

26._Q3._ZULKIFLI_DJAFAR- ILHAMZAH.pdf

by

FILE	26._Q3._ZULKIFLI_DJAFAR-ILHAMZAH.PDF (1.66M)	WORD COUNT	2807
TIME SUBMITTED	05-SEP-2020 10:48PM (UTC+0700)	CHARACTER COUNT	14471
SUBMISSION ID	1380253883		

 Technical Report

Special articles: JCREN I

特集: JCREN I

Effect of Seawater Immersion on Impact Strength of Composites Reinforced Ramie Fiber

Zulkifli DJAFAR[†], ILHAMZAH, and Ilyas RENRENG

(Received November 20, 2019)

Composites have absorption properties, namely the ability to absorb water at a specific time. The nature of absorption is a problem because this can reduce the mechanical strength of composites. This study aims to determine the effect of seawater immersion on the impact strength of the composite. The composites used are made of epoxy resin as matrices and ramie fiber as reinforcement. Variation in the orientation of the fibers is given, i.e., continuous and woven fibers. Ramie fiber composites are expected to be able to provide consideration for the primary raw material for shipbuilding so that the composite is carried out on a scale-scale seawater immersion to determine the effect of immersion on impact strength, and immersion is carried out for 0, 2, 4, 6, 8 and 10 weeks. Impact strength testing refers to the ASTM D 5942-96 standard. The results obtained show that the impact strength of unidirectional ramie fiber composites decreased by 30.76% and stronger than ramie's woven strength composites which decreased by 17.08%. Still, the impact strength on unidirectional ramie fiber composites (150.14 kJ/m²) is more when compared to ramie woven composites (83.26 kJ/m²).

 Key Words

Natural Fibre, Water absorption, Ramie composite, Seawater immersion, Impact strength

1. Introduction

Ramie plant (*Boehmeria nivea*) is a plant that has a very high cellulose content. However, until now its use has only been limited to making cloth and paper. Ramie fiber can be used for composite materials in many applications such as the shipyard industry as a substitute for synthetic fibers. Utilization of composite materials reinforced with ramie fiber in the seawater environment, especially for ship applications, has bright potential in the future. It can empower natural potential by developing ramie fiber as a shipyard material. Ramie fiber has hydrophilic properties so that the potential exists for dimensional instability in the fiber if it is immersed in water for a long time. The reason is that water will fill the pores of the fiber because of the chemical bonds in the cellulose fiber molecules. The strong bond between the fiber and the matrix is an essential factor for ramie fiber as a reinforcement of composite materials. The resistance of ramie fiber composites in the seawater environment has an important role, especially in the shipping industry¹. Water absorption in composite materials

is the ability of composites to absorb water vapor within a specific time. Water absorption is very influential on weak interface bonding and decreasing material mechanical properties.

Resistance to water absorption in natural fiber-reinforced composites can be improved by modifying the fiber surface. Decreased mechanical properties of composite materials due to immersion, occurs because the density and chemical content absorbed by the specimen will weaken the bonding of the interface (debonding) and cause the appearance of micro cracks that have the potential to affect larger pore sizes. This will cause the energy absorbed by the test specimen to lessen and affect the decreasing mechanical properties of the composite material². Gibson³ states that a composite is a compound of two or more materials in structural units and has a combining of properties of the constituent materials. Length of soaking fiber can cause damage to the binding cells on the surface of the fiber. The increased mechanical properties which are directly proportional to the increase in the volume fraction of the fiber shows that the fiber plays an essential role in holding the load on the material⁴.

 Department of Mechanical Engineering, Universitas Hasanuddin

[†] Corresponding author: zulkiflidjafar65@gmail.com

The use of composites in marine applications has been widely carried out. There are two main advantages of composite polymers than metal materials that are resistant to the marine environment, especially reducing galvanic corrosion, and composite polymers have better strength to weight ratios⁵. The use of polymers in marine applications generally uses resins that cure at room temperature, thereby reducing fabrication costs. The resin functions as a binder and protector for the fiber so that it can reduce the occurrence of blisters⁶. Although rarely used in marine applications because of the very high cost and requirements, epoxy resins are still used for high-performance shipbuilding⁷. Resin epoxy for marine application is a sturdy, permanent, and waterproof adhesive. This type of epoxy resin adheres to surfaces that are plunged into the water or regularly exposed to water. Unlike other forms of resin, it can even use in the underwater and it will still cure. Marine epoxy can be used safely on a number of surfaces including, glass, metal, and wood⁸. Compared to the other resin, Epoxy is extremely resistant to moisture, and even some formulations might be applied underwater. Meanwhile, polyester resin has less moisture resistance, is considered water-permeable and can easily fracture.

In small boat construction, they are usually using glass fiber and carbon fiber as a reinforcement. But in its application, carbon fiber is rarely used because of cost factors. Carbon fiber has an additional problem because it can corrode metals that come into contact with it in the presence of water⁹. The use of these fibers is limited, not only because of the cost but also because they cannot withstand much of the burden in compression. Blistering can occur in sea gel-coated laminates. The cause is complicated, and blisters can occur due to the selection of the materials or because of the processes used in fabrication¹⁰.

Ramie fiber (*Boehmeria nivea*) is a cellulose-based natural fiber thought to originate from China. The use of this fiber has been known since 3000 BC, as raw material for rope and as a mummy wrapper in Egypt. In 1733 the ramie plant was introduced to Europe by George Boehmer of Wittenberg, a German national. About a century after ramie was introduced in Europe, in 1855, this plant began to be developed in southern America, and its use was established as a raw material for clothing in early 1911¹¹. Ramie plant is a commodity that needs to be developed. This commodity, besides producing high-quality natural fiber, also has by-products of economic value, such as decertified waste compost and the use of ramie leaves for animal feed. The new variety of Ramindo 1, previously known as Pujon 10, has long been developed by farmers and has proven its superiority both in the community and

research results. Ramindo 1 provides high fiber productivity (2-2.7 t/(ha year)) with good fiber quality and has extensive adaptability so that this variety is feasible to be developed in all types of land¹².

Widiatmoko¹³, in his research on the effect of volume fraction on the tensile strength of composites, reinforced waru bast fiber. The results of his study obtained the lowest tensile strength value at 5% volume fraction, with a value of 11.973 MPa. And for a 10% volume fraction, an amount of 12.997 MPa is obtained. The tensile test results show that the addition of a volume fraction significantly influences the tensile strength of composite materials. Based on the results of the Scanning Electron Microscope (SEM) showing fiber pull-out and voids are the main causes of composite failure¹³. In another study, Agung¹⁴ conducted research on the effect of time immersion of waru bast fiber (*Hibiscus tiliaceus*) on seawater on microstructure and tensile strength. The results of his study showed that soaking resulted in the emergence of gaps between sub-fibers and the longer soaking tensile strength decreased. Maximum tensile strength obtained by immersion for two hours at 48.35 kg/mm². The use of natural fibers as reinforcement has not been widely applied to structural parts that carry external loads, especially for shipping applications¹⁵.

In this study, researchers used ramie fiber as a composite reinforcing material with epoxy resin as a matrix, then empirically analyzed the impact strength. The results of this study are expected to be considered as the main material for shipbuilding.

2. Experimental (or Procedures)

Composite material for test specimens was made using hand lay-up techniques combined with compression molding with variations in fiber orientation, *i.e.*, continuous unidirectional ramie fiber, and woven ramie, as shown in Fig. 1. As a matrix used "Eposchon" epoxy resin produced by PT Justus Kimiaraya, Fig. 2.

Composite specimens in the form of panels with a size of 28 cm × 28 cm, with a matrix ratio of 60% resin and 40% hardener and reinforcement fibers with a weight equivalent to 5 ply woven fibers with dimensions of 25 cm × 25 cm and ply thickness 0.8 mm with average weight 85 g, which were made at the Applied Mechanics Laboratory, Hasanuddin University.

The process of making a specimen, using a mold made of steel (Fig. 3) with a pressure tool with 20 tons strength. The dies process is carried out for 8 hours 8 h, according to the epoxy resin curing time (Fig. 4). The process of making the specimen panel is based on the weight fraction where the weight of the fiber used for a

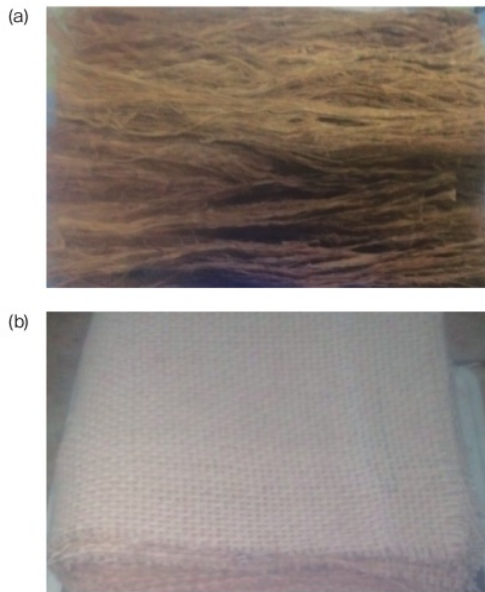


Fig. 1 (a) unidirectional fiber; (b) ramie woven



Fig. 2 Resin epoxy



Fig. 3 Pressurized composite mold

panel (unidirectional fiber and woven ramie) is the same, is the same amount of 92.5 g.

Before the seawater immersion process, the weight of the composite panel was weighed. The seawater immersion process was carried out on Barranglompo Island,

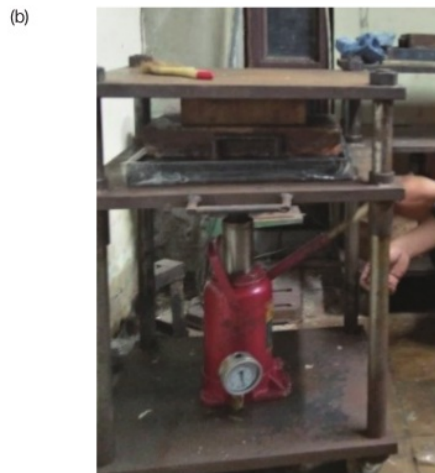


Fig. 4 (a) Making specimen; (b) Pressing process

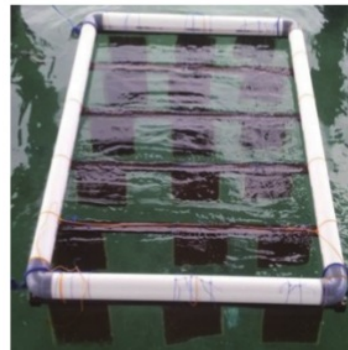


Fig. 5 Seawater immersion process

Sangkarrang District, Makassar, for 2, 4, 6, 8, and 10 weeks (Fig. 5).

Specimens that have been immersed are then weighed and followed by post curing for 2 h at 110 °C. The test specimens are then formed according to ASTM D 5942-96 standards. (Figs. 6 and 7)¹⁶⁾:

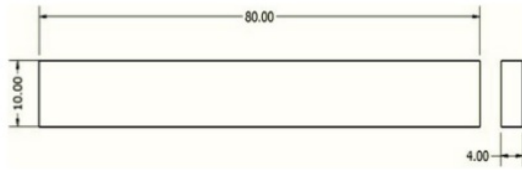


Fig. 6 Impact test specimens refer to ASTM D 5942-96

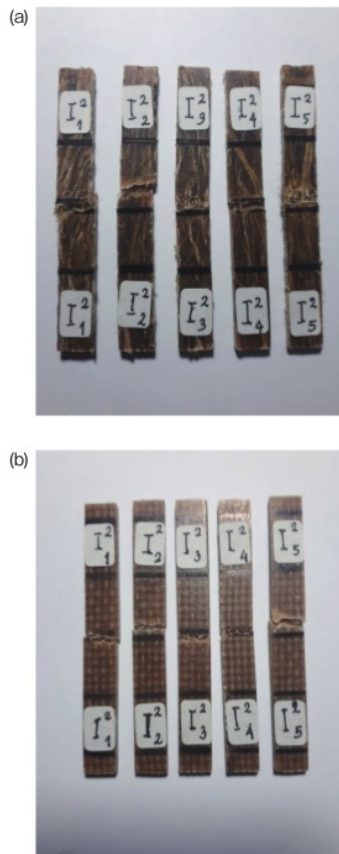


Fig. 7 Typical rupture of impact testing specimen; (a) Unidirectional, (b) Ramie woven

3. Results and Discussion

Table 1 shows the Impact test results for composites reinforced unidirectional ramie fiber.

Seawater immersion can significantly cause mechanical strength degradation in composite materials. After experiencing seawater immersion for ten weeks, there was a 30.76% decrease in strength in the unidirectional ramie fiber composites material. This decline is possibly due to the weathering of the fiber by the seawater environment. Weathering can occur due to porosity and the release of bonds between fibers and matrices. While the impact strength test results for the ramie woven composite can be seen in Table 1, there was a decrease in the impact strength on the ramie woven composite up to the 10th week by 17.08%. It can be seen that the impact of strength degradation in ramie woven, the decrease is not as sharp when compared to unidirectional ramie fiber composite.

Fig. 8 shows the correlation between immersion time and impact strength on unidirectional ramie fiber composites and ramie woven composites.

Fig. 8 shows that the impact strength value for unidirectional fibers is higher than woven fibers. But when viewed from the impact strength degradation, up to the 10th week there was a significant decrease in unidirectional fiber, in contrast to woven ramie whose strength tends. This finding is consistent with that of Won *et al.* (2014)¹⁷⁾, who states the low impact strength is affected by fiber orientation. Fibers that are perpendicular to the direction of impact have a higher strength than parallel fibers. The higher impact strength on unidirectional ramie fiber composites than to ramie woven composite occurs due to better interface adhesion between fibers with epoxy resins. The increase in interface adhesion occurs due to reduced infiltration and fibrillation effect, resulting in epoxy resin quickly penetrating the fiber structure. The phenomenon has an impact on increasing the surface contact area with the matrix so that it requires higher energy in the fracture process. Besides, the ramie woven in the manufacturing process has undergone chemical treatment resulting in a decrease in the value of strength.

SEM analyses and observations were also carried out in this study (Figs. 9 and 10). In Fig. 9 show the bonding interface of the fiber and the matrix at 2 weeks looks more robust than 10 weeks. This can be seen from the still many

Table 1 The Charpy impact test results for ramie fiber composites (5 samples)

Impact toughness (kJ/m ²)	Immersion time (weeks)					
	0	2	4	6	8	10
Unidirectional	216.84 ± 47.88	190.44 ± 20.18	185.73 ± 7.15	180.70 ± 10.00	163.99 ± 20.89	150.14 ± 8.08
Ramie woven	100.41 ± 6.01	88.12 ± 2.97	85.57 ± 10.63	104.00 ± 5.06	94.81 ± 4.14	83.26 ± 6.26

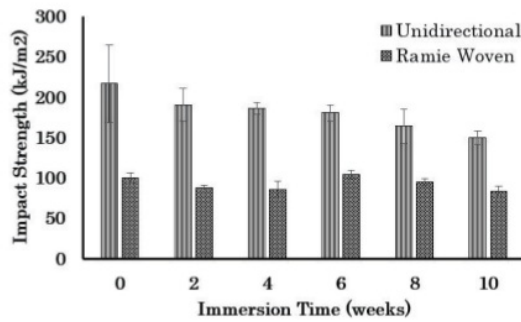


Fig. 8 Correlations between immersion time and impact strength

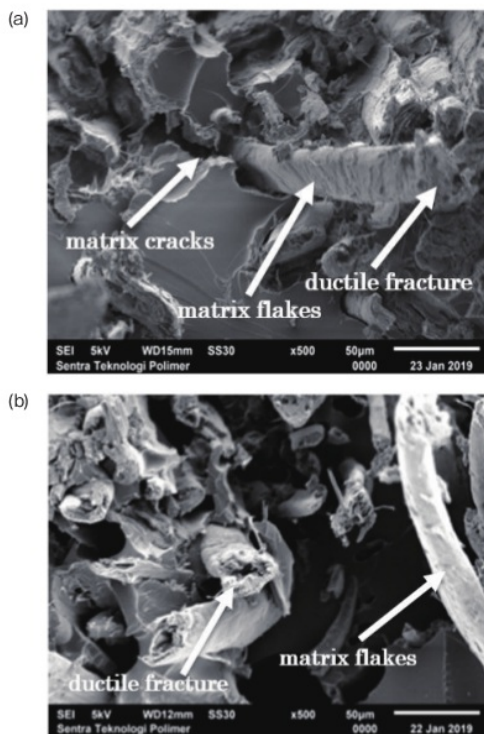


Fig. 9 Seawater immersion for 2 weeks: (a) unidirectional ramie fiber; (b) Ramie woven

matrix fragments that are still attached along the surface of the fiber. This sturdy bond is no longer visible for 10-week immersion specimens, where the surface of the fibers looks cleaner from the attached matrix. This indicates that the bonding between the fibers and the matrices is being pulled out or has been pulled out completely. From the fiber fracture, it was also seen that the fiber which had been immersed for two weeks was still resilient as seen from uneven splits. On the other hand, the fracture of the fibers

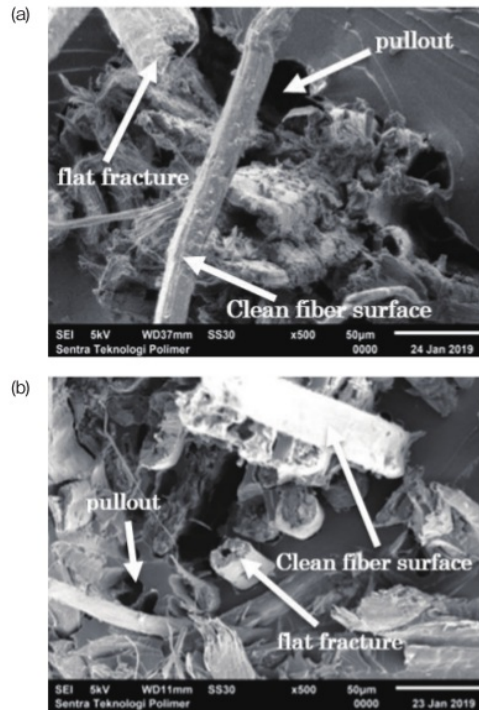


Fig. 10 Seawater immersion for 10 weeks: (a) unidirectional ramie fiber; (b) Ramie woven

at the 10-week immersion tends to be flat showing that the fiber has been brittle.

4. Conclusion

- 1) A higher impact strength value was obtained in unidirectional ramie fiber composites (150.14 kJ/m²) compared to ramie woven composites (83.26 kJ/m²).
- 2) The length of immersion can affect the mechanical strength of the composite. The longer the immersion of a composite, the impact strength tends to decrease. However, when viewed from the percentage of impact strength degradation, ramie woven composite is lower at 17.08% compared to unidirectional ramie fiber composite at 30.78%.

Acknowledgment

We would like to thank “Direktorat Riset dan Pengabdian Masyarakat Direktorat Jenderal Riset dan Pengembangan” Ministry of Research, Technology and Higher Education, because this research was carried out from the 2019 research grant funding “Skema Penelitian Terapan Unggulan Perguruan Tinggi”.

References

- 1) Zulkifli, D. J., Studi sifat mekanis dan degradasi Akibat Lingkungan Air Laut Pada Komposit Berpenguat Tenunan Rami, Electronic Theses & Dissertations (ETD) Gadjah Mada University, 2015
 - 2) Jones. R. M., Mechanis of composite material, Mc. Graw-Hill, New York USA., 1987
 - 3) Gibson, Principle Of CompositeMaterial Mechanic, Mc Graw Hill, Inc, New York, 1994
 - 4) Matheus, J.; Irawan, Y. S.; Soenoko, R., *Jurnal Rekayasa Mesin*, **4**(2), 212-219 (2013)
 - 5) Peters, S. T., Hand book of composites, second edition, Springer Science and Business Media Dordrecht, California,USA, 1998
 - 6) Burrell, P. P.; Herzog, D. J.; McCabe, R. T., A Study of Permeation Barriers to Prevent Blisters in Marine Composites and a Novel Technique for Evaluating Blister Formation, Proc. 42nd Annual SPI Conference, 1987
 - 7) Gougeon, Gougeon Laminating System, Product literature, Gougeon Brothers Inc., 1992
 - 8) Marine Epoxy, retrieved from <https://howtoepoxyresin.com/marine-epoxy/> (Last access: January 2, 2020)
 - 9) Tucker, W. C., *J. Energy Resources Technol. Trans. ASME*, **1134**, 264-268 (1991)
 - 10) Marino, R.; Rocket, T.; Rose, V., Blistering of Glass Reinforced Plastic Marine Materials: A Review, NOAA/Seagrant Technical Report, 88, Marine Advisory Service, Narragansett, RI., 1985
 - 11) Maiti, R., World Fiber Crop: Ramie (*Boehmeria nivea*), chapter 4, Science publ., USA, pp. 63-73 (1997)
 - 12) Bursatriannyo, Publikasi Varietas unggul Ramie, 2014
 - 13) Widiatmoko, R. D., Pengaruh Fraksi Volume Terhadap Kekuatan Tarik Komposit Berpenguat Serat Kulit Batang Waru (*Hibiscus Foliaceus*) – Resin Epoksi, Universitas Lampung, Bandar Lampung, 2016
 - 14) Agung, P., Pengaruh Waktu Perendaman Serat Kulit Pohon Waru (*Hibiscus Tilaceus*) Pada Air Laut Terhadap Struktur Mikro dan Kekuatan Tarik. Skripsi. Semarang. Universitas Wahid Hasyim, 2016
 - 15) Olessen, P. O.; Plackett, D. V., Perspective on the Performance of Natural Plant Fibers, Natural Fibers Performance forum, Copenhagen, 1999
 - 16) ASTM D 5942-96, Standard Test Method for Determining Charpy Impact Strength Of plastics, ASTM International, West Consoshocken, PA, USA, 1998
 - 17) Won, H. J.; Seong, D. G.; Lee, J. W.; Um, M. K., *Composites Research*, **27**(2), 52-58 (2014), DOI: 10.7234/composres.2014.27.2.052
-

ORIGINALITY REPORT

%**4**

SIMILARITY INDEX

%**2**

INTERNET SOURCES

%**4**

PUBLICATIONS

%**0**

STUDENT PAPERS

PRIMARY SOURCES

- 1** "Handbook of Composites", Springer Science and Business Media LLC, 1998 %**2**
Publication

- 2** Hotna Marina Sitorus, Rajesri Govindaraju, Iwan I. Wiratmadja, Iman Sudirman. "Interaction perspective in mobile banking adoption: The role of usability and compatibility", 2017 International Conference on Data and Software Engineering (ICoDSE), 2017 <%**1**
Publication

- 3** www.researchgate.net <%**1**
Internet Source

- 4** id.123dok.com <%**1**
Internet Source

- 5** Arunjunai Raj Mahendran, Günter Wuzella, Nicolai Aust, Uwe Müller, Andreas Kandelbauer. "Processing and Characterization of Natural Fibre Reinforced Composites Using Lignin Phenolic Binder", Polymers and Polymer Composites, 2018 <%**1**

6

edoc.pub

Internet Source

<% 1

7

kupdf.net

Internet Source

<% 1

EXCLUDE QUOTES ON

EXCLUDE
BIBLIOGRAPHY ON

EXCLUDE MATCHES < 5
WORDS