Effective poroelastic properties of softwood in relation to moisture induced swelling

A. Rafsanjani[1, 2], J. Carmeliet[3, 4], and D. Derome[5]

[1]*Wood Laboratory, EMPA, Dübendorf, Switzerland*
[2]*Department of Civil, Environmental and Geomatic Engineering, ETH Zürich, Switzerland*
[3]*Laboratory for Building Science and Technology, EMPA, Dübendrof, Switzerland*
[4]*Chair of Building Physics, ETH Zürich, Switzerland*
[5]*Department of Civil and Mechanical Engineering, EMPA, Dübendorf, Switzerland*

ABSTRACT: Wood is a natural porous material with a hierarchical microstructure. At the mesoscopic scale, wood consists mainly of honeycomb-like cells called tracheid. The cell wall of tracheids is composed in almost equal quantity of stiff crystalline cellulose microfibrils immersed in a soft hydrophilic polymeric matrix, organized in a layered manner. At the dry state, the cell wall is essentially non-porous. Sorption of water molecules in between hydrophilic molecules pushes the constituents apart, resulting in swelling by formation of nanopores in the cell wall and consequently reduction in stiffness. This behavior is reflected at the macroscale in anisotropic swelling and moisture dependent mechanical properties. In this work, a computational homogenization procedure using finite element method is adopted to up-scale the microscopic constitutive behavior of poroelastic honeycomb cellular solids which are an approximation of the mesoscopic architecture of softwood. The effective poroelastic properties (Biot coefficients and solid Biot modulus) are computed by solving boundary value problems over representative elementary volumes with periodic boundary conditions. The effect of the microstructure properties, i.e. geometry, density and arrangement of the cells as well as the material properties of the cell wall on the overall properties is investigated. The relation between the effective poroelastic constants and the swelling behavior is discussed.