Degree of reaction and alkali-leaching of geopolymer containing Ca-rich source material and dipotassium hydrogen phosphate

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Abstract. Disparity of anion and cation in geopolymer framework may result in the formation of efflorescence on the surface of hardened geopolymer specimen. The existence of efflorescence would be intensified with the use of dipotassium hydrogen phosphate (K_2HPO_4) as a chemical retarder for geopolymer mixture. In this study, paper mill sludge ash (PMSA) was used as a Ca-rich aluminosilicate source to reduce the development of efflorescence crystals. PMSA was utilized to partially replace fly ash at 5% and 10% (by weight of fly ash). Meanwhile, K_2HPO_4 was used as the external agent with various proportions, which were 0.1%, 0.3%, and 0.5% (by weight of fly ash). The external agent in this study was purposed to extend the setting time and enhance the mechanical properties of geopolymer. Fly ash and PMSA (if any) were activated by reacting them with 6M sodium hydroxide and sodium silicate solution. Freshly cast specimens were cured for 24 hours in electronic oven with the temperature setting of 30°C and 90°C. They were demoulded after 24 h and kept at room temperature (28±2 °C) until the testing day. Evaluation on the setting time characteristic of fresh geopolymer mortar was conducted with Vicat test while degree of reaction was performed on the hardened specimens to measure the reaction of fly ash during geopolymerization. Based on the experimental result, the inclusion of 5% PMSA shows the greatest effect in reducing the development of efflorescence crystal and increase the degree of reaction of geopolymer system. It is presumed that PMSA has altered the geopolymerization process by activating calcium oxide precursors to form three tetrahedral structures in the framework.

Introduction

High calcium fly ash based geopolymer is one of the best alternatives to cement binders that have been widely recognized in the construction industries around the world due to its high performance and environmentally friendly properties. However, high amount of calcium in the fly ash will likely to contribute to the acceleration of setting time and low workability characteristic. It will limit the scope of application of geopolymer for concreting work, particularly during compaction process that requires good workability to avoid honeycomb and porous structure. Despite of its effect on the alteration of fresh geopolymer properties, the presence of calcium plays a significant role in developing the mechanical strength of hardened geopolymer specimen. Higher reactivity in this mixture will lead to the better hardening process in shorter curing time.