Valorization of bamboo in temperate climates from a low-carbon and circular architecture perspective: exploitation potential and insulating properties.

Keywords

Bamboo, Bio-based insulation, Circular construction, Energy renovation, Territorial adaptation

Abstract

Aligned with the European objectives of transitioning towards a circular and carbon-neutral economic model, the construction sector must accelerate the energy renovation of the existing building stock and adopt insulating materials with low environmental impact that are durable, reusable, or recyclable. In Wallonia (Belgium), bio-based insulating materials currently account for only 8% of the market [1], but their production will need to increase substantially, requiring a diversification of local bio-based resources. Bamboo, with its rapid growth and high yield [2,3], represents a promising resource, particularly as several plantations are emerging in this specific region and some industrial sectors are already seeking new outlets. Its physical properties are similar to wood [4], which is already used as an insulating material, but wood is increasingly under pressure from climate change and global demand for timber products, positioning bamboo as a viable alternative for new insulation applications. Its use could simultaneously address the growing demand for insulation and pressing environmental challenges.

This research pursues two main objectives: (1) to demonstrate the adaptation of selected bamboo species to the climatic and edaphic conditions of Wallonia, and more broadly to temperate European climates; and (2) to assess their potential as insulating materials for sustainable and circular renovation. The first objective relies on a territorial approach integrating climate, soil, and local agricultural practices. The second focuses on the use of bamboo as "loose-fill" insulation (fibers and granules) and as “composite” insulation (combined with lime or earth), materials that are minimally processed, low-energy, reversible, and suitable for different building components (walls, roofs, floors).

The research is structured around four complementary components:

(1) **Agronomic validation**: analysis of growth, maturity, and climatic sensitivity of the selected species, to define sustainable and adapted cultivation practices.
(2) **Material characterization**: laboratory experiments on the physical, thermal, and hygroscopic properties of three insulating forms, to evaluate their performance and industrial feasibility.
(3) **Construction development**: survey of existing techniques, both vernacular and contemporary, and the design of construction systems for roofs and façades integrating reversibility and circularity, with the aim of building a technical and normative basis.
(4) **Environmental assessment**: life-cycle analysis and circularity study of the most promising material, compared with existing bio-based insulators.

The methodology builds on an exploratory, interdisciplinary, and eco-design approach, linking agronomic validation, material performance, architectural implementation, and environmental impact, to position bamboo as a strategic resource for circular, low-carbon construction in temperate climates. This contribution will present the detailed methodology and first results of the agronomic validation, as well as the methodology developed for the material sampling campaign.

References

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