Fresh State Characterization of Lime Mortars with PCM Additions

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Abstract:
The application of sustainability principles in construction encourages the development of new products, with new functionalities and applications, able to improve buildings environmental performance. The use of latent heat storage materials in lime mortars aims to reduce the energy consumption of buildings. This work intends to evaluate the impact of phase change materials (PCM) incorporation in rheological and hardened state properties of aerial lime mortars. A fresh state characterization was conducted through the rheological study complemented with flow table tests of different mortar formulations. To complete the mortar characterization some hardened state properties (porosity, mechanical strength and microstructure) after 28 days, were also evaluated. It was concluded that, the PCM microcapsules incorporation does not compromise aerial lime mortars overall performance and may help to improve some characteristics like workability and mechanical strength. Therefore, it is possible to reduce the energy demand in old buildings, improving their performance and sustainability.

Zusammenfassung:
Die Anwendung von Nachhaltigkeitsprinzipien im Baubereich fördert die Entwicklung neuer Produkte mit neuen Funktionen und Anwendungen, die die Umweltbilanz von Gebäuden verbessern können. Die Anwendung von versteckten Wärmespeichermaterialien in Kalkmörteln hilft, den Energieverbrauch von Gebäuden zu reduzieren. In dieser Arbeit wird der Einfluss der Verwendung von Phasenänderungswerkstoffen (sogenannte Phase Change Materials, PCM) auf die rheologischen und Feststoffeigenschaften von oberirdischen Kalkmörteln untersucht. Eine Charakterisierung des Ausgangszustandes wurde mittels einer rheologischen Studie von verschiedenen Kalkmörteln durchgeführt, die durch Ausbreitversuche ergänzt wurde. Um die Charakterisierung der Kalkmörtel zu vervollständigen, wurden einige Feststoffeigenschaften (Porosität, mechanische Festigkeit und Mikrostruktur) nach 28 Tagen bestimmt. Die PCM-Mikrokapseln verschlechtern oberirdischen Kalkmörtel nicht und helfen, einige Eigenschaften wie z. B. Verarbeitbarkeit und mechanische Festigkeit zu verbessern. Somit ist es möglich, den Energieverbrauch in alten Gebäuden zu reduzieren und dadurch die Leistung und Nachhaltigkeit zu verbessern.

Résumé:
L'application des principes de développement durable au secteur du bâtiment encourage le développement de nouveaux produits, possédant de nouvelles fonctionnalités, de nouvelles applications et capables d'améliorer la performance environnementale des bâtiments. L'utilisation de matériaux de stockage de chaleur latente dans les mortiers de chaux aérienne vise à réduire la consommation énergétique des bâtiments. L'objectif du présent travail est l'évaluation de l'impact de l'incorporation de matériaux à changement de phase (PCM) sur les propriétés rhéologiques et de l'état durci des mortiers de chaux aérienne. Une caractérisation du mortier à l'état frais a été réalisée, notamment par le biais de tests rhéologiques complémentés par des tests sur table d'écoulement pour plusieurs formulations différentes de mortier. Les propriétés du mortier durci (porosité, résistance mécanique et la microstructure) ont également été évaluées après 28 jours. Il a été conclu que l'incorporation de microcapsules PCM ne compromet pas la performance globale des mortiers de chaux aérienne et peut contribuer à améliorer certaines de ses caractéristiques comme la maniabilité et la résistance mécanique. Il est par conséquent possible de réduire la consommation énergétique des bâtiments anciens tout en améliorant leur performance et leur durabilité.

Key words: phase change materials, rheology, flow table, lime, mortars

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the thickening of the pastes. This effect can be caused by the action of two factors: higher free water content and PCM spherical shape. With 10 wt% PCM incorporation the excess of free water in the mixtures overlaps the expected effect of PCM particle shape. The mortars will show higher porosity and slightly lower mechanical strength than REF ones. The addition of 20 wt% PCM reduces the relative amount of free water and consequently, beneficial effects became visible in the fresh and hardened state properties. Mortars are less porous and are composed by finer pores (lower average pore size), resulting in a higher mechanical strength, when compared with the reference sample (without PCM). The PCM addition to aerial lime mortars made the rheological characterization more difficult. The results for the mechanical strength tests, after 28 days, indicate that it is possible to add PCM to aerial lime mortars without compromising its hardened state properties. Hence, the use of latent heat storage materials in rehabilitation mortars seems feasible. However, future work related to hardened state properties will include durability studies.

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