Computational homogenization of microstructured material layers

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For material layers that possess a both heterogeneous and microstructured mesostructure, we are interested in the macroscopic material properties based on the underlying meso/micro structural properties.

To this end, we pursue a multi-scale approach with the material layer represented as a cohesive interface at the macro scale [2]. In order to account for both heterogeneities and a relatively large intrinsic microstructure, the underlying meso/micro structure is modelled as micromorphic representative volume elements (RVE) [1].

The relation between the macro separation and the macro traction is determined by a homogenization of the quantities in the micromorphic RVE. In particular, the deformation, the traction, and the virtual work on the macro level have to be equivalent to the corresponding averages over the underlying micromorphic RVE. Special hybrid boundary conditions are applied, with prescribed meso and micro deformation on the RVE boundaries towards the bulk, and periodic meso and micro deformation along the interface. In the nested two-scale nonlinear finite-element solution the material layer is represented by cohesive interface elements, at their integration points the constitutive relation is evaluated in micromorphic RVEs.

Beyond the current restriction to cohesive interface elements, this numerical multiscale framework can be relevant for many other numerical methods for the modelling of discontinuities, especially in combination with inelastic microstructures.

References

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