Progress in Engineering Application and Technology Vol. 2 No. 1~~2~~ (2021) 924~~387~~–929~~392~~

PEAT

H~~Journal h~~omepage:
http://penerbit.uthm.edu.my/periodicals~~ojs~~/index.php/peat
~~ISSN : 0000-000X~~ e-ISSN : 2773-5303~~0000-0000~~

Compression of Bamboo Culm Subjected to Different Treatment Duration

Mohamad Amirul Fahmin Mat Noh[1], Mohd Nazrul Roslan[1]*

[1]Department of Mechanical Engineering Technology, Faculty of Engineering Technology,
Universiti Tun Hussein Onn Malaysia, 84600 Pagoh, Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/~~rpmme.00.00.0000.00.0000~~peat.2021.02.01.088
Received 13 January 2021; Accepted 01 Month 2020; Available online ~~02 Month 2020~~25 June 2021

Abstract: Bamboos belongs to the Bambusoideae subfamily of the Poaceae class that is a tall treelike grass. Bamboos are some of the world's fastest growing plants. Environmentally friendly bamboo fibers have good mechanical properties that make them suitable substitutes for conventional fibers. This paper investigated the compression properties of Gigantochloa wrayi (Buluh beti) bamboo according to ISO 22157 (compression test for bamboo culm). This study involved three different internodes of the bamboo that includes the basal part, middle part and top part of the bamboo. All of the part undergo chemical treatment with different soaking time. The different durations of the bamboo treated in the chemical treatment is to investigate the effect of the time on the compression strength of the bamboo. Once the fiber had been treated, the fibers went to testing process in order to obtain the compression properties. From the result, basal part of the bamboo with 6 hour of treatment exhibited highest value of 5840.33N compare to others part and duration of treatment.

Keywords: Bamboo, Natural Fiber, Chemical Treatment

1. Introduction

Bamboo is a type of grass that one of the fastest plants to grow. The fast growth of bamboos is due to it special rhizome-dependent mechanism. Unlike other trees, individual bamboo culms grow at maximum diameter from the ground and growth to full height in a one growing season [1]. Advantages of using bamboo compared to other plant is low density, high growth rate, low cost, stiffness and high in mechanical strength. Some bamboo species can grow 36 inches within 24 hours, at a rate of approximately 1 1⁄2 in an hour [2]. After grown, culms usually take three to five years to fully mature, during which they experience silicification and lignification. After five to six years, the strength of the culm starts to deteriorate. The stem is segmented by branches, bands at regular intervals. The node manifests as a diaphragm within the culm, which helps avoid wall buckling. The node space is called the internode. The internodal spacing varies from species to culm. Within the internodes, cellulose

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*Corresponding author: nazrul@uthm.edu.my

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fibers and vascular bundles run parallel to the culm length while they intersect at the nodes, some crossing into the nodal diaphragm [3]. In Malaysia, bamboos grow almost everywhere, but located on river banks, in disturbed lowland forests, on hillsides and ridge tops.

Bamboo appears to grow in a "belt" running through tropical, subtropical and temperate climates up to 3500 meters above sea level. Bamboo consists of cellulose fibers that is a nature 's prime building material for living matter and imbedded in a lignin matrix. Cellulose fibers are aligned over the length of the bamboo giving optimum tensile, flexural strength and rigidity in that direction. A bamboo segment clearly shows that the fibers density is not uniform which mean it has higher density at the outer periphery, maximizing flexural properties [4]. Bamboo fibers can be turn out by mechanical as well as chemical processing. Through mechanical processing, first cut and shattered wood of the bamboo is handled with natural enzymes that turn the bamboo into a soft and mushy material. The natural fibers can be separates mechanically to extract individual fibers, accompanied by spinning yarn from them. The fabric processed through this method is also called termed bamboo linen and this process is known to be eco-friendly since no hazardous chemicals are used.

In this study, the bamboo is treated with chemical treatment with different duration of time in order to find duration that achieved high mechanical properties of the bamboo and analyzed the characteristic of each part of the bamboo.

2. Materials and Methods

2.1 Materials

The bamboo fiber species used in this study was Gigantochloa wrayi (Buluh beti), which is commonly known as beti bamboo and was obtained from Batu Pahat, Johor. The bamboo was cut into three different section which is basal, middle and top section. Then, each section of the bamboo is cut into 3 cm length and 2 cm width. The wall thickness is depending on the section of the bamboo. Physical characteristics of bamboo section shows in Table 1.

Table 1: Physical characteristic of bamboo

Section	Length(cm)	Diameter (cm)	Wall Thickness (mm)
Basal	17 – 25	15 – 20	20 – 35
Middle	15 – 35	10 – 18	10 – 25
Top	30 – 40	2 – 10	10 – 15

2.2 Chemical treatment

For the first step, the bamboo strips were subjected to a water-retting process before they were soaked in chemical treatment. After that, the strips were soaked with 50 g/L NaOH solution mixed with Na_2SO_3 based on 2 wt. % of mass bamboo strip and 3 g/L of fatty alcohol-polyoxyethylene ether (JFC), at a different soaking time. In this work, three different times are used to soak the bamboo strips (6, 12, and 18 hours). Treatment is done for at least 6 hours so that the treatment can reach all parts of the bamboo. NaOH concentration can vary from 1 to 10 wt. %. High concentration of NaOH can worsen the mechanical properties of bamboo strips [5]. In this work, 2.00 % concentration of NaOH is used. Next, after the specified time of treatment, the bamboo strip is washed using fresh water to remove

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chemical content from them. The bamboo strips then are dried using a piece of fabric. Immediately after that, the bamboo strip is bringing to testing at universal testing machine.

2.3 Testing

At the universal testing machine, jig used in this study is compression platen jig with 20000 N lock seal. The compression platen jig is installed to the universal testing machine. Next, after the machine is turned on, computer linked to the machine is boot up. The software used is NEXYGENPlus. Setup used in this testing is compression till rupture test with speed of 5 mm/min. The machine is run and will start compression till the bamboo strips totally broke. All the data will be safe by the software and analyses in Microsoft excel.

3. Results and Discussion

Table 2 below shows the result of compression test for bamboo culm on different duration of soaking time. The percentage coefficient of variation (CV) shows result gained for all testing is less than 46.00 %.

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Table 2: Compression test for bamboo culm

Section	Duration (hour)	Average Max load (N)	CV (%)
Basal	6	4256.60	38.09
	12	3575.00	45.71
	18	1800.2	29.10
Middle	6	3130.3	15.46
	12	2493.9	8.20
	18	1077.5	33.70
Top	6	1675.6	16.00
	12	1618.8	13.55
	18	1108.7	29.48

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Figure 1, Figure 2 and Figure 3 shows load-extension curve for basal, middle and top section respectively.

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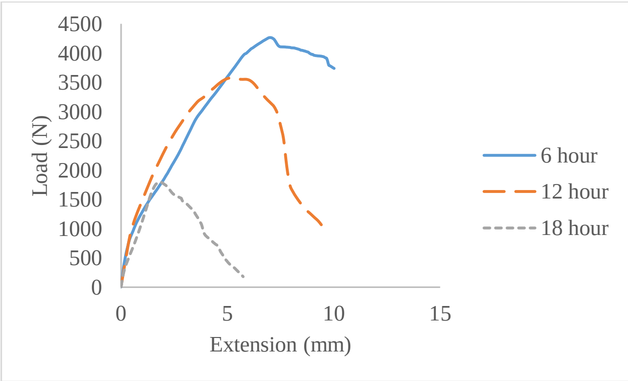

Figure 1: Load-extension curve for basal section

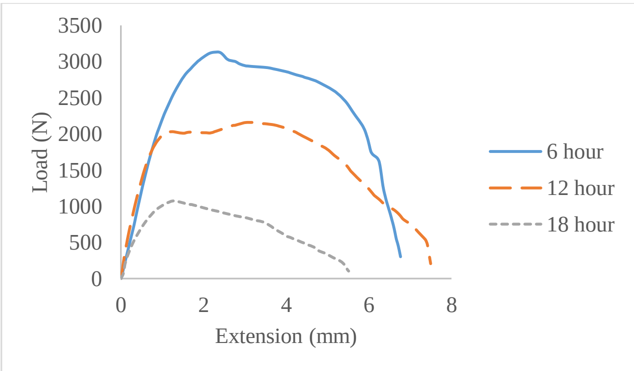

Figure 2: Load-extension curve for middle section

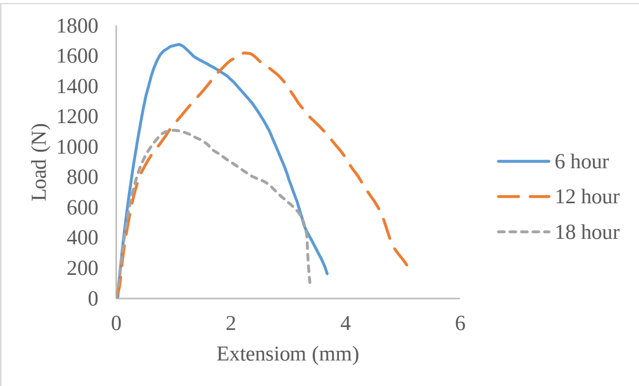

Figure 3: Load-extension curve for top section

All the curve for the bamboo section shows the same trend in which 6 hours of treatment required highest load to break follow by 12 hours treatment. For 18 hours of treatment in all section show it has

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the smallest load required to break the bamboo culm. The longer the duration time for bamboo culm in treatment, the load required to break the bamboo culm is lower. This is due to the bamboo culm has lost lignin during the treatment process. The longer the soaking time, more lignin are dissolved in the treatment. Lignin is a polymeric constituent of the bamboo cell wall that serves supportive and impermeability functions in the vascular tissue [6]. Loss of the lignin contribute to the loss strength of bamboo strips. Thus, load require to break the bamboo strips is small if the bamboo soaked in treatment for longer duration. In this study, the maximum load is acquired at the highest point of break. In Figure 1, maximum load to break the bamboo strips for basal section are 4256.60, 3575.00 and 1800.20 N for 6, 12 and 18 hours of soaking time respectively. In Figure 2, maximum load to break the bamboo strips for middle section is 3130.30, 2160.33, 1077.51 N for 6, 12 and 18 hours of soaking time respectively. For Figure 3, maximum load to break the bamboo strips for top section are 1675.60, 1618.80 and 1108.71 N for 6, 12 and 18 hours of soaking time respectively.

Figure 4 below shows the structural change during (a) and after (b) compression test for the bamboo strips.

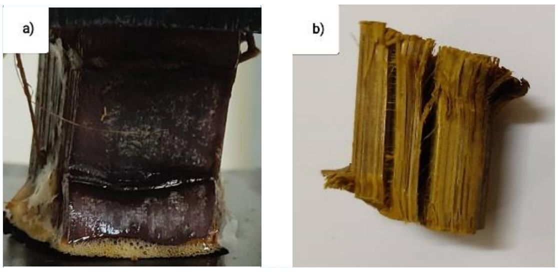

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Figure 4: Image of bamboo strips during (a) and after (b) compression test

4. Conclusion

An experimental investigation was conducted in this study to know the compression properties for the bamboo strips on different soaking time. It was found that various soaking time will affect the strength of the strips. The soaking time of 6 hours resulted in optimized mechanical properties, while increasing the soaking time to 12 and 18 hours yielded the weakest performance on the strength of bamboo strips. The strength of the bamboo is significantly improved after treatment mixture of NaOH, Na_2S0_3 and JFC for 6 hours. The performance of the bamboo was enhanced with 6 hours of soaking time. It also found out that strips from basal section have the highest load to break as it has the bigger wall thickness compare to middle and top section.

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Acknowledgement

The authors would like to thank Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for its support.

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