# GRANITE WASTE INCORPORATION IN EXTRUDED FLOOR TILE

**C. M. F. Vieira [1], T. M. Soares [1], C. C. Peiter [2], R. Sánchez [1] and S. N. Monteiro [1]**

[1] State University of North Fluminense - UENF / Advanced Materials Laboratory -LAMAV. Av. Alberto Lamego, 2000, Campos dos Goytacazes, RJ, 28013-600, Brazil. vieira@uenf.br
[2] Mineral Technology Center- CETEM. Av. Ipê, 900. Ilha da Cidade Universitária. Rio de Janeiro-RJ, Brazil.

## 1. INTRODUCTION

In the county of Campos dos Goytacazes, located in the northern region of the State of Rio de Janeiro, in the southeast of Brazil, there is an area of approximately 900 $km^2$ with an abundance of alluvial clays formed by quaternary sediments carried by the Paraíba River. This has led to the development of a red ceramic sector, which started 40 years ago. Today, the red ceramic sector consists of more than 100 industries of different sizes, with a production, mainly bricks, estimated at 135 million pieces/month. There is also a low production of extruded floor tiles, estimated at 20.000 pieces/month.

A preliminary analysis regarding these floor tiles has shown an excessive porosity, which results in high water absorption and low mechanical strength[1, 2, 3]. Due to the kaolinitic predominance of the clays used in the ceramic body composition, the firing behaviour of the floor tile body is typically refractory. To decrease the porosity of the products, it is necessary to reformulate the ceramic body by increasing the amount of fluxes. Granite is one option as a flux material due to the high content of alkaline oxides. In the county of Santo Antônio de Pádua, about 150 km from Campos dos Goytacazes, there is a great production of ornamental rocks that generates approximately 700 ton/month of granite waste from sawing operations. The present work was undertaken to evaluate the effect of the addition of this granite to a typical extruded floor tile body from Campos dos Goytacazes.

## 2. MATERIALS AND METHODS

Initially the raw materials were characterized in terms of X-ray diffraction (XRD), chemical composition and particle size distribution. After that, 10, 20 and 30% granite waste additions were incorporated into the clay body. Plasticity tests were then carried out on these bodies by determining the Atterberg limits. Specimens were fabricated by extrusion and then fired at temperatures varying from 900 to 1150°C. These specimens were tested for water absorption, linear shrinkage and three-point bending strength.

## 3. RESULTS AND DISCUSSION

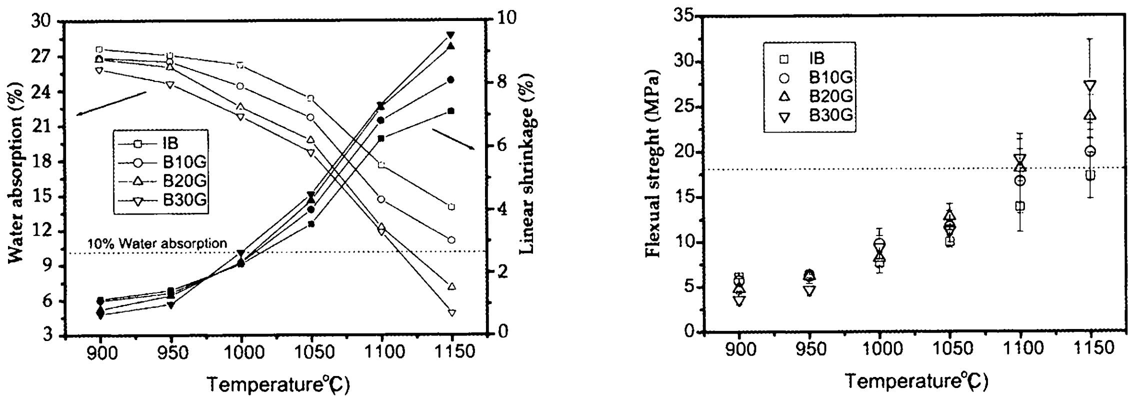
The XRD patterns of the raw materials indicate that the clay is predominantly kaolinitic with the presence of quartz, micaceous mineral and gibbsite. The presence of micaceous mineral, amphibole, quartz, plagioclase (calcium-sodium feldspars) and potash feldspar was observed in the granite waste. Micaceous mineral and feldspars are sources of alkaline oxides, such as $K_2O$ and $Na_2O$, which act as fluxes to improve the sintering process[4, 5].

The chemical composition of the clay is typical of a kaolinitic-based material with low amounts of alkaline oxides, 2.37%, and relatively a high amount of $Al_2O_3$, 25.94%. The high percentage of ignition loss, 10.90%, indicates an elevated fraction of clay minerals. The chemical composition of the granite waste, in addition to $SiO_2$ and $Al_2O_3$, shows a relatively large amount of alkaline and alkaline earth oxides, 8.11%. This confirms the flux potential of the granite. The significant amount of $Fe_2O_3$ in both raw materials, 9.14% (clay) and 4.40% (granite), is responsible for the reddish colour of the specimen after firing.

According to the particle size distribution of the raw materials, one may note that the percentage of clay minerals, i.e., the fraction with particle size below 2 $\mu$m, is 34.6%. The sand fraction in the clay, i.e., the fraction with particle size above 20 $\mu$m, is 38%. The granite waste, as a non-plastic material, has also a relatively fine particle size with 14% of the particles retained on 325 mesh (44 $\mu$m). This characteristic of the granite waste is of great importance for the red ceramic process by avoiding milling and increasing its reactivity during firing.

The progressive incorporation of granite waste has a very significant effect on the plasticity of the clay. The lower plastic limit is reduced with the granite waste addition. This is advantageous for the drying stage, decreasing time, facilitating the water output and reducing energy costs.

Figure 1 presents the firing technological properties evaluated. Figure 1(a) shows that the granite waste addition increases linear shrinkage and decreases the water absorption with increasing in temperature. However, the range of water absorption stipulated by the standards for floor tile application, < 10%, is only reached at temperatures higher than 1100°C for the compositions with 20% and 30% granite waste addition, B20G and B30G, respectively. Figure 1(b) indicates that the flexural strength does not present any important changes with the granite waste addition up to 1050°C. At higher temperatures, the flexural strength increases markedly and exceeds the minimum of 18 MPa required by the standard. This is a consequence of the fluxing action of the alkaline oxides, which makes the vitrification process more effective, closing and reducing the porosity of the bodies.




(a) (b)

*Figure 1. Propreties of the ceramic bodies. (a) Vitrification diagram; (b) Flexual strenght.*

## 4. CONCLUSION

The results indicate that the granite waste has a considerable fluxing potential due to its high alkaline oxide content and fine granulometry. In the pre-firing stages the granite waste improved the workability of the ceramic body, facilitating the drying stage. However, the values obtained for the technological fired properties indicate that the fluxing action is only effective at high temperatures.

## 5. ACKNOWLEDGEMENT

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