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USE OF GRANITE POWDER IN DEVELOPMENT OF PARTICULATE POLYMER COMPOSITES – MECHANICAL PROPERTIES

Erick Ramon Medeiros do Nascimento
Fernanda Beatriz Aires de Freitas
Universidade Federal Rural do Semi-Árido, Campus Caraúbas, Caraúbas, Brasil
erickiramon@gmail.com
beatrizfernnanda@outlook.com

Evans Paiva da Costa Ferreira
Universidade Federal do Rio Grande do Norte, Natal, Brasil.
evans@ct.ufrn.br

Daniel Freitas Freire Martins
Ana Claudia de Melo Caldas Batista
Universidade Federal Rural do Semi-Árido, Campus Caraúbas, Caraúbas, Brasil
dffm@ufersa.edu.br
ana.batista@ufersa.edu.br

Abstract. *For some time, one of the biggest concerns that the modern world is facing is to improve its relationship with the environment. Among these issues the improper destination of solid residue is highlighted, in the west region of Rio Grande do Norte, one of the most common environmental problems regarding solid residue, it is generated by quarries, where the industrialization of the crude stone produces the powder stone, which is not used in other processes and ends up accumulating in all surrounding area. In this scenario, this work aims to analyze the environmental effects generated by powder stone accumulation and develop a new material which makes use of those tailings. The purpose of this work is to develop two polymeric composites, using as reinforcement the mineral load (Granite, obtained by the quarry waste), in one the materials was used the percentage of 10% and in the other material was used the percentage of 30% of the stone powder. For both materials the polyester matrix was used. The mechanical characterization is performed by a uniaxial tensile test according to ASTM D638. To study the influence that the mineral load has on the polymer resin, purely polymeric specimens were also made. With the research it can be concluded that as the percentage of stone powder (Granite) increases, stiffness improves and tensile strength decreases, an increase of 55.75% and a decrease of 29.40%, of the 30% of the granite composite specimens in relation to the pure resin specimens, respectively.*

Keywords: *Environment, residue, particulate polymer composites, granite, mechanical properties.*

1. INTRODUCTION

Nowadays, one the biggest concerns that modern society confronts is its relation with the environment (Da Costa, 2011). Over the years, many natural resources have been explored inappropriately, and as consequence of these problems related to human actions of degradation have begun to appear. Most of these actions are related to the improper disposal of industrial residue.

Many works in the area use solid residue in polymer matrix composites, for example, seeking a use for it. Santos (2005) studied the addition of industrial waste polyester and EVA with mineral sand loads and diatomite in polyester matrix, and obtained an increase in the modulus of elasticity relative to the pure resin and an improvement in the impact resistance. Almeida and Pontes (2002) utilized the fine waste of marble and granite generated at the sawmills in the region of Cachoeiro de Itapemirim - ES, and concluded that the environmental impact was reduced through the implementation of technological processes for the use of tailings in the ceramics and precast industry. Carvalho *et al* (2002) studied the use of fine residue from sawmills of San Antonio region of Padua (RJ) and concluded that the environmental impacts were reduced due to the use of waste in the mortar composition. Whereas (Filho, 2015) produced a polymer composite formed of orthophthalic resin reinforced with treated silica particles, and concluded that the tensile strength will vary according to the size of the silica grain, when the grain is smaller it presents a higher resistance.

In the west region of Rio Grande do Norte, one of the most common environmental problems with regard to residue is the solid residue generated by quarries (Da Luz, 2008 and De Sousa, 2007), where the industrialization of the crude stone produces the stone powder, which is not used in other processes and ends up accumulating in all surrounding area. New alternatives come to remedy this problem. One of them would be the use of stone powder in some process.

Considering this scenario, this work proposes the use of this residue in polymer composites reinforced by particles, in which the mineral load (granite powder tailings, panorama de rochas ornamentais na Bahia (1994)) act as reinforcement and the polyester resin as matrix. The particulate polymer composites were studied in two percentages (10% and 30%), were also made purely polymeric specimens to quantify the influence that the percentage of the granite stone powder has on the resin. The mechanical characterization was performed using the uniaxial tensile test, according to (ASTM D 638, 2014).

2. EXPERIMENTAL PROCEDURE

In order to analyze the properties of the polymeric composite reinforced with stone powder particles (granite) some materials and processes were used. Initially, an X-ray fluorescence spectroscopy was performed on Granite powder to determine its composition and influence on the final product. After this, the granite powder obtained from the quarry of the city of Caraúbas-RN was defined as reinforcement, and as a matrix the Orthophthalic resin 5061, due to its desirable work characteristics and its low cost.

It was made also the process of granulometry in the material studied for the project. The granite powder analyzed was selected in sieve #100 and #200, according to the Fig. 1.

Figure 1. Process of sifting of the granite powder.

For confection of the composite was used a mold of glass plaques to give form and thickness to final material (Fig. 2). The dimensions and amounts of the plaques were:

- 02 plaques of 40 cm X 02 cm, with 03 mm of thickness;
- 01 plaques of 38 cm X 02 cm, with 03 mm of thickness;
- 01 plaques of 40 cm X 40 cm, with 08 mm of thickness;
- 01 plaques of 35 cm X 40 cm, with 08 mm of thickness.

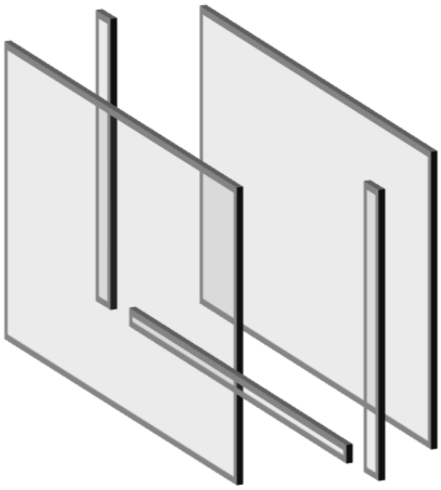


Figure 2. Illustration of the glass plaques used as mold.

Together with the plaques, was used clips of steel kind “C” to fix the mixture within of the plaques. Also was used release agent (applied in the superficies), manometer (2%), catalyst (0.5%) and a vacuum pump for retired of bubbles and impurities.

The first step for the confection of the material was the preparation of the mold. Initially applied the release agent in the superficie of the glass plaque, of form to isolate the material. Then, the plates were trapped with the steel C clamp, with an empty space of 03 mm between both, thickness of the material studied. After the completion of the plates, the material cured for about 24 hours.

The first material produced, for comparison, was pure polymer. For manufacturing was weighed, mixed and dumped in a pot 360g of orthophthalic resin together with 2% monomer. After, the mixture was brought to the vacuum pump for withdrawal of bubbles for 10 minutes and after was added 0.5% of catalyst. The material was mixed manually and the mixture was brought back to the vacuum pump. After this time, the material was poured into the mold, where it remained for 24 hours for the curing process and posteriorly was demolded (Fig. 3).

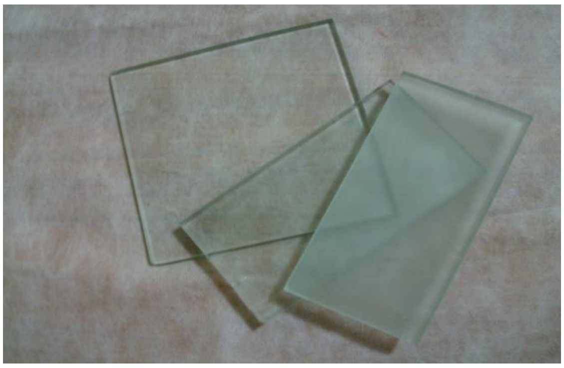


Figure 3. Desmouded plaque of pure orthophthalic resin.

With respect to the composite that uses the Granite as reinforcement, it was made from the orthophthalic polyester resin, weighing 360g of it. After this, 2% of monomer was added into the mixture and carried it to the vacuum pump for 10 minutes. Then, 0.5% catalyst was added for curing, returning to the vacuum pump. Finally, with the resin duly mixed, the granite powder was added in proportions, one with 10% of granite (G_10) and other with 30% of granite (G_30), completing the formation of the compound. The mixture was last taken to the vacuum pump for 10 minutes and poured into the mold.

After the entire manufacturing, curing and demoulding process, the specimens were cut (by laser) with dimensions following ASTM D638 (Fig. 4). With the specimens of the granite cut, the uniaxial tensile test was performed in order to know the properties of the proposed materials. The tests were also performed based on ASTM D638 (Standard Test Method for Tensile Properties of Plastics).

(a) (b) (c)

Figure 4. Specimens: (a) pure resin, (b) granite 10% (G_10) and (c) granite 30% (G_30).

3. RESULTS AND DISCUSSION

Initially, accomplished quantitative analyzes in the granite powder, to get the material composition. In next, accomplished the tests of uniaxial traction and with the results plotted the graphic stress x strain of each specimens, as well as the modulus of elasticity (calculated for 30% of the tensile strength).

First, quantitative analyzes were performed on the granite powder to obtain its composition, the results obtained by the X-ray fluorescence spectroscopy test are shown in Tab. 1.

Table 1. X-ray fluorescence spectroscopy test – Granite.

Constituents	Composition
SiO_2	54.337%
Fe_2O_3	16.713%
Al_2O_3	13.524%
K_2O	6.559%
CaO	4.047%
ZrO_2	2.964%
TiO_2	0.995%
MgO	0.646%
MnO	0.215%

After the granite characterization, the uniaxial tensile tests were performed in the specimens with the pure polymer and in the specimens with the proposed composites. With the results obtained, by the test, it was possible to plot the stress x strain graph (Fig. 5, 6 and 7) of each specimen, as well as its elastic modulus (Calculated for 30% of tensile strength). The Tab. 2, 3 and 4 are possible to observe the mechanical properties obtained by the uniaxial tensile test.

Table 2. Mechanical properties - The resin of ortho-terephthalic 5061.

Mechanical properties	Average	Standard deviation
Tensile Strength (MPa)	33.90	±5.23
Strain (mm/mm)	0.05	±0.01
Elastic Modulus (GPa)	1.13	±0.04

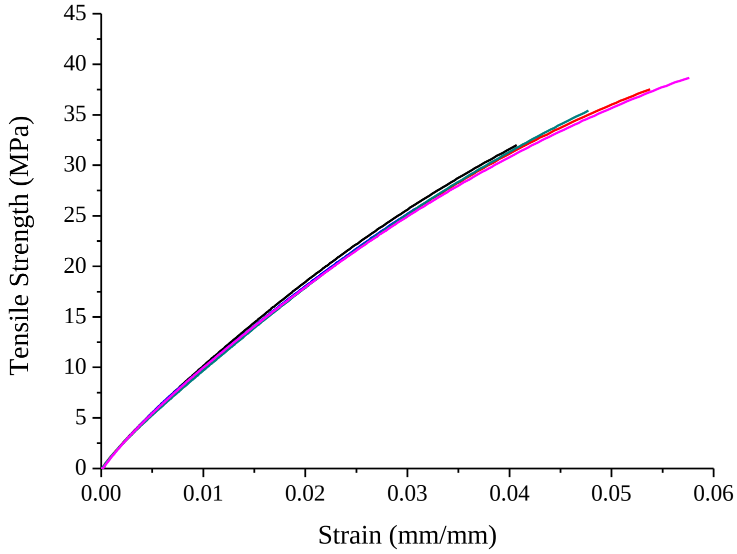


Figure 5. Stress x Strain graphic - pure resin.

Table 3. Mechanical properties - 10% granite.

Mechanical properties	Average	Standard deviation
Tensile Strength (MPa)	29.84	±1.51
Strain (mm/mm)	0.03	$\pm 2.23 \times 10^{-3}$
Elastic Modulus (GPa)	1.33	±0.06

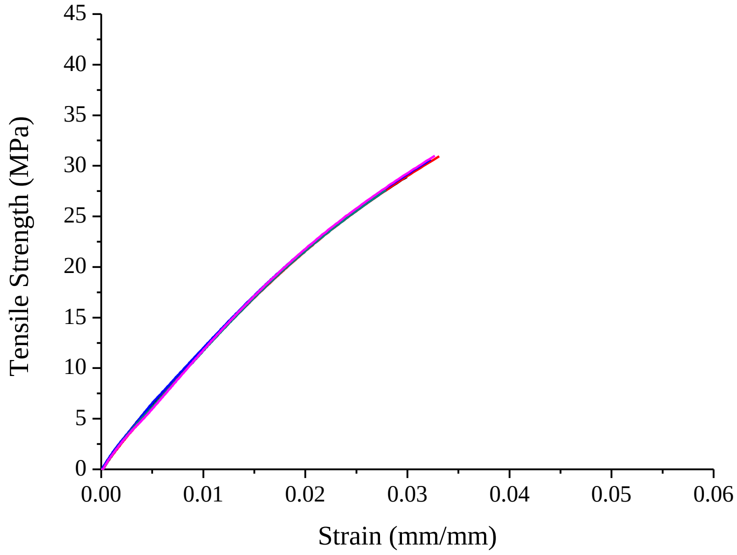


Figure 6. Stress x Strain graphic - 10% of granite.

Table 4. Mechanical Properties - 30% granite.

Mechanical properties	Average	Standard deviation
Tensile Strength (MPa)	23.92	±0.93
Strain (mm/mm)	0.03	$\pm 3.38 \times 10^{-3}$
Elastic Modulus (GPa)	1.76	±0.14

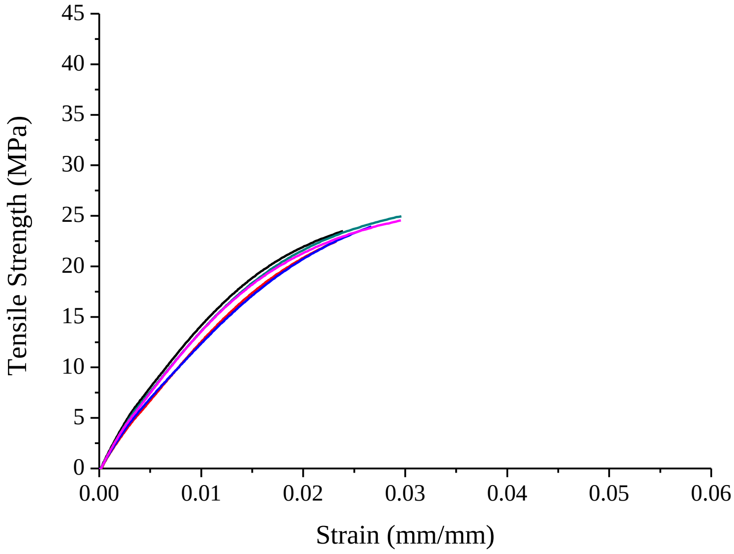


Figure 7. Stress x Strain graphic - 30% of granite.

By the tensile tests were possible to see that the tensile strength of the 10% Granite plate presented small variation in comparison with the pure resin, showing that the bubbles/imperfections present in the test specimens were minimized. It was also observed that the elastic modulus was significantly higher in the compound with 30% of Granite. The 30% Granite specimen showed linearity loser in the end of curve, not shown by the other materials tested.

Regarding the influence of the percentage on the composition of each material, it was possible to notice that as the percentage of stone powder was decreased the resistance (loss of 29.4%) and stiffness was improved (increase of 55.75%) of the specimen with 30% of granite relative to the pure resin specimen, respectively. With respect to the strain of particulate polymer, composites that presents a percentage of 10% of granite (G_10) to the polymer which presents a percentage of 30% (G_30) granite did not occur any significant change.

3.1 Influence of the granite percentage

Comparing the influence of the percentage of stone powder in the composition of the materials, in the fractions of 10% and 30% of granite, we have the Fig. 8 that shows the graphic of the average curves of the pure resin, for this analyze, being able thus accomplish a comparative of the mechanical behavior of these materials.

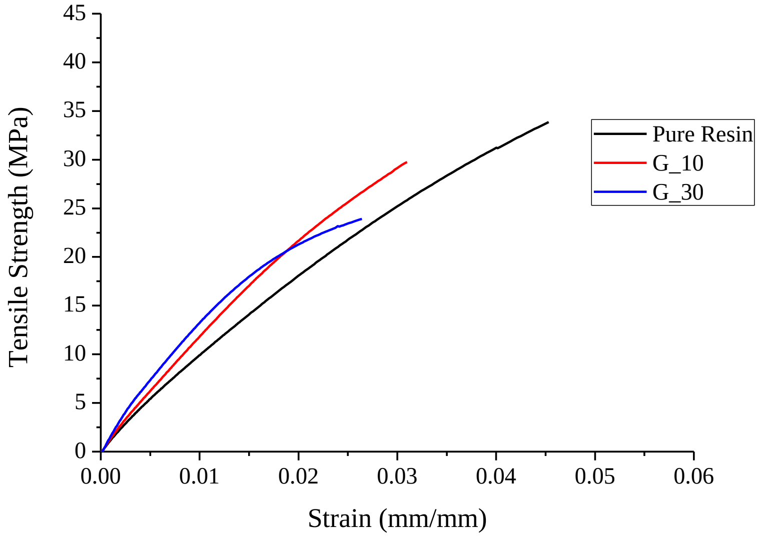
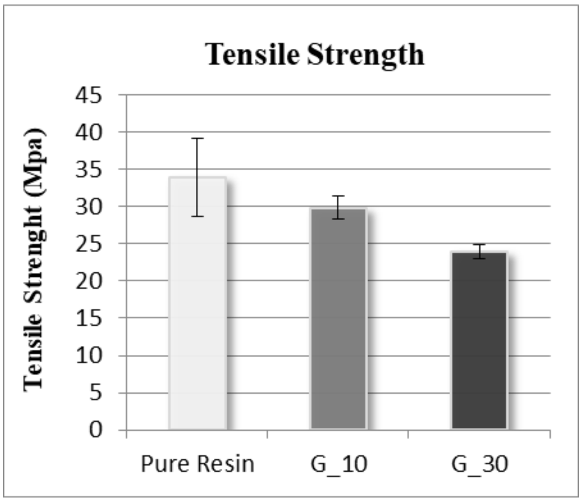
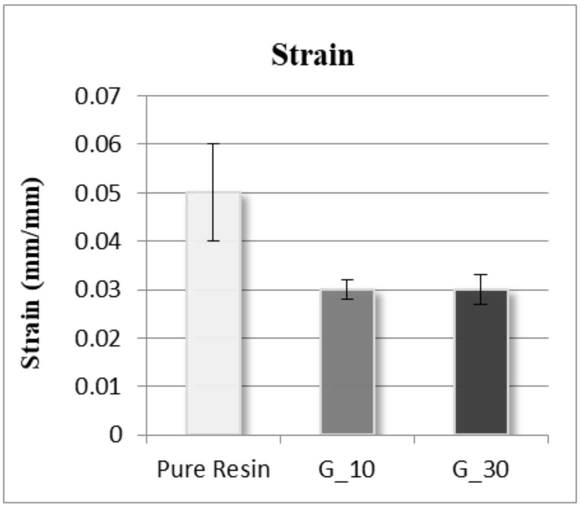


Figure 8. Graphic stress x strain: Pure Resin, G_10 and G_30.

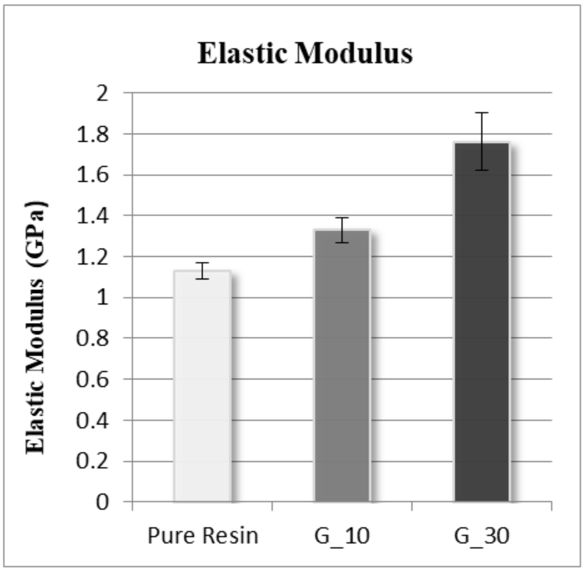
For another edition, Fig. 9 shows the comparative average values of the three materials, for each property separately, in the form of a bar graph.



(a)



(b)



(c)

4. CONCLUSIONS

From the analyzes and tests performed on the composites throughout the work, it was possible to conclude that with the addition of mineral load in polymers significant changes occur in the mechanical behavior of the material, as the inserting of the stone powder (granite), which causes a reduction in the standard deviation and the number of voids. It was also concluded that the specimens with 30% of granite showed an increase in the modulus, with the increase of 55.75% in stiffness, when compared to the pure resin specimens.

From the studies carried out during the research, it was possible to conclude that the stone powder residue accumulated in quarries can be reused in the manufacture of new materials, reducing the amount of residues and thereby avoiding damages to the environment.

5. ACKNOWLEDGEMENTS

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