Continuous-discontinuous computational homogenization

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Mechanics of Materials

TU/e Technische Universiteit **Eindhoven** University of Technology

Continuous-Discontinuous Computational Homogenization

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M2i Materials innovation institute

Introduction

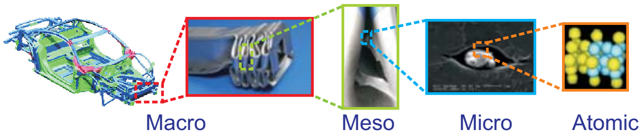

Figure 1: Ductile damage is a multi-scale process.

Design of products and metal forming operations requires reliable predictions of the manufacturability and product properties after forming. Ductile fracture is characterized by microscale damage and macroscale strain localization, finally resulting in fracture.

The aim is to develop a computational homogenization technique for the multi-scale modelling of engineering materials up to the point of macroscopic failure.

Modeling ductile damage in metals

Micromechanisms of ductile fracture of most metals involves void nucleation, growth and coalescence. Representative Volume Elements (RVEs) that capture the relevant microscale damage mechanics are used to model this evolution.

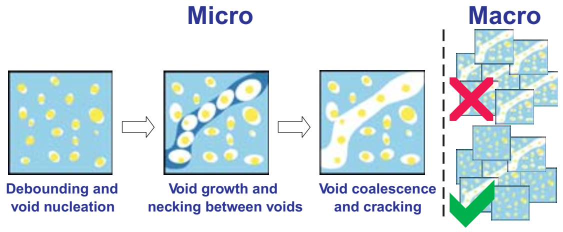

Figure 2: Damage and strain localization within a microstructural volume and the limits of the local representability of an RVE.

A two-scale Computational Homogenization (CH) scheme, relates the micromechanics to macrostructural behavior. Classical schemes require separation of length scales, which should hold for both the geometry and the deformation gradients. To overcome this limitation, for moderate localization, a second-order CH procedure leading to a higher-order continuum on the macrolevel has been proposed by Kouznetsova, et al. [1]. The scheme still relies on locally representative RVEs and can't capture extreme localization between voids.

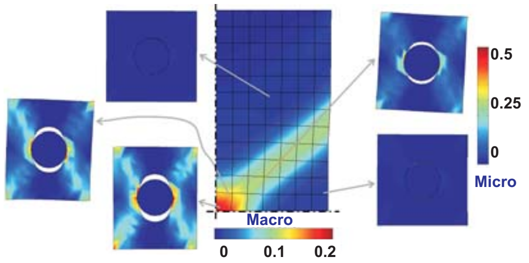

Figure 3: The second-order scheme is capable of capturing moderate localization bands [1].

The Continuous-Discontinuous CH approach overcomes this limitation. It is based on the idea that the microscopic deformation can be splitted into a bulk and a localization type of deformation. The macroscopic continuum is enriched with a cohesive discrete crack, which lumps the strain localization and residual load carrying capacity of the underlying microstructure.

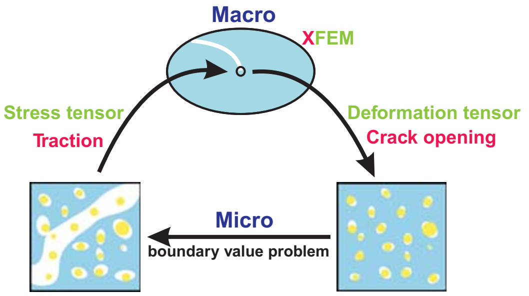

Figure 4: Continuous-Discontinuous CH scheme is able to capture a severe strain localization band within the microstructural volume.

Conclusion

- Computational homogenization is a versatile and powerful analysis tool for structures with any, possibly very complex, microstructure.
- The innovative Continuous-Discontinuous CH allows for simultaneous analysis of microscale damage evolution and macroscale fracture mechanics.

References

[1] Kouznetsova, Geers, Brekelmans (2004). Multi-scale second-order computational homogenization of multi–phase materials: a nested finite element solution strategy. *Comput. Methods. Appl. Mech. Engrg.* **193**, 5525–5550.