Mycelium-Based Biocomposites and Raw Earth: A Circular Alternative to Traditional Building Materials

Urban and Environmental Engineering

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Context and State of Art

In the current context of a global ecological crisis, the construction sector stands out as one of the most impactful. It alone accounts for approximately 39% of global greenhouse gas emissions [1], largely due to material production, which represents 8 to 10% of these emissions [2]. Consequently, the pursuit of more responsible approaches to material production has progressively become a key area of investigation within sustainability research over the past few decades [3].

Situated at the interface between biology and architecture, mycelium, which is the vegetative structure of fungi, [2] is attracting growing interest as a promising next-generation material. It is characterized by its ability to form mycelium-based composites (MBC), produced through the colonization of an organic substrate [4]. Beyond their modularity and compatibility with circular approaches, these composites exhibit bio-adhesive properties [5] that open the way to innovative biological assemblies.

Methodology

Selection and preparation of components

Choice of fungal species

P. oestreatus, G. lucidum

Choice of substrate

Straw, sawdust

Substrate pasteurisation

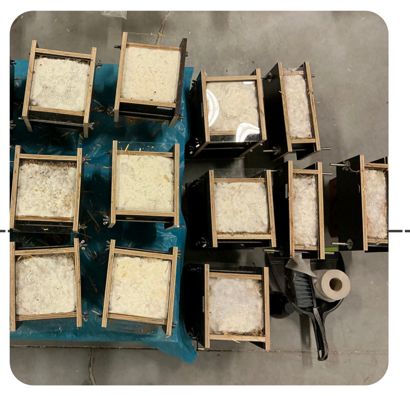
With hot water or hydrated lime

Substrate inoculation

Molding in successive layers

Pre-growth before molding

Growth



Incubation

15 to 30 days

Growth outside the mold

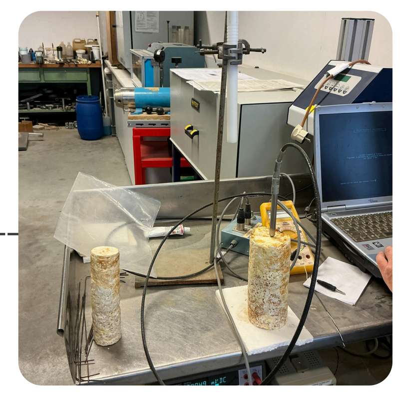
24 to 48h

Post-tratment

Heating

Drying at 80°C for 24 to 48h

Testing campaign



Density, thermal conductivity, water absorption, adhesion, ...

Main Results

The MBCs have a density ranging from 146.74 to 293.00 kg/m³ (ISO 9427), which classifies them among lightweight materials. Their shrinkage rate is relatively low, between 9.56 and 10.47%. From a thermal performance perspective, their thermal conductivity varies between 0.041 and 0.045 W/mK (needle probe test), confirming their potential as insulating materials.

Regarding hygroscopic behavior, water absorption by capillarity ranges from 16.61 to 31.4 kg/m² (EN 13057), while immersion absorption reaches up to 327% after 96 h.

Regarding the adhesion between the MBC and the raw earth, tests carried out with the Instron 5585 indicate a breaking load ranging from 19.62 to 20.22 N, corresponding to a breaking stress of 0.0019 to 0.0021 N/mm². In most cases, failure occurred within the MBC, indicating that the interface was not the most critical point.

Discussion / Interpretation

- High contamination risk: nearly 50% of the samples were infected by external pathogens (e.g. Trichoderma), making it the main challenge. Substrate pasteurization is only a partial decontamination process, and its effectiveness remains lower than that achieved through sterilization.
- Substrate granulometry: particle size must be adjusted to the dimensions of the mold.
- Molds: they must be airtight, reusable, and thoroughly disinfected between each cycle
- Thermal treatment: oven-drying is essential to ensure the performance of the MBC (particularly its thermal properties), although natural drying remains possible but less effective.

Conclusion & Perspectives

Mycelium-based materials represent an innovative approach to construction, aligned with principles of low-impact and sustainable technologies. Due to their advantageous thermal properties and low density, mycelium-based composites (MBC) constitute a credible alternative to conventional materials, particularly for insulation applications. Furthermore, they open up possibilities for revaluing the interactions between humans and living systems, interactions that are increasingly overlooked in a sector as highly industrialized as construction.

Reference

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