Size-dependent homogenized model for isotropic porous materials

Jérémy Hure[*] and Jean-Michel Scherer[†,*]

[*] DEN-Service d'Etudes des Matériaux Irradiés,
CEA, Université Paris-Saclay
F-91191, Gif-sur-Yvette, France
Email: jeremy.hure@cea.fr

[†] MINES ParisTech, PSL Research University
MAT – Centre des Matériaux, CNRS UMR 7633
BP 87 91003 Evry, France
Email: jean-michel.scherer@mines-paristech.fr

ABSTRACT

Size effects have been predicted at the micro- or nano-scale for porous ductile materials from Molecular Dynamics, Discrete Dislocation Dynamics and Continuum Mechanics numerical simulations, because of Geometrically Necessary Dislocations [1] or due to the presence of a void matrix interface. As voids size decreases, higher stresses are needed to deform the material, for a given porosity. However, the majority of the homogenized models for porous materials used in ductile fracture modelling are size-independent, even though micrometric or nanometric voids are commonly observed in structural materials. Based on yield criteria proposed in the literature for nanoporous materials [2,3], a size-dependent homogenized model for porous materials is proposed for axisymmetric loading conditions, including void growth and coalescence as well as void shape effects. Numerical implementation of the constitutive equations is detailed. The homogenized model is validated through comparisons to porous unit cells finite element simulations that consider interfacial stresses, consistently with the model used for the derivation of the yield criteria, aiming at modelling an additional hardening at the void matrix interface. Potential improvements of the model are finally discussed with respect to the theoretical derivation of refined yield criteria and evolution laws.

REFERENCES

[1] M. Hussein, U. Borg, C. Niordson, V. Deshpande, "Plasticity size effects in voided crystals", *J. Mech. Phys. Solids* **56**, 114–131 (2008).

[2] V. Monchiet, D. Kondo, "Combined voids size and shape effects on the macroscopic criterion of ductile nanoporous materials", *Int. J. Plasticity* **43,** 20–41 (2013).

[3] V. Gallican, J. Hure, "Anisotropic coalescence criterion for nanoporous materials", *J. Mech. Phys. Solids* **108**, 30–48 (2017).