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BAMBUSA VULGARIS: DETERMINATION OF MECHANICAL STRENGTH AS BIO-COMPOSITE MATERIAL

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ABSTRACT

This research examined the mechanical properties of the developed bio-composite material. The manufactured bio-composite was made from combinations of two materials, which are bamboo scientifically named as *Bambusa Vulgaris* and a polymer named HDPE. The main objective of this paper is to expose the performance of a bio-composite material in term of its tensile strength value. This parameter is considered as the critical advantage of the developed bio-composite material to be proposed in building structure applications. The possibility of replacing conventional materials used in structure application with the proposed material was also explored in this study. The bio-composite was manufactured using WPC technique before it becomes a solid bio-composite material. The tensile strength of this bio-composite material was measured using an experiment that follows ASTM D638 standard.

Keywords: *Bambusa Vulgaris*; bio-composite; mechanical strength; tensile test.

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1. INTRODUCTION

Due to increasing demand in wood structure development, many ranges of products have been produced to replace the conventional wood used in polymer technology. At the moment, many applications of polymers are using biodegradable polymers. It was widely used in biomedical applications due to its hydrolysis properties in the body [1]. Once it achieved its purposes, this kind of polymers would degrade, leaving a non-toxic remaining products. In addition, biodegradable polymers have added benefit such that at the end of their life. It can be converted into biomass or water and carbon dioxide [2].

Composite materials are also known as reinforcement material. In general, the reinforcement material which combined more than one material is stronger compare to the original matrix. Composite material can be divided into two categories based on the matrix and on the reinforcing structure. Composite matrix might be a metal, polymer, carbon or ceramic while reinforced composite might be based on natural fiber or particle which can be created from glass, cellulose or carbon. Either matrix or reinforced forms, both composites have advantages to their specific applications. Composite matrixes are widely used in commercial and high-performance aerospace applications [3], while reinforced composites are widely used in building structure applications [4]. Since composite materials provided good mechanical characteristics, it is therefore beneficial for a study into other types of material be explored to harness the possibility of improvements from said approach.

In this research, a species of bamboo known as *Bambusa Vulgaris* was selected to be exploited as research material for bio-composite application. *Bambusa Vulgaris* is one of the well-known bamboos in South East Asia. Initially, *Bambusa Vulgaris* was planted in Southern China before it spread out across Asia region. In addition, *Bambusa Vulgaris* is one of the biggest species among existing bamboos on earth. Furthermore, it can be found in abundance rainforest tropical countries.

Bamboo is a self-dependent plant. Under normal condition, it can grow into large volume without needing much care and attention. As such, it can be found aplenty in high wetness areas such as near a river or in watery bushes. Generally, most of the bamboo can be harvested after 3 years of sprout out [5-6].

Bamboos have an extensive association with society since the earliest time. It has been used broad applications ranging from infrastructure such as bridge and household properties such as a chopstick. Even with current advancement in technology experienced today, the use of bamboo can still be found driving many new innovations and in abundant of applications. Among such are in chemical and medical industries.

2. METHODOLOGY

2.1. *Bambusa Vulgaris* Sample Preparation

A sample of mature *Bambusa Vulgaris* found near to the river in Kampung Durian Mentangau, Terengganu were harvested and cleaned. It would then be processed via chipping and grinding to become sawdust or filler. Afterward, the sawdust was heated and dried using hot oven. This is done to minimize the water content within the sawdust and ultimately prevent any air bubble occurring during the compression process. Next, the sawdust would be subjected into a number of processes as stated in wood plastic composite (WPC) technique to merge *Bambusa Vulgaris* and selected polymer together. The selected polymer which was used in this research is called High Density Polyethylene (HDPE). In WPC technique, the polymer is used to augment the mixtures' strength. Generally, WPC technology consists of several procedures. It starts by mixing raw element between fiber and polymer at the high temperature mixer. The temperature setting would depend on the thermal capability of the polymer used. Thus, for this research the temperature was set to 180°C to effectively break down the polymer element before being mixed with the sawdust. Then, the well-blended resultant product would be sent into the compression process. Hot and cold flat compression machine was used in this research. During this process, a mould is needed to produce the needed WPC products. Fig. 1 shows the sequence summary of WPC process.

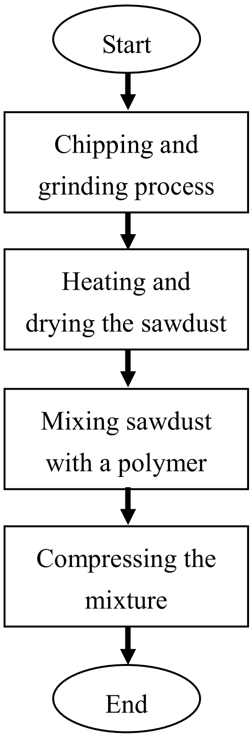

Fig.1. Process of wood plastic composite (WPC)

In this experiment, several samples have been produced. The difference between each sample is the mixtures' composition. Table 1 describes all the bio-composite mixture compositions that have been fabricated in this research. Meanwhile, Fig. 2 shows the appearance of sample 1 till 4 from left to right respectively. It is noted that within the study, all of the samples have similar particle size.

Table 1. Mixture compositions of bio-composite material

Sample Number	**Composition (%)**	
	Bambusa Vulgaris	**High Density Polyethylene**
1	0	100
2	10	90
3	20	80
4	30	70

Fig.2. Developed bio-composite materials

2.2. Mechanical Strength Measurement

A common method that can be used to measure the mechanical strength of certain material is tensile strength test. For this tensile test, a sample must be in a dumbbell shape as shown in Fig. 3. Dimensions of dumbbell shape are in accordance with American Society for Testing and Material (ASTM) D638 standard [7]. The standard dictates that maximum allowable thickness would be 14 mm.

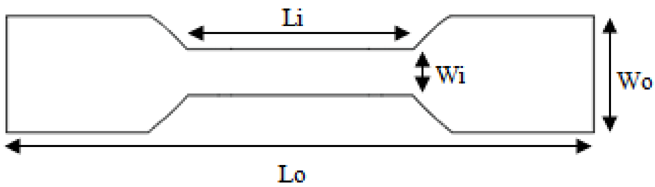

Fig.3. Dumbbell shape that be used in a tensile test

Further, there are 5 types of specimens that are eligible for mechanical strength measurements. Since this research would use a sample thickness of 1.6 mm and material being used is a polymer, it was suggested that the dimensions of dumbbell to be formed would follow the specifications mentioned in Table 2.

Table 2. Specimen dimensions of dumbbell shape

Parameter	Dimension (mm)
Outer Length, Lo	165
Inner Length, Li	57
Outer Width, Wo	13
Inner Width, Wi	19

All tensile strength measurements of the developed bio-composite was made on an INSTRON 5569 testing machine that has a 11250 pound capacity. Fig. 4 shows an experiment which has been set up to measure the mechanical strength of the bio-composite material. It consists of a personal computer and tensile test machine itself. The personal computer is used to monitor and obtain the experimental result.

Fig.4. Experimental setup of measuring mechanical strength

During this tensile test, the dumbbell shaped bio-composite sample will be stretched out. This would cause the end of the dumbbell shaped bio-composite sample to be pulled out until the bio-composite sample break. Once the sample breaks, it would mean the sample has reached the maximum capability to hold the stretched force.

Subsequently to measure the mechanical strength of the developed bio-composite, several samples with the same composition are needed. This is important to check the accuracy of the measurements. According to ASTM D638 standard, at least 5 specimens are needed for each sample to be measured [7]. Thus, for this exploration, 5 samples for each composition have been considered.

3. RESULTS AND DISCUSSION

Once all the bio-composite samples have been completely fabricated, it would be subjected into an experimental process as have been mentioned in the methodology section. In each mixture composition, 5 samples were tested. The sample of obtained output signal is as shown in the figure below.

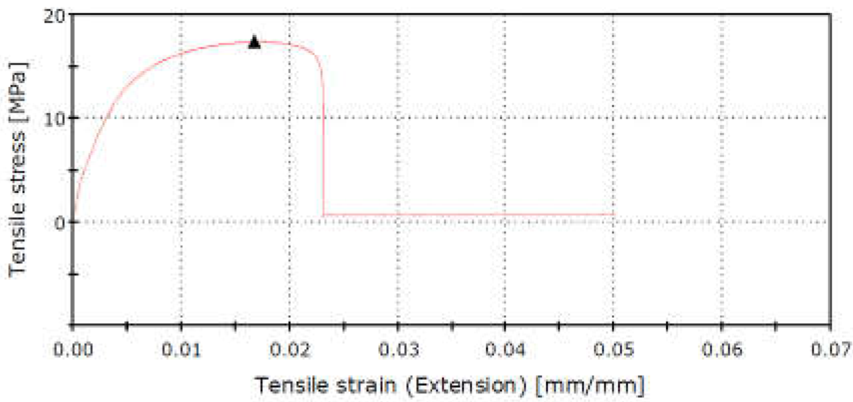

Fig.5. Stress-Strain curve for one of mixture compositions

The above graph shows stress-strain curve for sample number 4. This graph is important as it shows the measurement of the bio-composite mechanical strength. Mean data for each composition are presented in Table 3.

Table 3. Summary of measurement results

Sample Number	Maximum Load (N)	Maximum Stress Value (MPa)	Strain Value (mm/mm)
1	256.86	26.72	0.03648
2	229.25	23.85	0.02486
3	196.35	20.34	0.02064
4	147.72	15.16	0.01979

As shown in Fig. 5, an inclination could be observed on the leftmost of the graph which results from the force or load being increased until maximum load was found. At this point, the strain of the sample will be measured. Then, an extreme decline could be seen as a result from the sample that has passed its straining point and thus broken. Fig. 6 shows the sample conditions before and after the experimental session.

Fig.6. A sample before and after the experimental session

Table 3 shows the value of all measurements made which are maximum load, maximum stress value and strain value. All of these properties can be seen decreases as the elements of *Bambusa Vulgaris* would grow in sizes within the bio-composite mixture. It can be concluded that the sawdust of *Bambusa Vulgaris* would have an inverse effect towards the mechanical strength of the developed bio-composite material. Adding more sawdust elements into the mixture would result in weaker observable mechanical strength of the bio-composite. This relationship is shown in Fig. 7.

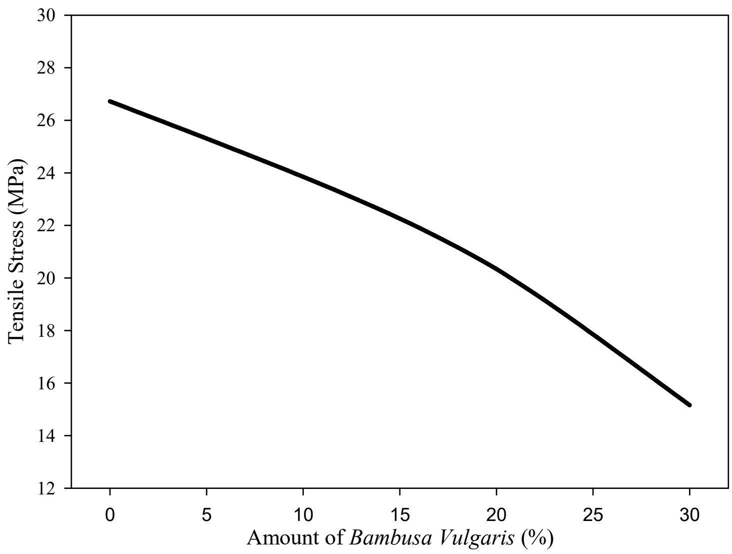

Fig.7. A relationship between mechanical strength and amount of sawdust exists in the bio-composite mixture

From Fig. 7, it can be stated that a reduction in mechanical strength would result in reduced performance of the bio-composite to withstand the amount of forces being applied onto it.

4. CONCLUSION

Several bio-composite materials with difference mixture compositions were successfully developed. Some measurements and analyses have been made in order to determine the mechanical strength characteristic of the bio-composite materials. The amount of sawdust in the bio-composite mixture was determined to have an inverse effect toward its mechanical strength. It was concluded that lesser amount of sawdust would yield more strength to the bio-composite material.

5. FUTURE RECOMMENDATIONS

To understand deeper on the mechanical strength performance of the produced bio-composite material, this research should be continued and improved. Several recommendations are made to further investigate the mechanical strength such as fabricating more samples of which would be mixed with different particle size of *Bambusa Vulgaris* sawdust. Additionally, the use of different polymer materials such as polypropylene and polyvinyl chloride can be explored.

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