A two-scale framework for modeling strain localization in solids

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ABSTRACT

In computational homogenization of solids, the effective response can be obtained from underlying simulations on, e.g., Statistical Volume Elements (SVEs). Although standard nowadays, such an approach leads to poor results when strain localization and fracture occurs in the material. Remedies to this problem exists in the literature, however often focusing on particular choices of constitutive models on the microscale.

In the present work, we aim to circumvent the need for high-resolution discontinuity tracking of all micro cracks by developing a two-scale modeling scheme for fracturing solids, where the eXtended Finite Element Method (XFEM) is chosen for representation only of the macroscale discontinuities, see [1,2].

The formulation, which is based on Variationally Consistent Homogenization (VCH), results in a weak problem of finding the (possibly discontinuous) displacement field. Here, we have the freedom to consider either explicit modeling of the nucleation, growth and coalesce of microcracks or damage development via continuum damage theory.

The macroscale weak equilibrium equations contains three terms: the standard bulk contribution, a term of cohesive zone type and a novel correction term needed for consistency upon strain localization and macroscopic discontinuity. The macroscale discontinuities are imposed on the microscale SVEs using weakly periodic boundary conditions that are aligned to the macroscale localization direction [3]. A key feature is that the smearing width employed in the discontinuity transitions is related to the SVE size used for the fine scale analysis at the effective discontinuity. By combining the smeared discontinuity transitions with the strict ellipticity condition, we obtain a modeling framework that can be employed without restrictive assumptions on the constitutive models employed on the microscale.

Numerical investigations are presented in two spatial dimensions. In particular, it is noted that the method does not result in pathological dependence on macroscale mesh-size, nor on the size of the SVE.

REFERENCES

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