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PCM-enhanced lime plasters for vernacular and contemporary architecture

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In 1997, the European Union (EU) pledged to reduce the amount of greenhouse gas emissions by 20% below the levels of 1990 by the end of 2020. In recent years it has become evident that, in order to reach that goal, EU Member States must take measures to encourage sustainability in the building industry, which is a major energy consumer. Such measures should involve the use of innovative, environmentally friendly materials and methods in new constructions, as well as the renovation of existing properties by upgrading their current state of energy efficiency.

Phase Change Materials (PCMs) have the ability to absorb and release thermal energy, in the form of latent heat, during the melting or solidifying processes respectively. Thus, they may be used as additives in the production of thermally efficient composite building materials. A PCM-enhanced plaster is a heat storage medium combining an appropriate PCM with a cementitious or non-cementitious matrix to produce a low-cost thermal storage material with structural and thermostatic properties.

Although innovative technologies, such as PCMs, have certainly contributed to the boost in the evolution of the building materials industry in recent years, a significant proportion of these technologies and practices have not yet been fully exploited in materials based on traditional principles. This paper focuses on the design and production of novel cementless PCM-enhanced lime plasters, in line with the traditional production technology of lime composites. The new plasters are produced using either hydrated or natural hydraulic lime binder, crushed calcarenite sand (0-2 mm) and commercial microencapsulated PCM in powder form (5% w/w of solids).

Results from comparative tests between reference mixtures and mixtures with the addition of PCM, carried out 28, 56 and 90 days after laboratory production, prove the potential of PCMs in enhancing the thermal performance of traditional lime-based composites. The modified composites have significantly lower (by 55%) thermal conductivity and increased (by almost 20%) specific heat capacity at 90 days after laboratory production. At the same time, even though porosity values are higher for the PCM-enhanced renders, compared to the reference mixtures, their capillary absorption coefficient is significantly reduced (up to 60%). This is of great importance in the case of renders and may well be an indication for better expected durability in the long-term. Regarding the mechanical properties of the laboratory composites, PCM addition seems to have a negative effect on the hydraulic plasters. In contrast, when PCM is added to the hydrated lime-based plaster, no change is observed for the flexural strength, while the compressive strength is notably improved (up to 36%).

The apparently improved properties of the PCM-enhanced plasters render them particularly appropriate for application in southern European climatic conditions. Due to their compatibility with traditional substrate materials (e.g. natural stone), the aforementioned composites may be used not only in new contemporary structures, but also for the renovation and retrofitting of existing buildings. The lime-based nature of their matrix and their physico-mechanical properties further extend their applicability to listed and monumental buildings.