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Structure and properties of clay-based geopolymer cements: A review

Liew Yun-Ming [a,*], Heah Cheng-Yong [a], Mohd Mustafa Al Bakri [a,b], Kamarudin Hussin [a,b]

[a] Center of Excellence Geopolymer and Green Technology (CEGeoGTech), School of Materials Engineering, Universiti Malaysia Perlis (UniMAP), P.O. Box 77, D/A Pejabat Pos Besar, Kangar, Perlis 01000, Malaysia

[b] Faculty of Engineering Technology, Universiti Malaysia Perlis (UniMAP), P.O. Box 77, D/A Pejabat Pos Besar, Kangar, Perlis 01000, Malaysia

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ABSTRACT

This paper reviews about geopolymers fundamental focusing in clay materials. The review includes the chemistry and structure of geopolymers, reaction mechanism and prime materials involved in geopolymer formation. The characterization of geopolymers in term of microstructural, crystallographic and functional groups is elucidated. Besides, the important factors (such as alkali concentration, mixing parameters, curing conditions, and water contents) affecting properties (such as setting time, bulk density, strength, thermal properties, and stability) of clay-based geopolymers are critically reviewed. Finally, the paper also includes the previous geopolymer applications that have been successfully marketed and the potential current and future areas or focuses of study and application.

Contents

* Corresponding author.
E-mail addresses: yun86_liew@yahoo.com, ymliew@unimap.edu.my (Y.-M. Liew).

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1. Introduction

The review of geopolymeric materials in term of their formation, mechanism, development and application has been widely discussed mainly on the industrial waste, natural or artificial silico-aluminate. In this paper, the structure and properties of geopolymer materials based on clay materials are reviewed.

In general, geopolymers are inorganic polymers formed by mixing aluminosilicate with concentrated alkali hydroxide or alkaline silicate medium. This is followed by curing process at room temperature or slightly higher temperature in the range of 20–100 °C [1,2]. The reaction of geopolymer formation is called geopolymerization reaction.

In other words, geopolymer formation involves mixtures of solid and liquid (Fig. 1). The solid is aluminosilicate sources in powder form with a suitable proportion of high reactive silica and alumina. Meanwhile, the liquid is a highly concentrated alkaline solution.

2. Geopolymer terminology and structure

The word "geopolymer" was coined by Davidovits [3]. The prefix "geo" symbolizes the inorganic aluminosilicate based on geological materials which reacted with an alkaline solution to form binder through polycondensation reaction. The proposed terminology of geopolymer structure categorizes geopolymers into three basic forms depending on their Si/Al ratios, namely poly(sialate), poly(sialate-siloxo) and poly(sialate-disiloxo) as shown in Fig. 2 [4].

Geopolymer has amorphous to semi-crystalline structure with three-dimensional Si—O—Al polymeric networks. The SiO_4 and AlO_4 tetrahedral are linked alternatively by sharing all oxygen atoms, with the Al in IV-fold coordination (Fig. 2) [5,6]. This leaves a negative charge in the IV-fold coordinated Al, which is then charge-balanced by cation such as Na^+, K^+, Li^+, Ca^{2+}, Ba^{2+}, NH^{4+} and H_3O^+. The presence of cations is important to maintain the neutrality of the structure [7]. However, it is believed that asides from providing a charge-balancing role, the incorporation of cation is crucial to determine the structural integrity of the final product. Based on Saidi et al. [8], the Na^+ ion affect the fragility of geopolymers.

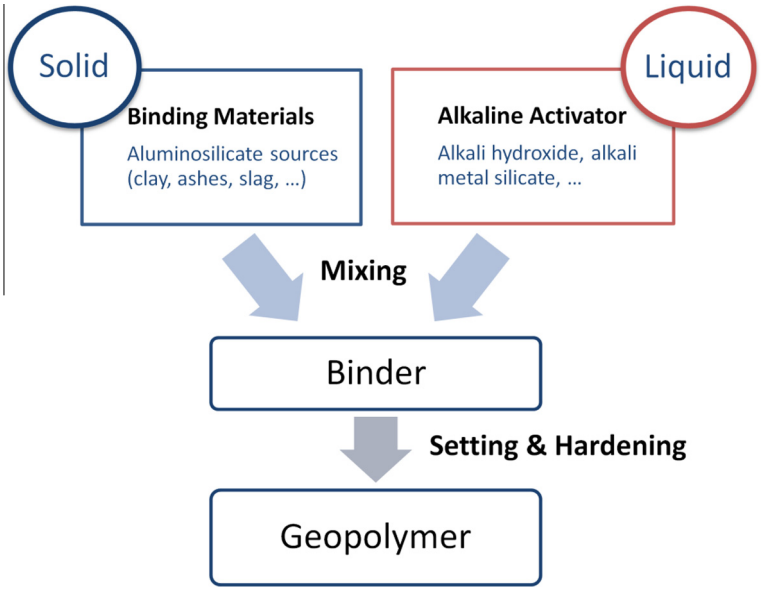

Fig. 1. Schematic diagram of geopolymer formation.