An adaptive global-local approach for phase-field modeling of anisotropic brittle fracture

N. Noii*, **F. Aldakheel**†, **T. Wick*** **and P. Wriggers**†

* Institute of Applied Mathematics (IFAM)
Leibniz Universitaet Hannover
Welfengarten 1, Hannover 30167, Germany
e-mail: noii@ifam.uni-hannover.de, thomas.wick@ifam.uni-hannover.de/

† Institute for Continuum Mechanics (IKM)
Leibniz Universitaet Hannover
Appelstr. 11, Hannover 30167, Germany
e-mail: aldakheel@ikm.uni-hannover.de, wriggers@ikm.uni-hannover.de

ABSTRACT

This work addresses an efficient global/local approach supplemented with predictor-corrector adaptivity applied to anisotropic phase-field brittle fracture. Following the recent work [1], different criteria of anisotropy are outlined via (i) second- and fourth-order structural tensors into the crack surface density function (ii) energetic and stress-like failure criteria entering the crack phase field evolution. In this context, a split in tension and compression modes in anisotropic materials is considered.

Clearly, the formulation of anisotropic phase-field modeling is strongly non-linear and calls for the resolution of small length scales. Its single-scale treatment is computationally demanding. As such, an idea of multi-scale approach that enables to "send" the multi-field non-linearity problem to a lower (local) scale, while dealing with a purely linear elastic problem at an upper (global) scale, seems particularly appealing.

In line with [2], we propose an adaptive global/local approach applied to phase-field modeling of fracture in anisotropic brittle solids. In particular, a predictor-corrector global mesh adaptivity scheme, according with [3], is developed, which does not require any a priori-knowledge of the crack path. Evidently, a non-matching finite element discretization of an interface between the two nested scales becomes feasible. In order to handle non-matching grids, a dual mortar method [4] is implemented for improving the regularity of the corresponding FE meshes.

With several numerical examples, we show that the proposed approach indeed yields results similar to the reference single-scale solution yet they are obtained with much superior efficiency. We note that the presented method is (algorithmically) perfectly suitable for the parallel computing concept thus promising further reduction of computational effort.

REFERENCES

[1] Teichtmeister, S., Kienle, D., Aldakheel, F., Keip, M.-A. Phase field modeling of fracture in anisotropic brittle solids, International Journal of Non-Linear Mechanics, Vol. 97, (2017).

[2] Gerasimov, T., Noii, N., Allix, O., De Lorenzis, L. A non-intrusive global/local approach applied to phase-field modeling of brittle fracture, Advanced Modeling and Simulation in Engineering Sciences, Vol. 5:14, (2018).

[3] Heister, T., Wheeler, M. F., Wick, T. A primal-dual active set method and predictor-corrector mesh adaptivity for computing fracture propagation using a phase-field approach, Computer Methods in Applied Mechanics and Engineering, Vol. 290, (2015).

[4] Wohlmuth, B.I. A mortar finite element method using dual spaces for the Lagrange multiplier, SIAM Journal on Numerical Analysis, Vol. 38, (2000).