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REUSE OF WASTE INDUSTRY BUTTONHOLE FOR MANUFACTURE OF GLASS AND JUTE FIBER COMPOSITE MATERIALS: STATIC AND DYNAMIC CHARACTERIZATION

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Abstract. *With the advancement of technology and the search for materials that contribute to sustainable development, the manufacture of new materials, especially composites, using industrial waste has grown considerably. In this way, this paper intends to analyze the mechanical properties of resistance of a new sandwich composite material in a hybrid configuration of epoxy matrix and the feasibility of the filling in industrial and engineering applications. Considering the use of renewable and less environmentally friendly materials, natural jute fibers in the form of fabric (0° / 90°) were used together with fiberglass blanket as a reinforcement for making the plates in this configuration in which the filling is coming from the button industry. Natural fibers excel at synthetic fibers due to their biodegradability, low density, good toughness, good thermal properties, and low cost, but their mechanical performance is still considerably lower. The test specimens were made using the manual method (Hand Lay Up) and were subjected to three-point uniaxial tensile and flexural tensile tests to study the mechanical properties according to ASTM D3039 / D3039M (2014) and ASTM D790 (2015). The results indicate that the construction of a new sandwich composite material using waste from the button industry presents characteristics that allow its application in various branches of industry and engineering.*

Keywords: *Sandwich composite. Mechanical properties. Industrial waste. Jute. Fiberglass.*

1. INTRODUCION

The growing search for new alternative materials replacing the traditional ones (metal, wood, ceramic, others) has been developing in the last years due to the technological advance, the demands of the market and, mainly, the relevant concern with the preservation of the environment environment. Composite materials, ie those that combine two or more materials with better properties than their separate structures, have gradually become more important in many industrial applications (Herakovich, 1997). The structural application of these materials showed a considerable growth due to the improvement in the manufacturing processes involved and the design of new reinforcement configurations and laminar structures (Oliveira, 2007)

In Brazil, due to the fact that the country has its economy based on agriculture, the raw material obtained from renewable sources, such as sugarcane, pineapple, sisal, curauá, jute (hard and long fibers) , may be an alternative for use in composite materials and are widely available in our territory (Pires, 2009).

The main applications of these composites are found in the construction industry (Carneiro and Teixeira, 2009), furniture industries (Silva, 2008), aeronautics industry (Batista, 2015) and, mainly, in the automobile industry (Campos, 2009) in general, used as functional material or for light and medium loads (Suddell et al., 2002; Dahlke et al., 1998).

The manufacturing, use and disposal of traditional composites, commonly made from glass, aramid or carbon fibers, has been criticized for environmental problems (Ellison and McNaught, 2000). It is important to note that the use of composite fibers is an important alternative to the biodegradability of these fibers, which favors the decomposition of the composites to which they are associated and the fact that they are not pollutant residues, which are considered advantageous for some applications (Nothenberg, 1996).

In general, vegetable fibers compared to synthetic fibers have low mechanical performance (Gowda et al, 1999). In this way, the hybrid composites that result from the combination of two or more types of fibers used as reinforcements in one or more types of matrices were idealized in order to meet certain properties that a single type of fiber or matrix would not achieve (Barros, 2006).

The present article focuses on the development of a hybrid composite material in which the configuration chosen for this composite is in principle based on the use of jute fiber fabrics in conjunction with glass fiber in a sandwich composite structure. It was also used waste from the industry of buttons for the filling of the composite as an alternative of reuse of this material, thinking about a solution for the destination of this residue, avoiding its disposal to the environment and with the purpose of analyzing its viability of use.

2. MATERIALS AND METHODS

The experimental procedure was initiated by the preparation of a sandwich composite hybrid composite board using an epoxy resin matrix. Two-way fabric of jute fiber and glass fiber blankets were used as reinforcing materials that can be seen in Figure 1 (a) and (b). In the filling layer, button-making residue (Figure 1 (c)) was used, through which an increase in the rigidity of the composite structure was expected.

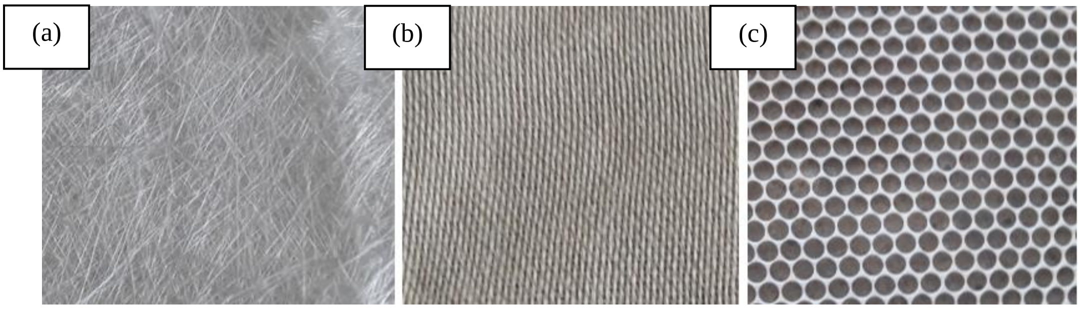

Figure 1. (a) Glass fiber blanket; (b) Two-way jute fiber fabric; (c) Residue from the manufacture of buttons

The button residue used in the research is derived from the machining and finishing process of the Bonor factory (Industria do Botões do Nordeste S.A.), located in the municipality of Parnamirim / RN. The alternative for the disposal of the waste from this industry considered in this research was to reuse it as a filling for the manufacture of polymeric composite material and to analyze its viability for industrial applications.

The chosen sequence of the layers for composing was presented as follows, as shown in Figure 2.

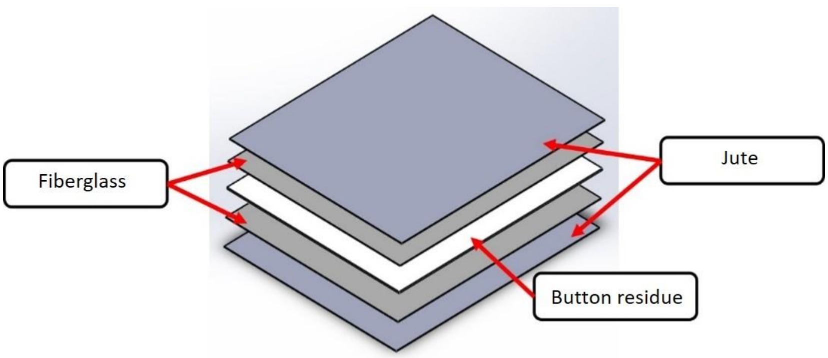

Figure 2. Schematic representation of the hybrid sandwich composite

1. Jute fiber fabric;
2. Fiberglass blanket;
3. Button waste;
4. Fiberglass blanket;
5. Jute fiber fabric.

For the development of the composite material, a tempered glass mold of size 59 x 50 x 10 cm was used where the matrix and the reinforcements were applied. For the fabrication of the board, the hand lay-up method was used in an open mold, consisting of a manual lamination, in which the layers of the jute fiber fabric, fiberglass blanket and button residue were arranged while applied the epoxy resin.

Rolls were used in order to aid in the impregnation of the resin in the layers and to prevent the formation of bubbles that could cause failures in the laminar structure of the composite material, causing, consequently, damages in its mechanical properties. To facilitate removal of the composite plate from the mold, a release agent was applied to the walls of the mold. The curing time of the resin lasted for about 24 h. Figure 3 shows the composite construction using the hand lay-up method.

Figure 3. Hand lay-up composite fabrication

The board has acquired dimensions of width, length and thickness such as the dimensions of the mold. The thickness of each layer of material has, on average, the dimensions of Figure 4.

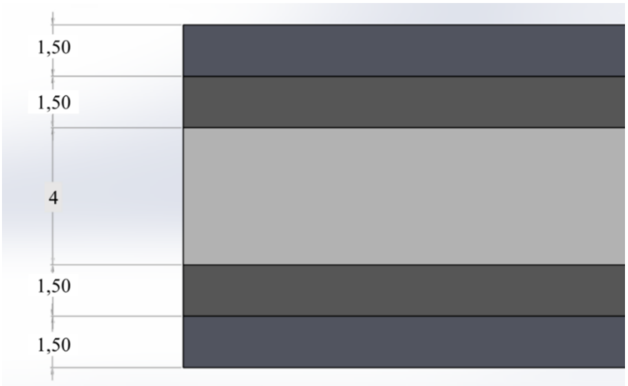

Figure 4. Sketch of the thickness dimensions of the material layers in millimeters

The specimens were sawn using a cutting machine. Its final dimensions and the specifications of the three-point uniaxial tensile and flexural tests were ASTM D3039 (2014) and ASTM D790 (2015), which presented a rectangular shape (Figure 5). The specimens were 250 x 25 x 10 mm. All tests were performed at room temperature (about 25 °C).

Figure 5. Representation of test pieces in rectangular form

The uniaxial tensile test used thirteen specimens and the useful length (gage) used for this test, according to ASTM D3039 (2014), was 160 mm, shown in Figure 6.

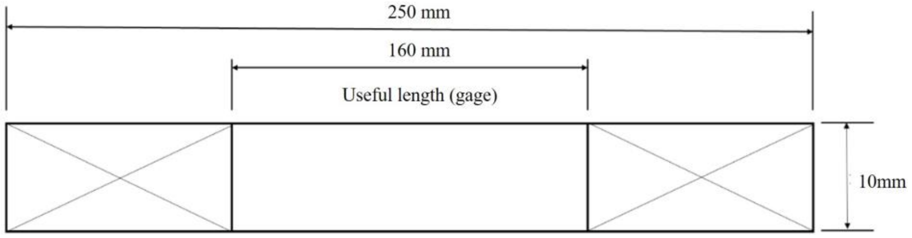

Figure 6. Representation of gage size based on ASTM D3039

The equipment used for the test was the universal machine for mechanical tests of the manufacturer Shimadzu (Figure 7) with a maximum load capacity of 300 kN, the speed used being 1 mm / min.

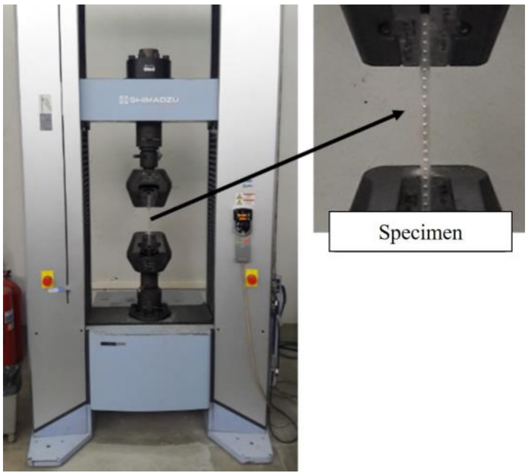

Figure 7. Shimadzu universal mechanical testing machine

This test was used to determine the ultimate tensile strengths, i.e. the maximum tensile strength of the specimen before the fracture, and the cross modulus of elasticity according to the standard specified for the test.

For the three-point flexural test, the specimens were made with the same dimensions as those used in the tensile test (Figure 5), with 13 specimens being used. The greyhound according to the standard was 165 mm, shown in Figure 8. For this test, the machine used was the universal machine for mechanical tests of the manufacturer EMIC (Figure 9) with a maximum load capacity of 100 kN. The speed employed was 2.5 mm / min.

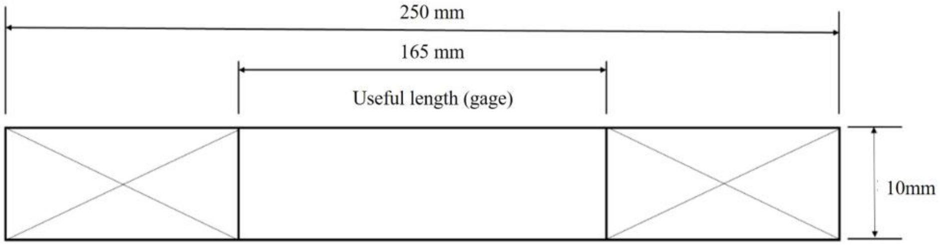

Figure 8. Representation of the size of the gage obtained for the three-point flexural test

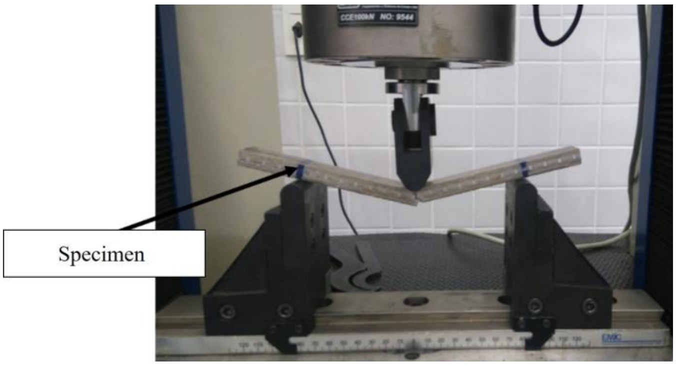

Figure 9. Representation of the three point bending test using the universal machine of the manufacturer EMIC

The purpose of this test was to determine the ultimate flexural strength of the load submitted to the test body caused by the fracture measured on the lower surface, where the tensile stresses in the specimen and the modulus of elasticity act.

3. RESULTS AND DISCUSSIONS

Figure 10 shows the results obtained by the uniaxial tensile test. By means of these results, a linear behavior of the material between the tension and the deformation until its final rupture was observed, showing that the structure using jute fiber fabric, fiberglass blanket and button industry residues as a filling did not change the typical response of the materials submitted to this type of test.

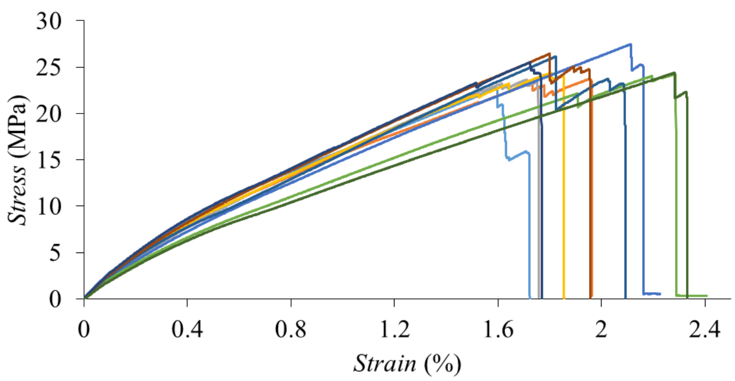

Figure 10. Voltage x Deformation graph obtained by the uniaxial tensile test

The mean values of tensile strength, modulus of elasticity and maximum strain and their dispersion percentages are shown in Table 1. The elastic moduli of each specimen were calculated in a region of the graph that shows few deviations (region linear), avoiding error in obtaining the value. The fracture can be perceived through the noise emitted in the micro cracking in the matrix and by visual inspection.

Table 1. Mean values of the results obtained in the uniaxial tensile test.

Mechanical Properties	Mean Values	Dispersion
Last tension to traction	24,91	5,89
Modulus of elasticity	9,48	10,24
Deflection Break	1,91	12,64

We considered only the test bodies that broke within the useful length (greyhound) that was determined following the norm, as can be seen in Figure 11a, taking as example test piece 4. Figure 11b shows the occurrence of fracture out of length useful, whose results were not considered for the characterization of the mechanical properties. The bodies of evidence that presented this type of fracture were the bodies of 10 and 11.

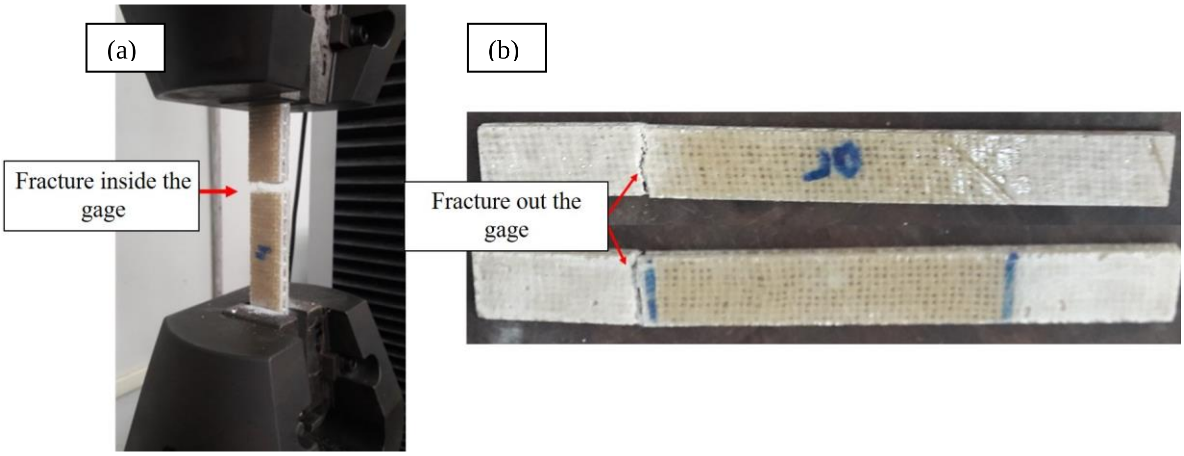

Figure 11. Test specimens (a) fractured within the greyhound; (b) with fracture outside the gage

It can be seen that the configuration using the button industry waste filling (PIT screen) provided an increase in the rigidity of the material. However, it was also realized that this configuration caused a significant reduction in the ultimate tension to the traction.

Figure 12 shows the Voltage x Deformation graph of the test specimens when tested at three-point bending. It was observed that the curves of the results showed a linear behavior at the beginning of the loading application, as well as in the tensile test specimens. As the percentage of deformation increased, the composite lost linearity and the elastic viscoelastic behavior of the resin was highlighted.

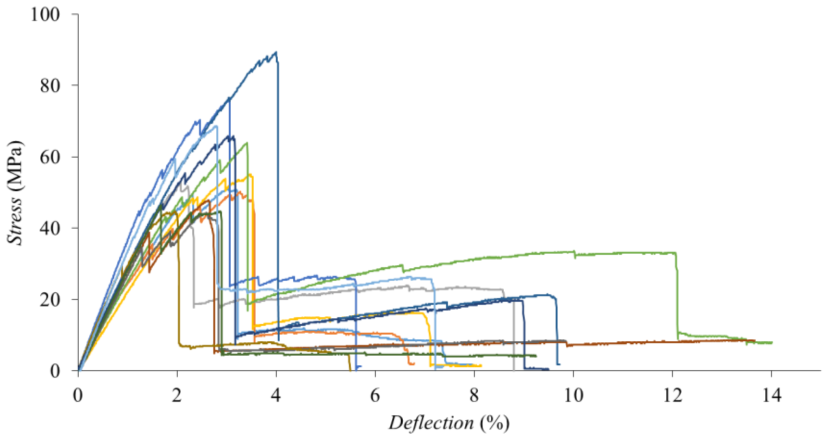

Figure 12. Voltage x Deflection graph obtained by the three-point bending test

The mean values of the bending test results are shown in Table 2.

Table 2. Mean values of the results obtained in the three point bending test.

Mechanical Properties	Mean Values	Dispersion
Last bending stress	58,196	23,56
Modulus of elasticity	11,756	13,74
Maximum Deflection	2,858	23,12

As for the uniaxial tensile test, it was found that the material obtained an increase in stiffness also provided by the presence of the button residue filling. However, the limit of flexural strength obtained a significant reduction caused by the presence of the filling and due to phenomena, such as delamination and early fracture.

The regions of the diagram showing tension variations, as the deformation increases, indicate the presence of delamination and early fracture caused by shearing occurring at the neutral line of the material, which is located at the centerline of the button residue. Figure 13 shows the occurrence of delamination in one of the specimens during the three-point bending test.

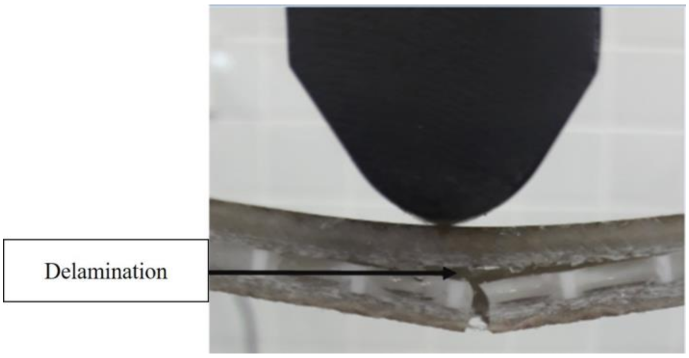

Figure 13. Delamination occurred in the test specimen submitted to the three point Flexion test

4. CONCLUSION

This work aimed to develop a hybrid sandwich composite material that presented viable properties for industrial and engineering applications when compared with conventional materials and other composite materials. The preparation of this material showed satisfactory results, being used in its structure reinforcements of natural and synthetic fibers of easy access in the commerce, as well as the reutilized the residue that would be discarded by the industry of buttons and for the impregnation of the fibers was applied a resin of commercial use.

The destructive tests of uniaxial traction and flexion in three points were carried out to characterize the static properties, bringing to light the properties of a low cost composite material that allows the reuse of industrial waste and which presents itself as a sustainable alternative for applications.

It was possible to observe that this composite sandwich type reinforced with jute fabrics and fiberglass blankets, when filled with waste from the button industry, have excellent properties, mainly in their rigidity, as shown by the results obtained for the static modulus of elasticity.

The mechanical strength of the material presented in the tensile and flexural tests was compromised by the effect of phenomena such as delamination caused by the difference in stiffness between layers and early fracture. However, the expected gain of the rigidity due to the use of the residue filling made the results feasible for applications that require high stiffness and low resistance.

5. ACKNOWLEDGMENTS

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