Homogenization of heterogeneous polymers towards cosserat media

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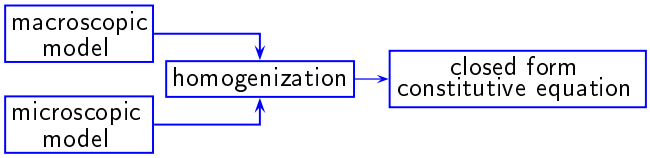
1 Introduction

Experiments: the microstructure of polymer blends has substantial influence on the macroscopic deformation behaviour.

Objective: determination of macroscopic constitutive equations from microstructural analysis:



2 Macroscopic Model

Model requirement: proper description of strain softening behaviour → non-local models necessary.
Choice: **Cosserat media**:

- *Additional degrees of freedom:* independent rotations.
- *Kinematical quantities:* strain tensor $\bar{\varepsilon}_{ji}$ and torsion tensor $\bar{\kappa}_{ji}$.
- *Dynamical quantities:* stress tensor $\bar{\sigma}_{ji}$ and couple-stress tensor $\bar{\mu}_{ji}$.

The constitutive equations are formulated as

$$\bar{\sigma}_{ji} = \frac{\bar{E}(\bar{\varepsilon}_{eq})}{1+\bar{\nu}}\left[\bar{\varepsilon}_{(ji)} + \vartheta\bar{\varepsilon}_{\langle ji\rangle} + \frac{\bar{\nu}}{1-2\bar{\nu}}\bar{\varepsilon}_{kk}\delta_{ji}\right],$$

$$\bar{\mu}_{ji} = \frac{\bar{D}(\bar{\varepsilon}_{eq})}{1+\bar{\mu}}\left[\bar{\kappa}_{(ji)} + \eta\bar{\kappa}_{\langle ji\rangle} + \frac{\bar{\mu}}{1-2\bar{\mu}}\bar{\kappa}_{kk}\delta_{ji}\right],$$

with $(.)$ the symmetric, and $\langle.\rangle$ the skew-symmetric part of a tensor.

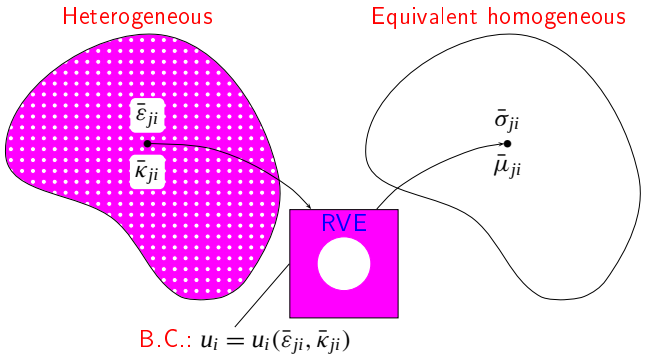
3 Microscopic Model

Model requirement: proper description of the deformation behaviour of a Representative Volume Element (RVE).

Choice:
- PolyCarbonate with microscopic holes.
- **compressible Leonov**-model.

4 Homogenization Procedure

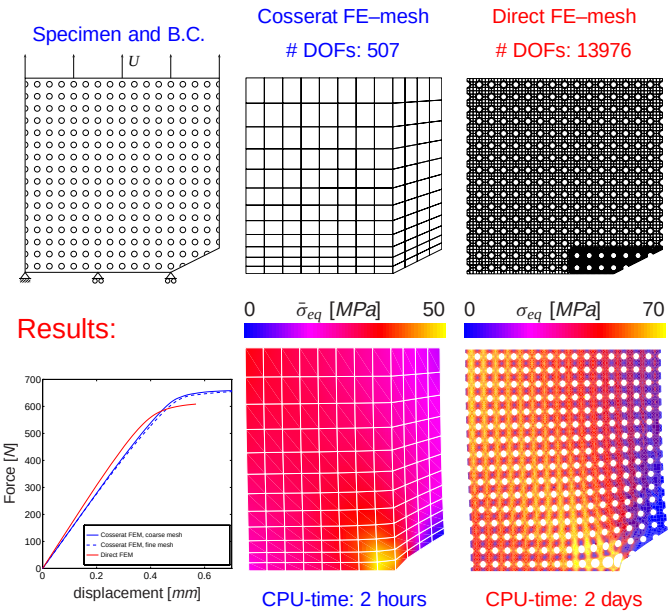
Requirement Boundary Conditions on RVE:
independent variation of macroscopic deformation quantities by using micro-macro definitions → displacement field $u_i = u_i(\bar{\varepsilon}_{ji}, \bar{\kappa}_{ji})$.



The response of the RVE provides the evolution of the macroscopic state variables → determination of the macroscopic constitutive equations of the equivalent homogeneous material.

5 Application and Verification

Application for a tensile test on a single-edge notched specimen.
Verification with 'direct' finite element calculations of the heterogeneous material.



6 Conclusions

- Cosserat FEM is capable of describing strain softening (mesh-independent solution).
- Due to the model limitations, the homogenized Cosserat model is correct in a qualitative sense.