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RESEARCH ARTICLE

Characterization of sewage sludge incineration ashes from multi-cyclones and baghouse dust filters as possible cement substitutes

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Abstract

Incineration is not a final disposal method for sludge management since a significant amount of ash is generated. Although some published literature reported on the use of sewage sludge ashes (SSAs) as a cement replacement, none of them referred to the air pollution control unit of the incinerator where the SSA is collected. The properties of SSAs from different air pollution control units were investigated with the purpose of usage as a cement replacement in the present study. The SSA samples obtained from multi-cyclone units (MC-SSA), where SSA is collected at the bottom of the unit with the help of inertia and centrifugal forces, and baghouse dust filters (BHD-SSA), where SSA is collected at the fabrics of the unit, of the sludge incinerator were analyzed for chemical and physical characteristics, including heavy metal leaching, mineralogy (XRD), and particle morphology (scanning electron microscopy). Mortar samples were prepared with 15 and 30% of MC-SSA and BHD-SSA additions and analyzed for workability, strength activity, strength development, and freeze–thaw resistance. Heavy metal leaching results of both of the MC-SSA and BHD-SSA and their mortars were below the legal requirements of landfills, inferring that the toxic elements in SSA would not be of environmental concern in case SSA is used in cement matrices. The present study identified the variability of the physical and chemical properties of both SSAs over time and their differences. Incompliances of the SSAs to the pozzolanic material standards were observed, although moderate pozzolanic activity was concluded. In order to obtain the required flow value, different amounts of polycarboxylate ether-based superplasticizer were used in all of the mixtures. The levels of amorphous phases were found to be 23.3 and 39.3% for MC-SSA and BHD-SSA, respectively. MC-SSA exhibited less porosity with larger agglomerates than BHD-SSA. Ninety-day compressive strength levels of MC-SSA mortars with 15% replacement, which was found as 50.53 MPa, was higher than that of BHD-SSA mortars by 6% (47.65 MPa). The freeze–thaw resistance and water adsorption capacity of SSA mortars were comparable with that of the cement mortars. It was inferred that the contribution of SSA substitution to the strength development was influenced by hydraulic activity more than pozzolanic activity.

Keywords Sewage sludge ash · Multi-cyclone units · Baghouse dust filters · Cement replacement · Pozzolanic activity · Hydraulic activity

Highlights
- Sewage sludge ashes did not conform to the criterion of pozzolanic materials.
- Finer particle size of sludge ashes does not always mean a less porous structure.
- Superplasticizer helped to control the increase of water adsorption levels.
- Multi-cyclone ash yielded higher strength than baghouse dust filter ash.
- Freeze and thaw resistance of the sewage sludge ash mortars were comparable with cement mortar.

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