PRODUCTION OF CEMENTITIOUS LAMINATES REINFORCED WITH FIBERS FROM AMAZONIA

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Abstract

This project's aim is to develop and characterize cementitious composites laminates reinforced with tissue of jute fibers. The laminates studied were reinforced with 2 layers of fiber, and some composites have treatment with polymer in their reinforcement, intending to improve the behavior of the fibers. Some cementitious compositions of laminates were changed with the desired objective of creating a free calcium hydroxide matrix, by partial replacement of cement by pozzolanic material, the metakaolinite. Bending tests were performed, allowing a comparison between the behavior of different types of laminates developed. The composites were submitted to mechanical tests after 180 days and the results make feasible the evaluation of fiber durability, indicating that the treatment is very effective.

Key-words: cementitious composites, pozzolanic material, flexural strength.

1. INTRODUCTION

Composite materials are made from two or more materials combined which stay distinct and identifiable, this combination result some final characteristics different from all the individual components.

The development of cementitious composites reinforced with natural textile fibers indicates a progress for society, because it is a material based on natural resources and still can achieve high resistance. It is a material with many applications in the civil construction. Reinforcements of structural elements, panels, partitions between environments and elements of cover are some examples.

The low production cost of the tissues of these fibers should be noted, which makes it feasible to work with this type of material and, especially, the encouragement generated to the numerous families of the varzea regions in the North of the country, who live from Jute fiber extraction, for example.

Jute fiber is found commercially in the fabric form and has good tensile behavior. When working with tissue-shaped fibres, for better uniformity in your distribution, when compared to the random fibers, in addition the better productivity. In addition it was realized that this fiber can show great performance as reinforcement of cimentícias arrays, increasing the resilience of the set.

The studies on this theme aim to enhance and develop a composite with the best conditions possible. Among various factors that can be considered, the present work emphasizes not only the mechanical strength of cementitious laminates but also the behavior of the set as the durability, since the cement hydration results in the calcium hydroxide, which tends to change the structure of the fibres [1].

Therefore, this research purpose the development and characterisation of cementitious composites reinforced with jute tissue. Being possible to carry out a brief performance comparison thereof, by means of tests of flexural strength, given some changes such as an matrix of free calcium hydroxide and the polymer tissue treatment.

2. MATERIAL AND METHOD

2.1 Methodology

It was considered different composites in their matrix, being composed mainly of sand, Portland cement and superplasticizer, changing the matrix took from the partial replacement of Portland cement by a Pozzolanic material, making it free calcium hydroxide. Mechanical characterization of plates produced from flexion tests.

With these data it is possible to draw up a comparative between the plates with different characteristics. The composites developed were manufactured with cementitious matrix and Jute fiber reinforcement in the form of fabric. As mentioned before, certain composites feature free matrix of calcium hydroxide, through the partial replacement of Portland cement by metacaulinita. As well as polymeric treatment performed in some composites reinforcement. The different types of laminates produced are described in Figure 1.

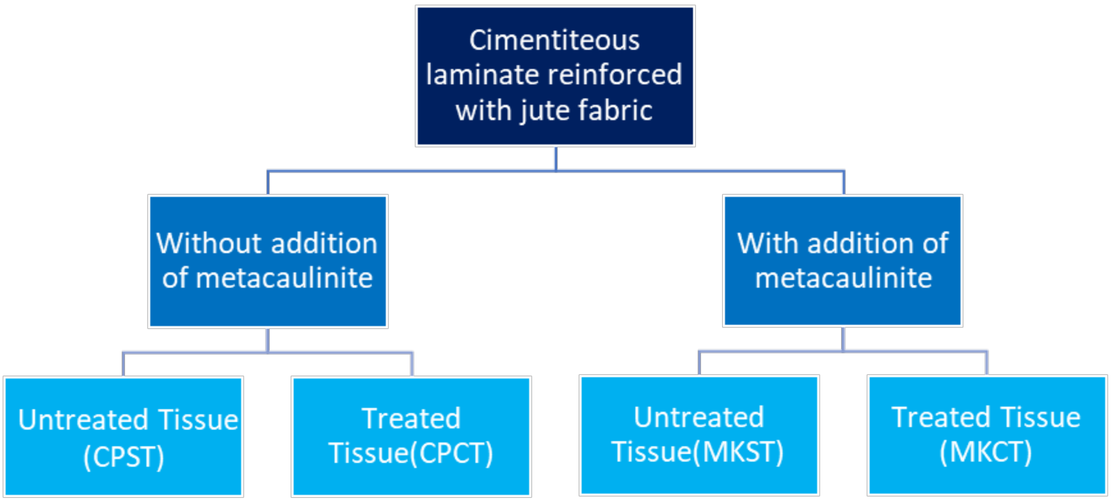

Figure 1 – Flow chart of composites produced.

2.2 Preparation and treatment of fabric fibers

The jute fiber fabric, Figure 2, is presented in the form of trade. The same was cut with 400x400mm measures and treatment of did by impregnation with varnish, Figure 3, since the polymer aims to form a physical barrier to protect the fiber from contact with the hydration products, improving the durability of composite [2]. We used a brush to spread the varnish on the fibers, then were extended in a line of ropes to dry for about 12 hours, an average temperature of 25ºc. After this process the tissue was maintained for a period of at least 24 hours in open container until the molding of composite.

Figure 2 – Jute fiber in the form of fabric.

Figure 3 – Preparation and treatment with varnish (Polymeric Treatment) of fibre tissue.

2.3 Preparation of mortar

Based on the data used by Melo Filho (2012) [3], to the mortar of the present work, 1 stroke: 1:0.4 (cementitious material: sand: water), and plasticizer content of 0.3%. For certain composites, made also an adaptation in the constituents used in the partial replacement of cement by replacing 50% of the mass of cement by 50% metacaulinite. The mass of materials for each dosage, with and without Pozzolanic material, is described in Table 1.

Table 1 – Dosages used

Dosage	Cement	Metacaulinite	Sand	Water	Superplasticizer
1	785,20g	-	785,20g	311,10g	5,30g
2	392,60g	392,60g	785,20g	311,10g	5,30g

The preparation of matrix follow these steps:

– Manually mixture of dry components (cement, metacaulinita and sand) for 1 minute;

- Addition of dry materials in mixer and mix for 1 minute on low speed;
- Dilution of superplasticizer on water and gradual release on mixer, until the mixture presents visually homogeneous;
- Remained the mixture for 2 minutes on low speed and 2 minutes on high speed.

2.4 Lamintates production process

The molding process of the laminates is done in a cast acrylic with dimensions 400 mm x 400 mm. The molding scheme, Figure 4 (a), is to put a layer of mortar and spread, Figure 4 (b), with the aid of a spatula. After the mortar is applied on a layer of fiber fabric and this process is repeated until conclude the third layer of mortar. At the end, there is a plate with 6 mm thick, and 2 layers of fabric and 3 layers of mortar, interspersed with each other.

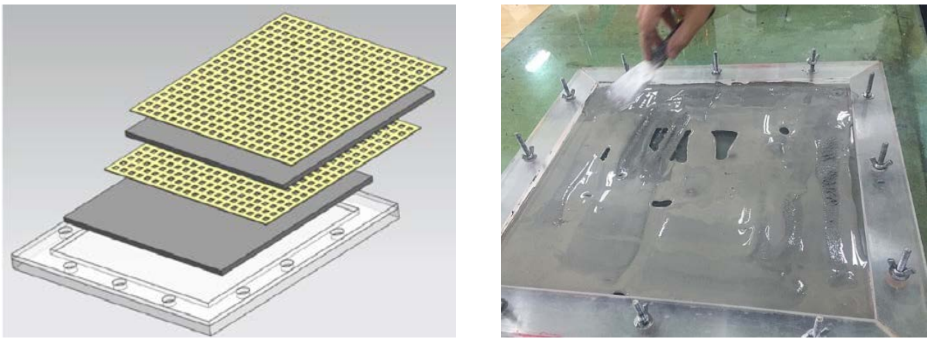

Figure 4 – Diagram of molding. Source: Portela, 2016 [4] (a) initial production process (b).

2.5 Pull test on bending of composites

The three-point bending test consists of applying a load in the center of the specimens supported by two points. The test was conducted on a universal testing machine Instron 5980. The speed used in the test was 0.5 mm/min, standardized for all bending tests. The gap between support was 250 mm

The results are expressed in flexion voltage, Equation 3, based on the resistance of materials, according to Equation 1 and Equation 2.

$$\sigma = \frac{M \, . \, y}{I_z} \tag{1}$$

$$I_z = \frac{b \, . \, d^3}{12} \tag{2}$$

$$\sigma_{máx} = \frac{3 \, . \, P \, . \, L}{2 \, . \, b \, . \, d^2} \tag{3}$$

Being that:

M = bending moment
y = distance to the neutral line
Iz = moment of inertia in relation to the neutral line
σ = flexion traction voltage;
P = load;
L = distance between the supports;
b = width of the sample;
d = thickness of the sample.

3. RESULTS AND DISCUSSION

The laminates produced weigh about 10 kg per square meter, and in Figure 5 are presented the typical stress-deflection curves obtained from flexion tests in 3 points, carried out in four different types of composites produced.

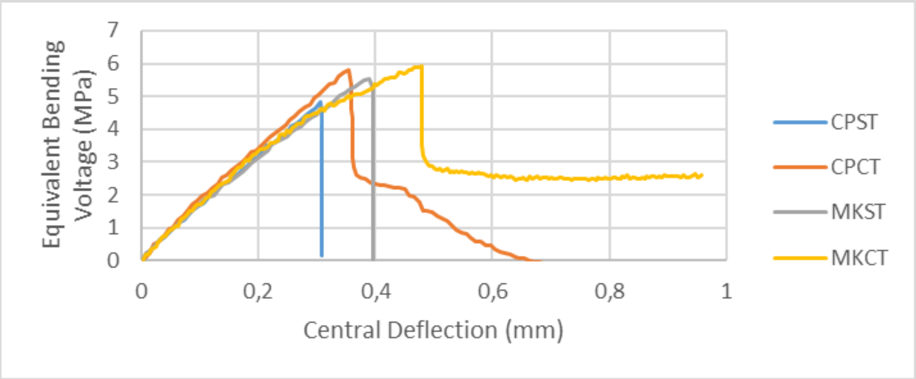

Figure 5 – Curves obtained from the bending test on 3 points

In Table 2 are expressed the results of first crack deflection, voltage of first cracking and stress cracking post.

Table 2 – Values of deformation and tension of the first fissure, post tension cracking and their coefficients of variation

Laminados	d_{1f} (mm) CV (%)	σ_{1f} (MPa) CV (%)	σ_{pf} (MPa) CV (%)
CPST	0,31 (4,14)	4,84 (9,13)	0,00 (0,00)
CPCT	0,35 (23,25)	5,82 (22,25)	2,53 (0,00)
MKST	0,39 (0,00)	5,53 (0,00)	0,00 (0,00)
MKCT	0,47 (16,07)	5,92 (11,27)	2,91 (1,51)

The CPST laminates and MKST have brittle fracture mode. Comparing both free plates of calcium hydroxides, the PBX shows better results for deformation and breakdown voltage, which is 20% higher than in CPST, maintaining a post tension cracking.

MKST composites and MKCT were produced from the same array and not show difference of breakdown voltage very significant, so the 50% replacement of Portland cement by metacaulinite did not affect the resistance.

For the laminates that not show widespread rupture, has a residual voltage (σr), which can be associated with the polymer and fiber treatment compared with each other for analysis of array. The MKCT array has residual resistance almost uniform up to 1 mm of deflection, with an approximate value of 2.55 MPa, while the voltage a main post MKST cracking of 2.53 Mpa but that suffers constant decrease until it reaches 0 Mpa in 0,65 mm. It may be noted the difference of voltages of composites in 0,5 mm and 0,6 mm offset. Therefore, the laminate MKCT features far superior deformability when compared to other laminates produced.

4. CONCLUSIONS

- Treatment with polymer resin in natural fibre fabric shows an improvement in the mechanical behavior of the composite, as it raises both the tensile strength for bending as the deflection of the same, causing a break mode develop laminate less fragile.
- The use of metacaulinite provided a more durable matrix, since the composites with the partial replacement of cement showed best result of resistance to bending efforts.
- The use of natural fibre fabric has improved the features of the set, since the cementitious material by itself does not reach such resistance, and can be a promising material for construction.

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