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PEG–mortar and PEG–gypsum composite materials for passive thermal energy storage (TES) applications in buildings

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INTRODUCTION & AIM

Conventional phase change materials (PCMs) often suffer from leakage and low thermal conductivity, limiting their practical use; shape-stabilized composite PCMs (sscPCMs) have been developed to overcome these challenges by integrating PCMs with supporting matrices or conductive fillers.

Two types of *shape-stabilized composite* Phase Change Materials (*ssc*PCMs) — PEG_{1000}/ silica/ MWCNTs (noted as TP4_1000) and PEG_{6000}/ silica/ MWCNTs (noted as TP4_6000) , respectively — were embedded in two different inorganic matrices that are commercially available as building materials (lime-cement mortar and gypsum) in order to obtain building elements with latent heat storage properties.

METHOD

The two PEG/silica/MWCNTs materials were prepared in our lab using a previously published method [1]. Three different concentrations of the two *ssc*PCMs (2.5%, 5%, and 10%) were added to the mortar, whereas only a 10% concentration of *ssc*PCMs was investigated for gypsum. The new PEG–mortar and PEG–gypsum composites were cast in parallelepiped molds (L x w x h = 50 mm x 30 mm x 20 mm) to obtain brick-type construction elements (for building facades). The bricks thus produced were characterized from a morpho-structural point of view and were subjected to tests regarding their compressive strength. In order to verify their functionality, the behavior of the materials after exposure to 62 repeated heating–cooling cycles was also evaluated.

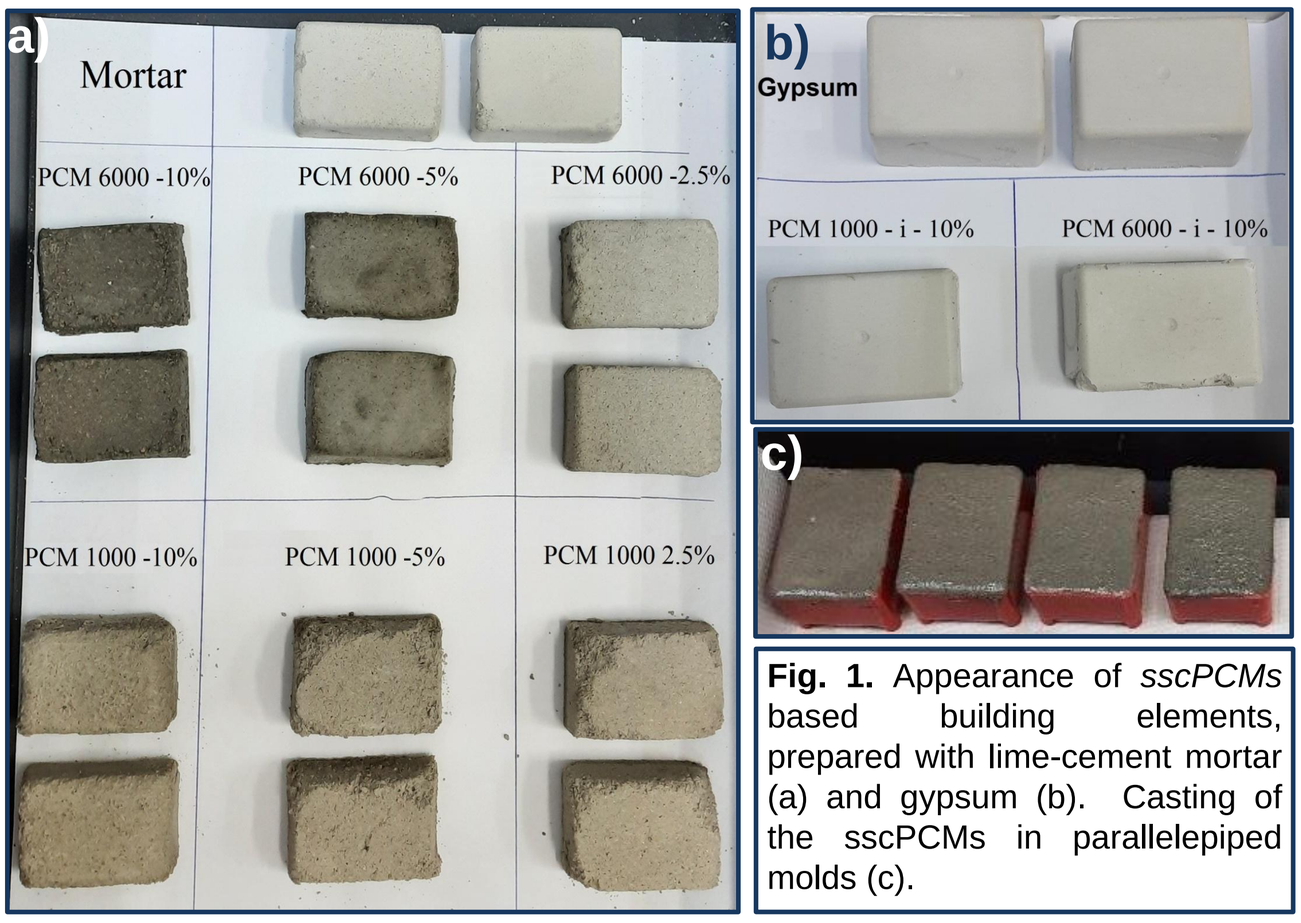

Fig. 1. Appearance of *sscPCMs* based building elements, prepared with lime-cement mortar (a) and gypsum (b). Casting of the sscPCMs in parallelepiped molds (c).

RESULTS & DISCUSSION

Table 1. Composition of thermal energy storage building elements, based on lime-cement mortar and gypsum, respectively

Sample	PCM type	PCM Concentration (%)	Mortar (g)	PCM (g)	Water (mL)
Mortar	-	0	400	-	65
PCM 1000_2.5%	TP4_1000	2.5	487.5	12.5	100
PCM 1000_5%		5	380	20	80
PCM 1000_10%		10	360	40	80
PCM 6000_2.5%	TP4_6000	2.5	487.5	12.5	100
PCM 6000_5%		5	380	20	80
PCM 6000_10%		10	360	40	80
Gypsum	-	0	150	-	60
PCM 1000-i-10%	TP4_1000	10	135	15	60
PCM 6000-i-10%	TP4_6000	10	135	15	60

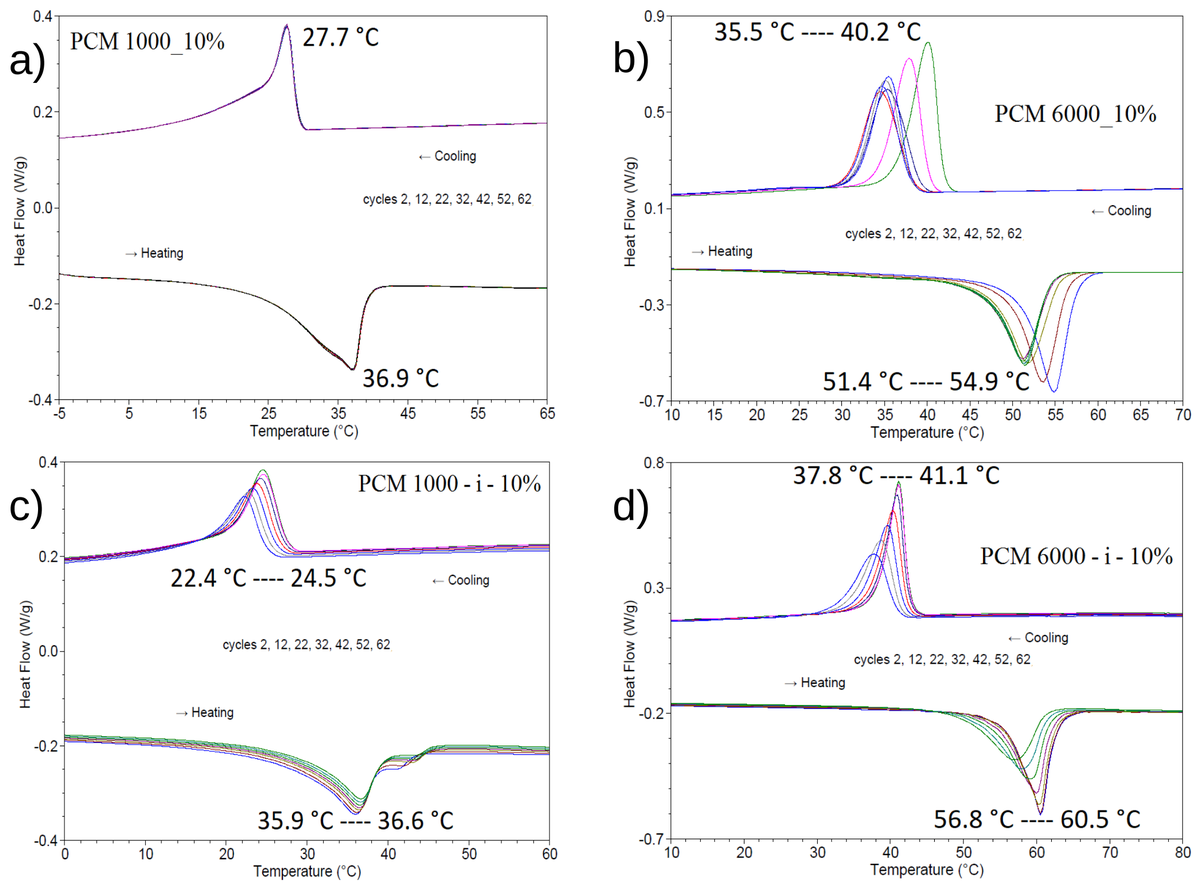

Fig. 2. Thermal behavior of *sscPCMs* based building elements, prepared with lime-cement mortar ((a),(b)) and gypsum ((c),(d)), during 62 successive DSC heating–cooling cycles .

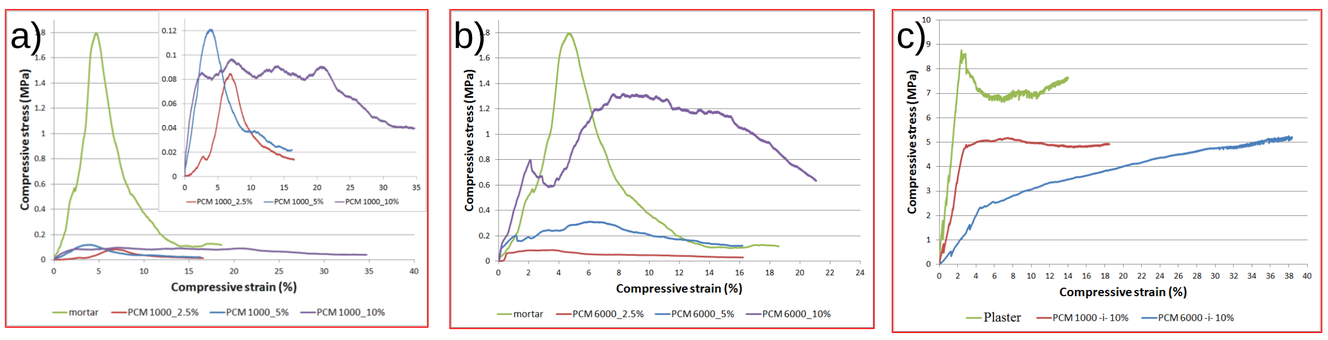

Fig. 3. The compressive strength tests performed on construction elements based on mortar and PCM at various concentrations (a) – PCM_1000 and b) – PCM_6000) and on gypsum © - at 10% PCM).

CONCLUSION

It was found that gypsum-based materials produced the best results in terms of mechanical properties after tests were conducted to confirm theyr functionality (mechanical test and behavior under multiple heating-cooling cycles). However, gypsum-based PCMs lose more of their phase transition enthalpy values (and implicitly their capacity to store thermal energy) after being incorporated into the final building elements than mortar-based PCMs ($\Delta HPCM_{1000}$_10% decreases from ~ 10 J/g for the mortar sample, to ~ 7 J/g for the gypsum sample, and $\Delta HPCM_{6000}$_10% decreases from ~ 15 J/g for the mortar sample, to ~ 10 J/g for the gypsum sample).

Also, taking into account the temperatures at which the melting and solidification of the final PCM takes place, the optimal product recommended to be used for the construction elements is based on TP4_1000 (PEG 1000 - silica - carbon nanotubes), incorporated into lime-cement mortar.

FUNDING

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