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Geopolymer Based on Mechanically Activated Air-cooled Blast Furnace Slag

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Abstract: An efficient solution to increase the sustainability of building materials is to replace Portland cement with alkali-activated materials (AAM). Precursors for those systems are often based on water-cooled ground granulated blast furnace slags (GGBFS). Quenching of blast furnace slag can be done also by air but in that case, the final product is crystalline and with a very low reactivity. The present study aimed to evaluate the cementitious properties of a mechanically activated (MCA) air-cooled blast furnace slag (ACBFS) used as a precursor in sodium silicate alkali-activated systems. The unreactive ACBFS was processed in a planetary ball mill and its cementing performances were compared with an alkali-activated water-cooled GGBFS. Mixes based on mechanically activated ACBFS reached the 7-days compressive strength of 35 MPa and the 28-days compressive strength 45 MPa. The GGBFS-based samples showed generally higher compressive strength values.

Keywords: mechanochemistry; alkali activation; air-cooled slag; ground granulated slag; mechanical activation; cement-free mortars

1. Introduction

The production of Portland cement uses processing temperatures exceeding 1400 °C, thus leading to a large CO_2 footprint [1]. Environmental benefits can be achieved by the use of binders made of CO_2 neutral alumina silicate rich industrial by-products or wastes. Fly ash and ground granulated blast furnace slag (GGBFS) are typical examples. The GGBFS, which is in the focus of this research, can be utilized either as partial or full replacement of Portland cement. In the case of partial replacement, the GGBFS undergoes a secondary pozzolanic reaction due to the alkali activation process induced by the hydrating Portland cement [2]. At full replacement, the solidification is controlled by a combination of alkali activation processes and hydration. The chemical reactions are induced by strong alkalis such as sodium silicate or sodium hydroxide [3–6].

Blast furnace slag (BFS) is a by-product of iron production in a blast furnace. The global production of slag is estimated to reach around 450 million tons per year and the value is expected to increase in the coming years [7]. In the process, a mixture of pelleted iron oxides, limestone and carbon is heated