Utilization of flue dust arising from metakaolin production for alkali-activated materials preparation

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Aim

The aim of this work was to prove the possibility of using flue dust in its original state without sufficient thermal activation. This material has already undergone a calcination process in a rotary kiln, and it contains besides metakaolin also residues of kaolinite. Physical observation, workability and leachability test of alkali-activated materials are reported in this paper.
Materials
Metakaolin (MK) and blast furnace slag (BFS) were used as main initial materials. Rotary kiln flue dust (RON) is a by-product of metakaolin production.

Sample preparation
MK and BFS were used as the primary aluminosilicate raw material. Ratio SiO2/Na2O was 6.9 and ratio SiO2/Al2O3 was 4.28. MK and BFS was partially replaced by RON at 0-100 wt.%. The solid materials were mixed with potassium alkaline-activator in ratio S/L 1.25. A filler was used in a weight ratio of 1:1. The mortars were casted into moulds sized 40 × 40 × 160 mm. Hardened specimens were stored in plastic bags under laboratory conditions for 180 days.

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Testing methods

The consistency of prepared mortars was determined according to EN 12350-5 using the flow table test, where the mean diameter of a test sample was measured. Initial setting time of geopolymer pastes was determined using the Vicat needle method according to EN 196-3:2016. The flexural strength of a hardened mortar was determined by three point loading of a prism specimen, subsequently to the failure and breakage of this specimen the compressive strength was determined on each half of the prism 160 × 40 × 40 mm. The samples were tested in several terms up to 180 days.

The leachability test was performed after 28 days at 20 °C. The samples were soaked in water up to 7 days. The volume of water was determined by calculated surface of the tested prism at the volume ratio of 1:5. Once a day the leachate was stirred. The resulting leachate was analysed by ICP-OES method (ICP IRIS Intrepid II XSP Duo) and K⁺, Na⁺, Ca²⁺ and SO₄²⁻, NO₃⁻, Cl⁻ were determined.

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Figure 1. Results of consistency determination (a) and initial setting time (b) depending on the RON content in the mixtures.

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Figure 2. Development of compressive strength (a) and flexural strength (b) in time.
Figure 3. XRD pattern of samples after 180 days – a) peak of kaolinite (7.14 Å) b) peak of calcite (3.03 Å)
Figure 4. Development of concentration of cations (a) and anions (b) in leachate in dependence on RON content in the geopolymer matrix
• Conclusions

• For the preparation of geopolymer materials, the flue dust of 0-100% was used as a substitute in blast-furnace slag and metakaolin matrix. It was found that this material can also be used successfully for the preparation of geopolymers, but due to the content of kaolinite, which dissolves very slowly in the alkaline environment, such a high-quality and appropriate aluminate-silicate structure is not formed. The addition of the flue dust results in reduced compressive and flexural strengths, prolongation of setting time and affects the floability of the mixtures.
Thank you for attention

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