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Numerical modeling of moisture transport in wood

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ABSTRACT

Material properties of wood are strongly dependent on moisture state and history. Wood, being a hygroscopic material, is always interacting with the ambient climate. This implies that for an adequate material model of wood it is necessary to include moisture state and history either as input to or implemented in the model. A plain illustration of the microscopic structure of wood, figure 1, shows that there are two ways moisture can be transported, as water vapor in the cell lumen and bound water in the cell wall. The interaction between the two phases of water is the sorption of moisture to and from the wood cell wall.

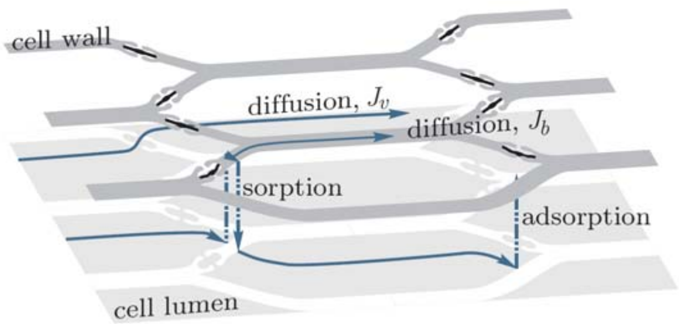

Figure 1: Sketch of the moisture transports in wood porous structure

The present work deals with modeling the moisture transport, moisture fixation and moisture induced deformations. For non-extreme quasi isothermal conditions three coupled processes govern moisture transport in wood; diffusion of vapor, c_v, sorption, $\dot{c}$, and diffusion of bound water, c_b, which all are considered in the model [1]. The constitutive equations are written as two coupled transport equations where the coupling is the source/sink term, $\dot{c}$, as defined in (1).

$$\frac{\partial c_b}{\partial t} = \nabla(D_b \nabla c_b) + \dot{c}$$
$$\frac{\partial c_v}{\partial t} = \nabla(D_v \nabla c_v) - \dot{c} \quad (1)$$

The moisture hysteresis between vapor and bound water of wood is also accounted for in the non-linear sorption term, $\dot{c}$, [2]. The sorption term depends on the sorption rate function, H, which governs the rate at which equilibrium is reach and the state and degree of non-equilibrium between the vapor and bound water in the wood as shown in (2).

$$\dot{c} = H(c_{bl} - c_b) \tag{2}$$

Figures 2 illustrate the relation between the concentrations of moisture in the two phases, vapor and bound water, and the difference $c_{bl} - c_b$.

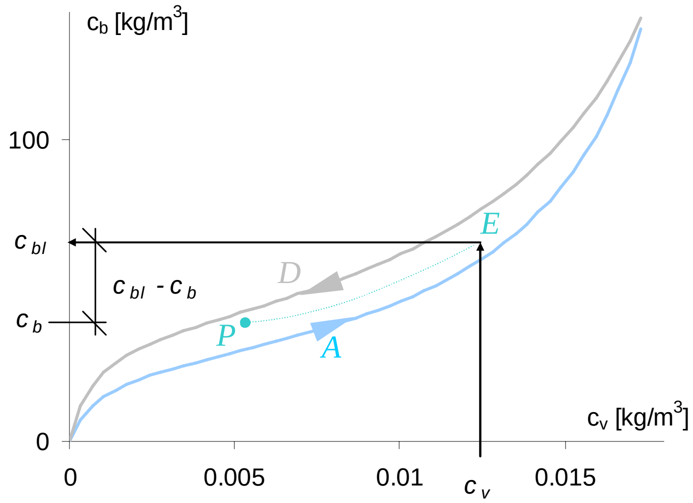

Figure 2: Sorption isotherm for moisture concentrations of vapour and bound water in wood, *A*, absorption boundary curve, *D*, desorption boundary curve, *P*, state prior moisture change, *E*, equilibrium for new moisture state.

Two cases are numerically simulated, the moisture penetration as a result of periodically varying ambient climate and moisture induced deformations. For both studied cases comparisons are made between results generated with the traditional Fick's law based model and the presented coupled model. Results from both moisture penetration and induced deformation simulations show that only a coupled constitutive model can describe the modeled behavior realistically [3].

References

[1] Frandsen, H. L, L Damkilde and S. Svensson, 2007: A revised multi-Fickian moisture transport model to describe non-Fickian effects in wood. *Holzforschung*, 61, pp 563 – 572.

[2] Frandsen, H. L, S. Svensson and L Damkilde, 2007: A hysteresis model suitable for numerical simulation of moisture content in wood. *Holzforschung*, 61, pp 175 – 181.

[3] Frandsen, H. L and S. Svensson, 2007: Implementation of sorption hysteresis in multi-Fickian moisture transport. *Holzforschung*, 61, pp 693 – 701.