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# Blended alkali-activated fly ash / brick powder materials

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**Abstract**

Aluminosilicate materials can be transformed into very compact binding material by the process called alkaline activation. The paper presents results of alkaline activation of fly ash and waste fine-grained brick body. Prepared geopolymers were tested for the compressive and flexural strengths, bulk density, and microstructure was examined by means of SEM. The results of investigated parameters showed the differences in relation to the ratio of fly ash to brick binder.


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*Keywords:* Brick powder; fly ash; alkaline activation; compressive strength; flexural strength; microstructure

## 1. Introduction

Alkaline activation of aluminosilicate materials is known from the thirties of the last century. Alkali-activated materials (geopolymers) are good alternative to Portland and blended cements. Geopolymers are formed by the chemical reaction between aluminosilicate materials and alkali-silicate solution. The result is partially or fully amorphous inorganic polymers with Si–O–Al bonds arranged through $SiO_4$ and $AlO_4$ tetrahedra into three dimensional structure. The great attention has been paid especially to the alkaline activation of metakaolin, clays, fly ashes, slags. Nowadays, there have been published several papers that studied the possibility of using fine grain ceramics for alkaline activation. Reig et al. [1,2] studied effect of $SiO_2/Na_2O$ ratio on a short-time compressive strengths and microstructure of mortars prepared from brick powder, alkali-activator of silicate modulus from 0.0 to 2.0, and sand. Mortars were stored at 65 °C and relative humidity 90–95% for 3 and 7 days. Although thermogravimetric analysis identified initial zeolitic structure, this trend disappeared with increasing concentration

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of alkaline solution. The best results showed mortar with $SiO_2/Na_2O$ ratio 1.60. Mortar reached compressive strength of 30 MPa after 7 days. The ceramic material derived from municipal waste collection as a potential alkali-activated material was studied by Sun Zengqing et al. [3]. The ceramics was crushed and pulverized; the mean particle size was 30 µm. The ceramic dust was activated either by sodium silicate solution of $SiO_2/Na_2O$ molar ratio 3.2 or sodium silicate solution with various concentration of sodium (potassium) hydroxide. Samples were cured at 65 °C for 28 days. The geopolymer of optimum mix design gave the highest compressive strength of more than 70 MPa. Higher strengths were acquired after 2 hours of calcination at 1000 °C.

Komnitsas et al. [4] applied the demolition waste ceramic materials for the preparation of geopolymers. Waste material was collected, cleaned, dried, and pulverized to reach $d_{50}$ = 35 µm. Sodium silicate and sodium hydroxide solutions of different concentration were used as activating agents. The samples were cured at temperatures 60, 80, and 100 °C for 7 days. Brick powder was successfully geopolymerized reaching a compressive strength up to 50 MPa, and after heating to high temperature (800 °C) compressive strengths moderately decreased.

Rakhimova and Rakhimov [5] used blended binder prepared from granulated blast furnace slag (GBFS) and brick waste powder (BP) at different ratio by alkali-activation using mixed solution of sodium silicate, sodium hydroxide and sodium carbonate. The compressive strength of mixture with GBFS/BP ratio 60/40 was higher than for one component binders. The compressive strength reached 120 MPa when GBFS and BP were milled together.

Nowadays, the heat-insulating bricks have to be fairly plain; hence, they are skived. The waste brick powder arises during this process; it is partially re-used as opening material in the brick production but great amounts are disposed. This material has very fine grains with no inappropriate substances; therefore, further modification is not needed. With respect to lower pozzolanic activity of brick powder, mixtures prepared from fly ash and brick powder were studied. Characterization of the composition, results of compressive and flexural strengths and microstructure reached at an ambient temperature are described in this paper. The study is in agreement with trends in concrete technology where blended binders are preferred.

## 2. Materials and methods

The fly ash (FA), waste material from Power plant Chvaletice (CZ), and brick powder (BP), waste material from skiving of heat-insulating bricks (Heluz, Dolní Bukovsko, CZ), were the basic raw materials for alkali-activated binder. No modification process of fly ash and brick powder were required. Chemical composition is presented in Table 1.

Table 1. Chemical composition of fly ash and brick powder.

| Material | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $K_2O$ | $Na_2O$ | S tot. | LOI (1100 °C) |
|---|---|---|---|---|---|---|---|---|---|
| FA | 52.21 | 29.59 | 8.44 | 1.82 | 1.16 | 1.66 | 0.3 | 0.86 | 2.12 |
| BP | 57.67 | 14.91 | 5.02 | 9.81 | 3.74 | 3.20 | 1.45 | 1.86 | 0.00 |

Table 2. Mineralogical composition of brick powder.

| Component | Content (%) |
|---|---|
| Quartz | 47.32 |
| Microcline | 15.65 |
| Muscovite | 9.80 |
| Albite | 11.30 |
| Orthoclase | 4.83 |
| Hematite | 3.26 |
| Rutile | 2.88 |
| Anatase | 2.75 |
| Sanidine | 2.21 |
| Amorphous phase | 18.49 |