Roles of Calcium in Geopolymer containing Paper Mill Sludge Ash

Norbaizurah Rahman[1], Andri Kusbiantoro[1]*, Nabilah Mamat[1], Khairunisa Muthusamy[2], and Mohd Mustafa Al Bakri Abdullah[3]

[1]Faculty of Engineering Technology, Universiti Malaysia Pahang, 26300 Malaysia

[2]Faculty of Civil Engineering and Earth Resources, Universiti Malaysia Pahang, 26300, Malaysia

[3]Faculty of Engineering Technology, Universiti Malaysia Perlis, 01000, Malaysia

*Corresponding author: andri@ump.edu.my

Keywords: Geopolymer, Paper Mill Sludge Ash, Curing Temperature, Strength, Degree of Reaction.

Abstract. High amount of calcium oxide (CaO) in source material is known to positively influence the mechanical strength of fly ash based geopolymer. This study was conducted to investigate the suitability of paper mill sludge ash (PMSA) to partially replace fly ash in geopolymer mortar based on the characteristic of its degree of reaction. Fly ash was activated by a combination of sodium silicate and 6M sodium hydroxide solution. The mixtures were designed to replace fly ash content with PMSA at 5%, 10%, and 15% (by weight of fly ash). To observe its effect on the degree of reaction, the specimens were cured in three different temperatures, which are 30°C, 60°C, and 90°C for 24 hours. After 24 hours, the hardened specimens were demoulded and stored in room temperature until the testing days. Measurement on fresh geopolymer properties was conducted with setting time and flowability tests, while degree of reaction test was conducted on the hardened specimen at 1 and 28 days. Based on the result, 5% of PMSA demonstrated superior degree of reaction than other mixtures in every curing temperature. It signifies the prospective benefit of PMSA for further use as an additive in geopolymer.

Introduction

Recently, geopolymer is gaining attention and interest in the construction industry due of its advantage that utilizes waste product to reduce greenhouse gases emission, high early strength, low creep and shrinkage, and temperature resistant. Previous studies revealed several factors that contribute to the enhancement of mechanical behavior and durability properties of geopolymer, such as chemical oxide composition of aluminosilicate source, alkali activators, curing temperatures, type of admixtures, and mix design. Nevertheless, only few researchers focused towards the effect of high amount of CaO content in the source material of geopolymer. A number of experimental results discovered the positive effects of high calcium compounds in source material towards the performance of compressive strength of geopolymer.

Temuujin et al. (2009) investigated the effect of calcium compounds on the mechanical properties of fly ash geopolymer paste and discovered the enhancement of mechanical properties of fly ash based geopolymer with the inclusion of calcium compound (CaO) at room temperature [1]. The presence of calcium compound would produce a formation of calcium silicate hydrate or calcium silicate aluminate hydrate phases and simultaneously increase the dissolution rate of fly ash in the alkali medium. Meanwhile, Chindaprasirt et al. (2011) studied the production of high strength geopolymer using fine high-calcium fly ash [2]. The use of fine high-calcium fly ash has successfully produced geopolymer mortar with compressive strength up to 86.0 MPa at 28 days. Moreover, the geopolymer mortar kept on gaining compressive strength when stored in a normal atmospheric condition after the initial heat-curing period. Topark Ngarm et al. (2015) reviewed the effect of high calcium fly ash to the properties of geopolymer concrete, in terms of setting time, strength and bonding characteristic [3]. In their study, the use high calcium fly ash was very beneficial in generating high compressive