WREN2026 - World Renewable Energy Network Conference
November 2026 - Pará, Brazil

Thermo-energy performance of alternative materials with renewable components for use in ceilings of buildings exposed to the Amazonian climate

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ABSTRACT

The use of thermally efficient construction systems is particularly important in hot and humid climates, such as the Amazon region. This study evaluated the thermal performance of four ceiling configurations in a 25 m² single-storey building under the climatic conditions of Belém, Pará, Brazil. The scenarios comprised a reference case without a ceiling (C0), a PVC ceiling (C1), a plywood ceiling (C2), and a ceiling system consisting of a gypsum composite reinforced with 10% jupati (Raphia taedigera) petiole fibers combined with an expanded polystyrene (EPS) layer (C3). Building geometry was developed in SketchUp, while thermal-energy simulations were configured in OpenStudio and performed using EnergyPlus and its Heat Balance Method. Annual simulations were conducted using local weather data, assuming that doors and windows remained closed. The annual mean indoor air temperatures were 28.51 °C (C0), 27.31 °C (C1), 27.29 °C (C2), and 26.65 °C (C3). Compared with C0, C3 reduced the annual mean indoor temperature by 1.86 °C and lowered daily temperature peaks, indicating a more stable thermal response. However, C3 exhibited the highest annual mean indoor relative humidity (85.63%), highlighting the importance of considering moisture conditions and ventilation strategies alongside thermal performance. These findings suggest that combining a jupati-fiber-reinforced gypsum composite with EPS can improve the thermal performance of small buildings in hot and humid Amazonian climates. This approach supports innovation in construction materials and the development of more sustainable, climate-responsive buildings, contributing to Sustainable Development Goals 9 (Industry, Innovation and Infrastructure) and 11 (Sustainable Cities and Communities).

Keywords: Building thermal performance; Building energy simulation; Natural fibers; Thermal insulation.

Acknowledgments

The authors thank PROPESP/UFPA for its support through the Institutional Scientific Initiation Scholarship Program (PIBIC), including the scholarships awarded to undergraduate students. The authors also acknowledge CAPES and CNPq for their support, as well as the Laboratory of Composite Materials at UFPA for conducting the experiments reported in this study. Special thanks are extended to FEM/ITEC/UFPA and PPGEM/ITEC/UFPA for their support. The authors gratefully acknowledge the financial support provided by the Human Resources Program of the National Agency of Petroleum, Natural Gas and Biofuels (PRH-ANP) and the São Paulo Research Foundation (FAPESP).