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Variational phase-field formulation of non-linear ductile fracture

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In the present contribution we focus on a novel computational framework for the simulation of ductile fracture in elastoplastic solids. In particular, a fully non-linear formulation of gradient plasticity is applied together with a higher order phase-field approach to fracture to account for large elastic and plastic deformations along with three dimensional crack propagation.

The proposed formulation is based on a multiplicative decomposition of the deformation gradient into elastic and plastic contributions and a subsequent multiplicative decomposition of the elastic part into a fracture sensitive and a fracture insensitive contribution, see [1]. Postulating that fracture requires a local state of tensile/shear deformation, the latter decomposition is used to formulate the isochoric and tensile contributions to the elastic strain energy, whereas the compressive contribution remains unaffected by the crack phase-field and vice versa.

The modification of the Griffith brittle fracture theory to ductile fracture is most crucial and has to be adjusted carefully. Within our framework, this adaptation is considered as dependency of the critical fracture energy density by the equivalent plastic strain.

Concerning the elastic/plastic decomposition, we assume an isochoric plastic flow which requires special attention for the update procedure of the plastic deformation in the time discrete setting. To be specific, we apply an exponential time integration scheme such that we preserve the deviatoric state of the plastic deformation and obtain a correct evaluation of the phase-field driving force, see [1] for more details.

Eventually, a number of numerical examples will demonstrate the accuracy and capability of the proposed multi-field approach to large deformation ductile fracture.

REFERENCES

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