Bauxite Residue as Raw Material for Manufacture of Synthetic Aggregate

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Abstract

The amount of solid waste generated in mining and metallurgy is a relevant socio-environmental issue. The construction industry can be a potential consumer of most of this material, mainly to supply the shortage of raw material. In this context, this work presents the studies carried out for the recycling of bauxite residue as raw material for the manufacture of synthetic aggregate for construction. Two different types of synthetic aggregates were produced, varying the proportions of raw materials (bauxite residue, silica and clay) and sintered at 1200 ºC. The aggregates were characterized by X-ray fluorescence, X-ray diffraction, scanning electron microscopy and compressive strength. It was observed that the properties of these materials depend on the control of parameters such as free silica and clay content, particle size distribution and sintering temperature. The control of these variables allowed an understanding of the glassy phase formation, which is responsible for the properties of ceramic materials such as porosity, compressive strength and density. The results indicated that the different types of aggregates produced are in accordance with the technical criteria for the construction industry.

Keywords: Bauxite residue, Aggregate, Construction industry.

1. Introduction

Synthetic aggregate is known in the literature as lightweight expanded clay aggregate and has been used in Brazil since the 1980s in civil engineering projects including geotechnical applications, due to its diversity in density, high shear strength and favorable drainage characteristics [1], providing various applications in the construction industry.

The synthetic aggregate is formed from silicoaluminates submitted to a sintering process at high temperatures (1100 - 1250 ºC), and may also present expansion due to the inclusion of gases, normally processed in rotary furnace, resulting in an increase in the porosity of the grains and unique characteristics, such as: lightweight, water absorption capacity and insulation, both thermal and acoustic. Its low density makes this material suitable for use in construction as embankments on soils with low rigidity and as a filling material in retaining structures, aiming at reducing active pressures [2].

Because it is a manufactured product, many of its characteristics, such as porosity and density, can be properly modified in the manufacturing process in order to obtain the desired grain characteristics. Regarding its lightweight, the most important parameter is the porosity of the core. Pores can be divided into accessible and closed pores, which cannot be filled with water, even if the grain is submerged for long periods [1, 2].

Research shows that the compressive strength of the aggregate is conditioned by the characteristics of each grain; therefore, there are several studies on the compressive strength of grains under uniaxial compression in different materials. In addition to the material that forms the grain, breakage is influenced by other factors such as water content, grain size, shape and chemical composition, which depends on the composition of the original clay and other materials added during the process [2].

Studies have shown several successful applications of synthetic aggregate as a geotechnical infill material in the 1980s, including the rehabilitation of a river port terminal and the construction of a bridge. Due to its grain size and lightweight nature, synthetic aggregate is easy to transport, fill and handle. Developed during the sintering process, the pores can be fully closed within a given particle or exposed to its external surface, with the surface of the synthetic aggregate particle being more resistant than the interior due to the sintering of the expanded clay into a material of the ceramic type [1].

Synthetic aggregate is a versatile material used in various applications, such as in the construction industry, where it can be used in the production of lightweight blocks, precast concrete, as well as in structural backfill of foundations. Research has also shown that the aggregate can be used for water treatment, removing fluoranthene, phenanthrene and pyrene. Within horticulture or agricultural field, it can be used for wastewater treatment, due to its high capacity to remove numerous pollutants such as total suspended solids, polyphenols and nitrogen, pesticides and pharmaceuticals [3].

There are many publications related to the use of synthetic aggregate in the construction industry. These publications focus on the use of synthetic aggregate as a partial or complete substitute for normal weight aggregates, which provides greater workability to the resulting material [3]. The literature shows that the aggregate has been used in studies for the production of lightweight concrete, since the use of synthetic aggregate brings benefits by making construction safer, more economical and with less impact on the environment. Other authors have also studied the influence of aggregate sizes on the workability and compressive strength of concrete [4].

Due to different oxides in its composition, the bauxite residue can be an important raw material for the production of synthetic aggregate, since the amount of these oxides can influence the phase transformations that occur during the sintering of the aggregate [5-8]. In this context, the present work aims to carry out the production of synthetic aggregate with bauxite residue in a mixture with silica and kaolinite clay.

The application of bauxite residue, in mixtures with clay and silica, offered a great alternative for the manufacture of synthetic aggregate, mainly because they are low-cost raw materials that are generated in large quantities. The two samples, AGG-70 and AGG-80, presented satisfactory results of compressive strength, 35.57 and 26.30 MPa in 28 days, respectively, which should be better evaluated in experiments with full-scale elements (beams, slabs, and columns).

5. References

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