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Ph.D. thesis (2022-2025)
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DESICELL : Design approach for new recyclable cellulosic based materials in building industry

Nouveaux procédés d'obtention de matériaux cellulosiques et terre crue recyclable pour architecture

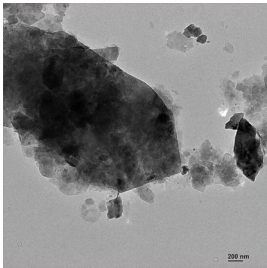
Context / Objectives

Recyclable cellulosic and earth-based panel

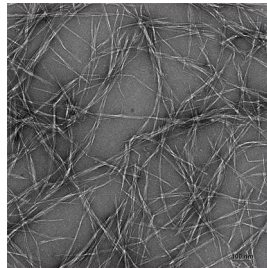
Lowering the environmental impact of building industry

- 23% of the French carbon footprint¹
- 86,8 Mt of inert waste in France in 2020²
- 2/3 of down-cycled waste and 1/3 landfilled³

Blend of earth, fibers and MFCs for finishing elements



TEM picture of the FAC



TEM picture of MFCs

- Low thermal conductivity⁴
- Hygroscopic behavior: passive cooling⁴
- Increase of mechanical properties⁵

References:

- Ministère de la transition écologique - 2022
- SDES, 2020
- Bastin A. Flux - 2019
- Giada G. et al., *Hygrothermal Properties of Raw Earth Materials* - 2019
- Stanislas T.T. et al., *Effect of cellulose pulp fibres on the physical, mechanical, and thermal performance of extruded earth-based materials* - 2021

Funded by:

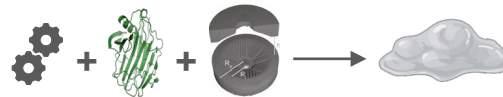


Methods

Production process

1. MFCs production

The production of MFCs is performed by refining, enzymatic hydrolysis and mechanical fibrillation.



2. Formulation

Mixture of cellulose fibers, micro-fibrillated cellulose and earth (FAC) in various proportion is made.



3. Mixing process

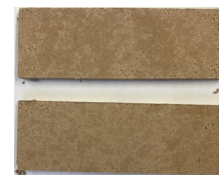
4. Compression process

Hydraulic press:
100 kN, 25°C



5. Drying process

Drying in standard room:
23°C, 50% RH, 72h



6. Recycling process

The final composite will be recycled following a protocol. The recovered mixture should be usable to produce a new material with the same level of properties.

Scheme: BioRender

Results

Mechanical properties

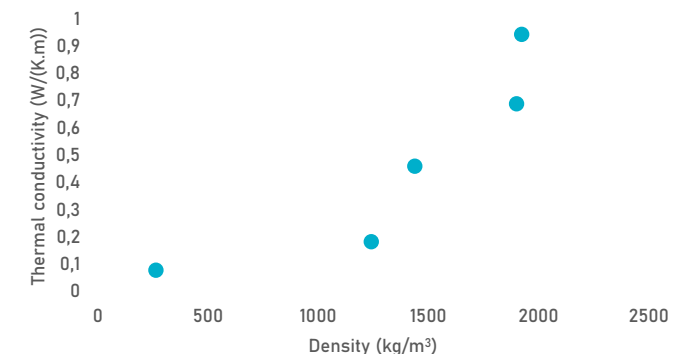
Sample	Modulus of Elasticity (MPa)	Modulus of Rupture (MPa)
FAC	711 ± 205	0.6 ± 0.5
FAC + fibers	903 ± 227	0.6 ± 0.2
FAC + additive	2824 ± 893	1.3 ± 0.1



3 point bending

The addition of fibers increases MOE but the MOR stays the same. Moreover, the addition of an additive increased significantly the MOE as well as the MOR.

Thermal conductivity



The addition of fibers decreases the density and so the thermal conductivity.

