Numerical heat transfer analysis of Phase Change Material (PCM) - enhanced plasters

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Introduction: An effective solution to alleviate the temperature fluctuations experienced in buildings located in summer- dominant environments and achieve energy savings is the incorporation of Phase Change Materials (PCMs) in the envelope.

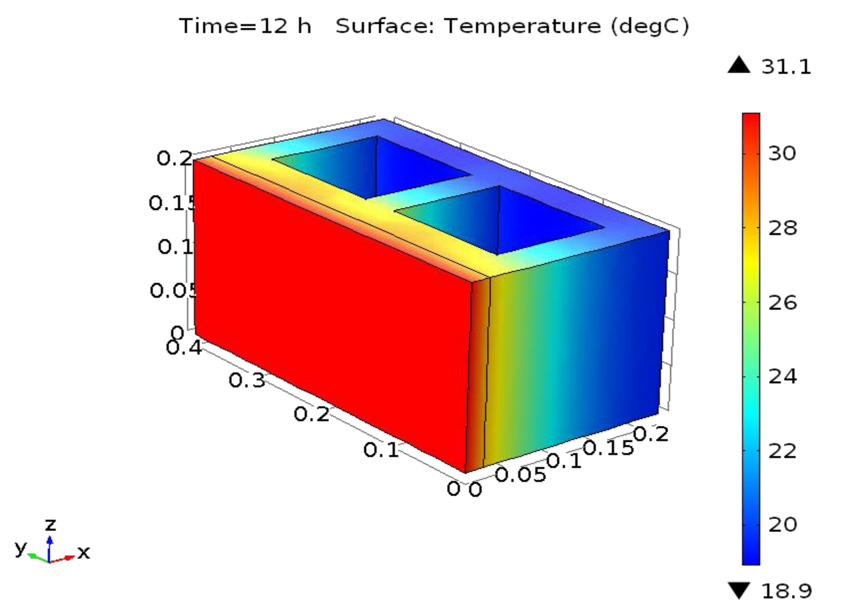

Figure 1. Surface temperature distribution in building element incorporating PCM-enhanced plaster

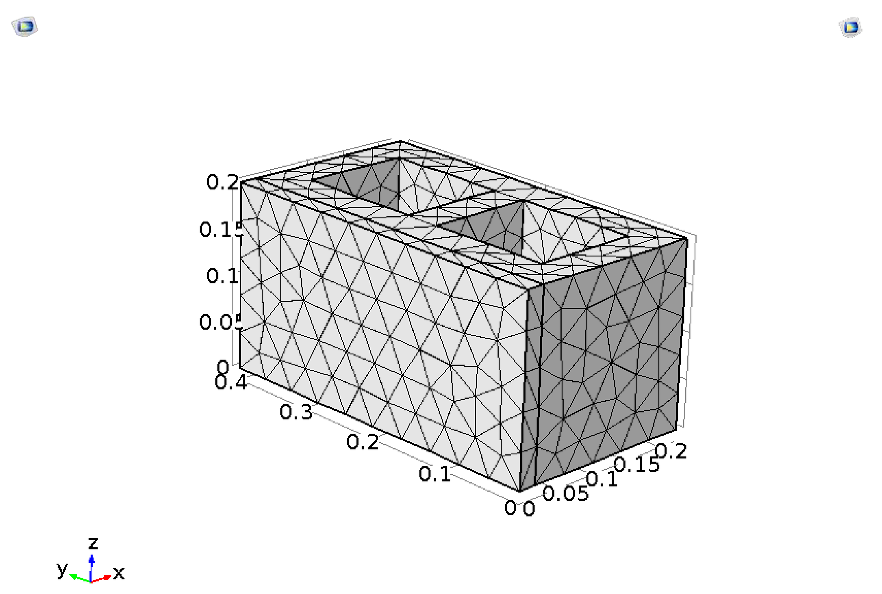

Figure 2. Geometry and mesh of 3D numerical models

Computational Methods: The Conjugate Heat Transfer module and the Heat Transfer with Phase Change feature node of Comsol Multiphysics were employed for modelling the behaviour of 4 different designs of PCM-enhanced plasters in summer- dominant summer climatic conditions:

1. REFPLASTER – conventional lime plaster
2. PCMPLASTER5 - 5% by wt. PCM
3. PCMPLASTER10- 10% by wt. PCM
4. PCMPLASTER20 - 20% by wt. PCM

Assuming a time- dependent study, the governing equation is:

$$\rho C_p \frac{\partial T}{\partial t} + \rho C_p u \cdot \nabla T = \nabla \cdot (k \nabla T) + Q + Q_{vd} + Q_p$$

Three- dimensional (3D) geometry and appropriate boundary conditions, based on actual measurements, were also employed for the problem definition.

Results: Numerical models have been experimentally validated. The reference case experiences the greatest diurnal variability. The more the percentage by weight PCM in plaster, the smaller the range of the diurnal fluctuation.

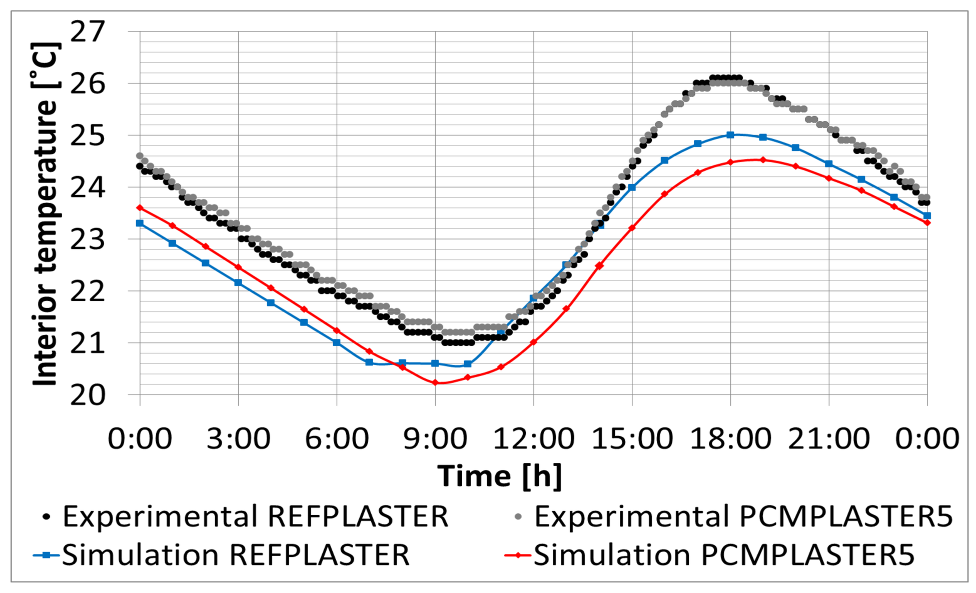

Figure 3. Model experimental validation results

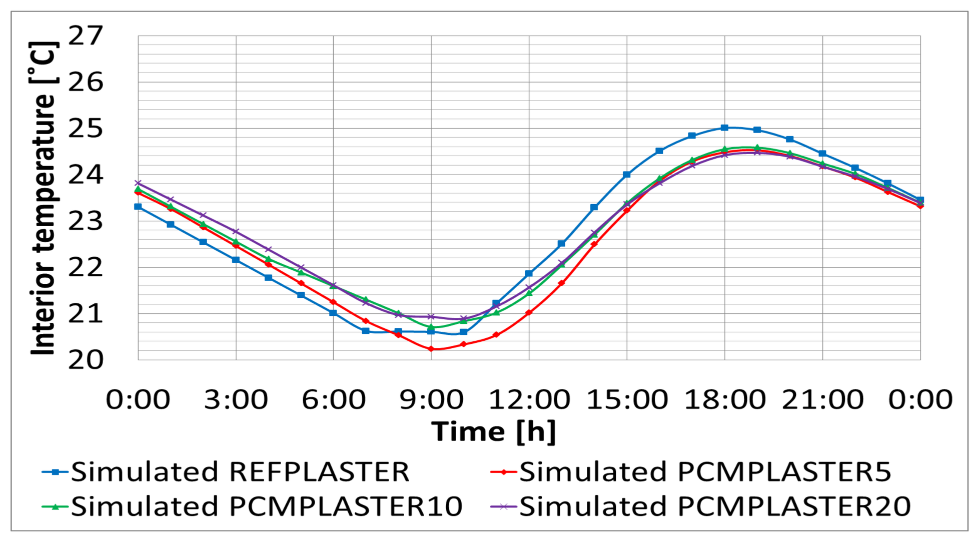

Figure 4. Simulation results for the designs under investigation

Conclusions: There is a positive correlation between the percentage by weight PCM incorporation, and the building's effectiveness in alleviating the impact of diurnal variability.

References:

1. Basecq et al., Short-term storage systems of thermal energy for buildings: a review, Advances in Building Energy Research, 7(1), 66-119 (2013)
2. Comsol Multiphysics, Heat Transfer Module User's Guide, Version 5.0

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