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Effects of elevated temperatures on the thermal behavior and mechanical performance of fly ash geopolymer paste, mortar and lightweight concrete

Abstract

This paper reports a comparative study of the influence of elevated temperature on geopolymer paste, mortars and lightweight aggregate geopolymer concrete (LWAGC) systems made by using fly ash (FA) as only source material. The mechanical, thermo-physical and macro/micro-structural properties of the geopolymers before and after the exposure to elevated temperatures of 400, 600 and 800 °C have been investigated. The sequential changes in the geopolymeric gel structure upon the exposure to the elevated temperature and their reflections on the geopolymers thermal behavior have been also explored. The physical properties of the unexposed geopolymers to elevated temperatures show that the LWAGC possesses lower density and water absorption than the geopolymer paste and mortar. The mechanical strength of the geopolymer materials prior firing shows that the geopolymer paste and mortar possesses significantly high strength compared to the LWAGC, due to the lightweight aggregate (LWA) low strength and porous microstructure. It is found that the relatively high activator content used to activate the raw material, FA, results in excellent mechanical and microstructural properties for the unexposed geopolymers to elevated temperatures. While, it is significantly participating in the deterioration of the geopolymers mechanical and physical properties after exposed to the elevated temperatures especially at 800 °C by producing high unreacted silicate species. Introducing the LWAs to the geopolymeric structure considerably enhances the mechanical and microstructural properties of the geopolymers at elevated temperatures. This is attributed to the low thermal conductivity characteristics of the LWAs which inhibited the heat diffusion through the structure. The reported excellent thermal performance of LWAGCs at the elevated temperatures would increase the suggested application for this novel environmentally-friendly material.

Keywords: Lightweight geopolymer, Thermal shrinkage, SEM, Elevated temperature, Thermal expansion, Compressive strength