Hyper-reduction of gradient plasticity

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ABSTRACT

The classical continuum theory fails to describe certain mechanical phenomena such as dispersion of elastic waves, size effects on material properties, or strain softening of materials. To capture these phenomena, the theory needs to be enhanced. One possible remedy is based on the so-called micromorphic formulation which introduces one or several material length scale parameters, see [1], [2].

The focus of this contribution is on reduced order modeling of materials with softening. It is well known that materials with softening leads to ill-posed problem, i.e., it does not have a unique solution with continuous dependence on the given data. Therefore, the model needs to be regularized in order to obtain mathematically, numerically, and physically meaningful results. To regularized the model, micromorphic theory based on gradient of the cumulated plastic strain is used which introduces one new material parameter with dimension of length.

However, finite element modeling of localization using gradient-dependent plasticity models leads to very high computational costs. To reduce this cost, the hyper-reduction method [3], [4] is used, and the generation of the reduced integration domain is examined in account of the generalized degrees of freedom. Moreover, the hybrid hyper-reduction strategy [5] is adopted to improve the results inside the localization zone. Finally, the method will be illustrated by numerical examples.

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