Experimental and numerical study of multiphysics properties of new green building materials applied as thermal insulation

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Abstract

The high demand of energy in the building is one of several factors having an impact on our life and environment. One of numerous promising alternatives issue to solve this problem, is the using of the biomaterials from vegetal and agriculture wastes as thermal insulation. These biomaterials need a low energy consumption for their production, reduce CO_2 emission and are renewable materials. In the CERTES laboratory, and with the collaboration of several research institutions, we develop a new biobased building materials build from mortar, plaster or polymers reinforced with date palm fibers (DPF) or with other (flax, corn, sisal,…) green materials.

Objectives and materials studied

- Important energy consumption and CO2 emissions in building construction field with using standard materials
- Use natural date palm waste as building construction materials

- Develop a new bio-composite material based on mortar, plaster or polymers with the natural fibers for building insulation

Plasterboard panel

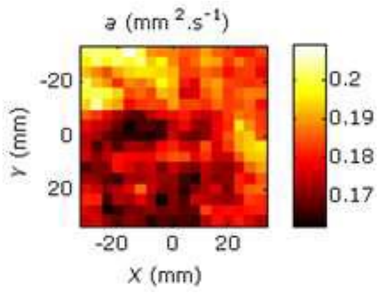
Structure/unsulating

PDPF panel on the ceiling

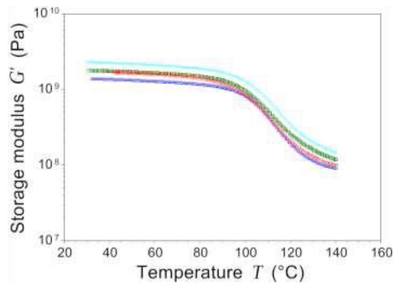
- Characterization and modeling : Thermophysical, mechanical, hygrothermal properties

- Effect of the composition, process and fiber treatment on the polymer matrix

Composites Epoxy/Flax

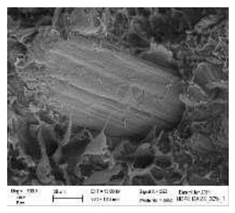


Collab. CIMAP Alençon

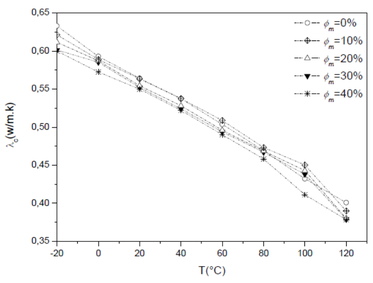


Nom	Traitement textile
Non traité	Référence
Lessivé	Lessivé au détergent
Blanchi	Blanchiment au peroxide
Mercerisé	Mercerisation NaOH à T=20-30°C

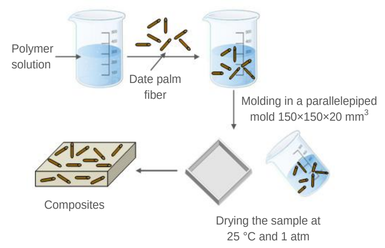
Composites HDPE/Corn



Collab. U. de Girona

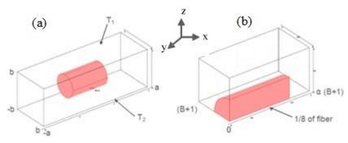


Composites Epoxy/Date Palm

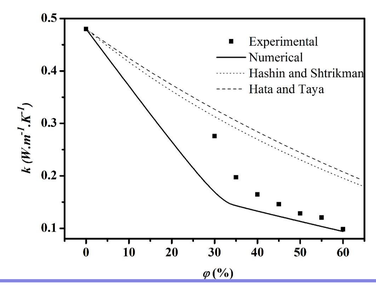


Collab. U. Batna

$$Q = \int_0^{1+B}\int_0^{\alpha(1+B)} \frac{dT}{dZ} dXdY \qquad E = \frac{k}{k_m} = \frac{Q}{\alpha(B+1)}$$



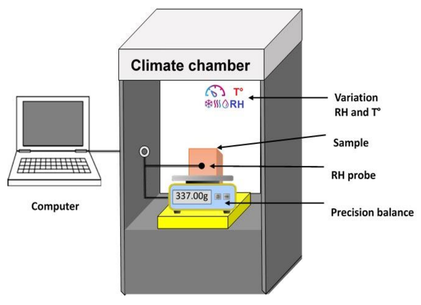
Numerical modelling of fibers



Methodology and characterization

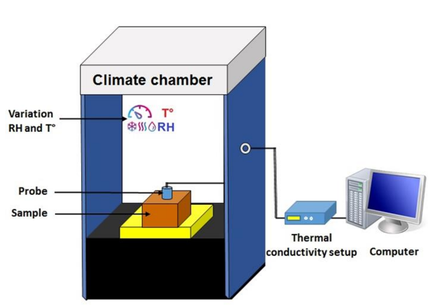
Materials Scale

- Measurement of Mechanical properties (Rc) with DPF %
- Investigation of thermophysical properties on variation of DPF% and temperature
- Measurements of hygric behavior on RH and Temperature variation

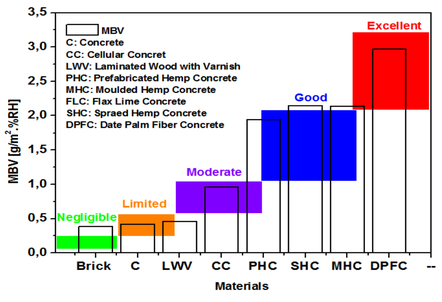


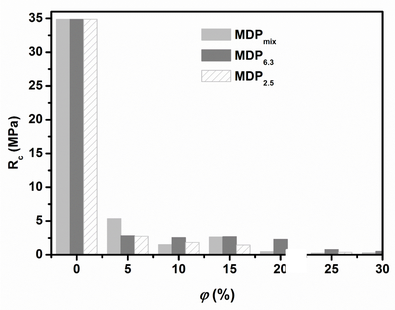
MBV measurement setup

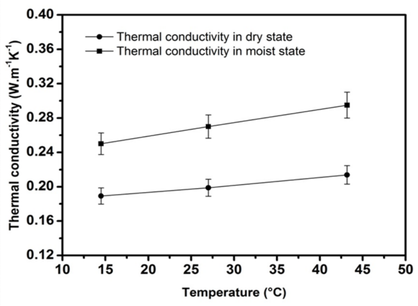
Mechanical measurement setup



Thermohydric measurement device



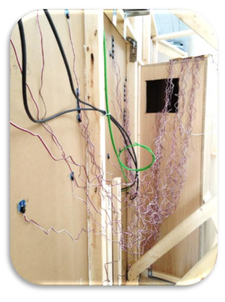




System Scale

- Measurements are performed in climatic chamber

Wall preparation



Wall instrumentation

Excitation and Measurement

- Modelling transfers and validation with experimental data

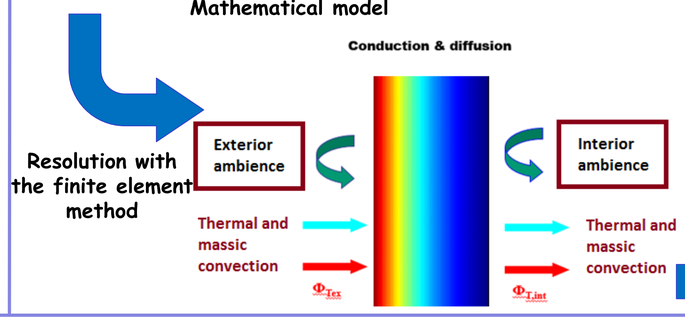
Heat transfer

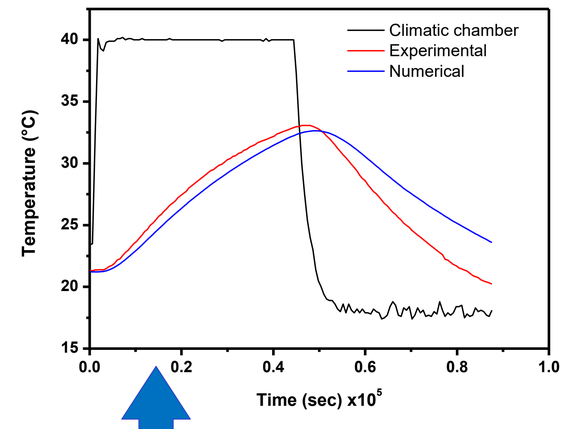
$$\xi_\varphi \frac{d\varphi}{dt} = \nabla\left[\delta_v \varphi \frac{\partial p_{sat}}{\partial T}\nabla T + (\delta_v p_{sat} + D_l)\nabla\varphi\right]$$

Moisture transfer

$$(\rho_0 c_0 + c_l w)\frac{dT}{dt} = \nabla\left[\left(\lambda + l_v \delta_v \varphi \frac{\partial p_{sat}}{\partial T}\right)\nabla T\right] + \nabla[(l_v \delta_v p_{sat})\nabla\varphi]$$

Mathematical model





Comparison of numerical and experimental data

Conclusion

In this work, we have experimentally and numerically investigated the multiphysic behavior of new biobased building composite materials based on date palm fibers filled in mortar, plaster or polymers matrix. Both mechanical and thermal properties indicate the possibility to use these kinds of composite materials as structural or insulating materials. In addition, these new biobased materials exhibit an interesting thermal and hydric properties compared to several conventional materials used in the building construction.