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DETERMINATION OF THE DELAMINATION PERCENTAGE OF COMPACTED BAMBOO GUADUA USING EXTENDED FIELD DIGITAL IMAGES PROCESSING

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Abstract. The percentages of delamination of Compacted Bamboo Guadua were calculated using digital images processing. Three processes were done in the development of this project: tests of delamination, digital image pre-processing and digital image processing of the images acquired. The test of delamination followed the ASTM 5824. The digital image pre-processing was supported on the acquisition of sequences of images, doing a sweeping of the samples, and finally the digital processing worked in the generation of panoramas with sequences of images acquired from the sample. Additionally, the total area from the sample was measured digitally, the segmentation and the measurement of delamination area were done, finding the ratio between the delamination area and the total area of the sample, and obtaining the value of percentage of delamination per section. Digitally, the obtained values for samples made with fibers obtained from Stick (Varillón), Top (Sobrebasa), Middle (Basa) parts and mixture of them were 16.97%, 9.96%, 5.96% and 8.64% respectively.

Introduction

This article presents the determination of delamination percentage in elements of Compacted Bamboo Guadua (BGC), using the extended field image processing, worked by Gonzalez [1]. This works is a part of the research project "Mechanical resistance and delamination in elements of Compacted Bamboo Guadua" developed by Universidad Nacional de Colombia (National University of Colombia) and financed by Departamento Administrativo de Ciencia, Tecnologia e Innovacion – Colciencias (Administrative Department of Science, Technology and Innovation – Colciencias). The technique of the image processing is used for determine the delamination areas, like it was worked by Gonzalez and Faúndez [2]. The procedure used on images processing were: selection, segmentation and measure of the regions of delamination in the image of the cross section; for these tasks it was necessary to create the panorama of the sample after sweep the cross section like worked by Brown [3], Jiu [4], Jing [5] and Heckbert [6].

The images processing is useful technique for the measurement of the percentage of delamination in the material. The aim of the images processing was to measure the delamination area and the total area of cross section for each sample; this measurement technique was different to the conventional measurement of the percentage of delamination established in the ASTM D5824-98 procedures [7] because the bond lines of the material of study had random directions. The percentage of delamination was taken as the difference between the initial vacuums percentage and the vacuums percentage after delamination test.

Material description

The material used on this research was produced by Induguadua S.A; four years old bamboo Guadua culms were cut from the Department of Quindío – Colombia and sectioned into three parts corresponding with stick, top and middle. In factory the production process begun with obtaining longitudinal sheets for each section; all sheets were polished for remove protuberances and excess of thickness in the knots, and remove the external layer. After that, the sheets were split in small longitudinal pieces as thin sheets of bamboo Guadua. In order to extract the starches that has the natural material, each sheet was introduced into an autoclave and then was required a dries of the material aimed that the moisture content was lower than a value established following the specifications of the provider of the adhesive. For the impregnation of the adhesive the thin sheets of bamboo guadua were immersed into the adhesive; then, following the recommendations of the adhesive producers, was necessary a second dry process. The final step consisted on the conformation of the elements, using a vertical and horizontal pressing process. The fabrication process is summarized on Fig.1.

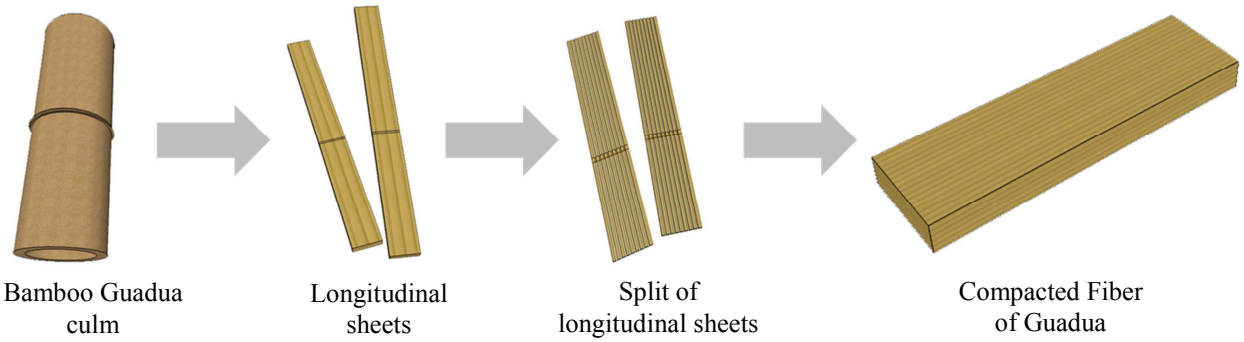

Fig. 1 Fabrication process of compacted fiber of Guadua

Experimental methodology

Four types of samples of BGC were tested. The classification of the types depends on the part where the fibers used for the manufacture of the material were obtained: from the Stick (Varillón), Top (Sobrebasa), Middle (Basa) parts and from the all parts. The types of the samples were named as: Stick, Top, Middle and Mixture. Fig. 2 shows the dimensions used for test samples.

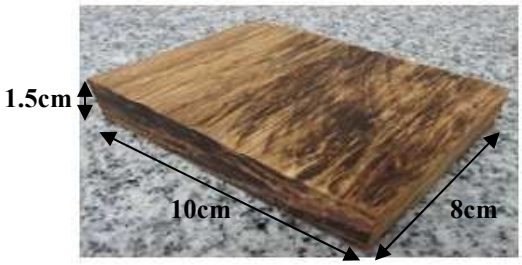

Fig. 2 Dimensions for test samples

Following the procedures on ASTM D5824-98, the samples were introduced into an autoclave in order to simulate the conditions of humidity and temperature indicated on the used code; the highest level of pressure was set in 109.3 kPa, because at this pressure, it was observed a percentage of delamination higher than the required for the ASTM D 2559 – 00 [8].

The delamination percentage was determined in twelve samples obtained of elements fabricated with Top, Middle and Mixture of fibers. For Stick type, the delamination percentage was determined only in four samples, because after the pressure process the samples were completely destroyed.

The cross sections of samples of BGC were reconstructed digitally before and after the delamination process. The initial vacuums percentage,$\%V_0$, was calculated using Eq. 1, where A_0 is the area of vacuum initial and A_{Ti} is the Total area initial. The vacuum percentage after delamination test was calculated using Eq. 2, $\%V_f$, where A_f is the area of the vacuum after the test and A_{Tf} is the total area after delamination test

$$\%V_0 = \frac{A_0}{A_{Ti}} \times 100. \quad (1)$$

$$\%V_f = \frac{A_f}{A_{Tf}} \times 100. \quad (2)$$

For measure of areas was made the following process: capture of sequence of images of the cross section of the sample (Fig. 3), digital reconstruction of the cross section of the sample (Fig. 4), digital cut of non-regular edges of the sample so the shape of the modified cross section is rectangular (Fig. 5), segmentation of the sample between vacuums and net areas (Fig. 6), measure of vacuums area and the total area of modified cross section of the sample. For the digital image processing was used the Image Pro plus software.

The result of percentage of delamination, $\%Del$, was calculated using Eq. 3.

$$\%Del = \%V_f - \%V_0 \quad (3)$$

Fig. 3 Sequence of images of the total area of a sample before autoclave.

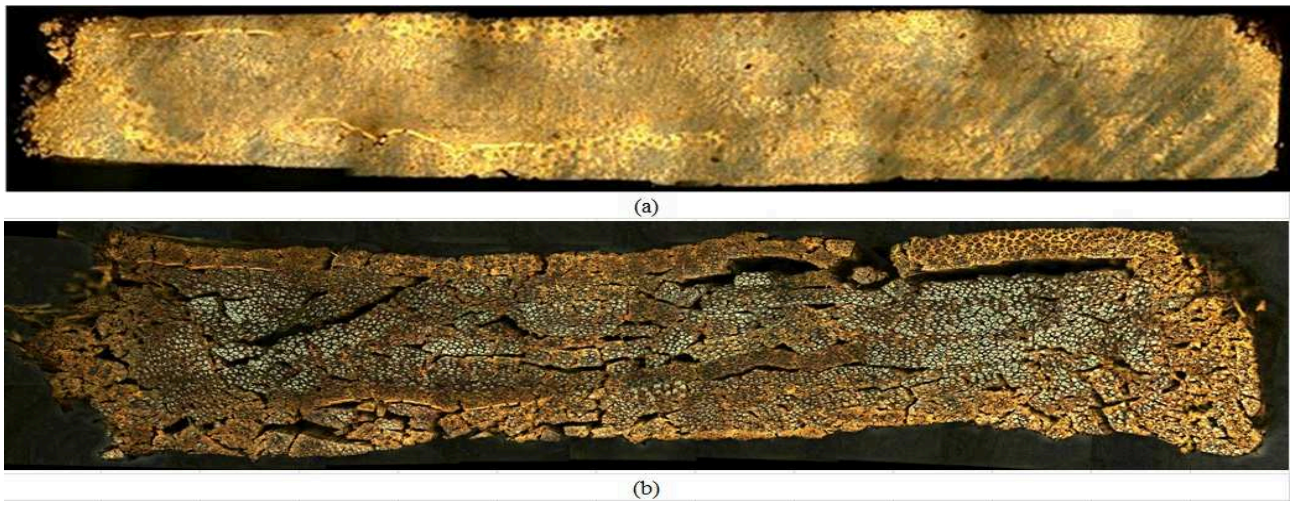

Fig. 4 Panorama: (a) before delamination test, (b) after delamination test

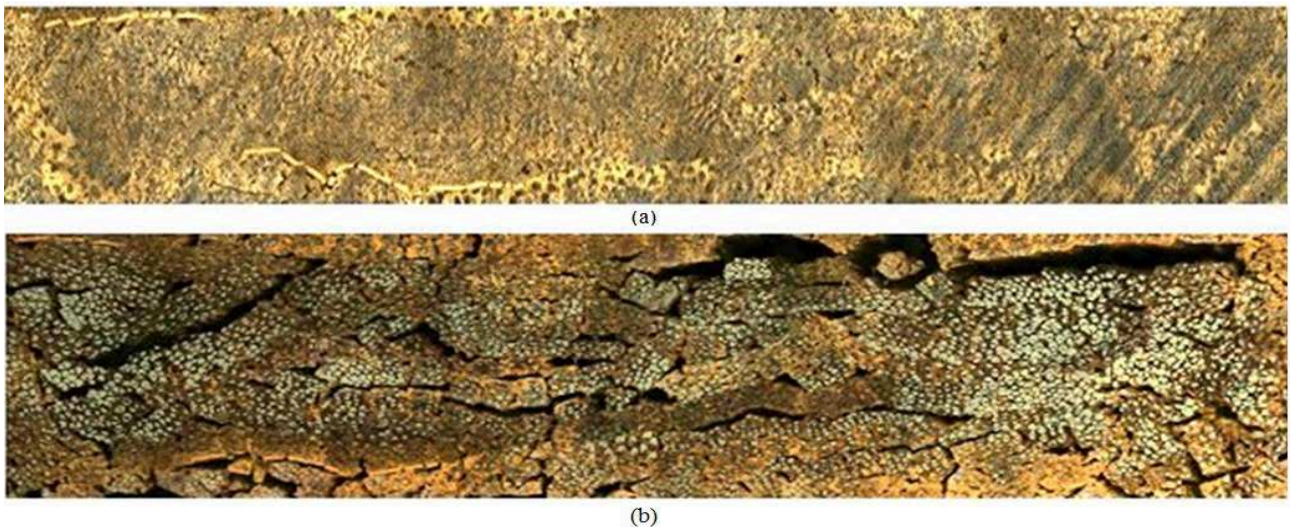

Fig. 5 Cross section without edges of the sample before (a) and after (b) the delamination process

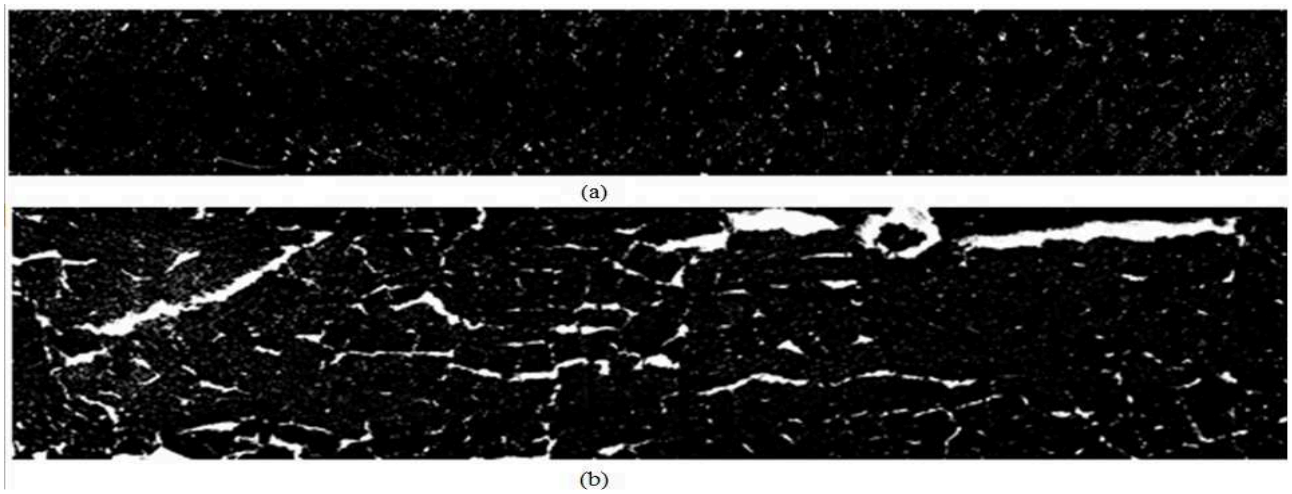

Fig. 6 Digital processing: segmentation of the modified cross section of the sample before (a) and after (b) the delamination process.

Calculation and results

The results for percentage of delamination are shown in Table 1.

Table 1. Experimental results of the percentages of delamination.

% DELAMINATION	STICK	TOP	MIDDLE	MIXTURE
MAXIMUM	28.69	19.45	12.04	14.65
MINIMUM	10.84	5.20	1.89	3.30
AVERAGE	16.98	9.96	5.96	8.64
STANDART DEVIATION	0.08	0.04	0.02	0.03

Conclusions

The technique of images processing could be used for the determination of percentages of determination for composite materials that have random bond lines.

As the process of manufacture of bamboo fiber compacted material is still improving, the initial results of delamination percentages are not concluding. Apparently, the delamination problem of the material depends on the part of the bamboo were the fiber come from.

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