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DEVELOPMENT AND ANALYSIS OF MECHANICAL PROPERTIES OF A TABOA FIBER COMPOSITE

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Abstract. *The worldwide concern to reduce the environmental impact and find solutions for the depletion of non-renewable natural resources is an incentive for the research and development of sustainable materials. The search for new materials takes into account factors such as need and sustainability. Several studies have been carried out to create cleaner processes with the use of renewable raw materials, generating products that are environmentally friendly without losing quality or performance. Vegetable fibers are inserted in this context as a promising alternative for the manufacture of composite materials. Thus, the objective of this work is to manufacture and study the mechanical properties, by flexural tests, of a composite with polyester resin matrix and reinforcement with random and unidirectional taboa fiber. It should be noted that the composite with unidirectional fibers presented higher resistances when compared to the fibers in random order. The result was satisfactory for several everyday applications.*

Keywords: *taboa fiber, mechanical properties, composite.*

1. INTRODUCTION

With the advancement of new technologies and intensification of environmental issues, it becomes necessary to search for materials that have specific properties. Science is bothering to create cleaner processes using renewable raw materials that do not have serious consequences for the environment but without losing the quality and strength of the material (Machado *et al*. 2010).

The incorporation of natural fiber-reinforced composites in all aspects of industry and life in general has increased and therefore the need for stronger, more renewable and more energy-efficient composites. Cellulose-based fibers have several advantages over other natural fibers, since they do not present the levels of toxicity found in minerals and are easier to handle, collect and store (Cavalcanti *et al.*, 2017).

Thus, several investigations involving the use of biodegradable polymers as substitutes for conventional synthetic polymers have increased in recent years, as well as the use of natural fibers as reinforcement. New composite materials are being developed, combining thermoplastic matrices and reinforcing loads of lignocellulosic origin (Machado *et al*. 2010) and these have low cost, lower density than conventional fibers, besides being renewable, non-abrasive, biodegradable and widely available sources in the territory national (Pires, 2009).

According to Castegnaro and others (2017) bio-composites represent an interesting solution to replace fiberglass in yachts, with the aim of increasing the environmental sustainability of the nautical sector. This replacement is already occurring in several industrial sectors, from the construction sector to the automotive sector. The search for the formation of composites from renewable sources that present good mechanical properties motivates the study of the properties of different materials, such as banana fiber, açaí fiber, guarumã splint, sugarcane bagasse and rice husk (Carvalho, 2015; Coelho and Santana, 2014; Costa *et al*, 2014a; Costa *et al*, 2014b; Paulino, 2018).

According Callister (2010), the matrix phase, in a composite, has the function of keeping the fibers aligned and spaced; transfer external forces to fibers; protect fibers from abrasion and chemical reactions and, due to their plasticity, serve as a barrier to the propagation of cracks. The region between the matrix and the fiber is called the interface where it has a strong influence on the characteristics of the composite, being in the mechanical properties and its structure, it is in this region that the differences in the elastic properties of the matrix and the fiber are interconnected through transfer of active efforts in matrix and fiber.

Taboa (Typha angustifolia L.) is an important macrophyte found in much of Brazil. It has a high potential for growth, causing management problems. In contrast, populations of Taboas can show different growth capacities, colonizing large or reduced areas of environmental water. These growth potentials may be related to anatomical changes in different populations of T. angustifolia (Corrêa *et al*. 2016). The viability of harvesting this plant is restricted to areas soaked and shallow water. Its propagation is facilitated and can even be cultivated.

The plant has a substance called phenol, which in excess can contaminate water. Thus, the use of the taboa as raw material allied to native forest control activities becomes a viable option. One of its most traditional applications is in the making of handicrafts, due to the resistance of its fibers. With it, it manufactures handbags, boxes and even furniture, generating businesses and becoming a source of income for the population (PEGN, 2013).

Also, destructive tests are often used in the industrial area due to the advantages of providing quantitative data of the mechanical characteristics of the materials, which allow to evaluate the feasibility of a more precise study of the possibilities of using the materials analyzed. Because of that, the general objective of this work is to develop and to study a composite material of polymer matrix reinforced with vegetal fibers, specifically polyester resin with taboa fiber and to evaluate its mechanical performance with flexural tests.

2. METHODOLOGY

The taboa was harvested in a dam located in the municipality of Pinheiros, north of Espírito Santo, which presents a tropical climate, Figure 1. After the leaves of the taboa were collected, they were washed and passed through the drying process in the sun for approximately 72 hours.

Figure 1. Plant picking location. Source: Authors.

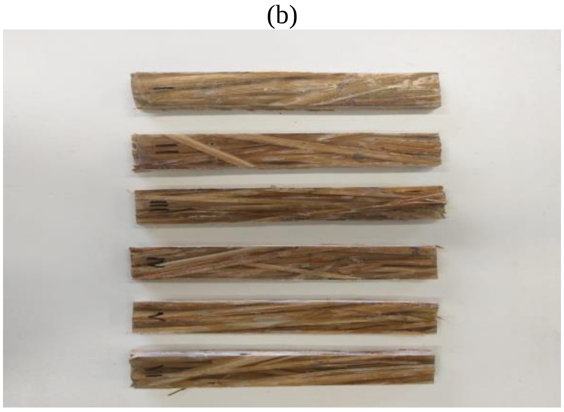
The leaves of the taboa were cut into fibers with a mean thickness of 5 mm, in which for the sample of random order were cut with length of 10 cm and for those aligned in parallel with 40 cm. And the resin used was the polyester used as the matrix of the composite. A peroxide catalyst of MEK (Butanox M50) was added to the resin the ratio of 0.15 g of catalyst to 61.5 g of resin.

However, the manufacturing method of the composite used was that of sandwich panel which consisted in placing layers of taboa fiber manually on the surface of a mold interspersed with polyester resin with the aid of a brush or roller, curing at room temperature. Then, to prepare the samples, the polyester resin and the fibers were placed in a 40 x 40 cm steel mold. The weight ratio of fibers to stipped resin was 1: 6. Thereafter, the mold passed the pressing process so that the fibers adhered to the resin. The total curing process for the samples was five days to be cut ready, as shown in Figure 2 (a). According to Fig. 2 (c), the specimens of the unidirectional fibers were cut so that the direction of force applied by the test machine was orthogonal to the fibers.

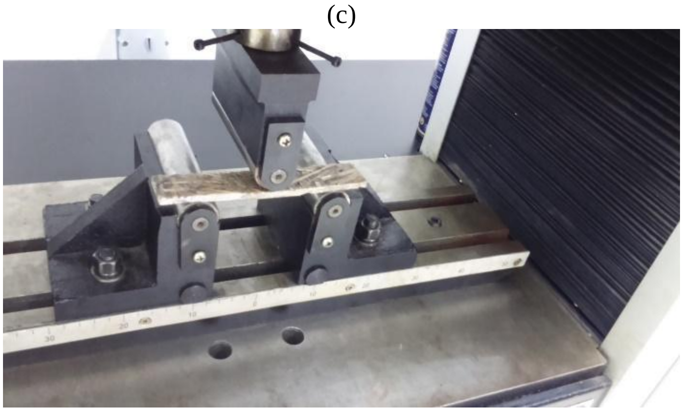
The cut of specimens was performed on a vertical band saw blades and the your dimensions, to the flexural tests, were performed according to ASTM D790. The tests were fully computerized from the Universal Testing Machine model WDW 200-E, Fig. 2 (d). Five test specimens and a displacement velocity of 2 mm / min were used for the assay.

(a)

(b)



(c)



(d)

Figure 2. Stages of work. (a) Post-cure molding samples. (b) Test specimens with fibers in random order. (c) Test specimens with unidirectional fibers. (d) Performing the flexural test. Source: Authors.

3. RESULTS

It should be considered that the preparation of the specimens was handmade, thus generating the appearance of porosities between the fibers and stress concentrator points. Having given rise to such tensions, the bodies of evidence have become more fragile.

At the end of each test, the data concerning the mechanical properties of the test specimen were collected and from this one can analyze its behavior regarding tension and deformation.

From these data, it is possible to estimate the modulus of elasticity of the material, the yield limit (the point where the linear behavior of the curve ends, is the maximum stress that the material still supports in the elastic deformation regime) and the limit maximum shear tension.

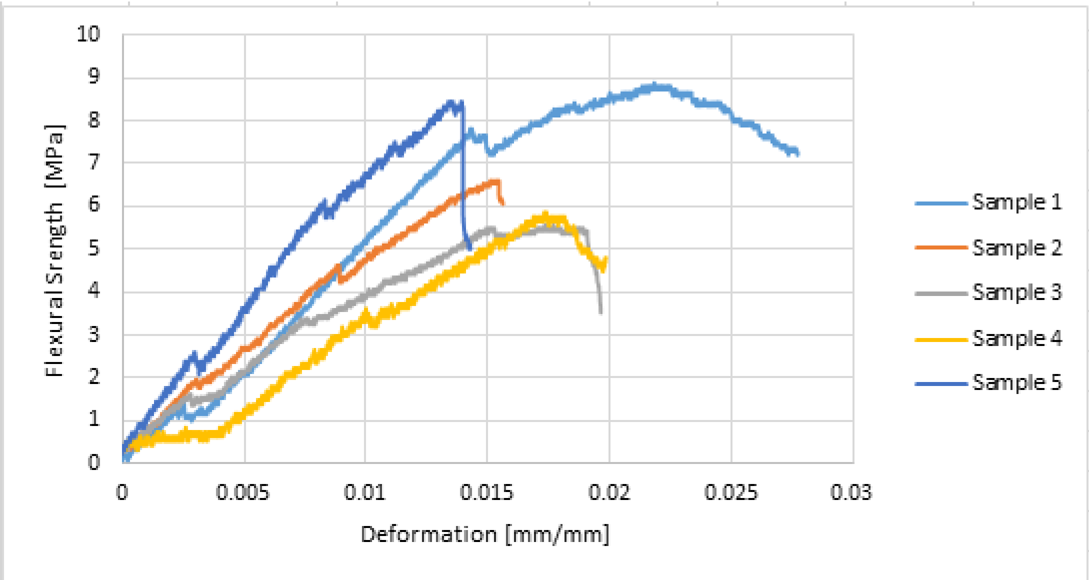
The modulus of elasticity or Young's modulus (E) is measured by the ratio of stress to relative strain within the elastic limit where the strain is fully reversible and proportional to stress and is related to the bond strength between the atoms. The same was calculated by the Tension x Deformation graphs, finding the angular coefficient of the lines by the Equation 1:

$$E = \frac{(\sigma_2 - \sigma_1)}{(\varepsilon_2 - \varepsilon_1)} \tag{1}$$

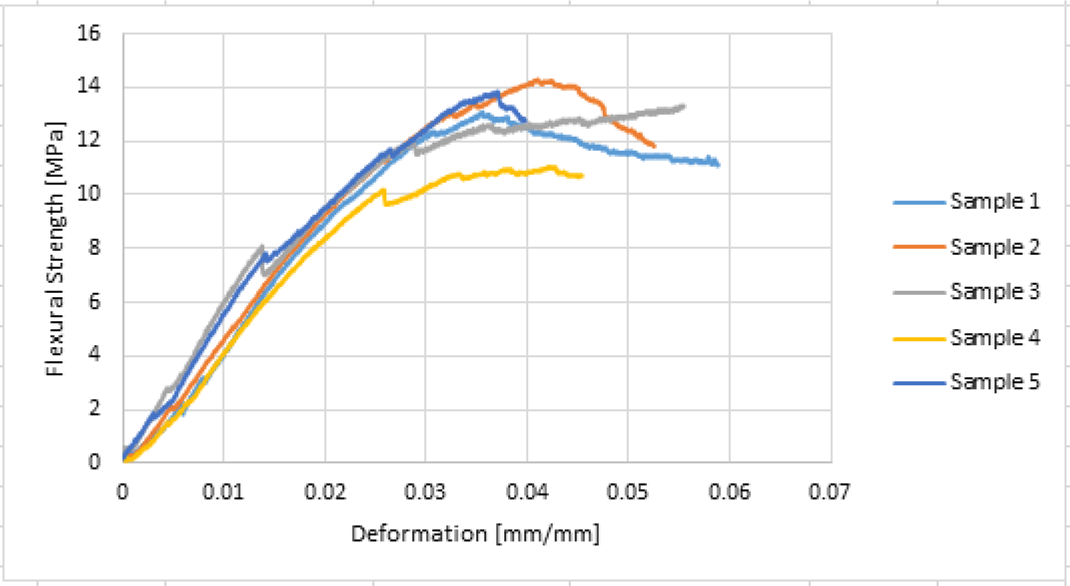
Where σ is the flexural strenght and ε is the deformation. From the graph for each type of composite, Figure 3, we have the values represented in Tab. 1, which show the maximum flexural stress, modulus of elasticity and shear stress associated with the standard deviation.

Table 1. Experimental results for flexural properties of the composites.

Composite Properties	Randomly directed fibers	Aligned Fibers
Flexural Strength (MPa)	7.020 ± 1.365	13.119 ± 1.117
Flexural Modulus (MPa)	345.972 ± 71.666	266.492 ± 35.523
Shear Stress (MPa)	0.496 ± 0.098	1.204 ± 0.127



(a)



(b)

Figure 3. Results from the flexural tests. (a) Randomly directed fibers. (b) Aligned Fibers. Source: Authors.

The composite presented lower resistance than that presented by synthetic fibers, as composites formed by carbon fiber or glass fiber according to Gama (2017) and smaller than epoxy resin composites, such as banana fiber made by Carvalho (2015). The results showed that its flexural strength is higher than the composite of banana fiber with polyester resin and coconut fiber with polypropylene (Silva, 2003). However, it presented the same behavior when the fiber arrangement was compared, in which the aligned fibers presented better results than the randomly arranged fibers, as presented in Carvalho (2015) and Sousa (2013).

4. CONCLUSIONS

Even with the high availability of raw material for the manufacture of the composite, the fiber extraction process is still manual. Thus, for the composite to be used extensively it is necessary that the process of making the fibers is improved. As expected, composites with unidirectional fibers presented better results than those with random order. However, its resistance is low when compared to the synthetic fibers, making it impossible to substitute for taboa fibers.

The present study shows itself as a research opportunity, since few works are related to this type of fiber and can be used in applications such as the manufacture of furniture and equipment that require less resistance. The area of study in natural fibers is motivated by the perspective of the development of products that present better disposal conditions and that bring less problems to the environment.

5. ACKNOWLEDGEMENTS

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7. RESPONSIBILITY NOTICE

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