Multi-scale modelling of localization and damage

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Introduction

Damage and strain localization analyses are necessary in many structural or functional material designs. Advanced technological developments rise a demand for coupled damage analysis at different scales.

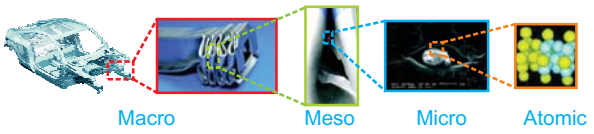

Figure 1: Upscaling of the microstructural response.

Project Goal: The development of a two-scale computational framework, which correctly upscales the effect of microscale damage on macroscale fracture.

Multi-scale modelling

Classical computational homogenization schemes are based on the solution of two nested boundary value problems. They rely on Microstructural Volume Elements (MVEs) which are locally representative for the microstructure. Strain localization inevitably limits the concept of homogenization.

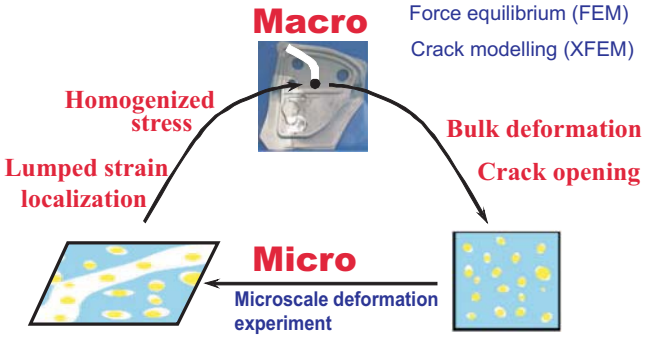

Figure 2: Developed multi-scale framework.

The innovative multi-scale scheme presented here splits the microscopic deformation into a bulk and localization type of deformation. The macroscopic continuum is enriched with a cohesive discrete crack, which lumps the microstructural strain localization and the residual load carrying capacity. This overcomes the limitation of classical schemes.

Results

Straining a voided material (see Figure 3) results in a pre-localization (1-7) and post-localization (8-12) fase. Pre-localization: the MVE is representative for the corresponding macroscopic material point. Post-localization: a strain localization band has developed that needs to be accounted for.

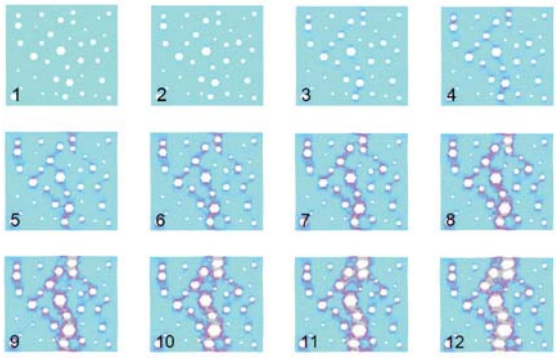

Figure 3: Strain localization within a voided elasto-plastic material.

Stress Homogenization: The definition for the stress homogenization is classical and is defined as the volume average of the microscale stress field.

Lumping of strain localization: The distinction between "strain localization" and "bulk deformation" is defined by a minimization of the microfluctuation field in a least square sense.

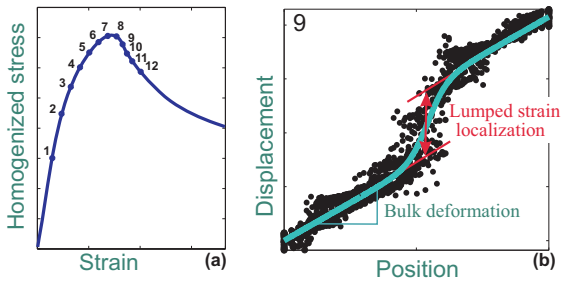

Figure 4: (a) Homogenized stress-strain response and (b) calculation of the lumped strain localization (frame 9).

Conclusion

Upscaling of the microstructural material response after the point of strain localization has been developed. This is a versatile tool for multi-scale analysis of damage.