PCMs integrated in radiant floor

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3 authors:


Michele Bottarelli
University of Ferrara


Silvia Cesari
University of Ferrara


Barbara Larwa
Cracow University of Technology

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Michele Bottarelli, Silvia Cesari, Barbara Larwa
Department of Architecture, University of Ferrara, Italy

With the global need to reduce energy consumption induced by space heating and cooling, along with the growing demand for indoor thermal comfort, new design strategies for radiant heating and cooling floor systems are being widely investigated. Radiant floor technology uses a lower temperature source for heating in comparison with conventional systems. Furthermore, by the direct heating of the floor surface they ensure an even heat distribution which increases thermal comfort. This technology is also suitable for the majority of generators, in particular heat pumps and boilers and can be operated with various sources of renewable energy.

Against this background, the H2020 European project IDEAS – Novel Building Integration Designs for increased Efficiencies in Advanced Climatically Tunable Renewable Energy Systems – is focused on the development of a novel low-cost building-integrated RES which will cost effectively exceed current RES efficiencies, generating electricity, heat and cooling and that will be optimised in different climatic conditions. Specifically, the WP3 (coordinator: University of Ferrara) aims to design a multi-source heat pump system able to balance the non-synchronous energy matching between renewable energies (sun, ground, air) and energy demands for space heating and cooling by means of innovative devices enhanced with phase chance materials (PCMs).

The integration of PCMs in radiant floor systems as technology for space heating and cooling was investigated by the University of Ferrara through numerical and experimental investigation. The commercial numerical finite element code COMSOL MultiphysicsV.5.3® as well as TRNSYS software were used for the calculations in steady as well as in transient state. Calculations in steady state were performed to choose the temperature of the working fluid, while transient state was used for calculations to choose the right PCM based on its melting point temperature both for summer and winter seasons. Results obtained from numerical analysis were further investigated and validated through experimental tests.

The PCMs used to carry out the tests, as well as those employed in all the phases of IDEAS project, were provided by PCM Products Ltd, which is a partner in the project. For the application in radiant floor, hydrated salts were chosen, as reported in Table 1.

Table 1: Thermal properties of selected PCMs

	S27	S21
Melting temperature [°C]	27	21
Latent heat [kJ/kg]	185	220
Density [kg/m^3]	1530	1530
Specific heat [J/(kgK)]	2200	2200
Thermal conductivity [W/(mK)]	0.54	0.54

PCMs were encapsulated in thin HDPE containers under which are positioned pipes with water flowing inside. The floor configuration analysed with the different layers is illustrated in Figure 1; the layering is not standard, but for a specific installation.

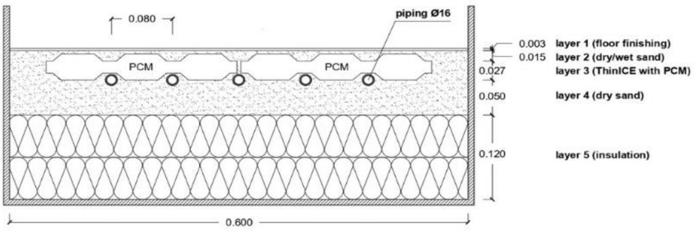

Figure 1: Floor configuration tested

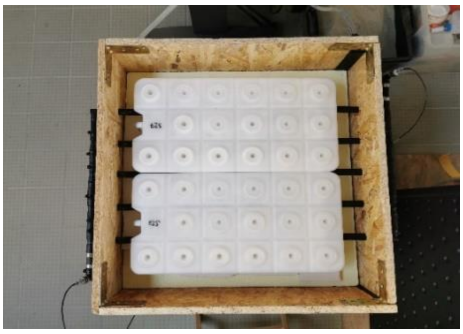

Figure 2: Experimental tests of the PCM integrated in radiant floor heating technology

Experimental tests (Figure 2) were conducted with a room heating set point temperature of 20°C. The behaviour of the system including temperature distribution and heat flux were analysed and the impact of using dry and wet sand (layer 2) on thermal performance was investigated.

The preliminary results have shown that the highest thermal conductivity of wet sand improved the overall performance in comparison with dry sand (Figure 3), and that PCM stopped the cooling of the floor for more than 12 hours when heating was turned off.

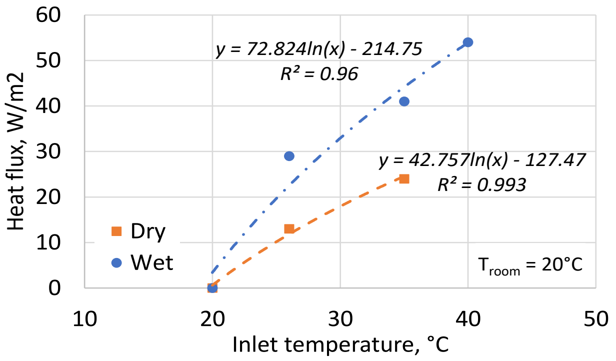

Figure 3: Thermal performance for dry and wet sand

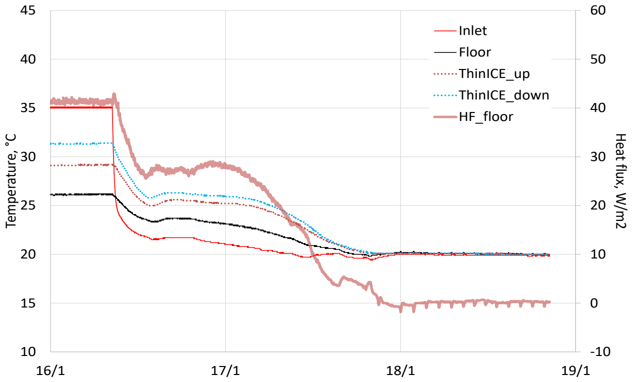

Figure 4: Effect of PCM