The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

A micromechanics-informed beam model of growing wood structures

Antonia Wagner[1,*], **Stefan Scheiner**[1]

[1] Institute for Mechanics of Materials and Structures, TU Wien
Karlsplatz 13, 1040 Vienna, Austria
antonia.wagner@tuwien.ac.at, stefan.scheiner@tuwien.ac.at

Keywords: *Reaction Wood, Growth Strains, Multiscale, Homogenization*

Growing trees respond to mechanical disturbances, e.g. resulting from environmental forces or gravity, by forming so-called reaction wood, i.e. compression wood in gymnosperms and tension wood in angiosperms. It enables the tree to control its posture by reinforcing and reorienting the axes of stems and branches [1] – a key prerequisite for reaching large heights. The movement is due to asymmetric cambial activity resulting in excentric growth and varying growth strains. While the underlying biological mechanisms of growth strain generation are not yet fully understood, various hypotheses correlating the induced macroscopic movement with the difference in cell wall structure of reaction and non-reaction wood have been proposed [2].

On that basis, a homogenization procedure was employed for upscaling of elastic properties and evaluating the macroscopic effect of growth strains implemented at the cell wall level. To do so, Hervé-Zaoui's n-layered cylindrical inclusion problem [3] was extended for anisotropic constituents and utilized for modeling of the cell wall.

Applying geometrically non-linear beam mechanics to a growing branch inclined with respect to the vector of gravity allows to simulate the reorientation process induced by growth strains at the cell wall level, introduced via the aforementioned micromechanics model. In combination with experimental data of the branch shape evolution found in literature of specific species, growth-related parameters can be deduced, giving access to new insights into the dynamics of wood growth.

REFERENCES

[1] M. Fournier, T. Almeras, B. Gril, J. Gril, Biomechanical action and biological functions. In The Biology of Reaction Wood. *Springer Series in Wood Science, Springer*, pp. 139–169, 2014.

[2] E. Mellerowicz and T. Gorshkova, Tensional stress generation in gelatinous fibres: a review and possible mechanism based on cell-wall structure and composition. *J. Exp. Bot.*, Vol. **63**, pp. 551–565, 2012.

[3] E. Hervé and A. Zaoui, Elastic behavior of multiply coated fiber reinforced composites. *Int. J. Eng. Sci.*, Vol. **33**, pp. 1419–1433, 1995.