Effect of Silica Fume and Alumina Addition on Fly Ash Geopolymer Concrete: A Comparative Study

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Abstract

This paper discussed the effect of the addition of silica fume (2 wt.% and 4 wt.%) and alumina (2 wt.% and 4 wt.%) on the properties of fly ash geopolymer concrete. The addition of 2 wt.% of silica fume increased the compressive strength by 105% with respect to the reference geopolymer (without additive). On the other hand, the compressive strength surged by 115% with 4 wt.% of alumina compared to the reference geopolymer. The addition of additives improved the compactness of the geopolymer matrix according to the morphology analysis.

Keywords: geopolymer; concrete; silica fume; alumina

1.0 Introduction

- Additives and reinforcements are commonly incorporated into geopolymer to increase the mechanical performance of geopolymer, such as silica fume and alumina.
- However, the dosage of silica fume and alumina incorporated in geopolymer were high and were added as a replacement to the aluminosilicate based on previous literature.
- Therefore, in this paper, the comparison between the properties of fly ash geopolymer concretes with the addition of silica fume and alumina were made, and the silica fume and alumina were added as an additive at low content. The dosage of silica fume and alumina was set at 2 wt.% and 4 wt.%.

2.0 Methodology

2.1 Materials

Fly ash was selected as the aluminosilicate material. Sodium silicate (Na_2SiO_3) was mixed with 10M of sodium hydroxide (NaOH) and the mixed solution was used as an alkali activator. The ratio of Na_2SiO_3/NaOH was fixed at 2.5. Silica fume (2 wt.%, 4 wt.%) and alumina (2 wt.%, 4 wt.%) were separately used as an additive. River sand and gravel acted as fine and coarse aggregates, respectively. The aggregate content was set to 70%. The sand/gravel ratio was fixed at 3:2, and the fly ash/alkali activator ratio was set at 2.0.

2.2 Synthesis of Geopolymer Concrete

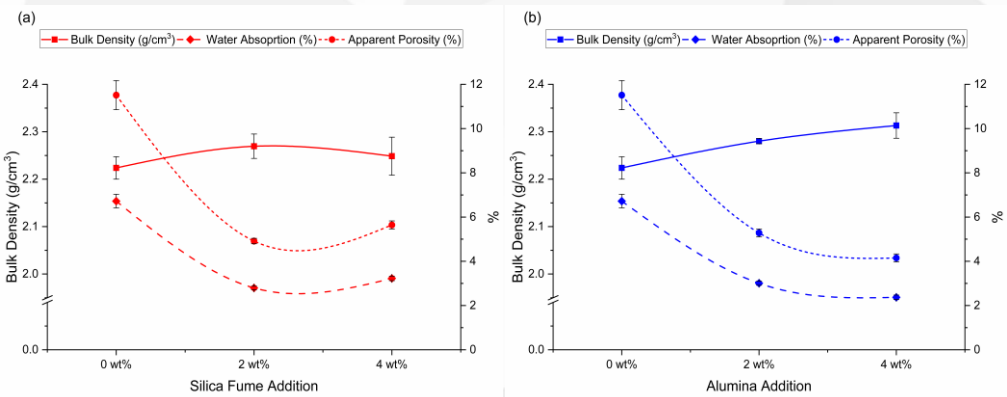
The reference geopolymer concrete was prepared by mixing fly ash, river sand, gravel and alkali activator. Silica fume and alumina were added separately into the geopolymer concrete mixture and cast into 100 × 100 × 100 mm moulds. The fresh geopolymer concrete was cured at room temperature for 24 hours followed by curing at 60℃ for another 24 hours.

4.0 Conclusion

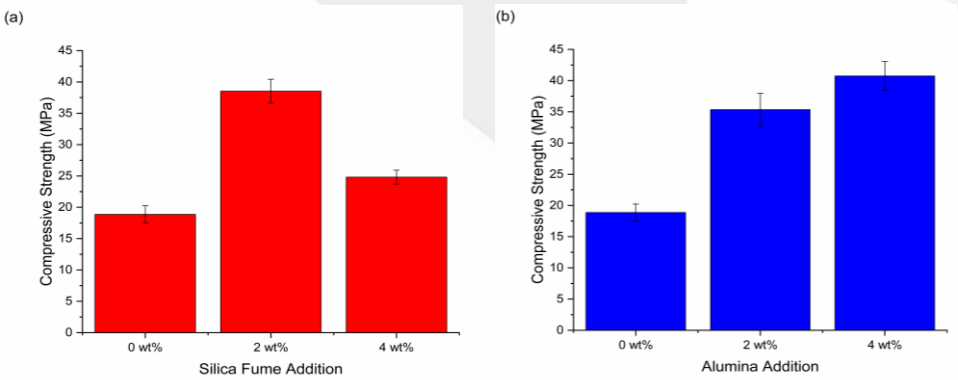
1. Geopolymer concrete with 2 wt.% of silica fume and 4 wt.% of alumina addition:
- Highest compressive strength
- Lowest porosity, water absorption
- SEM images = smooth and compact geopolymer matrix
- Reasons = silica fume and alumina induced supplementary Si and Al at the early stage to form the geopolymer network

2. Geopolymer concrete with 4 wt.% of silica fume addition:
- Lower compressive strength
- Reasons = high silica fume impede the dissolution of Al and Si from aluminosilicate (that is, fly ash) and subsequently affect the geopolymerization reaction

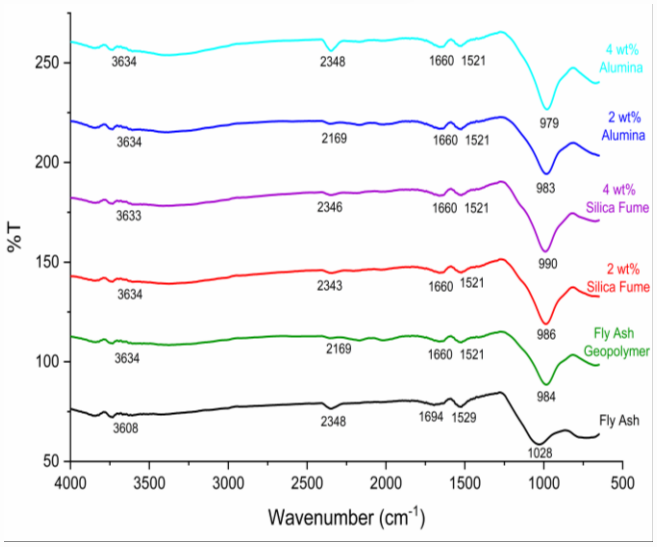
3.0 Result and Discussion



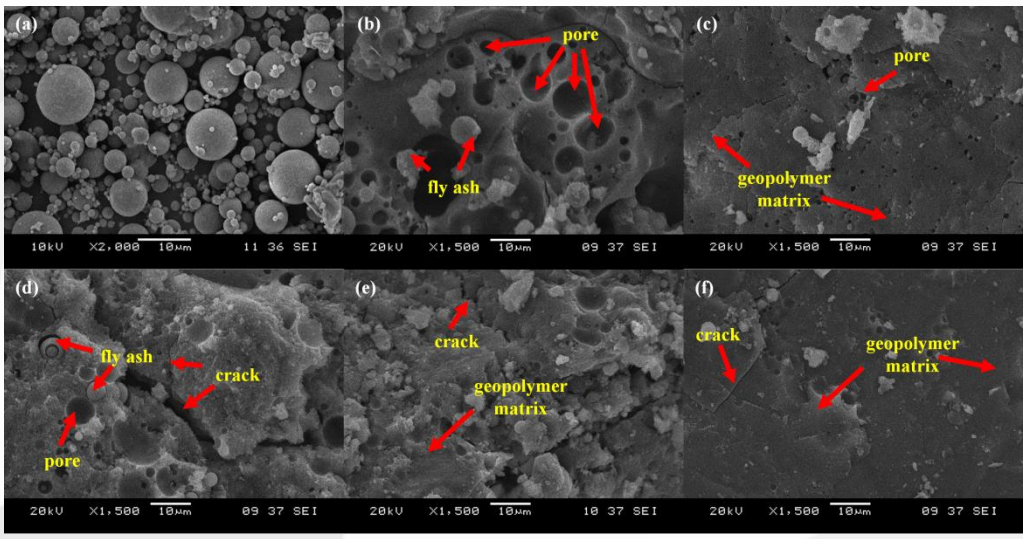
Bulk density, apparent porosity, and water absorption of fly ash geopolymer concrete with the addition of (a) silica fume and (b) alumina.



Compressive strength of fly ash geopolymer concrete with the addition of (a) silica fume and b) alumina.



IR spectra of fly ash and fly ash geopolymer concrete with silica fume and alumina addition.



SEM micrographs of (a) fly ash; fly ash geopolymer concrete (b) without additive; and with addition of (c) 2 wt.% of silica fume; (d) 4 wt.% of silica fume; (e) 2 wt.% of alumina; (f) 4 wt.% of alumina.