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Prewashed wood ash for utilization in cement-based materials

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Abstract

In the transition towards a more sustainable energy system, renewable energy sources, e.g. wood, are of significant importance in the withdrawal of the coal-fired power plants. This leads to a decrease in the availability of the by-product coal fly ash, which is traditionally used in the concrete production, and to an increase in the residual waste, wood ash. The performance of wood ash in cementitious materials varies markedly throughout the literature depending on the physicochemical characteristics, determined by, e.g. the wood product, temperature, combustion method, and on pretreatment of the wood ash before utilization. This aim of this study was to determine the influence from the physicochemical characteristics of wood ash from grate combustion of wood pellets and the properties of cementitious materials. The work includes both with partial cement replacements with the untreated (marked WA) and prewashed WA (marked WA-W).

The WA was divided into two portions. One portion was subjected to a washing treatment as follows: WA and distilled water were mixed to an L/S (liquid-to-solid) ratio 5 and shaken for 1 min. After settling, the water was decanted. This procedure was repeated three times and the suspension was vacuum-filtered. The morphology of the particles for cement, WA and WA-W was evaluated with SEM. Cementitious materials with 10 wt% cement replacement with WA and WA-W, respectively, were investigated. The w/b-ratio for all mixes was kept at 0.55. The workability was determined according to EN 196-3, the setting time according to EN 196-3 and the compressive strength at 7, 14, 28, 60 and 90 days according to EN 196-1. Development of phases were measured on cement paste with 10 wt% cement replacement with WA and WA-W, respectively, by XRD and TGA at 7, 14, 28, 60 and 90 days. Reference tests were conducted for all test with 100 wt% cement.

Use of WA and WA-W in the mortar mix resulted in a decrease in the workability due to the water absorption of the WA and WA-W and a delay in the setting time compared to reference mixtures. A more distinctive decrease in the compressive strength was seen for WA compared to WA-W. The delayed setting time and the decrease in compressive strength can both be attributed to the clinker dilution effect for both ashes. The rounded particles (filler effect) determined by SEM and the increase in portlandite content determined by TGA for WA-W can explain the higher compressive strength when WA-W is utilized compared to WA. The phase development showed a decrease for portlandite and the ettringite content for pastes containing WA and WA-W, more profound for WA. Thus, the washing treatment of wood ash from grate combustion of wood pellets facilitates a wood ash more suitable for utilization in cement-based materials.

Utilization of wood ash in cementitious materials presents new challenges. However, due to the possibility for hydraulic activity and the particles to function as a filler, the potential for wood ash as a partial cement replacement should be taken into consideration for new and sustainable cementitious materials.

Keywords: wood ash, prewashing, cementitious materials