Materials and Design 32 (2011) 3021–3028

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Technical Report

Anchorage of steel bars in concrete by geopolymer paste

Smith Songpiriyakij [a], Tawich Pulngern [b,*], Pompong Pungpremtrakul [b], Chai Jaturapitakkul [b]

[a] College of Industrial Technology, King Mongkut's University of Technology, North Bangkok, Bangkok, Thailand
[b] Department of Civil Engineering, Faculty of Engineering, King Mongkut's University of Technology, Thonburi, Bangkok, Thailand

ARTICLE INFO

Article history:
Received 30 August 2010
Accepted 26 January 2011
Available online 2 February 2011

ABSTRACT

This paper presents the bonding strength between the embedded rebar and substrate concrete by using geopolymer paste as the bonding agent. The determination of the suitable mix proportions of geopolymer paste as bonding agent was the main interest. Twelve different mix proportions of geopolymer paste by varying the amount of starting binder materials and alkaline concentration were prepared and tested for compressive and bonding strengths. The tested results indicated that both RHBA and SF incorporating with FA could be used in preparation of geopolymer paste. Mixes with SF gave the higher compressive and bonding strengths while the mixes with RHBA required the longer curing time. The bonding strengths of round bar and geopolymer pastes were slightly higher than that of control concrete (1.05–1.12 times) and there were significantly high in case of deformed bars (1.03–1.60 times). The ratios of bonding strength on the compressive strength were also presented. In comparison with commercial repair materials, the bonding strengths of geopolymer paste were higher than those of epoxies about 1.24–1.81 times. These tested results indicated that the bonding strengths using geopolymer paste were high enough and possibly used as bonding material for repair works. The mixtures containing high SF content and high NaOH concentrations were recommended to enhance both compressive and bonding strengths.

1. Introduction

In the field of building renovations, the commercial chemical anchorage bolts are typically applied to fix steel studs, rebars, bolts, and anchorages with the existing structures, usually the concrete beams or columns. However, the price of commercial a chemical anchorage is always expensive especially, for the bigger diameter of chemical anchorage bolts. Moreover, the commercial chemical anchorages cement-based type is usually composed of cement, which we know that it is not green materials and releases carbon dioxide (CO_2) into the atmosphere during its manufacture [1]. Therefore, there are very useful if an alternative bonding material with lower price can be applied to replace the commercial cement-based anchorages, especially the green material without cement, which results in less carbon dioxide emission and reduces the environment impact. Geopolymer was the green material without cement, which was created and named by Davidovits [2–4]. It was synthesized by poly-condensation of silica-alumina structures incorporating with highly alkaline solution such as NaOH and KOH. Khale and Chaudhary [5] reviewed the mechanism and the factors influencing the strength development of geopolymer including chemical reactions, source material, and the mix compositions, while the effect of alkali and Si/Al ratio on the mechanical properties of geopolymer was suggested by Duxson et al. [6]. Many researchers [1,7–9] attempted to apply the waste material such as fly ash (fuel ash) and bottom ash instead of kaolin and metakaolin to synergize the geopolymer paste.

Recent literatures [10,11] stated that geopolymer mortar had a potential to develop as a repair material since the bonding strengths between geopolymer mortar and substrate concrete was high enough in comparison with those of commercial repair materials. However, the bonding strengths reported in work of Yodsudjai et al. [10] were obtained by slant test in accordance with ASTM C 882-05 [12] and the binders used were fly ash and silica fume. One more work of Hu et al. [11] also determined the bonding strength between the geopolymeric repair mortar with steel slag (GRS) and old mortar substrate in sandwich specimens and found that GRS had higher compressive strength and the bonding strength than that of cement repair. The power metakaolin obtained by calcining kaolin at 750 °C for 6 h was used as binder.

Therefore, the main objective of this work is to apply the geopolymer paste, which is the green material and very low price, as the bonding material between the rebar and existing substrate concrete. The geopolymer in this study used the waste binders of Rice Husk and Bark Ash (RHBA) incorporating of lignite fly ash (FA) as starting material. Geopolymer pastes with these binders were suggested from our previous work [13] that they had high enough of compressive strength. The silica fume (SF) was also included to enhance the mechanical properties of geopolymer paste.

* Corresponding author. Tel.: +66 2 470 9145; fax: +66 2 427 9063.
E-mail address: tawich.pul@kmutt.ac.th (T. Pulngern).

0261-3069/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.matdes.2011.01.048