A gradient-extended damage-plasticity model for large deformations with combined nonlinear hardening

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ABSTRACT

The application of conventional ‘local’ continuum damage models in finite element simulations can cause a pathological mesh dependence of the results which in turn prohibits a physically meaningful and objective analysis of the latter. A way to overcome this problem is to use gradient-enhanced continua which introduce a ‘nonlocality’ into the formulation that regularizes the mesh dependence issue. In a finite element context, the consideration of gradient effects usually leads to further degrees of freedom in the computation that need to be solved for in addition to the displacements.

The increase in computing power has made feasible the use of such models in practically relevant simulations under ever-more realistic conditions. Nevertheless, many open questions remain that need to be investigated, e.g., the question of how to model and couple gradient-extended damage with large plastic deformations. The present work is concerned with this problem.

A quite flexible gradient-extended damage-plasticity model for finite strains is presented in which damage and plasticity are treated as distinct dissipative mechanisms. This is achieved by means of a ‘two-surface’ methodology in which independent damage and yield criteria as well as corresponding sets of loading / unloading conditions are utilized in the formulation. The model can be considered a geometrically nonlinear extension of a formulation for small deformations presented recently (see [1]). The model’s gradient-extension is derived by means of the convenient micromorphic approach according to Forest (see [2, 3]); it accounts for both nonlinear isotropic and kinematic hardening of Voce- and Armstrong-Frederick-type, respectively. Theoretical and numerical aspects of the model are discussed, as, for instance, the thermodynamic consistency of the model, the particular constitutive coupling between damage and plasticity in the formulation or the algorithmic treatment of the model. Several academic examples are presented which practically illustrate the mesh regularizing properties of the model in finite element simulations involving concurrent large plastic deformations and material damage.

REFERENCES

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