Tensile Strength of Banana Stem and Bamboo Fibres as Alternative Materials in Making Craft Products.

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Abstract

Natural fibres are currently used in various types of engineering applications to increase strength and to optimize weight and cost of the product. Many types of natural fibres such as coconut husk, straw, pineapple, bamboo and banana are used as reinforcement material. In this paper the banana stem and bamboo fibres were chosen for the development of craft products or as composite materials. Initially, these fibres are only used for making handmade papers. A mold is used to compress and to form a desired solid material. This will support and to determine the strength of these fibres. Tensile strength tests were used as the method in this study. A certain thickness is required in these experiments. Saturated fibres with small amount of methyl cellulose were used during the preparation. Fibres that have been compressed in a mold would be stronger. Fibre sheets are dried and dense tested on *Instron* tensile testing machine. Test results show the strength of both compressed fibre materials for the specific purpose such as the production of disposable products that are environment friendly.

Keywords: Natural fibres, industrial design, innovation, composite, material and processes

Introduction

Explorative research or experiments focused on this basic ingredient of natural fibre from banana stems and bamboo that can be produced for developing products to support the rural manufacturing industry. This is very significant to promote the One District One Industry (ODOI) underlined and hosted by the Prime Minister in 2012. The program was first introduced in Malaysia in 1992 as the One Village One Product (OVOP). The main objective of this program is to soaring local products as a viable industry. This will includes producing creative and innovative entrepreneurs among rural community through its commercial approach and eventually form unique products that give specific identity to the district involved.

The main objective is to study how natural fibres can help in providing creative products and innovation. In this case the natural fibres from banana tree trunks are easily obtained and available throughout the years, and it is a non-seasonal plant. Bamboo fibres from bamboo plant is also consider as the same as banana plant. Sruthi and Chand (2015) explained that these fibres have high specific properties and low density. Natural fibres are eco-friendly unlike synthetic fibres because they are bio degradable and non-abrasive. In this research, we also believe that all the steps and processes of producing fibre products can be counted as services within the industry. According to Szcygielski (2011), research on service design and innovation is no longer in its infancy, but is still something new to the rich literature on innovation in manufacturing.

Bananas are among the thousands of flora that grow in Malaysia. In terms of botanical science definitions, banana belongs to *Zingerberalis Order*, which is a collection of Musaceae family and Musa genus. Musa genus can be divided into two groups, Eumusa and Phusocaulis. Banana type is also popular because of it is easy to find and cheap. According to Fauziah Hassan (1989), the more bananas fruits were harvested and cultivated, the more other parts of the tree are not used. This can be declared as a noticeable loss and waste. Banana stems can produce products that are beneficial to the environment. The researchers wanted to see new products using banana fibres or other unattended natural fibres and as a result of that we could see the capability of reducing the materials that do not attach importance to the sustainability. Michel H. Porcher (2002), the cellulose content is pretty much contained in banana stems can be used as a material hardener that can be turned into a strong structure to hold fibres. This shows that it is a strong material with its natural property. It can become stronger if we can find another solution by adding more bonding agent to the structure.

Bamboo is from the plant family of Poaceae and is also known as monocots plants. According to Verma et al. (2012) bamboo is likely to be a substitute for wood because it can be used or can be harvested in three to four years from the time of planting compared to wood that takes more than a decade. The tensile strength of the stem (*culm*) will depend on the density of bamboo reeds along and across the fibres in it. Some of bamboo clearly shows that the fibre density is not uniform; it is higher in the outer layer and lower at the inside layer. Sreenivasulu and Chennakeshava (2014) says that bamboo can be found everywhere in the world and is abundant natural resources. It was a conventional building material since ancient times. This is not so important in this study because the main thing is how the strength of the fibres when it has to be transformed into sheets of different thickness. Isris Mohamad Zainal Abidin (1990) mentioned that, fibre can generally be distinguished or classified into two parts, natural fibres and man-made fibres (chemically). Banana, bamboo, cotton, pandanus, palm oil, sugar cane, rice straw are some examples of natural fibre derived from plants, while cotton lint and silkworm fibres of animal origin. Natural fibres are divided into three broad categories, namely fibres derived from plants, animals and also from organic materials. It is possible to transform natural fibres into different sort of forms or new materials to suit with the intended purposes.

Objective of Study

The objective of the study was only focused on the basics of how tensile strength values of natural fibres from banana stem and bamboo culm. This is also a basic guide to the beginning of the growth and development of creative products and innovation in the rural areas. In the ODOI program, Craft Products Cluster are covering the production and manufacturing the local craft products that were made out of local resources and skills. In summary, this study aims to identify the tensile strength comparison between banana stem and bamboo culm fibres. The test result would recommend which materials that can be considered in the development of craft products or any other viable products.

Methods and Processes

Each type of fibres will be obtained through the same process starting with crashing banana stem and bamboo culm into pieces separately. Then the chopped banana stem and bamboo will be soaked in a separate container with water in order to make it softer. A holander beater machine was used to prepare fine fibres as how as the handmade papers are made. The process of refining one kilogram of fibres will take about three to four hours.

Plate 1. The preparation of fine fibres for molding process.

After the refinement process, fibres will be left dampened and mixed 1 litre of methylcellulose that was blended with water in the earlier process. Not too much of it but only five to eight percent of the total fibre mixture. According to Fan, Dai and Huang (2012), the main composition of lignocellulosic fibres are cellulose, hemicellulose and lignin, while the minor constituents such as minerals, pectin, waxes and water-soluble components. Although lignin is present especially in the banana fibres but by adding small amount of methylcellulose will strengthening the structure.

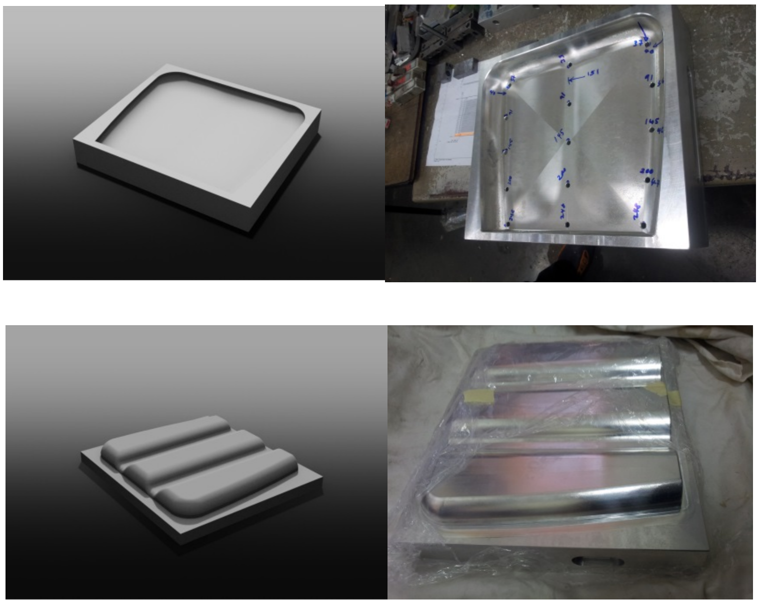

Plate 2. Preparation of the aluminium mold using 3D software called Inventor and fabricated using milling machine.

Plate 2, shows a picture of how the provision of an aluminium mold from 3D software to the milling machines for fabrication. On the right are pictures of the result from the fabrication process. Through holes were drilled for the purpose of draining the excess fluid and this also to facilitate the process of drying.

Plate 3. Fibres are compressed and proceeded through the drying process.

Plate 3, demonstrates how fibres are compressed into the aluminium mold using a hydraulic compressor. This compression will remove excess fluid from the moist fibres. After almost all the excess liquid out of through the drain holes provided in the mold, the test material will be placed in the oven with the temperature control to 35 degrees Celsius for 12 hours. It cannot be too high because it can lead to uneven shrinkage and it is easy to get warped. The design of the mold has not considered adding more ribs to the molded artefact. This is due to the tensile strength test need a flat surface with certain dimension.

Tensile Strength Test

The dried sample material has to be cut to specific size for measuring the tensile strength at the Instron machine. The study was conducted on a universal testing machine (Instron) under axial loading. Averages of three measurements were taken for each specimen pieces of fibres. Samples of fibre pieces are placed carefully in the middle of the cross-head with its end facing exactly perpendicular to the longitudinal axis to obtain accurate results. This process is usually carried out at crosshead speed of 2mm/min continuously (Verma, Chariar & Purohit 2012). The specimen was installed and adjusted properly in the test frame. Hydraulic clutch has been used to hold the test specimen. Stress-strain curves were generated for each test specimen. The test is performed to measure the force required to break the specimen of bamboo fibres compared with banana fibres and the extent to which the specimen stretches or extended to the breaking point. Plate 4 below shows the pieces of broken fibre sheet specimens during tensile test.

Plate 4. The condition of the specimens before and after the tensile test.

The use of laboratory tensile strength testing of this material is restricted to the tensile properties of the polymer. This test is a method that is damaging or destructive, standard shape and size of the specimens prepared in accordance with the ASTM D 638 standard test method for tensile properties of plastics. There are five types of curves; i) soft and weak, ii) soft and tough, iii) hard and brittle, iv) a hard and tough and v) is rigid. Material properties on tensile strength that are generally either from a brittle material to a stronger character or from brittle to a flexible type as an elastic strength.

No.	Width (mm)	Thickness (mm)	Max. Load (N)	Tensile Strength (MPa)	Elastic modulus (MPa)	Elongation@Break (%)	Energy
1(A)	20	5.5	252.125	2.292	144.775	2.283	45.044
2(B)	20	5.5	266.339	2.421	96.660	3.282	69.035
3(C)	20	5.5	240.989	2.191	113.866	3.626	71.558
4(D)	20	5.5	312.247	2.839	100.824	3.734	94.507
5(E)	20	5.5	274.865	2.499	77.976	3.915	88.690
Avg.	20	5.5	269.313	2.448	-	-	-

Figure 1. Results of tensile tests on five bamboo fibres specimens A, B, C, D and E.

Five specimens of bamboo fibre were tested and the results are as shown in Figure 1. Each specimen bamboo fibres has the ability of matching with a maximum load of 252N to 312N and strength is between 2,292 MPa to 2.839Mpa. These materials are classified as soft and weak when compared with harder materials such as wood (teak wood), which on average have a strength between 95-155Mpa (Verma, Chariar & Purohit 2012). The maximum load is reached, after the failure of the matrix and fibre failure occurs. Each bamboo fibre specimen has a reading of elastic modulus between 77Mpa to 100Mpa. The test is based on the size of the specimen that is 20mm wide and with a thickness of 5mm.

No.	Width (mm)	Thickness (mm)	Max. Load (N)	Tensile Strength (MPa)	Elastic modulus (MPa)	Elongation@Break (%)	Energy
1 (A)	20	3.5	482.841	6.898	299.941	3.097	120.107
2 (B)	20	4.5	477.956	5.311	241.492	2.906	101.710
3 (C)	20	3.5	399.468	5.707	311.874	2.391	70.649
Avg.	20	3.8	453.421	5.972	-	-	-

Figure 2. Results of tensile tests on three banana fibres specimens A, B and C.

Three specimens of banana fibres were tested and the results are as shown in Figure 2. Each specimen of banana fibres have the capability of matching with maximum load ranging between 482N to 399N and the strength is between 5.7Mpa to 6.9Mpa. With this achievement banana stem fibre material is also very similar to bamboo fibre material but has a slight edge strength. It is also classified as soft and weak. Each banana fibres specimen has its elastic modulus readings between 241Mpa to 311Mpa.

Conclusion

This study roughly confirms the strength of two types of fibres. Apparently specimen of banana stem fibre material is stronger than bamboo fibre material by tensile test. One possible reason is because banana fibres producing its own lignin. Lignin is not examined in this study. Lignin also play a role as fibre reinforcement. From this study we believe that a product can be produced according to the strength that corresponds to the function. It was a good exposure on the methods of preparation and the understanding of natural fibres and their relation to reconstruction technology and, product design and development. The nature of both natural fibres and composite connection might provide a suitable product. Further research on chemical composition, microstructure, architecture and characterization of fibre surface can be explored in relation to craft product development for sustainable rural manufacturing industry.

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