DECOMP.PRO

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ABSTRACT

Solid waste is known as any material that is unwanted or discarded once they have been consumed. Usually the leftover has little or no economic value to the user and thus went for disposal. Malaysia is facing critical issues for siting of solid waste disposal site due to exponential increase of solid waste generation. Agricultural waste largely from massive plantation activity is considered as one of the contributors in generating waste. Palm, coconut and banana stem fibers can be diverted and used as starter in matrix polymer composites (PMC) preparation. These materials were chosen and mixed with resin or polymer matrix in composite production and widely applied in the automotive and furniture manufacturing industries. The study of composites has long been carried out and is still ongoing to achieve the ideal properties of composites such as light and high durability. In this study, selected fibers were immersed in NaOH for 24 hours to remove impurities and lignin content. Resin composition is constant while oil palm fiber, coconut fiber and banana stem fibers are varied by 25%, 35% and 50% quantities compared to resin weight. The resins chosen are of the Epoxy type in the preparation of composites through hand coating methods. Test specimens performed were from bending tests. Test results showed that 25%, 35% and 50% composite mechanical properties resulted in bending strength of 41.05 N / mm2, 50.24 N / mm and 52.27 N / mm2 respectively. The findings showed that there was an increase in bending strength with the increase in the quantity of fiber from palm tree (fruit bunch), coconut shell, coconut fiber and banana stem fibers.

Keywords: composite, resin, palm, banana, coconut, fiber

1. Introduction

Composite is a material consists of two or more ingredients mixed with different chemical and physical properties which result in a new substance that has different properties with its compounding materials. One of common materials used as composite materials is solid fibers including fiberglass, kevlar or carbon fiber that provide exerted tensile strength, while other materials of matrix are usually a type of fibrous material such as polyester or epoxy that holds the fibers and makes the material hard and solid.

There are two types of compiler, namely matrix and fiber. Both substances that exerted different properties by which combining them both will obtain a new material ie composites having different properties of the (Gibson, 1994). Both compilers having different functions in which fiber work as framing material that composes composites while the matrix serves to bind the fiber and keep it in order from deformed. Mixture of fiber and the matrix will produce hard, strong and lightweight material. Fiber is easy to be altered either by cutting or print in accordance with its design requirements. In addition, the difference in fiber arrangement will determine the composite properties.

In addition to the ease of designing composites in any form, one of the main reasons for the use of composite materials is produce high material strength with lightweight than conventional materials. Composite materials are usually applicable to be used in construction of buildings, bridges and structures such as boating bodies, pool panels, racing car bodies, storage tanks, man-made granite, sinks and artificial marble table layers. The most advanced results are commonly used in spacecraft in a burdensome environment.

According to Jacobs (2005), a composite material is a complex material where composite of two or more materials are combined or merged simultaneously at a macroscopic scale to form a useful product which has better quality. The aadmixture is usually elastic and has good tensile strength but could not be used at high temperatures, while the matrix is usually resilient and binding if it reaches its freezing point. Both substances are combined to obtain a new material, example composites having different properties. When the composite formed, an interphase which also known as phase between the matrix phase and the add mixture that can be produced due to the chemical reaction between the matrix phase and the amplifier phase. Figure 1 shows the phase in the composite.

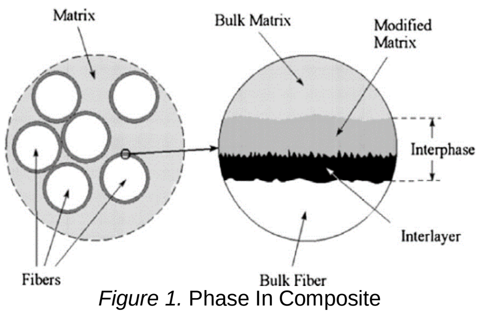

Figure 1. Phase In Composite

1.1. Structure of Composite

Based on the structure, composites are classified into 3 types, namely fiber composite (Fibrous composite), laminated composites, particle composites (Particulate composite).

1.1.1. Composite Fibers (Fibrous Composites)

Composite fibers are the type of composite that uses fiber as its reinforcing agent. In the manufacture of composites, fibers can be arranged elongated (unidirectional composites) or can be cut and then arranged randomly (random fibers) and also can be woven (cross-ply laminate). Composite fibers are often used in the automotive and aeronautical industries (Schwartz, 1997). Figure. 2 shows the composite structure of the fiber type.

Figure 2. Fibre Type Composite

1.1.2. Composite Coating (Laminar Composite)

Laminar composites are composites with two or more layers of arrangement, where each layer differs in terms of material, shape and orientation strengthening (Schwartz, 1997). Figure 3 shows the composite structure of the coating type.

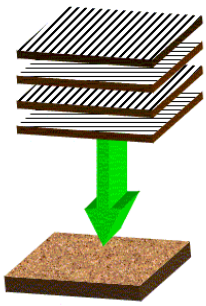

Figure 3. Layer Composite

1.1.3. Particle Compositions, (Particulalate Composites)

It is a composite that uses particles or powder as its amplifier and its distribution evenly within the matrix. Figure 4 shows a composite structure of a particle type.

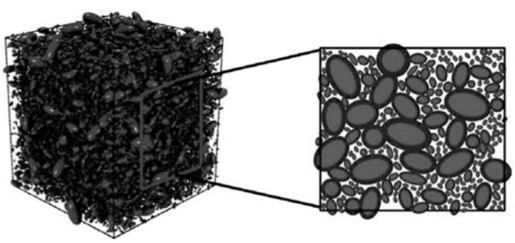

Figure 4. Particle Composite

1.2. Nature Fibers

Natural fibers are originating from nature (not artificial or human designs) as shown in Figure 5 Natural fibers are usually found from plant fibers such as bamboo fiber, banana tree fibers, pineapple fiber, coconut fiber fibers and so on. Usually before being used in composite production, natural fibers are cleaned first using chemical liquid such as NaOH 5% for 2 hours (Jamasri, 2005). It aims to reduce the water content and lignin in the fibers and result in a rough surface thus increasing the bonding with the matrix used.

Research and use of natural fibers are growing rapidly because many natural fibers have advantages over artificial fibers (synthetic) as lighter weight, can be processed naturally and environmentally friendly. Natural fibers are also the newest material and have relatively high strength and stiffness and do not cause skin effects (Oksman, 2003).

Another advantage is the quality can be varied and low heat stability. The most prominent feature of natural fibers is this material is readily available. This advantage causes many researchers to be interested in researching and developing the use of natural fibers. In addition to these advantages, natural fibers also have many disadvantages such as irregular dimensions, stiff, heat-resistant, easily absorbed water and sooner (Brahmakumar, 2005).

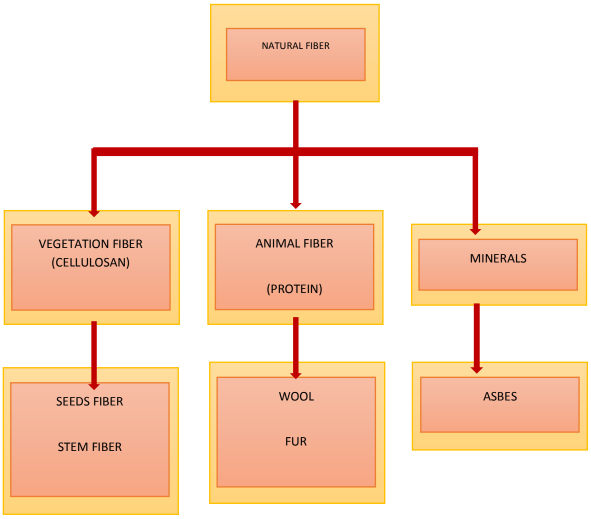

Figure 5. Natural Fiber Category

1.3. Banana Stems, Coconut Shell and Empty Fruit Bunch Fibers

Banana stems are the remains of bananas that have been chopped to harvest the fruit and have not been utilized much. Several studies have been carried out to make use of it such as for the production of particle board and fiberboard. Banana stem fibers are of good quality fiber and are one of the alternative materials that can be used as a filler in composite making process. The banana stem fiber chemical composition is shown in Table 1 as quoted from Building Material and Technology Promotion Council.

Table1. Chemical Composition Of Banana Stem Fiber

Komposisi Kimia	Kandungan (%)
Lignin	5-10
Selulosa	60-65
Hemiselulosa	6-8
Air	10-15

(sumber : *Building Material and Technology Promotion Council*)

The empty fruit bunch (EFB) is a collection of fibers left after separating the fruits from sterilized fresh fruit bunches (with evaporation at 294 kPa for 1 hour) [2]. EFB is relatively cheap, decomposable, non-toxic and are widely used in natural fibers. EFB also known as materials that contain thick and rough filaments. It makes the EFB more effective than non-renewable industrial materials, harmful to health and the environment, and expensive for small-scale production. EFB is used as a raw material for various applications including power generation and composite formulations.

Meanwhile, coconut fiber is usually employed in small household ware such as brooms, ropes and home appliances. Generally, coconut fiber has been widely used in a simple product manufacturing such as during mattress making industry, panel materials replace the compressed wood and so on.

1.4. Matrix

The matrix in the composite functions as a binding material into a structural unit, protects from external destruction, resumes or transfers external loads on the fibers and matrices, so that the matrix and fiber are interconnected. Composite based matrix has 3 types: MMC: Metal Matrix Composite (using metal matrix), CMC: Ceramic Matrix Composite (using ceramic matrix), PMC: Polymer Matrix Composite (using polymer matrix).

MMC: Metal Matrix Composite (using metal matrix) is a composite that uses metal as a matrix. This composite is widely used in the automotive industry. For example, the manufacture of a car piston.

CMC: Ceramic Matrix Composite (using ceramic matrix). This composite uses ceramic as a matrix or resin. CMC is a 2 phase material with 1 phase function as fiber and 1 phase as a matrix, where the matrix is made of ceramic. Examples of ceramic materials are oxide, carbide, nitride.

PMC: Polymer Matrix Composite (using polymer). This composite uses a resin as a matrix and fiber as its amplifier. The polymer matrix can be classified into two thermoplastics and thermosets. Some types of thermoset polymer matrices that are often used are polyester, epoxy, phenolics, and polyamids while those that include thermoplast polymer matrices are polyethylene, polypropylene, nylon, polycarbonate and polyether-ether ketones. The properties of thermoset polymers are hard and rigid (not flexible), if they are heated to harden, irreversible, insoluble in any solution, if the heated will melt, having a cross between the molecular chain. In this study the matrix used is the type of epoxy resin. The word "data" is plural, not singular.

1.5. Epoxy Resin

Epoxy resins are one of the thermoset polymers. Thermoset resin is usually liquid or solid liquid low point in its original form. This resin will switch to a solid stiff solid through a curing process involving the addition of a hardener agent. Once matured, the resin can no longer be diluted and re-molded or processed once again through heating. Epoxy is used in conjunction with a 5: 1 to 1: 1 ratio depending on the type and use of the resin.

2. Method

2.1. Participants and procedure

The manufacturing process of composite materials can generally be divided into two main methods of open molds and closed molds. The selection of this fabrication method depends on the structure to be constructed and the scale of the production. Basically, open methods such as Hands Lay - up do not require sophisticated and expensive craft tools or tools. The required mold does not require a high cost in the manufacturing process.

This study produced three different composite samples of banana stem fiber quantities. Composition of epoxy matrix is fixed while banana stem fibers are varied by 25%, 35% and 50% quantities compared to the weight of the matrix. Figure 6 illustrates the overall process of the study.

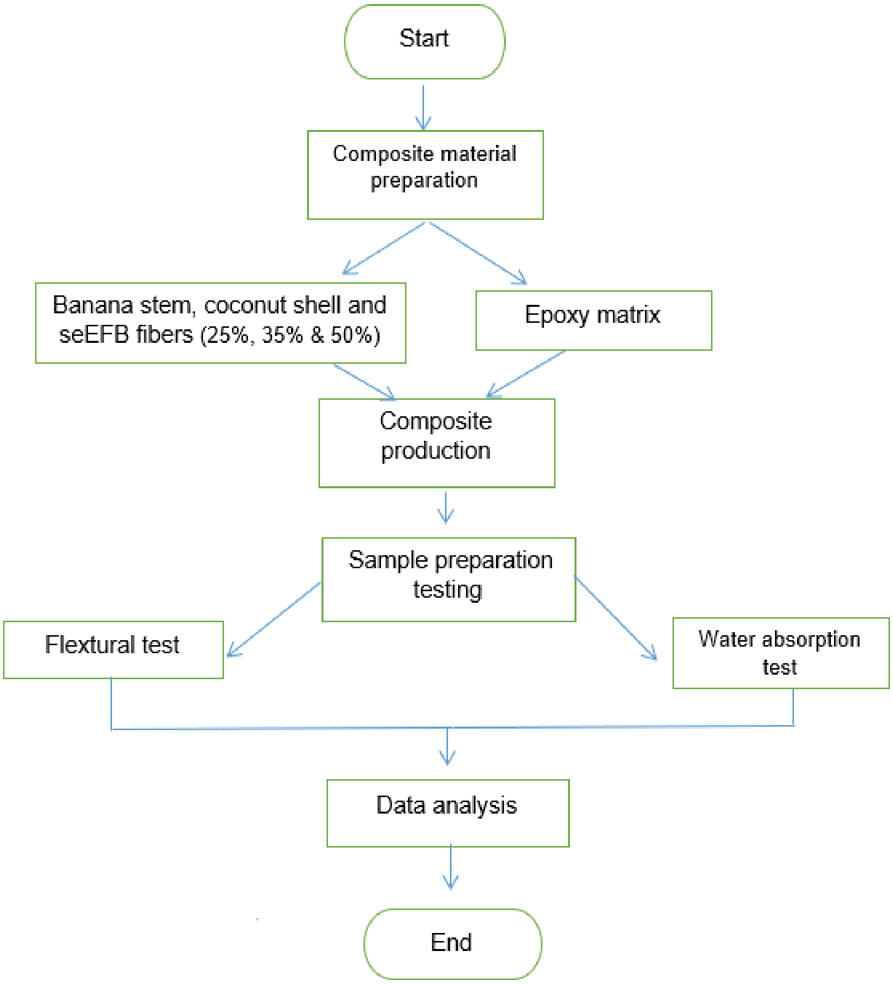

Figure 6. Flow Chart Of Research Methodology

2.2.1. Composite Production Process

The composite production process involves 3 steps which are preparation stages, fiber preparation stage and preparation of epoxy blends.

The 300mm x 200mm x 10mm steel frame is used as a composite mold as shown in Figure 7. This frame is placed on a mosaic or plywood that has a flat surface. Clay blend is attached to each outer space of the frame so that the epoxy fluid does not come out during hardening. Wax or mold releases are first applied to the inside of the frame and left for about 5 minutes for easy removal.

Figure 7. Composite Mold

Preparation of banana stems, coconut shell fiber, and EFB fiber only involves fibrous parts only. They were immersed in alkaline NaOH (Sodium hydroxide) solution of 5% for 24 hours to remove lignin and dirt. Then they were air dried. Figure 8 shows the fiber that can be used in composite production

Figure 8. Fiber Ready for Composite Production

Epoxy is used with admixture by using a ratio of 2: 1 and stirred until it is mixed. Figure 9 shows the epoxy mixtures with the weighing screws to facilitate the mix of fibers of varying quantities based on the weight of the matrix.

Figure 9. Epoxy

Then the mixture was poured into the prepared container. 25% of the banana stem fiber was added to the mixture. This process is repeated for 35% and 50% banana stem fibers. Figure 10 shows 3 completed composite samples

Figure10. Banana Stem Fiber Composite

2.2. Testing procedure

The test was a mechanical test called which was flexural test and water absorption test. The flexural test was done using the INSTRON 5582 model engine. Three samples having 150mm x 25mm dimension each. Figure 11 shows the samples tested for bending tests. The support span of the support span is 150 mm. Bending stress calculation using the following formula:

$$\text{Bending Stress} = \frac{1.5PL}{bd^2}$$

Where,
- P - maximum load
- L - the range of the sample
- b - sample width
- d - thick sample

Figure 11. Bending Tests

The sample preparation for the Water Absorption Test is shown in Figure 12. Three samples were made for each composite dimension of 25mm x 25mm each. Samples were immersed in distilled water for 24 hours at room temperature. Calculate the percentage of water absorption using the following formula:

$$\text{Water Absorption} = \frac{(W_t - W_0)}{W_0} \times 100\%$$

Where,
- W_t - mass after immersion,
- W_o - mass before immersion.

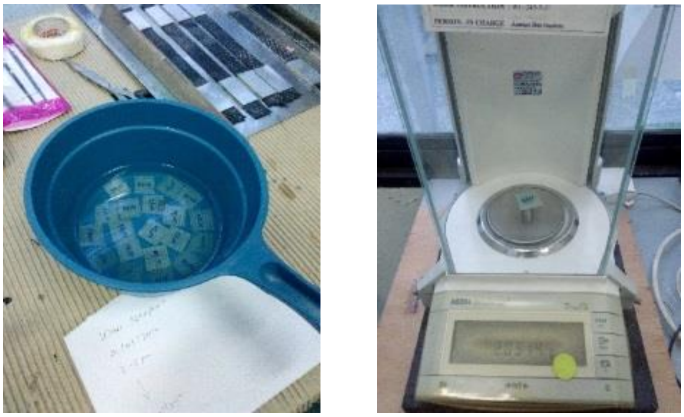

Figure 12. Water Absorption Test

3. Results

Mechanical test results are summarized as shown in Table 2(a, b & c) for flextural tests. Table 3 (a, b & c) summarized the result for water absorption test.

Table 2 (a). Flexural Test Result (Efb Fibers)

Composite sample	Length (mm)	Width (mm)	Max load (N)	Max flexural value (N/mm^2)
25 % fiber	200	150	223.52	43.05
35 % fiber	200	150	273.53	51.24
50 % fiber	200	150	284.59	53.27

Table 3 (a). Water Absorption Test Results (Efb Fiber)

Composite sample	Initial mass W_o (g)	Final mass W_t (g)	Water absorption (%)
25 % fiber	4.6502	4.6561	0.15
35 % fiber	4.5629	4.5833	0.42
50 % fiber	4.6602	4.7088	1.07

Table 2(b). Flexural Test Result (Banana Stem Fibers)

Composite sample	Length (mm)	Width (mm)	Max load (N)	Max flexural value (N/mm^2)
25 % fiber	200	150	223.52	41.05
35 % fiber	200	150	273.53	50.24
50 % fiber	200	150	284.59	52.27

Table 3(b). Water Absorption Test Results (Banana Stem Fibers)

Composite sample	Initial mass W_o (g)	Final mass W_t (g)	Water absorption (%)
25 % fiber	4.6502	4.6561	0.13
35 % fiber	4.5629	4.5833	0.45
50 % fiber	4.6602	4.7088	1.04

Table 2(c). Flexural Test Result (Coconut Shell Fiber)

Composite sample	Length (mm)	Width (mm)	Max load (N)	Max flexural value (N/mm^2)
25 % fiber	200	150	223.52	40.26
35 % fiber	200	150	273.53	48.55
50 % fiber	200	150	284.59	50.40

Table 3(c). Water Absorption Test Result (Coconut Shell Fiber)

Composite sample	Initial mass W_o (g)	Final mass W_t (g)	Water absorption (%)
25 % fiber	4.6502	4.6561	0.10
35 % fiber	4.5629	4.5833	0.39
50 % fiber	4.6602	4.7088	1.01

4. Discussion

Figure 2 shows the bar chart for flexural test. From the chart, the bending stress is increasing if the banana stem fiber content in the composite increases. Test results showed that 25%, 35% and 50% composite mechanical properties as shown in Table. 2. In addition, the epoxy matrix also serves to distribute the external load to the fiber material. The combination of these materials have increased the bending stress of the composite. However, the bending stress increase for 50% fiber composites is small (see Table. 3). The increase in banana stem fiber were found to reduce the content of the epoxy matrix that acts as a fiber material. Therefore, the increase of fiber over 50% is likely to reduce bending stress.

Figure 3 shows the water absorption percentage bar of water absorption test. From the chart illustrates the percentage of water absorption rates for composite 25% and 35% fiber not exceeding 0.5%. While the percentage of water absorption of 50% fiber composites increased significantly to 1.04%. It shows that the use of epoxy resins as a matrix can protect and prevent banana stem fibers from absorbing much water. Water absorption will decrease if the percentage of epoxy matrix content is increased. Because the compression method is made manually, the percentage of compression strength should be taken into account.

5. Conclusion

Overall, the result of the study found that 50% fiber composite had the highest bending rate of 53.27N / mm^2. So it can be concluded that the composite specimens with 50% epoxy matrix and 50% banana stem fibers are the best composite mixtures for flexural tests. A high bending stress value increases the strength if there is an external force acting on the composite. Bending stresses are increasing with the increase of banana stem fiber content. The bending stress increase is decreasing for 50% fiber content. Therefore, with the increase in fiber does not guarantee continuous bending stress increase.

The percentage of water absorption of 25% fiber is the lowest of 0.10%. The low percentage of water absorption is due to higher epoxy polymer content than banana stems. This means that the higher the percentage of fiber used the more water is absorbed into the composite panel. Low water absorption is very good for the composite panel as it can prevent panels from being quickly damaged.

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