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A multi-scale oddity : unifying localization and homogenization

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A multi-scale oddity: Unifying localization and homogenization

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Materials innovation institute

Introduction

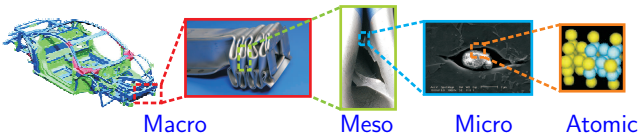

Fig. 1 *The world of engineering is multi-scale.*

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

Multi-scale modelling

Classical computational homogenization schemes rely on Microstructural Volume Elements (MVE) which are locally representative for the microstructure. Strain localization inevitably limits the concept of homogenization.

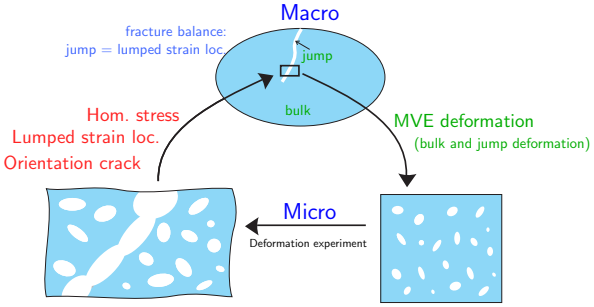

Fig. 2 *Localization enriched multi-scale framework.*

The developed scheme reconciles this conflict by disentangling the bulk and the collective strain localization behaviour.

MVE boundary conditions (BCs)

New BCs (called aligned) are proposed that provide a good estimate for the effective stiffness and simultaneously allow for a strain localization band to develop.

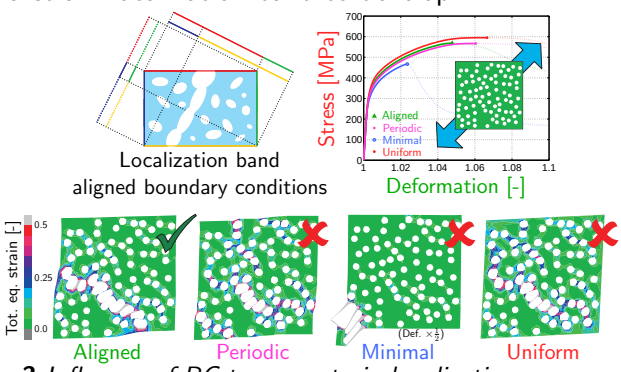

Fig. 3 *Influence of BC-type on strain localization.*

Numerical example

Horizontal stretching of a heterogeneous plate (see Fig. 4) results in a pre-localization o and post-localization o fase. The MVE crossed by the localization band (middle) continues stretching, while the other MVEs (right and left) unload.

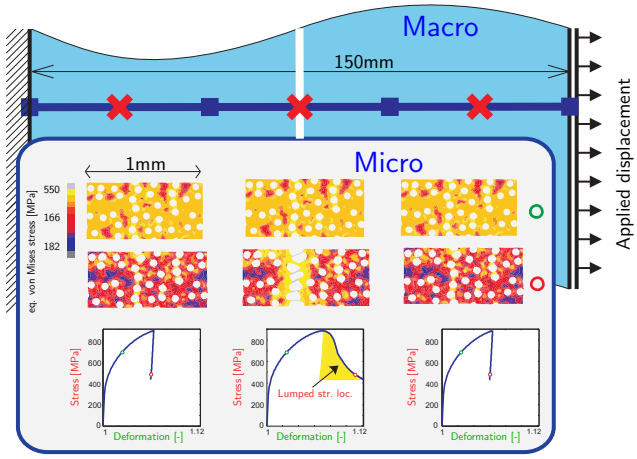

Fig. 4 *Microstructural response of a heterogeneous plate under applied horizontal displacement.*

The localization enriched scheme is well-regularized (no mesh dependency), the response is comparable to the reference result (direct numerical simulation, DNS) and the computational costs are much smaller ($\pm 1/50$).

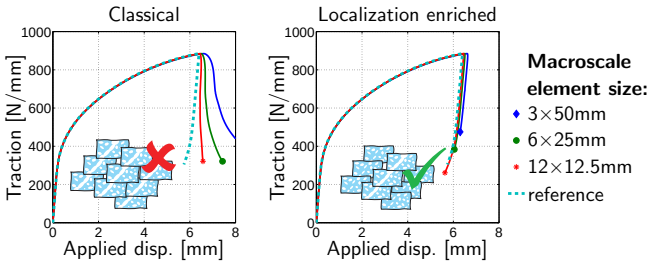

Fig. 5 *Macroscale response obtained by the classical and the localization enriched multi-scale scheme.*

Conclusion

The proposed multi-scale scheme in combination with the developed MVE boundary conditions comprises a versatile and powerful analysis tool for multi-scale problems involving localization and damage.