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Abstract

Influence of Precursor Materials on the Mechanical Behaviour of Ambient-Cured One-Part Engineered Geopolymer Composites †

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Geopolymer is an emerging low carbon cement-free binder that offers a sustainable and environmentally friendly alternative to ordinary Portland cement (OPC). Despite their outstanding environmental friendliness, geopolymer is still inherently exhibit brittle behaviour similar to conventional cement-based concrete. Recently, there is renewed interest to develop a new material combining geopolymer and Engineered Cementitious Composites (ECC) technologies. They named it as Engineered Geopolymer Composites (EGC). However, there are two major drawbacks associated with conventional geopolymer binder: firstly, handling of hostile, corrosive and viscous alkaline solutions; secondly, necessity for heat curing to improve geopolymerisation process and mechanical properties. To overcome such limitations, a new class of geopolymer composites known as "one-part" or "just add water" geopolymer was developed for this purpose.

The concept of ECC relies heavily on the micromechanics-based design principles, which provides guides for tailoring of fiber, matrix and fiber/matrix interfaces to attain desired tensile ductility. Through careful tailoring, the fiber volume fraction is usually remains moderate, typically less than 2.5%. Polyvinyl alcohol (PVA) fiber is the most common types of fiber used in ECC. To develop a cement-less EGC, a proper consideration on the geopolymer matrix design is essential. Research on EGC is still relatively new. Preliminary feasibility studies carried out on slag-based EGC [1] and fly ash-based EGC [2] shown very promising results with high tensile ductility over 4%. Studies on one-part EGC conducted by Nematollahi et al. [3] and Alrefaei et al. [4] further assure more detailed investigations are needed for potential applications of this technology in future eco-friendly civil infrastructure.

This paper presents the results of a preliminary investigation on the influence of precursor materials on the mechanical properties of one-part EGC. The aluminosilicate precursor materials used in this study consisted of combined fly ash (FA), ground granulated blastfurnace slag (GGBS) and quartz powder (QP). Sodium metasilicate anhydrous was used as the solid alkali activator to synthesize the ambient-cured one-part geopolymer composites. In order to minimize the matrix fracture toughness, all mixtures were prepared without addition of silica sand. All mixtures were designed with variations proportion of FA, GGBS and QP, amount of alkali activators and water contents. Mechanical properties were determined by compression and direct tension tests. Fresh properties and microstructure analysis of each mixtures were also studied and discussed.

The results indicate that combined GGBS with FA improve the reactivity of the mixture, compressive strength and enable possible ambient curing condition. Due to spherical nature of FA particle shape, best proportion between FA and GGBS in term of flowability was found at the percentage of 70:30 respectively. Increase on the amount of solid alkali activators used, reduce in the water contents and addition of QP could beneficially increase the compressive strength as well as uniaxial tensile cracking strength, ultimate strength and strain capacity. This is clearly reflected on the microstructure of the geopolymer gel, which showed more compact and denser morphology.

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