Study of the Incorporation of Residue of Ornamental Rocks in Ceramic Tiles

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Abstract The incorporation of industrial waste into ceramic tiles is a major trend in the search for alternative raw materials, and also in the search for environmentally correct disposal of waste. In order to evaluate the effect of the incorporation of residues from the ornamental stone industries, in the properties of ceramic tiles, incorporations of up to 40% by weight of the residue in ceramic mass were studied. It is noteworthy that this residue is constituted basically by limestone and its characterization was performed by grain size analysis, Atterberg boundaries, grain density and chemical analysis by X-ray fluorescence. The specimens were burned at 800 °C and the following properties were evaluated: linear retraction, water absorption and bending rupture stress. The results indicated that the residue of ornamental rocks is a material with potential to be used as a component in the mass of red ceramic tiles.

Keywords Ceramic tiles · Ornamental stone waste and red ceramic

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Introduction

The large clay reserve of the municipality of Campos dos Goytacazes motivated the advance of the red ceramics market in the region. However, even though it is a sector of great reach, the technological advances of the sector are still stationed and consequently the processes used since the beginning of the activities continue being used in great part of the ceramics.

It can also be verified a predominance of the exclusive manufacture of ceramic blocks, being the manufacture of tiles restricted to some ceramics of the region. The lower availability of tiles is justified by the inferior quality of the region [1], which provide ceramic pieces with a not so high quality and therefore, due to the high quality requirements of the tiles [2], these clays are not indicated for manufacture thereof.

In order to improve the quality of the ceramic pieces manufactured, in order to be able to produce tiles with the clay of the region, the incorporation of non-conventional materials becomes an alternative. Among the available materials in the region is the ornamental rock residue from Cachoeiro de Itapemirim, Espirito Santo.

The municipality of Cachoeiro de Itapemirim in the state of Espirito Santo, has one of the largest poles of ornamental stone production in Brazil and stands out by the beneficiation. The beneficiation is carried out by the cutting and polishing of the rock, however, these processes generate a residue of great potential pollutant and with great environmental impact, as Fig. 1.

In order to improve the properties of the ceramic pieces produced in the city of Campos dos Goytacazes, in addition to providing a suitable destination for the ornamental rock industry residue, this work aims to evaluate the properties of the ceramic pieces with substitution of clay by the residue in the incorporations of 0, 10, 20, 30 and 40%. With the addition of the residue it is expected that suitable properties for the production of ceramic tiles are obtained.

Fig. 1 The residue cutting rock ready for use

Materials and Methods

The materials to be used in the work are clay and the ornamental rock residue.

The clay used in the work was collected in one of the ceramics where tiles are already made with the clay in question. To characterize the clay, the granulometry, chemical analysis, Atterberg limits and actual grain density tests were performed.

The ornamental rock residue used in the work was collected in one of the industries responsible for the ornamental rock processing and where the residue is generated. The residue is composed of a slurry of high humidity, therefore, for use of the material at work, the material was dried at room temperature exposed to the sun and subsequently in an oven. To characterize the residue, the granulometry, chemical analysis and actual grain density tests were performed.

After the characterization of the materials was carried out, the ceramic specimens were prepared with 10, 20, 30 and 40% in addition to the reference with 0% substitution of the clay for the residue. The specimens were prepared by extrusion. Burning of the specimens was done in an oven at 800 °C.

Ceramic specimens were analyzed by linear variation, water absorption and flexural strength tests as recommended by NBR15310 [3].

Results and Discussion

The granulometric distribution has similarities between the materials, the sum of the silt + clay fraction for the soil used corresponds to 93.7%, whereas for the residue it corresponds to 98%. However, the residue presents bigger grain size since its main composition is of silt whereas the one of the soil is of clay (Table 1).

Table 2 indicates the results obtained in the chemical analysis of the clay and the residue. There can be great disparity between the materials in relation to the chemical elements.

Table 3 shows the results obtained by the Atterberg limits for clay and the actual density of the grains for the clay and the residue.

After the characterization of the materials and preparation of the test specimens, the tests were carried out on them. Figure 1 shows the results obtained for linear variation. It can be observed that the increase of the incorporation causes the decrease of the linear variation, however, the 40% content presented values significantly higher compared to the reference with 0% of incorporation (Fig. 2).

Table 1 Granulometric distribution

Samples	Boulder			Sand			Silte	Clay
	Thick	Medium	Fine	Thick	Medium	Fine		
Clay	–	–	–	0.5	0.8	5.0	35.1	58.6
Residue	–	–	–	–	1.1	0.9	58.9	39.1

Table 2 Chemical characterization

	SiO_2	Al_2O_3	Fe_2O_3	CaO	K_2O	MgO	TiO_2	SO_3	Na_2O	Others
Clay	60.02	11.94	8.65	3.57	2.26	5.12	0.89	0.27	3.14	4.14
Residue	7.21	9.23	0.75	80.26	–	1.08	0.33	0.97	–	0.17

Table 3 Atterberg boundaries and actual grain density

	CLAY	RESIDUE
LL	72.6	–
LP	28.7	–
IP	43.9	–
Yg	2.62	2.09
USCS	CH	SC

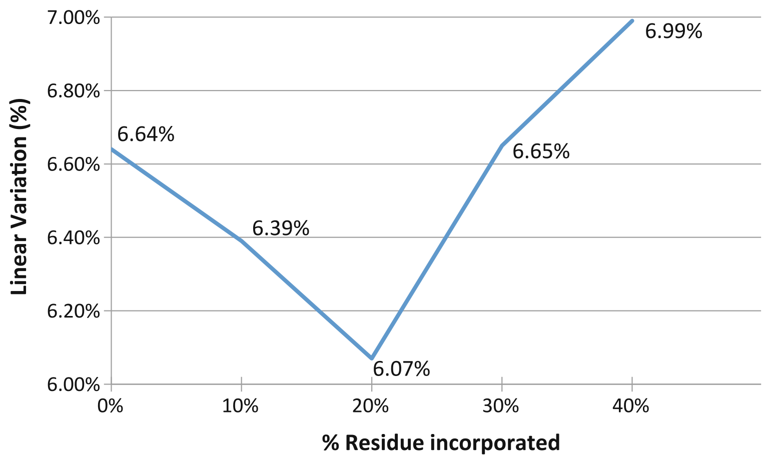

Fig. 2 Linear variation

The substitution of clay by residue also showed a decrease in water absorption, as well as in linear variation, the substitution of 20% of the clay by residue obtained the best results, besides, the incorporation of 40% also presented water absorption results expressively higher to reference (Fig. 3).

The flexural strength test also indicates the behavior of the other tests, where the incorporation of 20% obtained the highest strength and the incorporation of 40% resistance lower than the reference (Fig. 4).

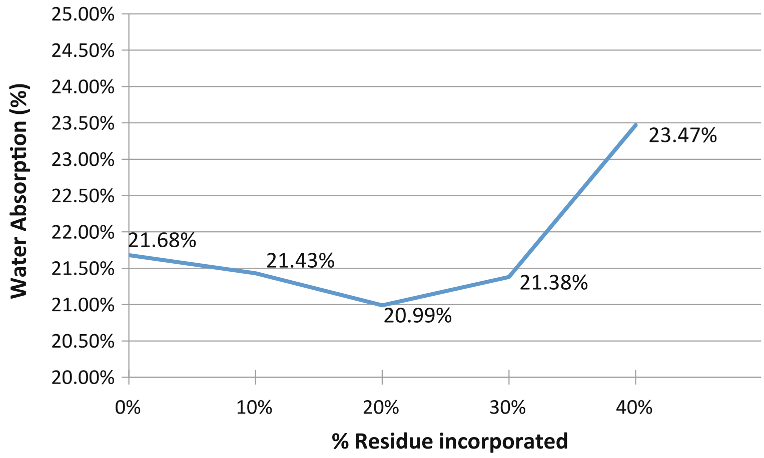

Fig. 3 Water absorption

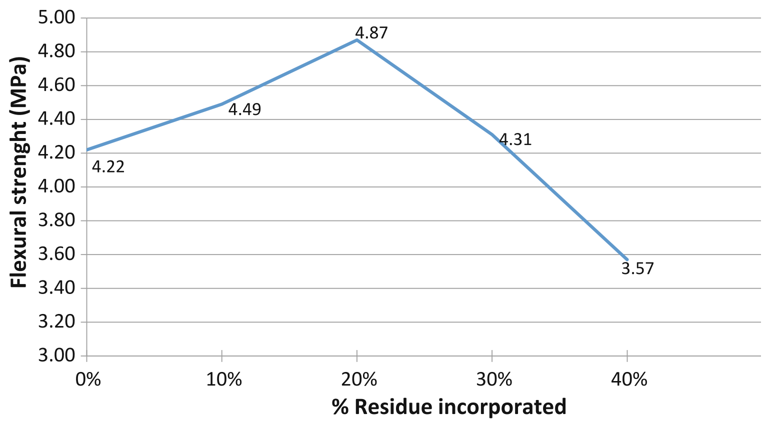

Fig. 4 Flexural strength

Conclusion

The use of ornamental rock residue in the production of ceramics is feasible, however, the amount of residue should be limited by up to 30% so that the properties of the tiles are not precarious.

Among the incorporations tested for use, the incorporation of 20% of residue presented the best results and is the most indicated to potentiate the properties of the tiles, however, all the results obtained by the water absorption test were higher than the NBR 15270-1 [4] requires, where the maximum value that a tile can have of water absorption is 20%.

It can thus be concluded that even with the improvement of tile properties due to incorporation of the residue, an increase is still necessary in order to further reduce the water absorption of the tiles so that they can be made in the standards required by the standard.

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