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Impact of Alkaline Activator Composition and Precursor Types on Properties and Durability of Alkali-Activated Cements Mortars

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Abstract : Alkali-activated materials are promising binders obtained by an alkaline attack on fly-ashes, metakaolin, blast slag among others. In order to guarantee the highest ecological and cost efficiency, a proper selection of precursors and alkaline activators has to be carried out. These choices deeply affect the microstructure, chemistry and performances of this class of materials. Even if, in the last years, several researches have been focused on mix designs and curing conditions, the lack of exhaustive activation models, standardized mix design and curing conditions and an insufficient investigation on shrinkage behavior, efflorescence, additives and durability prevent them from being perceived as an effective and reliable alternative to Portland. The aim of this study is to develop alkali-activated cements mortars containing high amounts of industrial by-products and waste, such as ground granulated blast furnace slag (GGBFS) and ashes obtained from the combustion process of forest biomass in thermal power plants. In particular, the experimental campaign was performed in two steps. In the first step, research was focused on elucidating how the workability, mechanical properties and shrinkage behavior of produced mortars are affected by the type and fraction of each precursor as well as by the composition of the activator solutions. In order to investigate the microstructures and reaction products, SEM and diffractometric analyses have been carried out. In the second step, their durability in harsh environments has been evaluated. Mortars obtained using only GGBFS as binder showed mechanical properties development and shrinkage behavior strictly dependent on SiO2/Na2O molar ratio of the activator solutions. Compressive strengths were in the range of 40-60 MPa after 28 days of curing at ambient temperature. Mortars obtained by partial replacement of GGBFS with metakaolin and forest biomass ash showed lower compressive strengths (≈35 MPa) and shrinkage values when higher amount of ashes were used. By varying the activator solutions and binder composition, compressive strength up to 70 MPa associated with shrinkage values of about 4200 microstrains were measured. Durability tests were conducted to assess the acid and thermal resistance of the different mortars. They all showed good resistance in a solution of 5%wt of H2SO4 also after 60 days of immersion, while they showed a decrease of mechanical properties in the range of 60-90% when exposed to thermal cycles up to 700°C.

Keywords : alkali activated cement, biomass ash, durability, shrinkage, slag
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