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IMPLEMENTATION OF A GRADIENT-ENHANCED DAMAGE MODEL – A HEAT EQUATION-BASED FRAMEWORK

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We provide a framework for the numerical treatment of a gradient-enhanced damage model within thermo-mechanically coupled finite element formulations.

The fully non-local, gradient-enhanced, geometrically non-linear damage formulation employed here was proposed in [1] and represents a finite-strain extension of a concept introduced in [2], where the local free energy function is extended by two additive contributions. The first additional term basically contains the referential gradient of the non-local damage variable. Secondly, a penalty term is added to enforce equivalence between the local damage variable—governed by an ODE—and non-local damage variable, governed by an additional balance equation of elliptic type.

The key observation here is that the additional elliptic balance equation is structurally similar to the steady-state heat equation. As a result, the framework at hand allows for the regularisation of damage using the heat equation—existing finite element codes providing thermo-mechanically coupled elements can be utilised to efficiently regularise the damage formulation. To this end, we show representative three-dimensional boundary value problems, the solution of which can take advantage of the features of existing, sophisticated finite element codes without the need for the implementation of user element routines.

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