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Combining Second-Order Homogenisation and Nonlocal Damage for FE2 Mesh-Regularisation under Moderate Localisation

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Abstract

Employing computational homogenisation to model the failure of structures and components across length-scales remains a challenging endeavor since strain localisation and softening lead to multi-scale mesh-dependent effects. This study investigates the attenuation of mesh-dependency in multi-scale computational-homogenisation-based models, including the role of the RVE (Representative Volume Element) length and the combined effects of micro- and macro-scale softening. To that end, three FE2 examples are presented, considering macroscopic geometries promoting strain localisation and porous RVEs to mimic ductile failure mechanisms. Microstructures with voids embedded in a matrix modelled by a finite strain elastoplastic-damage law are considered to trigger damage from the micro-scale. Second-order homogenisation reduces macro mesh-dependency and prevents spurious deformations due to the introduction of a macroscopic intrinsic length-scale. This characteristic length is intimately related to the RVE length, which is herein interpreted mainly as a numerical parameter. Its role in the resulting second-order multi-scale predictions is carefully assessed, and the limitations of this hypothesis are analysed. The second-order FE2 response for RVE lengths approaching zero does not converge to its first-order counterpart, as some second-order effects are preserved. Moreover, the second-order multi-scale formulation considered in this contribution does not tackle RVE mesh-dependency, which persists due to microscopic softening sources. Attenuating micro

mesh-dependency through a nonlocal damage approach increases the effectiveness of macro-scale regularisation, demonstrating the intricate interplay between mesh-dependent effects at both scales.

Keywords:

Second-order homogenisation FE2 Mesh-dependency Strain localisation RVE length Nonlocal damage