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SYSTEMATIC REGULARIZATION OF FINITE STRAIN ELASTOPLASTIC MODELS

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Finite element simulations involving strain localization lead to spurious mesh-dependence due mainly to ill-posedness of boundary-value problems in classical continuum theories [1]. Several regularization approaches have been developed using non-local integral operators, gradient formulations [2] or extra-degrees of freedom for smoothing strain fields. An approach based on the micromorphic theory allowing to restore the ellipticity of PDEs and predict size effects is presented. It relies upon the enrichment of classical continua with additional degrees of freedom and the enhancement of the free energy density. The present formulation is based on the multiplicative decomposition of the deformation gradient and an isoclinic intermediate configuration. The choice of micromorphic variable, either scalar or tensor, is discussed. Several variations of the formulation depending on generalized strains defined w.r.t Lagrangian, Eulerian, and intermediate configurations are treated. The first two ones lead to an additional Laplace term in the isotropic hardening law, whereas the third formulation enhances both isotropic and kinematic hardening laws. Depending on the constitutive choices, this approach leads to various regularization operators [3]. The regularization properties of such operators are studied through analytical and numerical analysis of various problems including bending, torsion and shear banding in a plate. The present formulation is implemented in a FEM code [4] allowing to regularize, systematically, a rich library of anisotropic finite strain thermo-elastoviscoplastic models [5].

REFERENCES

[1] E. C. Aifantis, On the microstructural origin of certain inelastic models, *Eng. Mater. Technol.* , Vol. **106**, pp. 326-330, 1984.

[2] N. A. Fleck and J. W. Hutchinson, Strain gradient plasticity, *Adv. Appl. Mech.*, Vol. **33**, pp. 295-361, 1997.

[3] S. Forest, Nonlinear regularization operators as derived from the micromorphic approach to gradient elasticity, viscoplasticity and damage, *Proc. R. Soc. A: Math. Phys. Eng. Sci.*, Vol. **472**, 20150755, 2016.

[4] Zset finite element code, http://www.zset-software.com

[5] M. Abatour, S. Forest, K. Ammar, C. Ovalle, N. Osipov and S. Quilici, A generic formulation of anisotropic thermo-elastoviscoplasticity at finite deformations for Finite Element codes, Preprint at https://hal.archives-ouvertes.fr/hal-03462216, 2021