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Performance evaluation of metakaolin clay geopolymers synthesised with bamboo wood ash as an activator

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Bamboo wood ash-derived alkaline activator for synthesis of metakaolin clay geopolymer

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Introduction

More environment friendly alkali-activated materials and geopolymers are receiving global attention as alternative binders to ordinary Portland cement (OPC), the manufacture of which is accompanied by high emission of CO_2, which is one of the major initiators of global warming. In spite of the merits of geopolymers over OPC, cost of production is an issue when compared with OPC. This demands investigation into low cost production materials. One of the important materials in the production is alkaline activator. Commonly, a mixture of alkali hydroxide (NaOH or KOH) and soluble alkali silicate (Na_2SiO_3 or K_2SiO_3) is used as activator. However, the environmental detriment, cost and non-sustainability of alkali-activated materials and geopolymer have been linked to alkaline solution applied as activator. Sequel to this, studies into the possibility of partially or completely replacing the pure chemical activators with biomass ashes are currently receiving attention. Bamboo wood is commonly used as structural support material during building and construction. Usually, it is disposed into the environment when it is no longer strong enough to bear loads. It can therefore be obtained as waste material, serving as a cheap source of alkali in place of the relatively expensive pure chemicals.

Aim and objectives

The focus of this study was to determine the possibility of replacing 8 M sodium hydroxide (NaOH) in the reference 8MNaOH/Na_2SiO_3 activator with alkali metal-rich bamboo wood ash in the synthesis of metakaolin-based geopolymers. The objectives were to:

(1) Examine oxide composition of waste bamboo wood ash;

(2) Determine the best proportion of the bamboo ash required to synthesise geopolymers of desirable properties;

(3) Determine the effect of the ash as the activator on geopolymer selected properties.

Methodology

- Geopolymers were synthesised using a metakaolin clay as aluminosilicate source, BWA as potential activator and 8M NaOH/Na_2SiO_3 as reference activator.
- The BWA was characterised by X-ray fluorescence spectroscopy.
- Geopolymers were synthesised using
  % ash/clay ratios of 5:95, 10:90, 20:80, 30:70, 40:60.
- Setting time, compressive strength and water absorption were determined.

Results and Discussion

- Major oxide compositions of BWA were K_2O (22.9%) and Na2O (5.59%).
- At 28 days, 10% WBA geopolymer exhibited highest compressive strength (45.5 MPa) compared with the reference (28.9 MPa) (Figure 1).
- Setting time increased with BWA addition, improving ease of handling.
- Water absorption capacities of BWA-geopolymers were lower than that of the reference geopolymer (Figure 2).
- BWA-geopolymer brick produced showed efflorescence free surface compared with reference geopolymer brick (Figure 3).

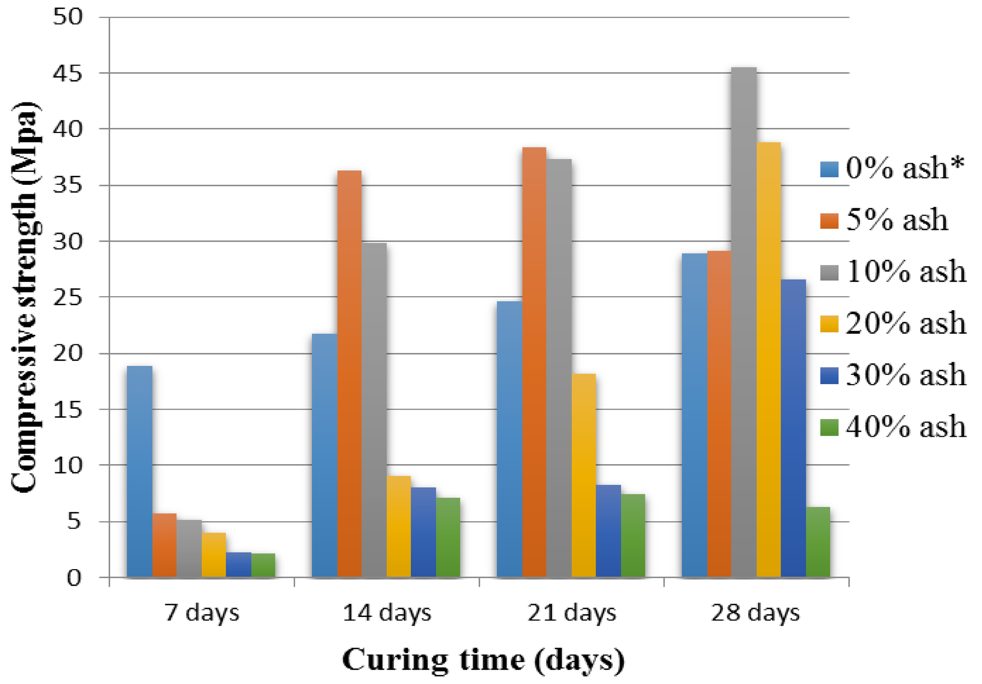

Figure 1. Compressive strength development of geopolymers activated with various ratios of BWA * 0% ash= 100% clay geopolymer (reference) activated with 8M NaOH/Na_2SiO_3

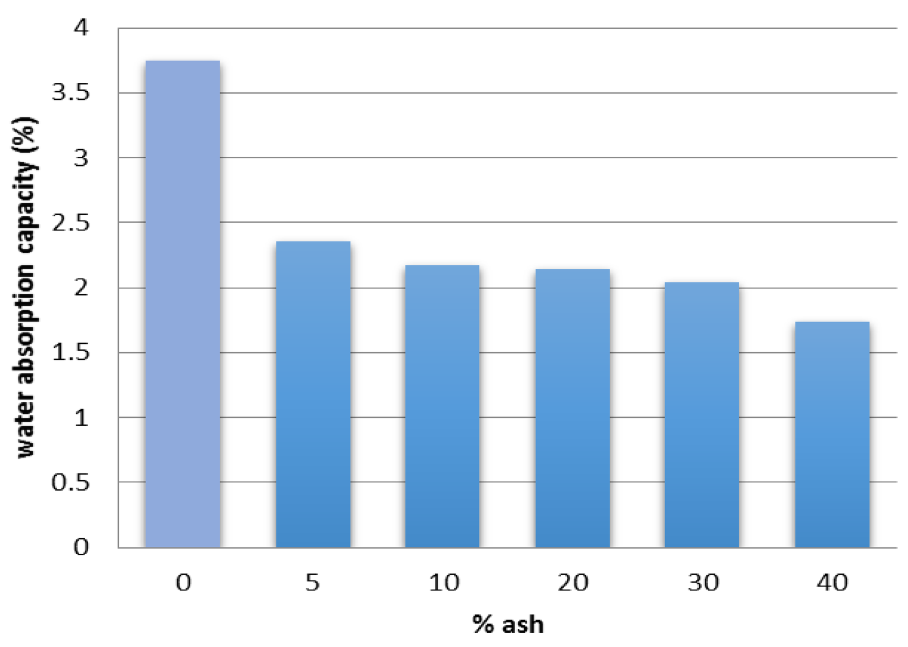

Figure 2. Water absorption capacity of geopolymers

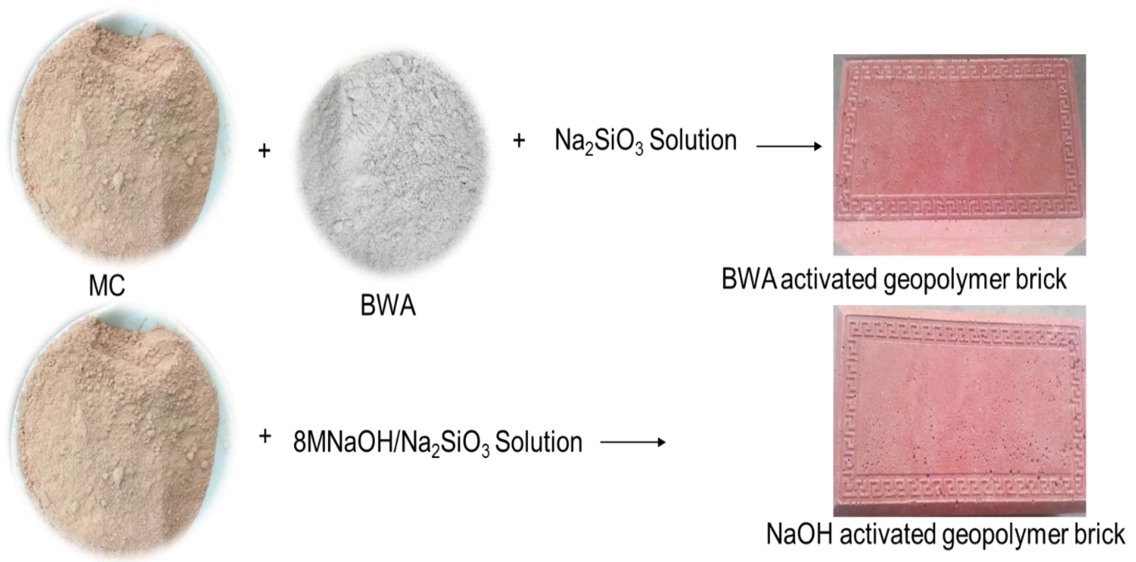

Figure 3. BWA activated and HaOH activated polymer bricks

Conclusion

Potassium-rich bamboo wood ash has potentials to activate aluminosilicate mineral in the presence of soluble silicate to produce metakaolin clay-based geopolymers of significant compressive strength and low water absorption capacity.