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# THERMAL PERFORMANCE, ENERGY AND ENVIRONMENTAL ASSESSMENT OF BAMBOOBASED PANELS FROM INDUSTRIAL WASTES FOR LOW CARBON BUILDINGS

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***Abstract –*** Insulation is one of the most effective methods for reducing energy consumption in both the heating and cooling of buildings. Selecting the right materials is crucial as, in addition to reducing emissions from the operation phase thanks to high energy efficiency, it is important that innovative materials also have a low impact during the production process. A growing interest focuses on the replacement of synthetic insulations with recycled materials. Among these are by-products from industrial transformation and manufacturing, residues from agro-industrial processes, and farming wastes. Natural materials have substantially less embodied energy than processed materials, so their use in new buildings and refurbishments can make a worthwhile contribution to sustainability. In this scenario, bamboo is an abundant and promising source. Its ability to capture $CO_2$ from the atmosphere, enhanced by its rapid growth, makes it an ally in mitigating climate change and GHG emissions. To sustain its $CO_2$ absorption capacity, bamboo requires regular harvesting. A valuable application of bamboo prunings is in the production of furniture and textiles. Furthermore, due to its exceptional strength-to-weight ratio and resistance to moisture and insects, bamboo is well-suited for manufacturing durable structural components and building materials, particularly in humid climates. This, however, results in a considerable amount of waste generated at various stages of the bamboo life cycle. This work aims to reduce construction environmental impacts using vegetal waste collected from the different phases of bamboo processing to produce monosheet thermo-insulating panels. Bamboo was characterized, milled to the particle size of 1.397 mm and incorporated into the adhesive. As low-impact alternatives to synthetic glues, two vegetal glues were used, specifically cellulose-based, selected based on polymer hydrophobicity and water solubility when dry, influencing the samples' permeability. Preparation and drying procedure was developed and preliminary tests identified the optimal mixtures which balance mechanical strength and minimum adhesive. 9 circular samples (φ=100 mm) 40 mm thick were prepared mixing bamboo grains with 3 types of glue (vinyl glue, methyl cellulose, 4 % CMC), each used in 3 different concentration levels (50 %, 75 %, 85 %). Thermal conductivity of the panels was experimentally evaluated by C-Therm TCi thermal analyser according to ASTM D7984. Energy saving potential of the best solution was compared to that of commercial synthetic panels through dynamic simulations on a case study building in central Italy. The environmental impact of the new component was assessed through a 'Cradle to Gate' LCA. The optimal vegetal glue

combination is the 85 %-one. It was observed that for higher densities, the thermal properties worsen. Considering the production phase, the innovative panel's embodied energy is over 20 % lower than that of traditional insulation material.

***Keywords – Bamboo; building insulating systems; dynamic simulation; energy performance; grinded fibers; Life Cycle Assessment; natural glues; recycled sustainable materials; thermal characterization***

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