

Physics of bio-based construction materials (Hygrothermal behavior)

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1. Introduction

- Energy considerations
- Wood, insulating materials, bio-based walls
- Example of Cob house
- Generalities on hygrothermal characteristics of bio-based construction materials
- General objectives of the course

2. Thermal comfort

- Notions of thermal comfort
- Temperature
- Humidity
- Air flow

3. Physical properties of bio-based materials

- Structure of cellulose fibers (from the atomic to the macroscopic scale)
- Wood structure (hardwood, softwood)
- Implications for large “fibers”
- Water content in wood
- Sorption-desorption characterization
- Physical origin of sorption processes
- Sorption properties of various cellulosic materials
- Induced swelling-shrinkage

4. Heat transfers

- Conduction: general expression, steady conduction through a homogeneous material; through a composite material; heat diffusion equation; boundary conditions; solution for convection surface condition; thermal inertia
- Radiation: basic knowledge
- Convection: similarity solution for air flow, heat or mass transfer; approximate solution

5. Humidity transfers in porous media

- Porous structure
- Steady flow through a porous medium, permeability
- Surface tension effects, Laplace law
- Capillary imbibition
- Drying of simple porous media: regimes and internal characteristics
- Imbibition and drying of wood

6. Moisture buffering effect of bio-based materials

- Bound water diffusion in a cellulose fiber
- Bound water diffusion in a wood piece
- Bound water and vapor diffusion through a fiber piling
- Water diffusion through a paste + fiber wall
- Exchange of a finite water mass (vapor or bound water) between a wall and a room: equilibrium amounts, dynamics
- Mass transfer in a wall under a steady air flow

7. Hygrothermal modelling

- Toy model
- Full modelling...