Thermal Activate Concrete Slabs with Microencapsulated PCM: Mechanical and Thermal Characterization

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Abstract

In the framework of an energy storage research project, an experimental campaign on concrete with incorporation of microencapsulated phase change material (PCM) was carried out. The main objective was to study various issues related to the behaviour, including the mixing and incorporation process, with particular emphasis on mechanical and thermal properties. Despite the thermal characteristics provided from the PCM incorporation into the concrete mixture, the mechanical properties are affected. Therefore, an experimental campaign was carried out to evaluate the compression and bending strength of concrete with PCM. The PCM concrete mixture analysed is composed by 3.21% of PCM in weight proportional to all aggregates, binders and other additives.

Following the NP EN 12390-3 [1] and NP EN 12390-5 [2], the concrete with PCM incorporation was characterized in terms of compression and bending strength at ambient and higher temperatures (simulating a thermal activated concrete screed slabs). Eighteen cubic specimens with 15x15x15cm^3 dimensions according to NP EN 12390-1 [3], twelve cylindrical specimens with a diameter of 15cm and height with twice the value of diameter and sixteen parallelepiped test specimens were produced.

Thermal tests to evaluate the behaviour of concrete with PCM in terms of energy storage capacity were performed. The test specimens were placed in a climatic chamber, heated up to 45°C to simulate thermal activation. When this temperature was reached the chamber was opened and cooled down until samples attained stable ambient temperature.

Experimented results revealed that PCM incorporated into concrete led to a reduction of the maximum compression strength of about 66% and a reduction of 52% of maximum bending strength (see Figure 1),in comparison with the reference concrete (specimens without PCM). These results are in accordance with others experiences caused out by other authors [4,5,6]. The same tests were repeated on other samples under the effect of temperature, in order to verify the effect caused by the phase change process of the microencapsulated PCMs.

In respect to the thermal performance of concrete incorporating PCM (see Figure 2) it was found that the use of this mix for a concrete slab screed layer, potentially contributes to reduce the energy consumed in buildings resourcing to active heating systems.

References

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[3] NP EN 12390-1, Testing hardened concrete. Part 1: *Shape, dimensions and other requirements for specimens and moulds*, (2012).

[4] M. Hunger, A. G. Entrop, I. Mandilaras, H. J. H. Brouwers and M. Founti, *The behavior of self compacting concrete containing micro-encapsulated phase change materials*, Cement and Concrete Composites, Vol 31, no. 10,PP 731-743, (2009).

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Figures

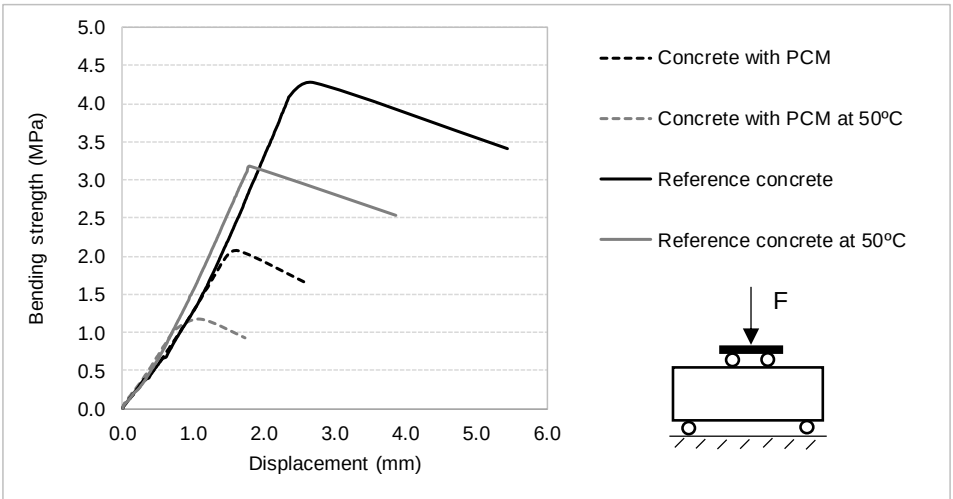

Figure 1 – Bending strength vs. displacement

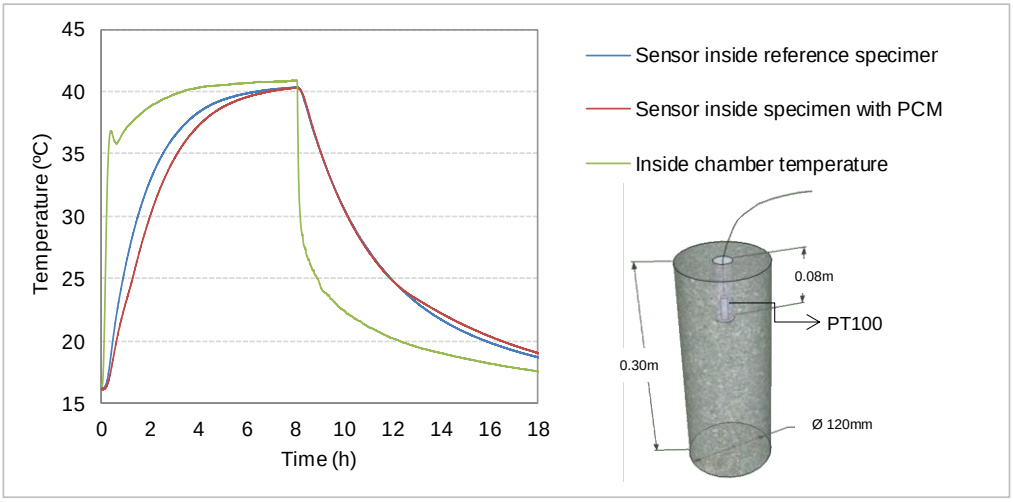

Figure 2 – Temperature profile overtime of test specimens inside chamber