Homogenisation of elastoviscoplastic solids at finite strain

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O. van der Sluis, P.J.G. Schreurs, H.E.H. Meijer

Eindhoven University of Technology,
Faculty of Mechanical Engineering,
Section Materials Technology,
P.O. Box 513, 5600 MB Eindhoven, the Netherlands

Introduction

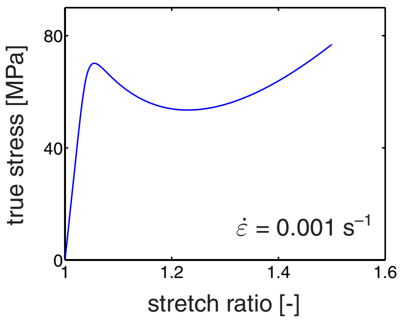
Homogenisation provides a way to relate the microstructural response of a material to its macroscopic mechanical behaviour [1]. The heterogeneous material is effectively replaced by an equivalent homogeneous continuum, which is defined by a closed form constitutive equation.

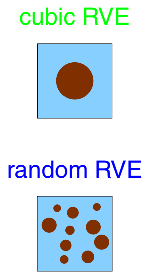
Homogenisation method

On both levels, Perzyna's elastoviscoplastic constitutive model is adopted [2].

Micromodel

The constitutive parameters for the micromodel are identified for polycarbonate with a fixed strain rate $\dot{\varepsilon}$. Two different representative volume elements (RVEs) are considered.



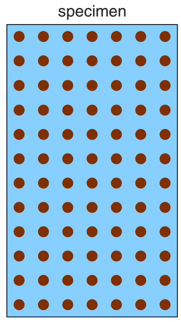


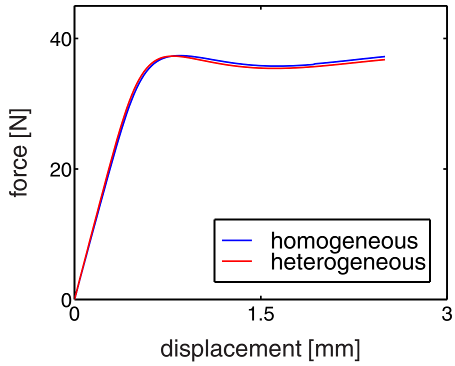
Macromodel

The constitutive coefficients for the macromodel follow from the homogenisation procedure developed in [3], extended to account for finite deformations.

Benchmark problem

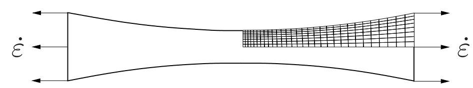
A tensile test on a polycarbonate plate with regularly distributed rubber inclusions is simulated in two different ways: (1) a homogeneous simulation using homogenised material parameters from the cubic RVE (CPU-time: 2 minutes); (2) a heterogeneous simulation where the structure is completely discretised ('reference solution': CPU-time: 3 days):



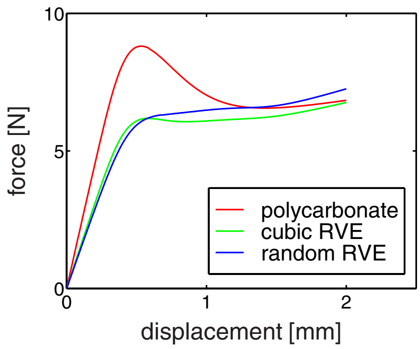


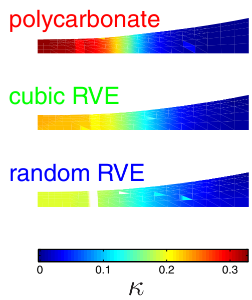
Application

As application of the method, a tensile test of a geometrically imperfect specimen is performed.



Modifying the microstructure of the material changes the overall mechanical behaviour of the heterogeneous tensile specimen significantly. The contourbands of the equivalent viscoplastic strain κ illustrate the difference between strain concentrations for the respective microstructures in the specimen.





Conclusion

The homogenisation method for elastoviscoplastic solids exhibiting large deformations results in a very good approximation of the mechanical behaviour of these materials, while reducing computational costs.

References:

[1] MAUGIN, G. (1992). *The Thermomechanics of Plasticity and Fracture*, Cambridge University Press.

[2] PERZYNA, P. (1985). 'On constitutive modelling of dissipative solids for plastic flow, instability and fracture', In *Plasticity Today: Modelling, Methods and Applications*, 657–679, London, Elsevier Applied Science Publishers.

[3] VAN DER SLUIS, O., SCHREURS, P., MEIJER, H. (1999). 'Effective properties of a viscoplastic constitutive model obtained by homogenisation', *Mechanics of Materials*, **31**, 743–759.