Phase Change Materials for Improving the Thermal Performance of LSF Construction

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Seminar - PCMs4Buildings

PCMs: Thermophysical characterization and buildings' applications

1. Motivation and Objectives

- The research project "PCMs4Buildings" (Systems with PCM-filled rectangular cavities for the storage of solar thermal energy for buildings) is funded by FCT and by FEDER/COMPETE2020/POCI.
- The main goal of this project is the development of systems with PCM-filled rectangular cavities for the storage of solar thermal energy in order to enhance the energy performance of buildings.
- Given their reduced thermal mass, lightweight steel framed (LSF) buildings are very suitable for the use of phase change materials (PCMs).
- Therefore, the PCMs4Buildings project mainly focusses on LSF construction, namely in Task 4 – "Tests in the Guarded Hot Box Apparatus" and in Task 5 – "Definition of full-scale prototypes".
- The main objective of this communication is to describe the research activities related with Task 4 and the obtained results, as well as the future work.

2. PCMs4Buildings Research Project

The research plan is composed by six tasks:

1. Thermophysical characterization of PCMs;
2. Numerical modelling and CFD evaluation;
3. Tests in the small-scale experimental setup;
4. **Tests in the Guarded Hot Box apparatus;**
5. Definition of full-scale prototypes;
6. Technical seminar and workshop.

PCMs4Buildings

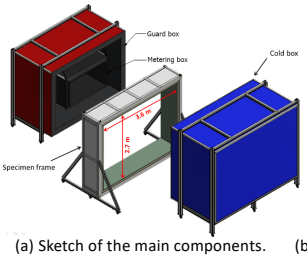
Systems with PCM-filled rectangular cavities for the storage of solar thermal energy for buildings

www.adai.pt/pcms4buildings

POCI-01-0145-FEDER-016750 | PTDC/EMS-ENE/6079/2014

3. (Guarded) Hot Box Apparatus

This equipment was designed and assembled at ISISE-DEC/FCTUC and will allow to measure the thermal transmittance *U*-value of heterogeneous walls at real-scale test-specimens.

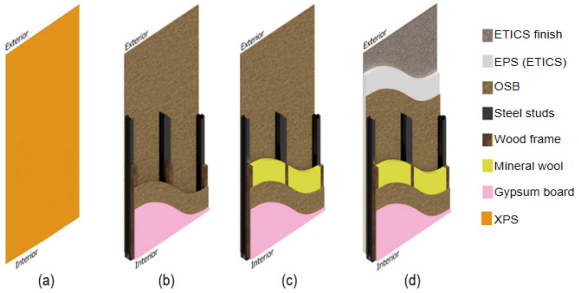


(a) Sketch of the main components.

(b) Photo of the equipment in the laboratory.

Main features:
Cold box min. temp.: **0°C**
Hot box max. temp.: **+50°C**
Max. air velocity: **5 m/s**
Ref. standard: EN ISO 8990

4. Experimental Tests



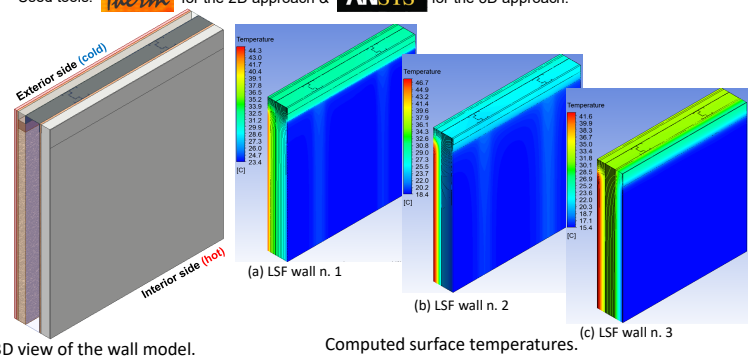
Tested walls: (a) homogeneous XPS panel; and heterogeneous LSF walls: (b) without thermal insulation; (c) with mineral wool (MW) in air-cavity; (d) with MW in air-cavity and ETICS.

Table 1. *U*-values obtained for the LSF walls based on experimental data.

Wall typology	Thermal transmittance, *U* [W/(m².°C)] Between steel studs 0	Near steel studs 1	Near steel studs 2	Overall weighted value
1-Without thermal insulation	1.568	1.041	1.203	**1.480**
2-With Mineral Wool (MW) in air-cavity	0.658	0.788	1.128	**0.711**
3-With MW in air-cavity and ETICS	0.279	0.363	0.470	**0.324**

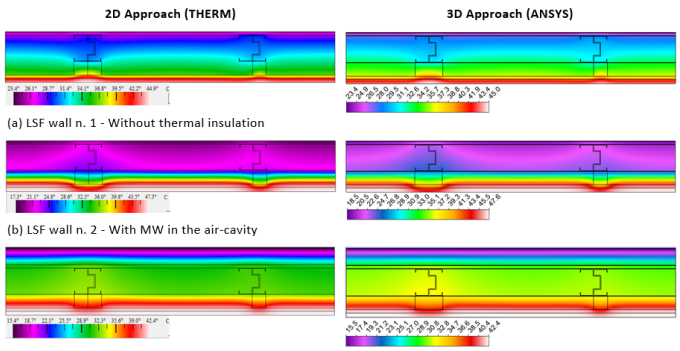
5. Numerical Simulations

Used tools: Therm for the 2D approach & ANSYS for the 3D approach.



3D view of the wall model.

Computed surface temperatures.



Cross-section temperatures predicted by 2D and 3D numerical simulations.

6. Experimental *vs* Numerical Results

Table 2. Experimental and numerical *U*-values obtained for the LSF walls.

	Wall n.1 - Without Thermal Insulation			**Wall n.2** - With Mineral Wool (MW)			**Wall n.3** - With MW and ETICS		
	Exp.	**ANSYS**	**THERM**	**Exp.**	**ANSYS**	**THERM**	**Exp.**	**ANSYS**	**THERM**
***U*-value** [W/m²/°C]	1.480	1.409	1.399	0.711	0.598	0.581	0.324	0.346	0.306
Absol. Diff.	---	-0.071	-0.081	---	-0.113	-0.130	---	+0.022	-0.018
Perc. Diff.	---	-4.8%	-5.5%	---	-15.9%	-18.3%	---	+6.8%	-5.6%

7. Future Work

- To include PCMs in the simpler LSF wall (already tested) and to perform tests not only in steady-state but also in transient regime.
- To test different LSF wall typologies with more complex steel frame (also horizontal and diagonal steel studs), with and without integrated PCMs.
- To compare the measured results with the numerical simulation results, including CFD (Computational Fluid Dynamics).

(a) PCM gypsum board over OSB panels.

(b) New LSF wall: B(A)ª system.

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