Abstract

Geopolymers have been the subject of substantial research and commercial interest during the beginning of this century. Through the alkali-activation process, by-products obtained from coal or co-combustion can be used as a valuable product. Regrettably, the variability of the chemical composition of the source materials results in fluctuation of performance levels of the alkali-activated materials (AAMs). Research has been until now focused on the factors influencing geopolymerization process, mechanical properties and durability: geopolymer composites have definitively excellent engineering properties as a building material. However, these high durability performances are greatly depending on different geopolymerization precursors, activators, types of specimens and research methodology.

The subject of this PhD research is the study of AAMs produced with new combustion by-products (biomass and co-fired fly ashes) and their potential to be used as building composites. The research was divided in two stages:

1. Investigation on alkali-activated precursor characteristics (bulk chemistry, physical properties of fly ash materials) with research on fly ash mortars with different alkaline activators (through mechanical and morphological analysis).
2. Investigation of possible use of alkali-activated fly ash-based mortars with several levels of calcium in construction sector (through mechanical, microstructural and durability tests).

In this thesis, three different fly ash samples are analysed: fly ash from coal combustion (RFA), co-combustion fly ash of coal with wooden biomass (CFA) and fly ash derived from biomass combustion (BFA). These fly ashes offer different chemical and mineralogical compositions, reactivities, densities and particle size distributions. Fly ashes were activated with single activators (sodium hydroxide, quicklime) or combined activators (sodium hydroxide with quicklime, sodium hydroxide with sodium silicate and quicklime with sodium silicate) to obtain pastes and mortars. To analyze the influence of calcium compound on mortar performances, CaO and BFA were added to alkali-activated mortars based on CFA and RFA.

This research proved that co-combustion fly ash can be used as a binder in AAMs. The biomass fly ash mortars present poor mechanical properties due to low alumina and silica content. BFA however can be used as a high-calcium additive with retarding properties. The 5% of CaO added to high-silica fly ash AAMs induces decreasing setting time but increasing of material density, mechanical properties and durability.

Biomass combustion fly ashes clearly represent promising material for replacing coal fly ashes for specific applications.