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Numerical Modeling of Phase Change Materials Walls under Reunion Island's Tropical Weather

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Abstract : The MCP-iBAT1 project is carried out to study the behavior of Phase Change Materials (PCM) integrated in building envelopes in a tropical environment. Through the phase transitions (melting and freezing) of the material, thermal energy can be absorbed or released. This process enables the regulation of indoor temperatures and the improvement of thermal comfort for the occupants. Most of the commercially available PCMs are more suitable to temperate climates than to tropical climates. The case of Reunion Island is noteworthy as there are multiple micro-climates. This leads to our key question: developing one or multiple bio-based PCMs that cover the thermal needs of the different locations of the island. The present paper focuses on the numerical approach to select the PCM properties relevant to tropical areas. Numerical simulations have been carried out with two softwares: EnergyPlusTM and Isolab. The latter has been developed in the laboratory, with the implicit Finite Difference Method, in order to evaluate different physical models. Both are Thermal Dynamic Simulation (TDS) softwares that predict the building's thermal behavior with one-dimensional heat transfers. The parameters used in this study are the construction's characteristics (dimensions and materials) and the environment's description (meteorological data and building surroundings). The building is modeled in accordance with the experimental setup. It is divided into two rooms, cells A and B, with same dimensions. Cell A is the reference, while in cell B, a layer of commercial PCM (Thermo Confort of MCI Technologies) has been applied to the inner surface of the North wall. Sensors are installed in each room to retrieve temperatures, heat flows, and humidity rates. The collected data are used for the comparison with the numerical results. Our strategy is to implement two similar buildings at different altitudes (Saint-Pierre: 70m and Le Tampon: 520m) to measure different temperature ranges. Therefore, we are able to collect data for various seasons during a condensed time period. The following methodology is used to validate the numerical models: calibration of the thermal and PCM models in EnergyPlusTM and Isolab based on experimental measures, then numerical testing with a sensitivity analysis of the parameters to reach the targeted indoor temperatures. The calibration relies on the past ten months' measures (from September 2020 to June 2021), with a focus on one-week study on November (beginning of summer) when the effect of PCM on inner surface temperatures is more visible. A first simulation with the PCM model of EnergyPlus gave results approaching the measurements with a mean error of 5%. The studied property in this paper is the melting temperature of the PCM. By determining the representative temperature of winter, summer and inter-seasons with past annual's weather data, it is possible to build a numerical model of multi-layered PCM. Hence, the combined properties of the materials will provide an optimal scenario for the application on PCM in tropical areas. Future works will focus on the development of bio-based PCMs with the selected properties followed by experimental and numerical validation of the materials. 1Materiaux ´ a Changement de Phase, une innovation pour le B ` ati Tropical

Keywords : energyplus, multi-layer of PCM, phase changing materials, tropical area
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