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Effects of Long-Term UV Exposure on the Performance of Cement Plasters Integrated with Thermochromic Paint and PCMs for Building Façade Applications

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1 Introduction

The exterior finish layer in building facades is exposed to considerable environmental loads, such as thermal stresses, and UV radiation, which can reduce the service life of the materials, increasing the need for replacement (Pisello, 2017). Specifically, temperature fluctuations in the exterior surface of finish materials decrease their durability due to rapid degradation and changes to material properties (Hernandez-Perez *et al.*, 2014; Pisello, 2017). New climate challenges impose to look more carefully at the long-term performance and durability of building components and materials. Increasing the lifetime of the building façade by reducing exterior thermal stresses becomes critical.

Several strategies exist on the material scale to regulate external solar and thermal loads by enhancing specific material properties. Particularly, the application of reflective coatings on exterior finish surfaces has shown promising results in reducing thermal stresses and UV degradation due to higher solar reflectance and emittance properties (Ascione *et al.*, 2018). This study proposes the application of a finish material to control surface temperatures and UV radiation by dynamically changing its thermal and optical properties. A cement plaster as a typical finish material used in different building types was enhanced by integrating phase change materials (PCMs), and thermochromic paint (TC). This combination of materials with the cement plasters allows for temperature regulation using the thermal storage capacity of PCMs, and solar radiation control using the properties of the TC paint. This research aims to measure the long-term performance of the cement plaster with different PCM and TC integration alternatives.

The main objective of the study is to quantify the effect of long-term UV exposure on the optical performance of the cement plasters. This was done by evaluating the rate of change in the solar reflectance and absorptance of the samples after exposure to long-term UV radiation. The developed cement plaster provides a high application potential to exterior facades as it can be used annually considering variable solar reflectance and thermal storage capacities that can be useful in the heating season and the cooling season. PCMs with three different melting temperatures of 18^{o}C, 24^{o}C, and 28^{o}C, and two colors of blue and red TC paint with a transition temperature of 31^{o}C were used in this study to be integrated into the cement plaster. Two types of samples were produced by varying the integration method of the TC paint. In Type 1 samples, the PCM and the TC paints were mixed within the cement plaster, and in Type 2 samples (Fig. 1a), the TC paint was applied on top of the PCM-cement plaster mixture. UV aging was performed to measure the effect of long-term UV exposure on the samples using accelerated UV aging to simulate the exposure of UV radiation for two years. The solar reflectance of the samples was characterized before and after the accelerated UV aging tests as the main parameter of investigation.

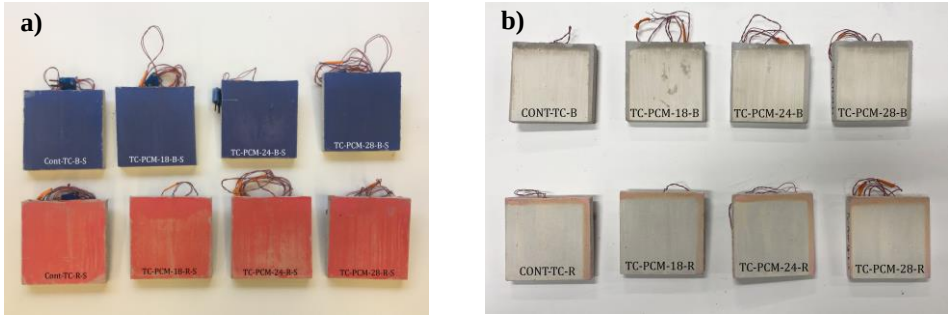

Figure 1. a) Type 2 samples (pre-aging); b) Type 2 samples (post-aging).

UV aging had a noticeable impact on the visual appearance of the samples, particularly Type 2 samples (Fig. 1b), as the color of the samples has completely faded due to UV exposure. The aging test results revealed that UV exposure impacts the solar reflectance of the finish material based on the method of integrating the TC paint to the cement plaster. As Figure 2 shows, the impact of aging on the control samples with only the TC paint varies considerably between Type 1 and Type 2 samples. In Type 1 samples, the solar reflectance was increased after aging, in the Type 2 samples, solar reflectance decreased after the surface color faded. In the case of TC paint applied to the surface, the solar reflectance of the plasters with only the TC is reduced by 15% after aging, while the ones combined with PCMs have a similar solar reflectance value after aging. The samples with both the PCM and the TC paint showed the lowest percentage of change in total solar reflectance after aging. This promising result indicates the capability of combining PCMs and TC to enhance a building finish material to preserve its initial material properties that could enhance its durability.

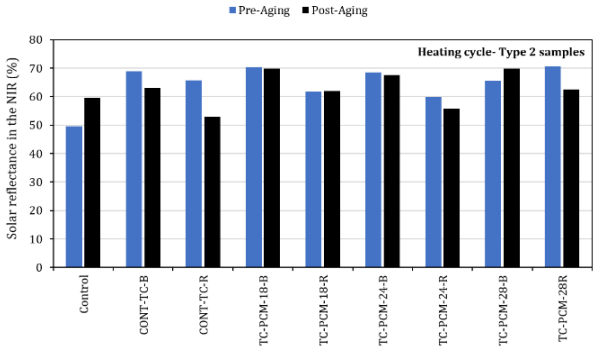

Figure 2. Rate of change in solar reflectance after aging in Type 2 samples measured at 45ºC.

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