Method of Representative Crack Elements for Phase-field Fracture with Finite Deformations and Dissipative Material Behaviour

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ABSTRACT

The realistic representation of material degradation at a fully evolved crack is still one of the main challenges of the phase-field method for fracture. Strobl and Seelig [1], Schlueter [2] and Steinke and Kaliske [3] have shown, that the well known V-D and spectral split approaches with tension/compression decomposition may lead to wrong predictions for the force transfer through the crack. That is why this standard phase-field models cannot represent the crack kinematic like a discrete crack model in a universal manner so far.

Strobl and Seelig [1] and Steinke and Kaliske [3] have presented a model with realistic material degradation for isotropic elasticity in the framework of small deformations. The model is designed by analysing the kinematics at a discrete crack and fits into the concept of an active and a passive part of the mechanical energy potential.

In this talk, a variational framework is presented fitting into standard phase-field formulations, which allows to derive the kinematically consistent material degradations. For this purpose, the concept of *Representative Crack Elements* (RCE) is introduced to analyse the fully degraded material state at a representative discrete crack model. The coupling of the RCE and the phase-field model is derived adopting the variational homogenisation framework of Blanco et al. [4]. The material degradation is further tested using the *self-consistency condition*, where the behaviour of the phase-field model is compared to a discrete crack model at component level.

The RCE framework was successfully applied to anisotropic elasticity and thermo-elasticity earlier [5]. The current talk focuses on the application to finite deformations and dissipative materials. The derived models are presented using well-known benchmarks from phase-field literature together with informations about the convergence behaviour.

REFERENCES

[1] Strobl, M. and Seelig, T. *A novel treatment of crack boundary conditions in phase field models of fracture*, Proceedings in Applied Mathematics and Mechanics 15 (1) (2015).

[2] Schlueter, A. *Phase Field Modeling of Dynamic Brittle Fracture*, PhD thesis, Technische Universitt Kaiserslautern (2018).

[3] Steinke, C. and Kaliske, M. *A phase-field crack model based on directional stress decomposition*, Computational Mechanics (2018).

[4] Blanco, P. J.; Snchez, P. J.; Souza Neto, E. A. and Feijo R. A. *Variational Foundations and Generalized Unified Theory of RVE-Based Multiscale Models*, Archives of Computational Methods in Engineering 23 (2014) 1–63.

[5] Storm, J.; Supriatna, D. and Kaliske, M. *On the analysis of crack-closure behaviour using the phase-field method together with the novel concept of Representative Crack Elements*, Annual Meeting of the International Association of Applied Mathematics and Mechanics, Vienna (2019).