at the global level. Its capability is demonstrated by the modeling of cylindrical structure subjected to both static and fatigue cyclic loading conditions, which can be appealing to industrial applications.

Acknowledgements
The authors acknowledge the funding received from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No 861061 – Project NEWFRAC.

Reference
Liu, Z., Reinoso, J. and Paggi, M., 2022. Phase field modeling of brittle fracture in large-deformation solid shells with the efficient quasi-Newton solution and global–local approach. Computer Methods in Applied Mechanics and Engineering, 399, p.115410.