Energy-Efficient Building Envelopes: use of Phase Change Materials in Cement-Based Composites

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Abstract

An exploratory research project, granted by European Commission - Joint Research Centre, called Eco-Energy Efficient Envelopes for innovative Buildings (*E4iBuildings*), has been recently started. The research project investigates and develops innovative products based on cement composites for building envelopes, studies the feasibility and the impact of different solutions based on Phase Change Materials (PCMs), through the assessment of mechanical and thermal properties. The paper presents the aims of the experimental activities ongoing at Joint Research Centre, and in particular the matters related to: performance analysis on three PCM families, methods for macro-encapsulation and thermo-physical characterisation of the innovative building material.

Keywords: Phase Change Materials, Cement Based Composites, Thermal Energy Storage, Precast Concrete Claddings.

1 Introduction

The energy efficiency of building envelopes can be developed using either an active or a passive behaviour. The *passive* approaches improve thermal performances with low conductivity materials. While the *active* methods obtain same results increasing the thermal inertia, using materials with high thermal capacity. Moreover, *Thermal-Energy Storage* (TES) materials profit by *Latent Thermal Energy* (LTE) or by *Sensible Thermal Energy* (STE). The *latent heat* of most building materials is in the range of several tens to several hundreds of joules per gram, if compared with the *specific heat*, a better heat accumulation is allowed for a low range of temperature. Considering water as an example, its *latent heat* is $\lambda = 333$ *kJ/kg* while its *specific heat* is $C_p = 4.2$ *kJ/(kg·K).* The LTE necessary to thaw (or freeze) a kilogram of ice is almost equal to the STE used to warm the same amount of water from 1° C to 80° C. Such a large heat storage capacity per volume unit, combined with high daily temperature changes, might to increase the heat retained within building envelope in daytime. Consequently, exploiting the LTE, a reduction of additional energy sources is achievable. A similar approach could be used to save the energy for cooling in the hot season. The U.S. Department of Energy in '80s began the early researches on *Phase Change Materials* (PCMs) to harvest LTE in buildings [1]. Wide literature reviews [2] [3], show the advances obtained in this field during the last decades. Claddings are the key point to improve the thermal efficiency of buildings, in fact the thermal exchanges between internal ambient and outdoor are located there. *E4ibuildings project* is looking for the best solutions to produce innovative *Cement Based Composites* (CBCs) to build wall panels exploiting the features offered by PCM.

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