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The micromorphic approach to gradient plasticity and damage

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ABSTRACT

A general constitutive framework is presented that encompasses a large variety of available generalized continuum theories designed for introducing material length scales into the mechanical modelling of structures and materials [1]. In particular, it reconciles so-called micromorphic and gradient theories developed in the last fifty years and applied to the plasticity and fracture of materials. The regularization operators of such models with respect to localization phenomena are derived within the finite deformation framework [2]. The approach is illustrated in the case of the propagation of Lüders bands in C-Mn steels under tensile [3,4] and shear loading [5].
The method is then applied to the plasticity and fracture of single crystalline materials [6]. Finite deformation crystal plasticity theory is enhanced to incorporate the initiation and propagation of damage with respect to crystallographic planes. The model is applicable to quasi-brittle single crystal undergoing cleavage fracture but also to ductile single crystals for which plasticity is a precursor of fracture. The approach is illustrated by means of finite element simulations of the initiation, propagation and bifurcation / branching of cracks in single crystal nickel base superalloys under cycling loading. Comparison with results from in situ microtomographic experiments at the European Synchrotron Facility are provided [7].

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