INFLUENCE OF COAL BOTTOM ASH ADDITION ON THE PROPERTIES OF CERAMIC MATERIALS

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ABSTRACT

Low cost and lower negative environment impact are the most important conditions for using industrial residues in fabricating ceramic materials. The composition and chemical-physical properties of coal bottom ash suggest the possibility of completely or partially substituting the precursor materials used in the ceramic elaboration. The present work describes the ceramic tile development process using coal bottom ash as a source of aluminium-silicates (10-40%). It also shows the influence of the ashes on water absorption, bulk density and flexural resistance of the standard mixture, sintered at 1150°C (X-ray diffraction, scanning electron microscopy). Standard material properties did not show the strongest change until substitution of 15% coal ashes by weight and higher ash substitution improved the mechanical properties of the studied materials. The above mentioned improvement was related to the crystalline phases present in the materials.

Key work: *Recycling, Ceramics and Coal Bottom Ashes.*

1. INTRODUCTION

The recycling viability of mineral coal ashes for the fabrication of ceramic materials represents an attractive alternative for resolving some environmental problems, besides the big prospect of producing a material with compatible characteristics for its use, while being economically competitive, characterized as being a long lasting commodity for use by the society [1].

The physical, chemical and mineralogical characteristics of the coal ashes are compatible with several raw materials used in the ceramic coverings industry, which indicates the possibility of partial or complete replacement of these raw materials by this residue. This residue is mainly composed of quartz (SiO_2) and mullite ($3SiO_2.2Al_2O_3$)[2]. The objective of this work is to characterize the mineral coal bottom ash residue and to investigate the possibility of introducing this material in ceramic tiles.

2. MATERIALS AND METHODS

The mineral coal bottom ash used is a residue of mineral coal, from the Jorge Lacerda thermoelectric power plant that is located in the state of Santa Catarina – Brazil. A standard ceramic mixture was used as a reference, designated "CI". The other compositions were prepared by adding 10, 15, 20, 25, 30 and 40% mineral coal bottom ashes to the standard mixture, and respectively called C1, C2, C3, C4, C5 and C6. The materials were prepared by 30MPa uniaxial pressing and sintered at a temperature of 1000°C, 1100°C, 1125°C, 1140°C and 1150°C. The time at each maximum temperature stage was 2 hours.

3. RESULTS AND DISCUSSION

The chemical analysis of the mineral coal bottom ashes and standard mixture are presented in Table 1.

	Oxides										
	SiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	TiO_2	CaO	Na_2O	K_2O	P_2O_5	LOI
Standard Mixture (%)	63.11	19.59	6.11	0.05	1.44	0.73	0.23	0.26	1.69	0.17	6.38
Coal Bottom Ashes (%)	54.04	25.19	4.61	0.03	1.43	0.91	2.26	0.86	0.95	0.22	8.52

Table 1. Chemical analysis of the mineral coal bottom ashes and standard mixture.

The water absorption in the materials decreases with the addition of bottom ashes, reaching a minimum at C1 (6.69%). With the other added percentages, there is a reverse behaviour: the absorption rises with the increase of the residue incorporation, due to reactions of the ash incorporated in the kaolinitic clay present in the standard mixture[3]. These reactions lead to a reduction of the C2, C3, C4, C5 and C6 composition sintering rate, causing a higher number of pores in the material and, as a consequence, higher water absorption. This behaviour is also influenced by the lower densification of the pieces that contain bottom ashes, due to the low plasticity of the solid by-product. Bulk density grows with the addition of bottom ashes, reaching a maximum in C1 (2.26 g/cm^3). In the following compositions it is possible to observe a decrease in the values of this property, as a consequence of reactions similar to those mentioned above, responsible for the increase in water absorption.

The rupture modulus tends to increase with the inclusion of bottom ashes, with a maximum for the C2 composition. The understanding of this mechanism can be given as a function of the crystalline phases present in the studied materials. Because the quantities of SiO_2 and Al_2O_3 are bigger or lower in the different compositions, i. e., are variable depending on the quantity of added ashes, the quantities of crystalline phases present also change, according to this parameter. In relation to the mullite phase, this tends to grow with the increase of the bottom ashes addition, and also through reactions of SiO_2 and Al_2O_3 that take place during sintering. However, one can see a decrease of the rupture modulus values for the compositions C3, C4, C5 and C6. This suggests that, for these compositions, the mullite phase is diminishing in equilibrium with the increase of the vitreous phase present, as a probable consequence of the reaction forming between the quartz with the bottom ash[3]. All the compositions that have incorporated bottom ashes presented better values for this property, when compared with the standard mixture.

4. CONCLUSIONS

Mineral coal bottom ashes present properties that allow their application in the production of ceramic flooring. The effect of the incorporation of this residue on the mechanic properties of the studied ceramic floor tiles can be explained as a function of the crystalline phases present. The material with the C2 composition, i. e., containing 15% bottom ashes presented the best results for this property. With regard to water absorption and bulk density, it can be observed that the addition of up to 15% of this residue originates no significant variations, when compared with a standard material.

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