A multi-phase coupled transient heat and moisture transport model in wood based on the hybrid mixture theory

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Building materials most commonly consist of porous structures involving high inhomogeneity in relation to structural formulations, material properties and constituents. Wood in general is one example, whose porous fibers exhibits high affinity towards moisture. The behavior of such porous materials when exposed to varying environmental temperature and moisture conditions is of special interest in the construction industry. This is due to the high effects and variations of the wooden material structure, strength and stiffness when moisture interacts with its fibers.

Moisture flow and distribution within a porous media involves additionally complex processes, where at standard ambient conditions of use the pores in wood usually contain moist air and water molecules are bonded to the fibers (bound water). Sorption processes of water to and from the fibers at different temperatures takes place and are a function of the equilibrium sorption isotherms relating the relative humidity and temperature to moisture content.

This study presents the application of the hybrid mixture theory (HMT), applying the balance principles in the realm of continuum mechanics governed by the principles of thermodynamics to describe a multi-phase multi-constituent heat and mass (moisture) flow process in wood. A tri-phase model consisting of the wood fibers, liquid moisture and gas is developed and implemented into a two dimensional 2-D test example in a non-linear, coupled finite element code. This study contributes to the stringent understanding of transient moisture transport in porous media through application of a sophisticated thermodynamically consistent model. Related studies involving the HMT have been successfully applied to a variety of other materials including: clay soils [1], biopolymers [2] and paperboards [3,4].

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