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Hydration and microstructural development of cement pastes incorporating diatomaceous earth, expanded perlite, and Shape-Stabilized Phase Change Materials (SSPCMs)

Abstract

The integration of phase change materials (PCMs) into building structures offers a promising solution to enhance energy efficiency and improve thermal comfort. In this study, shape-stabilized PCMs (SSPCMs) consisting of capric acid (CA) as the PCMs were incorporated into cementitious binders using porous minerals of diatomaceous earth (DE) and expanded perlite (EP). Various analyses including isothermal calorimetry, XRD, TGA, SEM, and compressive strength tests were conducted to investigate the effects of DE, EP, and DE/EP PCMs on the hydration kinetics and microstructure of the cementitious system. Isothermal calorimetry results showed that the presence of PCMs has reduced the available space for the nucleation and growth of C-S-H gel. Furthermore, the presence of PCMs triggered the formation of a new phase of sodium acetate, which does not have notieacable impact on concrete properties. Rietveld refinement analysis of XRD data indicated that the presence of PCMs delayed the hydration of main clinker phases over an extended period. It was observed that the hydrophobic nature of CA, which repels water during the mixing process, resulted in an excess of water available for cement hydration. Despite these findings, this study demonstrated that with appropriate choice of supporting material and optimal SSPCMs content, the pozzolanic nature of SSPCMs can mitigate the reduction in strength observed in concrete samples containing PCMs. Overall, this research highlights the potential of integrating SSPCMs into cementitious binders for efficient energy storage, providing insights into optimizing their content and addressing associated challenges in concrete performance.

Keywords

Cement; Hydration; Microstructure; Phase Change Materials