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Tensile Analysis of Epoxy Resin Composite Material With *Petung Bamboo* Strip Reinforcement

Frans R. Bethony[1*], Marthina Pineng[2], Formanto Paliling[3] ,Christof Geraldi Simon[4]
[1,2,3,4] Department of Mechanical Engineering, Faculty of Engineering, Indonesia Christian University Toraja, Jl. Jenderal Sudirman No.9, Bombongan, Kec. Makale, Kabupaten Tana Toraja, Sulawesi Selatan 91811, Indonesia
E-mail : frobethony@gmail.com

Abstract**—** This study aims to analyze the optimal tensile strength of epoxy resin composite material with woven *bamboo strips* (*Dendrocalamus asper*). Petung bamboo is made in *strips* measuring 0.01 cm, 0.1 cm wide, 45 cm long and then woven then soaked in brackish water with variations of soaking for 0, 1, 2, 3, and 4 weeks with river water salinity levels of 10, 20 and 30%. The printed composite material with a composition of 60% epoxy resin and 40% catalyst as a hardener with 1, 2, and 3-layer *woven strips* and held for 24 hours. Composite material printing by *hand lay-up* method. For 1 layer of woven composite material, epoxy resin is poured into a mold then woven petung bamboo strip and covered with epoxy resin pressed for 24 hours. The composite material is removed from the molded container and then left in an outdoor airtight room for one week. Composite materials are repaired to ascertain whether there are still defects or no longer exist, especially on the surface of composite materials. The next process is the manufacture of test samples, for tensile tests based on ASTM (D638-02) Before the test is carried out, the sample is repaired first to ensure that the sample is in a standard state to be ready for testing. Test results of optimal tensile strength of composite materials with woven reinforcement of petung bamboo strips without immersion of 1 layer (40.22 MPa), 2 layers (50.13 MPa), and 3 layers (60.07 MPa). The optimal tensile strength of composite materials with 1 layer of webbing and soaking time of 3 weeks (51.08 MPa) has increased (19.12%). The optimal tensile strength of composite materials with 2-layer webbing and soaking time of 2 weeks (61.05 MPa) has increased (20.69%). The optimal tensile strength of composite materials with 3-layer webbing and soaking time of 2 weeks (70.15 MPa) has increased (19.08%).

Keywords: composite material, bamboo petung, woven *strip,* brackish water, tensile strength.

I. Introduction

Continuous advancements in material engineering, particularly in composite materials, have sparked innovation in manufacturing. These advancements have transformed product design, manufacturing, and utility, enhancing performance and versatility. Industries are increasingly acknowledging the potential of composite materials, driving intensified research and development for breakthroughs in manufacturing processes and product capabilities, thus shaping the future of various sectors.

Bamboo is one potential source of biological fiber. The types of bamboo in the world are around 1200-1300 species and 11.9% of them are in Indonesia [1]**.** Research [2]quoted from [3] shows that bamboo fiber has a strength that is almost similar to glass fiber.

The book, entitled Principles of Composite Material Mechanics [4], explains that composites are a combination of materials selected based on the combination of physical properties of each constituent material to produce new materials with unique properties compared to the properties of the basic material before mixing and surface bonding occurs between each constituent material. From this mixture, composite materials will be produced that have different mechanical properties and characteristics from the forming materials.

Composite is a new type of engineered material consisting of two or more materials where the properties of each material differ from each other in both chemical and physical properties and remain separate in the final result of the material (composite material). An example can be seen in (Figure 1) below.

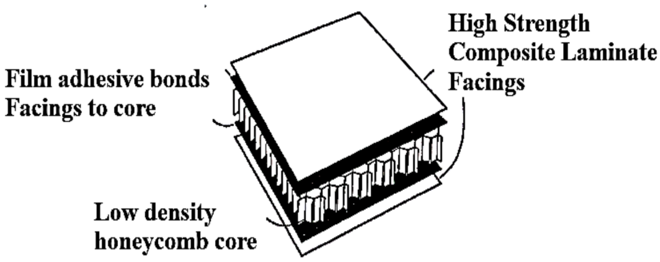

Figure 1. Composite shape schematic
Source: [4]

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Composite material mechanics [5], explains that composites are hybrid materials made of polymer resins reinforced with fibers, combining mechanical and physical properties. An illustration of a composite composition with fiber and resin constituent components can be seen in (Fig. 2).

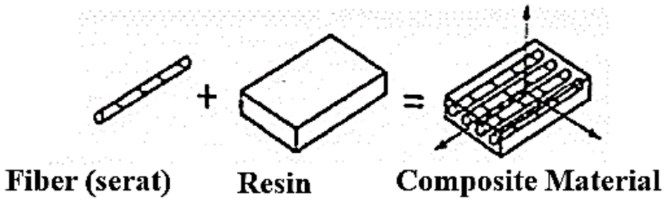

Figure 2. Composite Composition Illustration
Source: [5]

According to the identification results of the Land Rehabilitation and Soil Conservation Center (BRLKT) Region IX (1997), in South Sulawesi there are around 11,881 ha of bamboo land spread across 14 districts with total production annually reaching 28,960 sticks/ha. Tana Toraja Regency has the largest bamboo area of 6,071 ha. Generally, Toraja people know 6 types of bamboo that are widely used in everyday life, namely Pattung (*Dendrocalamus asper),* Parrin *(Schizotachyum zollingeri Stend.)*, Tallang *(Schizotachyum brachycladum Kurz.),* Ao' Maido *(Gigantochloa utter Hassk.)*, Ao' Mariri *(Bambusa vulgaris Schrad.)*.

One type of bamboo that is used for various purposes is Petung bamboo *(Dendrocalamus asper).* Petung bamboo has a much larger stem size than other types with shorter internodes. Petung bamboo shoots are commonly used as food ingredients while Petung bamboo sticks are widely used for construction materials because of the large size of the stems and have thick walls. Petung bamboo is a type of bamboo that has a rather tight clump, the height of the reed can reach 20 m with a diameter of up to 20 cm. On the books there are often short and clustered roots, the length of the internodes ranges from 40-60 cm, and the walls of the reed are quite thick 1-1.5 cm. This can be seen in (Figure 3) below.

Figure 3. Petung bamboo tree (*Denrocalamusasper*)
Source:
https://www.google.com/pohonbambupetungditanatoraja

One of the engineering technologies and innovations of composite materials is the use of natural materials as reinforcement, such as research conducted by [6] with the title of the article Application of natural composites sisal, bamboo, coir, and jute in structural improvement.

The use of natural materials as a reinforcement material for composite materials, generally in the form of strips, such as hemp strips, pineapples, coconut belts, kenaf, palms, banana stems, bamboo, and so on. Petroleum-based thermoplastics are widely used in a variety of applications, especially in packaging. However, its use has led to soaring emissions of pollutants. So, researchers are encouraged to look for environmentally friendly alternative packaging materials that can be recycled and biodegradable, such as research conducted by [7] with the title of the article Bamboo Fiber and Pineapple Leaves as Reinforcement of Composite Materials

Nature Tana Toraja provides a variety of abundant plants, including petung bamboo, it's just that its use is still limited to feasts of the dead and handicrafts such as souvenirs. Petung bamboo has good innate mechanical properties, which are greatly influenced by the chemical composition contained in it. One of the important mechanical properties of petung bamboo is tensile strength, this is the result of research conducted by [8] with the title of the article Optimization of hot sulfur water immersion on tensile

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strength and *strips of* petung bamboo (*Dendrocalamus asper*). Another study that uses *woven petung bamboo strips as a reinforcement material for composite materials is the analysis of bending stress and microstructure* of petung bamboo strips (Dendrocalamus asper) *due to cold sulfur water immersion treatment carried out* by [9] with the title of *the* article analysis of the strength of composite materials reinforced with woven bamboo petung (Dendrocalamus asper) conducted by [10], and analysis of mechanical and physical properties of epoxy resin composite material with woven *bamboo strip* reinforcement (*Dendrocalamus asper*) conducted by [11].

II. Research Methodology

The methods carried out in this study are experimental, manufacturing of composite materials., Testing, and data collection.

A. Research variables

The variables of the study were designed as follows: Independent variable, Soaking duration (0, 1, 2, and 3 weeks with river water salinity levels of 10, 20, and 30%). Chemical *Oxygen Demand* (COD) in brackish water.
Variable Bound, Material tensile strength of composite material, bending strength, and *wettability*.

B. Material and Tools

The tool used in this study is Parang, used to cut down petung bamboo trees as research material. Ruler, slide, and aluminum bar. To measure the thickness and length of petung bamboo strips. Saw, used for cutting petung bamboo prepared as testing material. Petung bamboo strip soaking container.

This study tests the mechanical properties of composite materials with tensile testing equipment. From this research, research results will be obtained in the form of tensile strength values observed both before treatment and after treatment. Similarly, the tensile strength of composite materials is obtained in the form of possible tensile test results that can be done by data analysis.

In this study, the research data were analyzed using descriptive analysis techniques, namely statistics that were used to analyze data by describing the data that had been collected as it was without intending to generalize the research results. In descriptive statistical data analysis techniques include, among others, the presentation of data through tables and graphs.

III. Results and Discussion

A. Research Result Data

The data used in this study were the average value of tensile strength of each sample in each layer of woven bamboo strips, both treated and without soaking or normal. The test was carried out to determine the optimal value that occurred in the composite material reinforced woven bamboo strip petung by immersion of brackish water media with variations in soaking duration of 0, 1, 2, 3, and 4 weeks with a salinity of brackish river water of 10, 20, and 30%.

The average tensile strength value resulting from testing samples of woven bamboo strip woven composite material both normal or without treatment or immersion, is presented below in graphic form, as below.

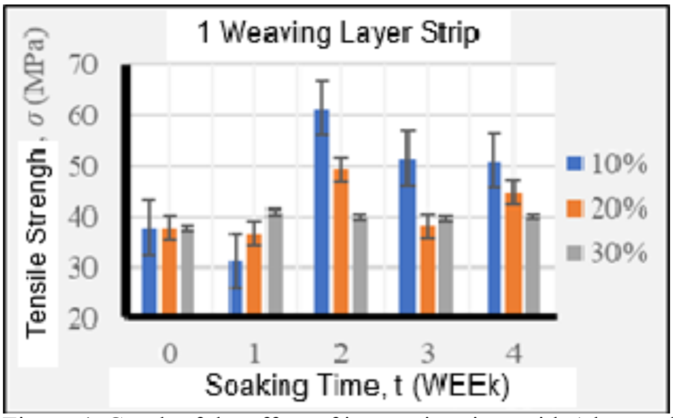

Figure 4. Graph of the effect of immersion time with 1 layer of woven *strip* on tensile strength

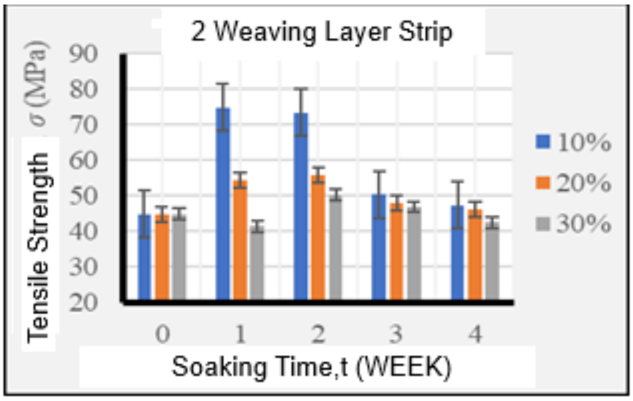

Figure 5. Graph of the effect of immersion time with 2 layers of woven *strips* on Tensile strength

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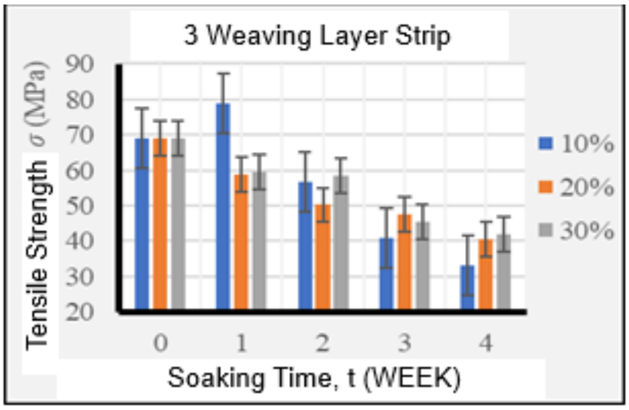

Figure 6. Graph of the effect of immersion time with 3 layers of woven *strips* on tensile strength

The figure above shows that the variation in soaking time with brackish water media (0, 1, 2, 3, and 4 weeks) in brackish river water salinity (10, 20, and 30%) affects the change in the optimal average tensile strength of epoxy resin composite material reinforced with woven bamboo strips. The optimal average tensile strength of the woven bamboo strip composite material without immersion is 1 layer (37.66 MPa), 2 layers (44.77 MPa), and 3 layers (68.95 MPa). Furthermore, this value is used as a comparison for the optimal tensile strength value of composite materials reinforced by woven petung bamboo strips that undergo immersion.

In composite material reinforced with woven 1-layer petung bamboo strips with brackish water immersion at 10% brackish river water salinity, the optimal tensile strength value was obtained at 2-week immersion of 61.25 MPa. While the tensile strength at 0-week immersion of 36.44 MPa increased by 17.12%. For composite materials reinforced with woven 2-layer petung bamboo strips at 10%, the optimal tensile strength of composite materials was obtained at 1-week immersion of 74.75 MPa, and tensile strength at 0-week soaking time of 45.84 MPa increased by 18.785%. In composite materials reinforced by woven 3-layer petung bamboo strips with brackish water immersion at 10% salinity, the optimal tensile strength value of composite materials was obtained at 1-week immersion of 78.71 MPa, while the tensile strength at 0-week immersion of 58.14 MPa increased by 11.20%.

IV. Conclusion

The optimal tensile strength of composite materials reinforced with petung bamboo strips without immersion is 1 layer (36,436 MPa), 2 layers (45,840 MPa), and 3 layers (58,143 MPa).

The optimal tensile strength of composite materials reinforced with woven *1-layer petung bamboo strips, 10%, and soaking time of 2 weeks (43.962 MPa) increased (17.119%).*

The optimal tensile strength of composite materials reinforced with woven 2-layer petung bamboo strips, 10%, soaking time of 1 week (56.443 MPa) has increased (18.785%). The optimal tensile strength of composite materials with woven 3-layer petung bamboo strips, 10%, and soaking time of 1 week (65.479 MPa) has increased (11.204%).

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