Phase Change Materials For Building Envelopes In Reunion Island, France

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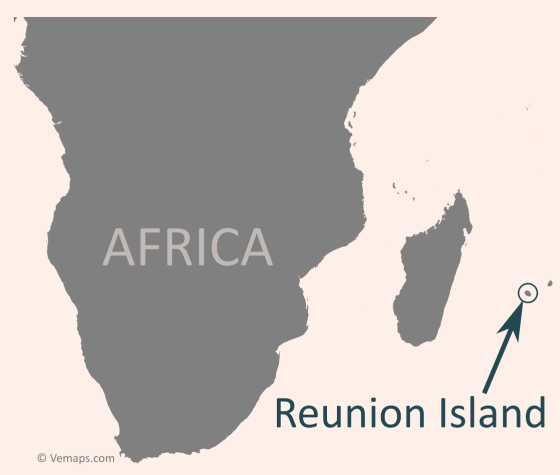
MCP IBAT

Introduction



The "Phase Change Materials: an innovation for Tropical Buildings" (MCP-iBAT) project is conducted to identify and develop local resources for the improvement of thermal comfort and the energy management of buildings in Reunion Island (France).

The present study evaluates the effects of a selected Phase Change Material (PCM) on an experimental lightweight building, located at Saint-Pierre, representative of the coastline area.

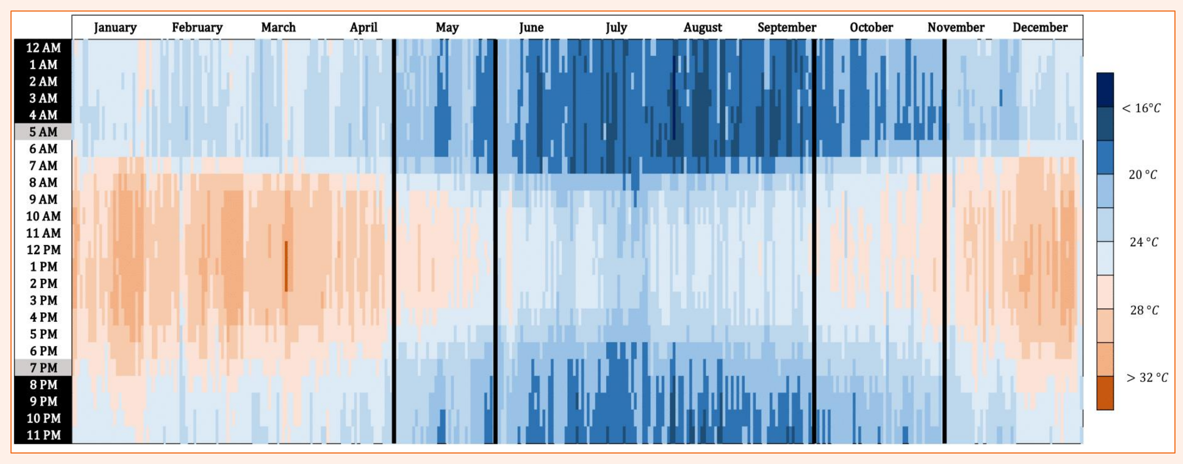


Figure 1: Mean annual evolution of the outdoor air temperature in 2018-2019, city of Saint-Pierre, Reunion Island.

Experimental set-up

Measured properties of Thermo Comfort PCM (WINCO Technologies)	
Melting temperature	26 *°C*
Latent heat of fusion	165 – 173 $kJ.kg^{-1}$
Mass Heat Capacity	Solid: 2400 $J.K^{-1}.kg^{-1}$ Liquid: 3600 $J.K^{-1}.kg^{-1}$
Thickness	0.005 *m*

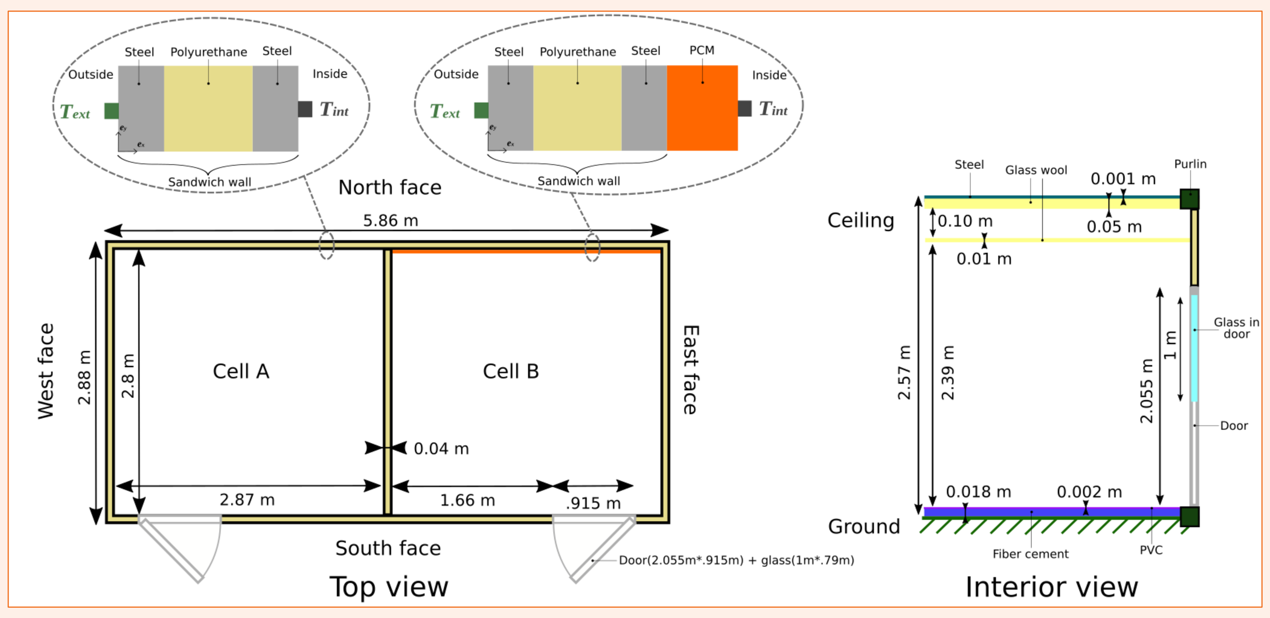


Figure 2: Top view of the lightweight building, with the dimensions and the composition of the walls.

Methodology

Objective: determining selection criteria for suitable PCMs in a tropical climate.

- Development of tools to collect and analyze local data;
- Modeling of the experimental benches with the measured properties of the selected PCM;
- Validation of the selected parameters with the simulation code, EnergyPlus™.

Experimental results

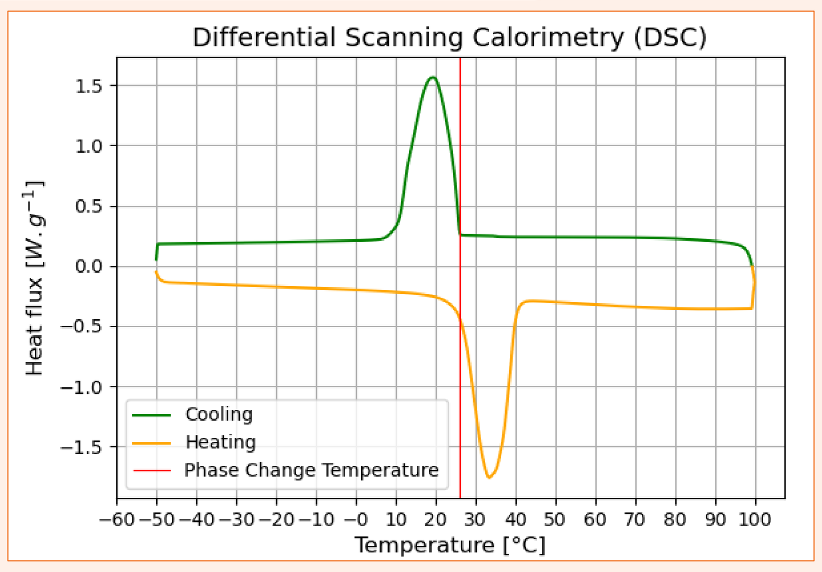


Figure 3: Differential Scanning Calorimetry of the PCM (5°C/min)

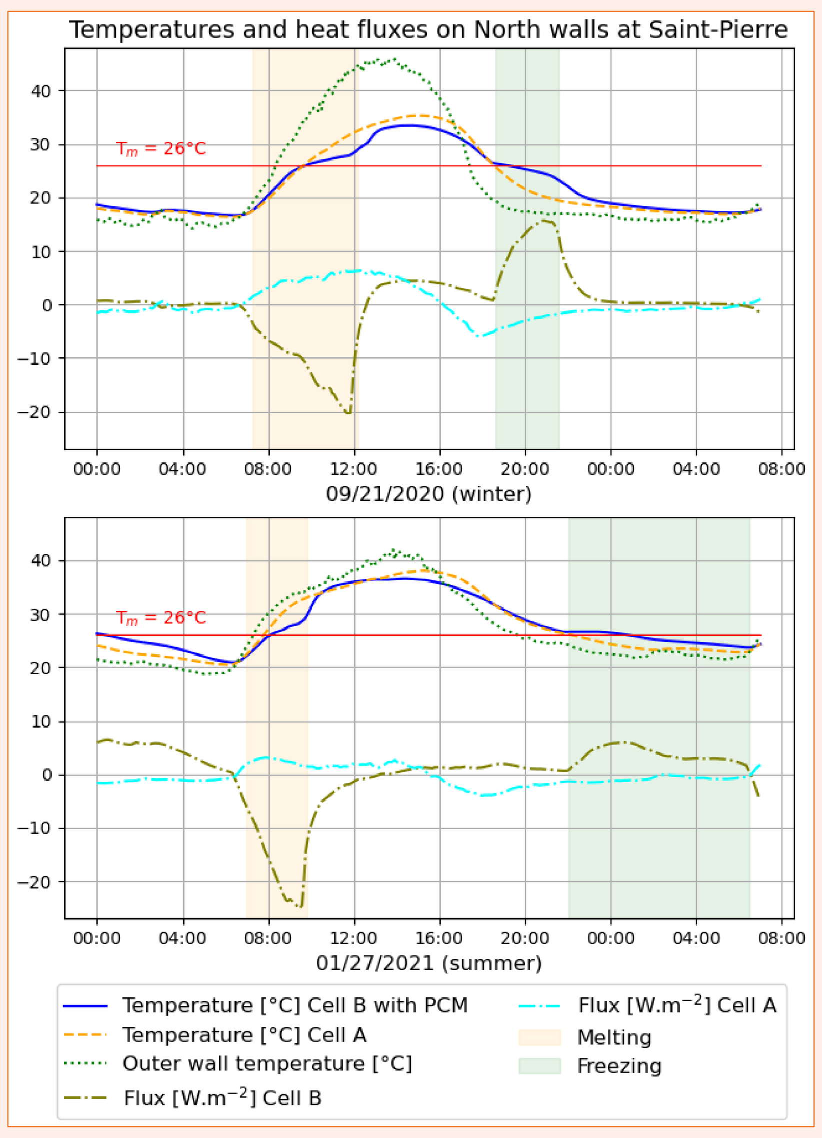


Figure 4: Temperatures and heat fluxes on North walls

Temperatures:

- Peak temperature delay: 3 hours in winter and 2 hours in summer.
- Temperature reduction during daytime: up to 4°C.
- During nighttime, wall temperature maintained around 26°C for 3 hours in winter. In summer: no visible effect.

Heat flux:

- Stored energy density greater than released energy density
- Phase Change temperature range wider than the PCM temperature variation

Period	Winter	Summer
Stored energy	207 $kJ.m^{-2}$	181 $kJ.m^{-2}$
Duration of storage	4h55*min*	2h50*min*
Released energy	132 $kJ.m^{-2}$	112 $kJ.m^{-2}$
Duration of release	3*h*	8h30*min*

Discussion:

- PCM solidifies only partially;
- The cumulative effect of the cycles makes the coating inefficient in summer;
- PCM should have a narrower interval of fusion and solidification temperatures.

Numerical results

Energy Plus™ simulations with the characteristics of the experimental set-up and the material properties.

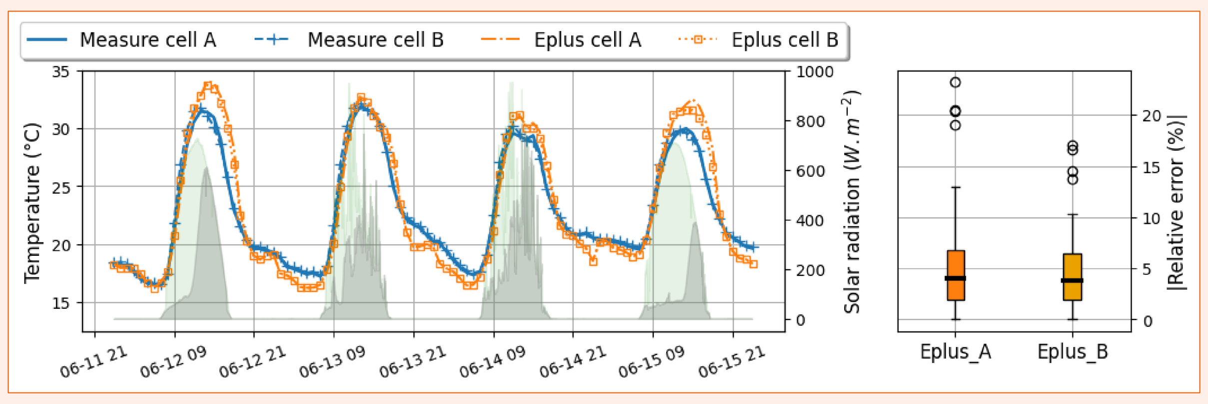


Figure 5: Simulation results for North wall without PCM

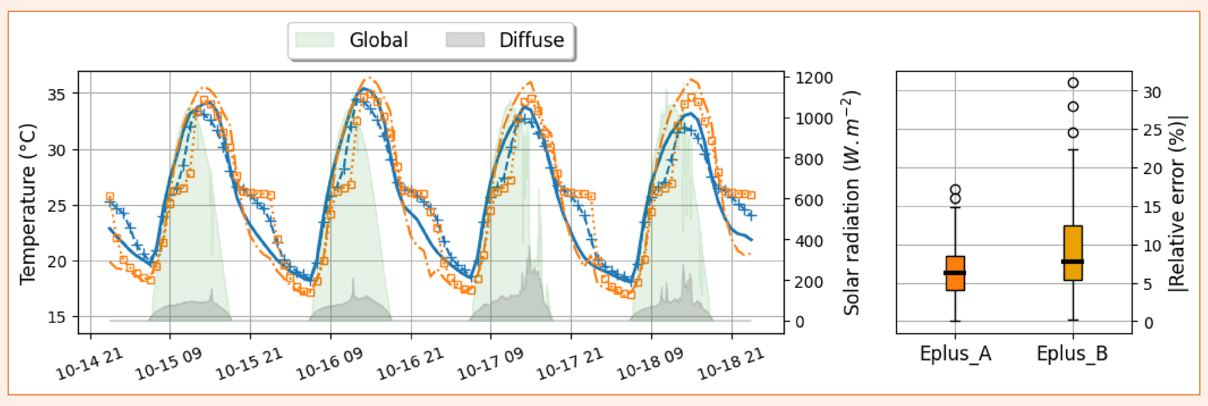


Figure 6: Simulation results for North wall with PCM

1. Numerical simulations performed with the known properties of the PCM and the others materials.
2. Optimization program launched to approach the measured temperatures, by calibrating the parameters.

Discussion:

- Interval of fusion and solidification have an important impact on simulation results;
- Latent heat reduced to **121.5 $kJ.kg^{-1}$** → PCM not fully exploited;
- Errors can be reduced with more precise environmental and building data.

Conclusion

The work presented in this paper aims to evaluate the effects of Phase Change Materials (PCM) on thermal comfort in buildings on Reunion Island.

- PCM was not optimally used due to its partial fusion: indeed, the complete melting needs temperatures ranging from 26°C to 40°C.
- The fusion and solidification temperatures intervals have to be clearly described to optimize the PCM efficiency and its impact on the building's thermal performance.
- Temperatures of thermal neutrality (in winter comfort and summer comfort) should be considered in the future as phase change temperature.
- Finally, simulation results have shown a good prediction of building's thermal behavior with and without PCM, and future work will focus on sensitivity analysis and thermal prediction.

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