IOCM 2025 Conference
The 4th International Online Conference on Materials
3–6 November 2025 | Online
MDPI

Utilization of ceramic and brick waste in geopolymers: A preliminary study of physical and mechanical properties

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INTRODUCTION & AIM

Geopolymers are alternative cementitious materials with a low environmental impact, capable of reusing industrial and construction waste for their production. They are formed through the alkaline activation of aluminosilicates, resulting in a structure with excellent mechanical strength and durability.

Ceramic and brick wastes contain significant amounts of silica and alumina, making them potential precursors for the manufacture of geopolymeric pastes [1]. However, the final properties depend on parameters such as sodium hydroxide (NaOH) concentration, the Na_2SiO_3/NaOH ratio, and curing conditions.

This research aims to evaluate the influence of these parameters on the workability and the physical and mechanical properties of geopolymers produced from recycled ceramic and brick powder, in order to optimize their performance for sustainable civil engineering applications.

METHOD

The ceramic and brick wastes used were ground in a rotating ball mill and sieved to a particle size smaller than 150 µm. The alkaline activators consisted of sodium hydroxide (NaOH) solutions with concentrations of 5, 7.5, 10, and 12 mol/L, and commercial sodium silicate (Na_2SiO_3). Mixtures were prepared with Na_2SiO_3/NaOH mass ratios of 2:1 and 2.5:1 [2], considering the dry mass of NaOH and the commercial silicate solution. The schematic diagram of this process is shown in Figure 1.

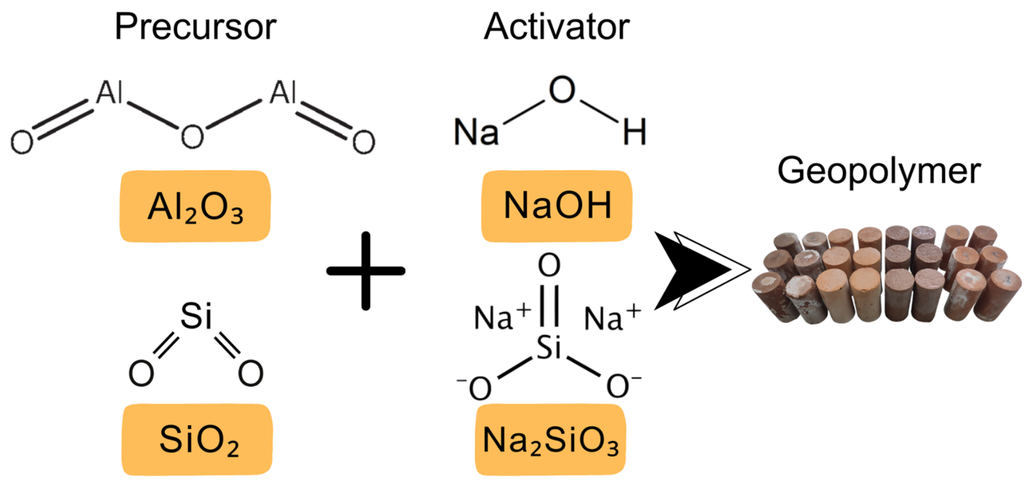

Figure 1: Schematic diagram of the alkaline activation process for geopolymer formation.

A liquid-to-solid ratio of 0.4 was adjusted with additional water to improve workability. To determine the optimal curing method, three curing regimes were applied: air curing for 7 days, wet curing, and mixed curing consisting of 6 days of air exposure followed by 1 day at 60 °C. The physical and mechanical properties were evaluated through density, absorption, voids, and compressive strength tests, following adapted ASTM C642 and C109 standards. The corresponding details are shown in Figure 2.

Figure 2: (a) Alkaline activators; (b) brick and ceramic waste powders; (c) preparation of geopolymeric specimens; (d) compressive strength test; and (e) density, absorption, and voids tests.

RESULTS & DISCUSSION

The compressive strength results for specimens prepared with a Na_2SiO_3/NaOH ratio of 2:1 are presented in Figure 3. The results indicate higher strength in brick-based pastes prepared with a sodium hydroxide concentration of 7.5 mol/L, reaching a compressive strength of 55.18 MPa.

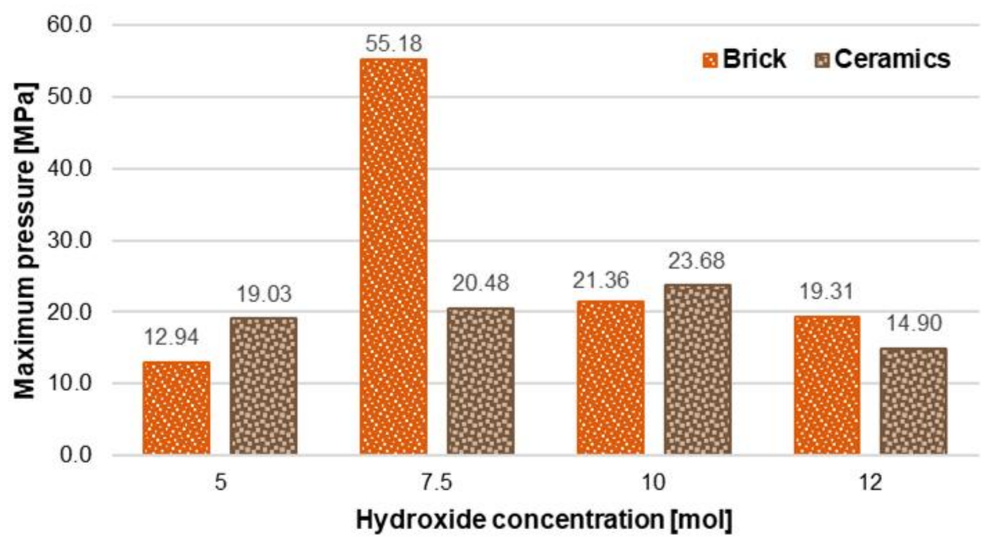

Figure 3: Na_2SiO_3/NaOH ratio of 2:1

Figure 4 shows the compressive strength results for specimens prepared with a Na_2SiO_3/NaOH ratio of 2.5:1. The maximum strength of 55.04 MPa was obtained in the brick-based mixture with a sodium hydroxide concentration of 7.5 mol/L.

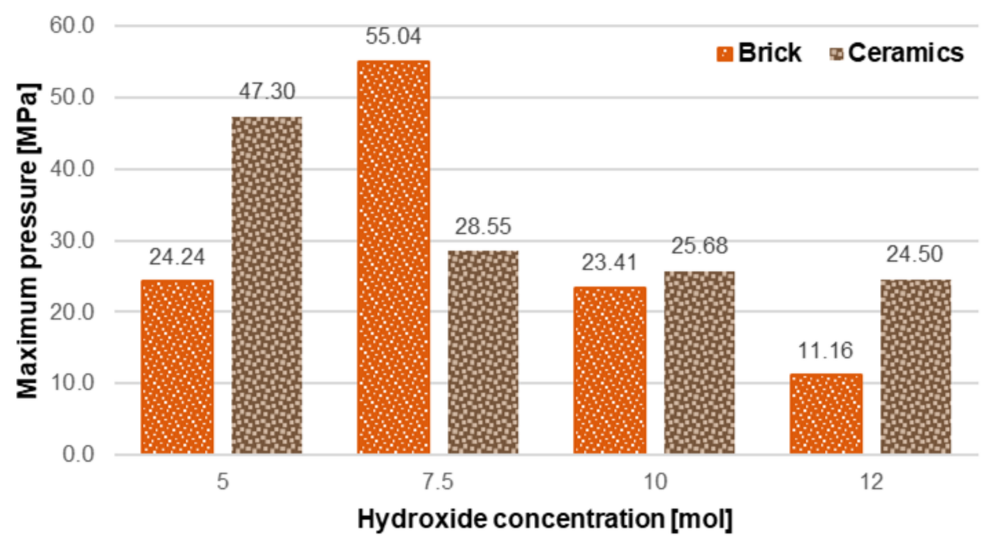

Figure 4: Na_2SiO_3/NaOH ratio of 2.5:1

On the other hand, the results of density, absorption, and voids tests allow correlating and explaining the variations in compressive strength observed at different activator concentrations, both in ceramic and brick-based mixtures.

CONCLUSION

The results confirm that ceramic and brick wastes are viable precursors for geopolymer production, achieving compressive strengths above 55 MPa with a NaOH concentration of 7.5 mol/L and Na_2SiO_3/NaOH ratios of 2:1 and 2.5:1. The density, absorption, and voids tests revealed that mixtures with higher density and lower porosity tend to develop the highest mechanical strengths.

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