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von

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am

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Effective properties of ageing linear viscoelastic media with spheroidal inclusions

in collaboration with Jean-François Barthélémy, Julien Sanahuja, Igor Sevostianov

Because of their rather simple implementation, homogenization schemes based on the Eshelby solution have become very popular for estimating the effective properties of heterogeneous materials featuring random microstructures. These schemes are used to build elastic or even non ageing linear viscoelastic properties thanks to the correspondence principle. In addition recent incremental approaches relying on constitutive laws approximated by means of adequate internal variables have allowed to take into account the ageing linear viscoelastic (alv) behavior of materials in the upscaling process. Besides, analytical and approximated solutions to the alv Eshelby inclusion problem have been recently uncovered and successfully applied to estimate the overall time-dependent strains of viscoelastic composite materials. However these analytical solutions are restricted to particular shapes of inclusions or compliances satisfying precise requirements and a proper consideration of the general alv case is still lacking.

One first recalls the complete solution of the Eshelby problem, namely the mechanical response of an ellipsoidal inclusion or heterogeneity embedded in an infinite matrix subjected to a remote homogeneous strain state, in the framework of ageing linear viscoelasticity, recently presented in [1]. The reasoning extends to the latter case the famous result obtained by Eshelby for elastic materials, i.e. the homogeneity of the strain and stress states within the inclusion. The solution relies on the construction of alv counterparts of the Eshelby and Hill polarization tensors for which a practical implementation is derived for an isotropic matrix and an ellipsoid of arbitrary shape and material symmetry. A numerical procedure based on the trapezoidal rule to estimate the Volterra integral operators involved in the alv law (see [2]) is finally needed to achieve the determination of the tensors.

Validation in the particular non ageing linear viscoelastic case by comparison with exact solution obtained by using fraction-exponential operators [3], and applications of this solution to alv media with spheroidal inclusions, with NIA (Non Interaction Approximation), Mori Tanaka and Maxwell alv homogenization schemes are then presented to illustrate the efficiency of the developed methodology.

References

[1] J.-F. Barthélémy, A. Giraud, F. Lavergne, J. Sanahuja, The Eshelby inclusion problem in ageing linear viscoelasticity, International Journal of Solids and Structures 97-98 (2016) 530 – 542.

[2] J. Sanahuja, Effective behaviour of ageing linear viscoelastic composites: Homogenization approach, International Journal of Solids and Structures 50 (19) (2013) 2846 – 2856.

[3] I. Sevostianov, V. Levin, Creep and relaxation contribution tensors for spheroidal pores in hereditary solids: fraction-exponential operators approach, Acta Mechanica 227 (1) (2015) 217–227.

Biosketch: Albert GIRAUD has received his doctoral degree in 1993 from Ecole Nationale des Ponts et Chaussées in France. He is currently professor at University of Lorraine in GeoRessources laboratory (Nancy, France). He has developed analytical and numerical methods and tools in mechanics of saturated porous media, taking into account thermal and hydraulical coupling. Since years 2003-2005 he is focused on multiscale and micromechanical models applied to heterogeneous porous media such as rock materials.