SUMMARY

The aim of the Ph.D. Thesis was to evaluate the feasibility of using quicklime as an alkaline activator of the ground granulated blast furnace slag to obtain a binder that could be used in the building composites. Quicklime is a cheaper and more environmentally friendly alternative to the currently most widely used alkaline ground granulated blast furnace slag activators. At the same time, the subject of activation of blast furnace slag with quicklime has been little recognized so far.

The literature part of the dissertation discusses the method of obtaining properties and applications of blast furnace slag and quicklime. Both materials' current and historical production volumes were analyzed, proving that alkali-activated slag binder with quicklime has implementation potential as a specialized binder. In this part of the dissertation, the process of alkaline activation of blast furnace slag was also analyzed in detail. In the context of the available literature, the activation mechanism and microstructure of slag-alkali pastes were described. The course of hydration of blast furnace slag in the presence of calcium hydroxide or oxide is described, and the properties of slag-alkali binders and composites obtained by alkaline activation of blast furnace slag with hydrated and quicklime are characterized.

The research part of the dissertation describes the course and analyzes the results of preliminary, basic, and optimization studies. As part of the preliminary research, selected physical properties and chemical composition of two blast furnace slags and four types of quicklime, hydrated lime and Portland cement were evaluated. Based on the results of preliminary studies, blast furnace slag from the Katowice Steel Plant was selected as a precursor of the slag-alkali binder.

In the basic research, the effect of the quicklime’s reactivity and its content in the binder on the properties of binders, pastes and mortars was analyzed. The scope of the research carried out in this stage included determining the characteristics of the binder setting process, its volume constancy and water demand, and the evaluation of the microstructure and calorimetric, rheological, deformation and strength properties of slag-alkaline slurries and mortars. These properties were determined by taking 5, 9 and 13% of the activator in the weight of the binder. Basic research was also used to determine the similarities and differences between the properties of binders, pastes and mortars containing quicklime and those of binders, pastes and mortars containing the reference activators: hydrated lime and Portland cement.

As a result of the basic research, it was established that the use of quicklime as an activator of blast furnace slag makes it possible to obtain a binder in which the heat of hydration, volume changes and kinetics of the setting process can be shaped in an extensive range, depending on the reactivity of quicklime and/or its content in the binder. This distinguished slag-alkali binders with quicklime from those with hydrated lime and Portland cement. Pastes and mortars with quicklime had similar mechanical properties to pastes and mortars with hydrated lime and were inferior to composites with Portland cement. Using quicklime instead of hydrated lime made it possible to obtain mortars with similar or lower, depending on the activator content in the binder mass, capillary rise absorption rate and similar or higher resistance to carbonation. Basic research was also used to select quicklime with a specific reactivity for the optimization research stage. As a result of the multi-criteria comparative analysis, it was decided to use light-burnt lime in the optimization studies.

The optimization study aimed to determine the optimum composition of slag-alkaline general-purpose masonry mortar, considering the mortar's w/s ratio and the activator content of the binder mass as dependent variables. Basic properties of masonry mortars, such as consistency, flexural strength, compressive strength, absorbability and capillary absorption, were used as criterion characteristics. A mortar obtained the highest value of generalized material utility with a compressive strength class of M5, a w/s ratio of 0,51, with a 5,95% content of light-burnt lime in the binder mass. This mortar had similar mechanical properties to commercial cement-lime mortars of the same compressive strength class and mortars with hydrated lime analyzed in the dissertation.

The tests carried out within the framework of the work made it possible to prove the thesis stated in the in the dissertation and established that quicklime can be successfully used as a safe activator of blast furnace slag in making an alkali-activated slag binder that can find application in building composites.

The dissertation consists of 277 pages, including 189 figures, 44 tables and 32 equations. The inventory of literature used includes 205 items.

Keywords: mineral binder, alkali-activated binder, blast furnace slag, alkali-activation, quicklime, geopolymers, low carbon binder