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The characterization of mechanical property and fatigue life of betel-falm fiber composite as environmentally-friendly material

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Abstract. Composites with natural fiber reinforcement have good potential to be developed. Natural fibers such as: palm fiber, coconut fiber and other natural fibers as a nonconventional and environmentally friendly material have not been studied completely yet. This research is to characterize the mechanical properties of betel-palm fiber as reinforcement in composite material. One of the most common ways of increasing composite properties is by performing chemical treatments, such as alkali (NaOH) to fiber. The method of this research was conducted experimentally to find out the mechanical properties of the composite, Tension test and Charpy-impact test were conducted to the specimens in order to get the tensile strength value and impact energy respectively. The tests were conducted either without alkali treatment or with alkali treatment. The fibers were treated with NaOH 2%, 3%, 4%, 5%, 6% and 7% were soaked for 2 hours. Than the specimens were cleaned by using water and dried naturally. The composite volume fraction used 10% fiber and 90% polyester resin. The results of the test obtained showed the tensile stress and the largest composite tensile strain are 0.6276 kg/mm2 and 2.271% in a 5% NaOH bath for 2 hours. The highest value of the impact strength of 10.9303 Joule was found out in the treatment of 5% alkali (NaOH).

1. Introduction

The need for new materials as a better substitute material encourages the development of technology in the field of materials. Non-metallic materials have advantages that are difficult to obtain from metal materials. Among them are light, corrosion-resistant and economical. Nonetheless non-metallic materials also have a deficiency that is not strong, cannot stand the high temperature and others. With these advantages and disadvantages, the composite is designated as an alternative new material.

The composite based on the reinforcing material is divided into two composites with artificial amplifier and composite with natural material reinforcement. The use of composites with synthetic amplifier is still considered expensive and less environmentally friendly. While the composite natural materials are judged to produce composite materials that are lightweight, strong, environmentally friendly and economical. Although easy to obtain, natural fibers also have a deficiency of unequal strength. Various studies have been done to increase composite strength with natural fiber reinforcement. One way is to improve mechanical bonding with chemical treatment, either to the fiber and to the matrix. Kuncoro Diharjo's study, showed a change in tensile strength between composites and chemically treated fibers and without chemical treatment [1].

This study uses chemical treatments with alkali treatments such as NaOH, because it is more economical. From this research can be known how the tensile strength and impact strength of composite betel nut fiber both without treatment and treatment of NaOH. This study also aims at how the effect of NaOH treatment on tensile strength and compact impact strength. And can be used as research material next.

Initial research conducted by Mukarromi [2], betel nut fiber has an average tensile stress (σ) of 98.914 MPa and an average tensile strain of 5%. Alkali treatment (NaOH) with a percentage of solution that is too high causes the cellulose structure on the surface of the fibers to become rough and porous. Damage to the surface of the fibers results from the dissolution of cellulose on the surface of the fibers into the NaOH solution. The chemical composition of the betel nut fiber as shown in Table 1.

Table 1. Chemical composition [3]

Composition	Persentase (%)
Selulosa	35,91
Hemiselulosa	26,60
Lignin	16,60
Water	11,7
Ash	9,19

2. Materials and Methods

Porang lining fiber is achieved from around Indralaya District Ogan Ilir South Sumatra. The fiber is taken from the betel nut which falls from the pinang tree that is more than 2 years old. The midrib is cut with a length of ± 40 cm. Soaked for 1 x 24 hours to easily get the fiber. After the fibers are taken from the midrib, dried in the sun. Made ready areca nuts 7 different types of treatment. Namely without treatment and betel nut fibers soaked in glass covered glass in each of 2%, 3%, 4%, 5%, 6% and 7% NaOH for 2 hours. For the matrix use polyester resin. With a volume fraction of 10% fiber and 90% polyester resin. The manufacture of tensile test specimens requires a fiber length of 200 mm, a width of 20 mm and a height of 20 mm. While for long impact test specimens E 23-88

Figure 1. Betel-falm tree [4]

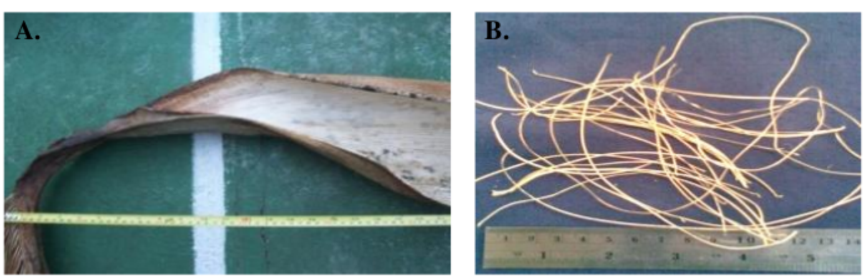

Figure 2. A. Leaf of betel-falm on dry condition, B. Fiber of betel-falm

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3. Result

Tensile tests were performed using only 80 mm, 20 mm wide and 20 high. The composite is made by using a mold of glass. After hardening approximately 2 x 24 hours, the specimen is removed from the mold. For the specimen the tensile test of the specimen is cut by using a small saw and refined using a sand paper. The specimens refer to ASTM D 638-90 standard. While specimens of impact test were formed referring to ASTM standard Universal Testing Machine type RAT-30P. Testing impact by using Charpy Impact Testing Machine with ASTM E 23-88 standard with hammer lift angle $\alpha = 90^{o}$. All specimens were tested at room temperature.

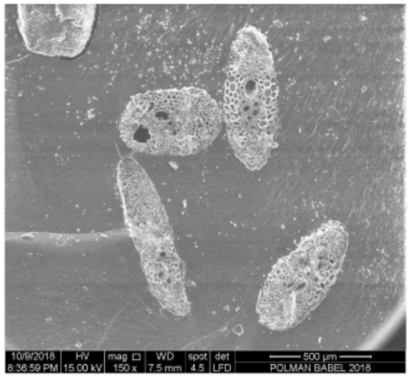

Figure 3. SEM result of Betel-Palm in 500 µm

3.1. Tension Test

Based on the tensile load versus the length increase can be calculated where the composite material is assumed to be a fiber bond and a perfect matrix. The shift between fiber and matrix is considered absent and fiber deformation is equal to matrix deformation (homogeneous). So it can use equation [5]:

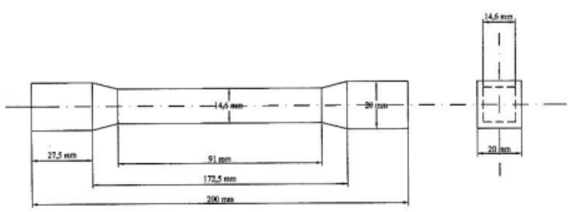

Figure 4. Specimen standar of ASTM 638-90

$$\sigma = P/A \tag{1}$$

$$\varepsilon = \Delta l/l \tag{2}$$

Where, σ as tensile strength in MPa, ε tensile strain, P load in N and l the initial length of rod.The result of tensile test can be seen in Table 2. Based on Table 2. and Figure 1. and Figure 2. The tensile stress and tensile strain most optimum are owned by composite fiber-pressed betel nut with alkaline treatment of 5% immersion for 2 hours.

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Table 2. Tensile strength and tensile strain

Alkali Treatment (NaOH)	Tensile strength (kgf/mm^2)	Tensile strain (%)
0%	0,4898	0,439
2%	0,5002	0,842
3%	0,5490	1,318
4%	0,5850	1,538
5%	0,6276	2,271
6%	0,5255	1,209
7%	0,5077	1,025

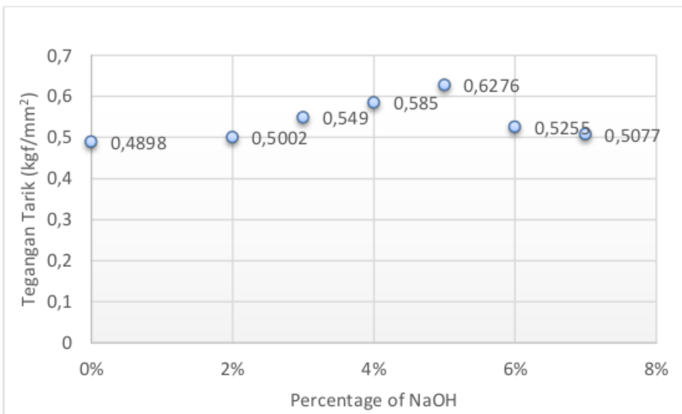

Figure 5. The relationship of tensile stress with percentage of NaOH treatment at 2 hours of immersion

The relationship of tensile stress and the percentage of alkali treatment for the duration of immersion for two hours is shown in Figure 2.

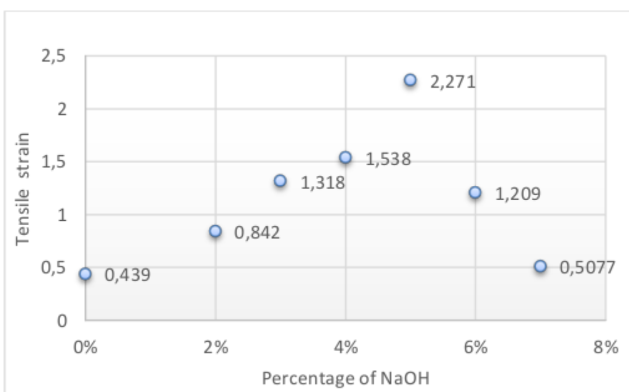

Figure 6. The relationship of tensile strain with percentage of NaOH treatment at 2 hours of immersion

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3.2. Impact Test

Impact strength or impact energy can be measured using the formula as follow :

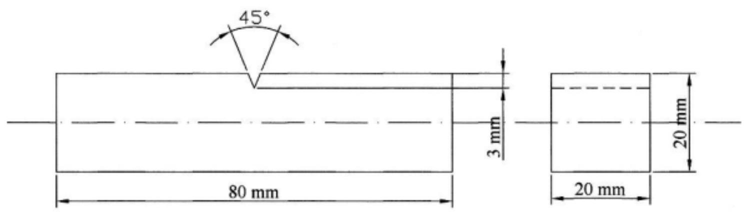

Figure 7. Impact standar ASTM E 23-88

$$E = E_1 - E_2 \quad (3)$$

According to value angle of hammer, is obtained:

$$E_1 = P\left(D - D\cos\alpha\right) \quad (4)$$

$$E_2 = P\left(D - D\cos\beta\right) \quad (5)$$

where :

E_1 = The potential energy is held at the lifting angle α of the hammer

E_2 = The position of energy held in the swing angle β from the hammer

P = Hammer weight (25,68 kg)

α = Angle lift hammer (90º)

β = Swing angle after hammer about the specimen

D = The distance from the center of the hammer axis to the center (0,6490 m)

Tabel 3. Impact Energy

Alkali Treatment (NaOH)	Impact Energy (Joule)
0%	1,9022
2%	4,7528
3%	6,6564
4%	9,0313
5%	10,9303
6%	8,5564
7%	3,8340

Impact energy relationship with percentage of NaOH treatment at the immersion time From Table 3 and Figure 3 above the highest impact energy is 10.9303 Joule at 5% NaOH for 2 hours of immersion.

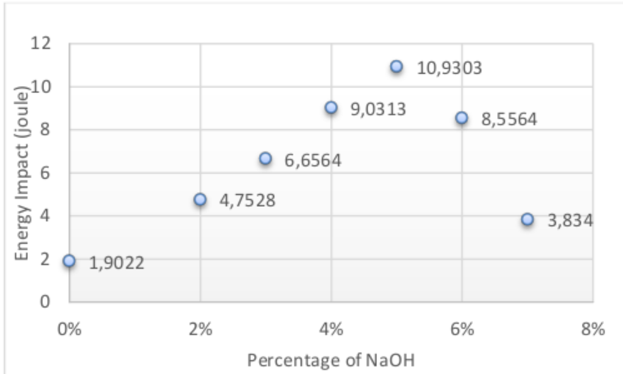

Figure 8. Result of impact test

3.3. Three point bending fatigue test

Table 4. Result of fatigue cycle

No	Specimen	Cycle
1	10% fiber + 90% resin polyester	54
2	12.5% fiber + 87.5% resin polyester	88
3	15% fiber + 85% resin polyester	138
4	17.5% fiber + 82.5% resin polyester	234
5	20% fiber + 80% resin polyester	364

4. Conclusion

The results of this study can be summarized as follows: 1. Composites that have betel nut fiber with 5% NaOH treatment for 2 hours have the largest tensile stress that is 0.6276 and the largest tensile strain is 2,271%. 2. Maximum impact strength occurs in fibers with 5% NaOH treatment of 10.9303 Joule. 3. Fault composite with betel nut without treatment and treatment with percentage of NaOH for 2 hours can be broken brittle. 4. The decrease in strength is due to damage to the cellulose structure on the fiber surface so that the fibers become more brittle.

References

[1] Diharjo K 2008 Pengaruh Perlakuan Alkali Terhadap Sifat Tarik Bahan Komposit Fiber Rami-Polyester
[2] Mukarromi 2009 Pengaruh Pelakuan Alkali (NaOH) Terhadap Kekuatan Tarik Serat Pinang
[3] Lai W and Mariatti M 2008 The Properties of Woven Betel Palm (Area catechu) Reinforced Polyester Composites
[4] Wikipedia 2008 Areca catechu
[5] SCHWARTZ M M 2002 Composite Materials Handbook

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