

Homogenization of heterogeneous polymers towards cosserat media

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Homogenization of Heterogeneous Polymers towards Cosserat Media

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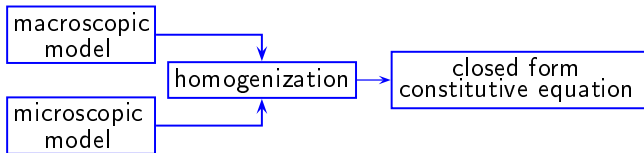
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1 Introduction

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

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

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

with (.) the symmetric, and (.) the skew-symmetric part of a tensor.

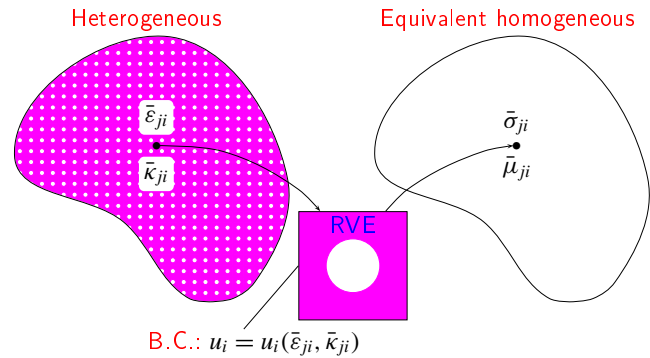
3 Microscopic Model

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 $u_i = u_i(\bar{\varepsilon}_{ji}, \bar{\kappa}_{ji})$.

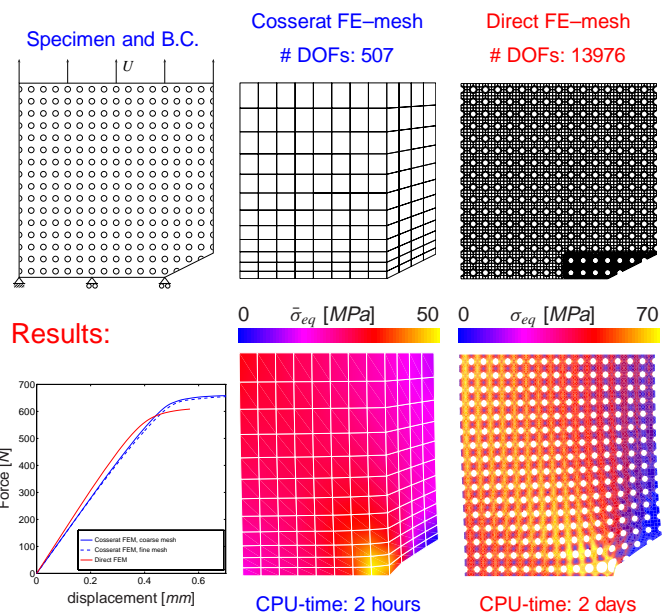


The response of the RVE provides the evolution of the macroscopic state variables → determination of the macroscopic constitutive equations of the equivalent homogeneous material.

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.