6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11 – 15 June 2018, Glasgow, UK

MULTI-SCALE MODELLING OF THE NONLINEAR BEHAVIOUR OF WOOD ACCOUNTING FOR STRAIN RATE EFFECT

J. Wouts[1], M. Oudjene[2], D. Coutellier[1] and H. Naceur[1]

[1] LAMIH, UMR CNRS 8201, Université de Valenciennes et du Hainaut-Cambrésis, 59313 Valenciennes, Cedex 9, France,
jeremy.wouts@univ-valenciennes.fr, www.univ-valenciennes.fr

[2] LERMAB, Université de Lorraine, 27 rue Philippe Séguin, 88026 Epinal, France,
marc.oudjene@univ-lorraine.fr , www.univ-lorraine.fr

Key Words: *Wood*, *Constitutive law, FEM, Strain rate, Damage, Choc absorber.*

This paper proposes a nonlinear micromechanical model for the simulation of wood material at large deformation under static and dynamic loadings. The mechanical behaviour of wood is extensively studied, experimentally and numerically, in the literature. The numerical studies include both macroscopic and microscopic approaches. Several comprehensive micromechanics models have been presented in the literature for the elasticity of wood [1-2], among others. Based on the work by Hofstetter et al. [1], the authors developed a simplified multi-scale model with the aim to reduce the number of required input parameters and data, leading to only two homogenization phases. The Representative Elementary Volume (REV) is composed of the cell-wall, which is assumed as homogeneous transversally isotropic and cylindrical inclusions (voids) oriented parallel to the grain. Based on the Mori-Tanaka scheme, an estimate for the homogenized macroscopic elastic properties is obtained. To model the nonlinear behaviour, an extension of the Gurson criteria is developed, based on the framework of limit analysis of Gurson (1977) [3] and its evolutions, in particular the work by Monchiet et al. (2008) [4]. Following the limit analysis method of Gurson, the approximate expression of the macroscopic yield function is obtained. An isotropic hardening effect is also introduced in the macroscopic yield function. Finally, both the longitudinal and transverse yield stresses as well as the isotropic hardening are assumed to be strain rate dependent parameters. The obtained micromechanical model was successfully implemented via a UMAT routine within the explicit dynamic code LS-DYNA and applied successfully for the modelling of some applications dedicated to impact limiters and choc absorbers.

REFERENCES

[1] K. Hofstetter, C. Hellmich, J. Eberhardsteiner. Development and experimental validation of a continuum micromechanics model for the elasticity of wood, European Journal of Mechanics-A/Solids, Elsevier, 1030-1053, 2005.
[2] EI. Flores, MI. Friswell. Multi-scale finite element model for a new material inspired by the mechanics and structure of wood cell-walls, Journal of the Mechanics and Physics of Solids, Elsevier, 1296-1309, 2012.
[3] A. Gurson. Continuum theory of ductile rupture by void nucleation and growth : Part I : Yield criteria and flow rules for porous ductile media, Journal of engineering materials and technology, American Society of Mechanical Engineers, 2-15, 1977.
[4] V. Monchiet, O. Cazacu, E. Charkaluk, D. Kondo. Macroscopic yield criteria for plastic anisotropic materials containing spheroidal voids, International Journal of Plasticity, Elsevier, 1158-1189, 2008.