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ANALYSIS OF MECHANICAL AND PHYSICAL PROPERTIES OF COMPOSITE MATERIALS OF REINFORCED EPOXY REINFORCED WOVEN BAMBOO STRIPS (DENDROCALAMUS ASPER)

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ABSTRACT

This study aims to obtain optimal mechanical properties of petung bamboo strip reinforced composite (Dendrocalamus asper) through tensile strength testing with universal tensile test equipment (Testometric Brand), and physical properties through microstructure testing equipment with Scanning Electron Microscope (SEM) due to immersion. woven strips of petung bamboo with brackish water. Petung bamboo is made in the form of strips 1 mm thick, 10 mm wide, and 300 mm long and then woven and then soaked in brackish water with salinity variations of 10, 20, and 30 parts per million (ppm) for 0, 2 , 4, 6, and 8 Sundays. The molded composite consists of 60% epoxy resin and 40% catalyst as hardeners with 1, 2, and 3 ply woven strips and held for 12 hours. Composite printing using the hand lay-up method, which is printing the composite manually. For composites of 1 ply woven, epoxy resin is poured into a mold and then woven and covered with epoxy resin and then pressed. For composites of 2, 3 layers of webbing, the process is the same as for composites of 1 layer of webbing. The composite that has been removed from the mold container is then left in the room for one week. Composites are repaired to check whether there are defects or not, especially on the surface. The next process is the manufacture of test samples, for tensile tests based on ASTM (D638-02) and bending tests according to ASTM (D790-02). Before the test is carried out, the sample is repaired first to ensure that the sample is in a standard state to be ready to be tested. The results of testing the optimal tensile strength of the petung bamboo strip reinforced composite without immersion were 1 layer (36,436 MPa), 2 layers (45,840 MPa), and 3 layers (58,143 MPa). The optimal tensile strength of composite with 1 ply woven, 10 ppm, and 8 weeks immersion time (43.962 MPa) increased (17,119%). The optimal tensile strength of composite with 2 layers of woven, 10 ppm, 2 weeks immersion time (56,443 MPa) increased (18.785%). The optimal tensile strength of composites with 3 layers of woven, 10 ppm, and 2 weeks of immersion (65,479 MPa) increased (11,204%). The optimal tensile strength of the composite with 1 ply woven 20 ppm and immersion time of 4 weeks (46,437 MPa) increased (21,537%). The optimal tensile strength of the composite with 2 layers of 20 ppm woven, and the immersion time of 4 weeks (50.921) increased (9.978 %). The optimal tensile strength of the composite with 3 layers of 20 ppm woven for 4 weeks (61,534) increased (5,511 %). The optimal tensile strength of composite with 1 ply woven, 30 ppm, and 6 weeks immersion time (45,337 MPa) increased (6,851 %). The optimal tensile strength of the composite with 2 layers of woven, 30 ppm, and 4 weeks of immersion time (48,946 MPa) increased (6,346 %). The optimal tensile strength of composite with 3 layers of woven, 30 ppm, and 4 weeks immersion time (61.408 MPa) increased (5.317%). By paying attention to the changes that occur in each layer and treatment, it can be stated that the most significant increase in tensile strength was at 4 weeks immersion at 20 ppm salinity and 1 layer woven, which increased (21.537 %). The Scanning Electron Microscope (SEM) results show that between the matrix and the woven bamboo strips of petung, some parts of the surface do not seem to bind together. This is due to the length of immersion so that the petung bamboo strip woven shows damage, especially on the surface.

Keywords: petung bamboo strip, brackish water, immersion time, mechanical properties, physical properties.

1. INTRODUCTION

The development of material engineering technology, especially composite materials, has recently made very significant progress, especially in the field of application in the manufacturing industry. One of the engineering technologies and innovations of composite materials is the use of natural materials as reinforcement [1] and [2].

The use of natural materials as a reinforcing material for composite materials, generally in the form of strips, such as strips of hemp, pineapple, coconut belt, kenaf, palm, banana stem, bamboo, and so on. Petroleum-based thermoplastics are widely used in a variety of applications, especially in packaging. However, their use has led to soaring pollutant emissions. So, researchers are encouraged to look for alternative packaging materials that are environmentally friendly that can be recycled and biodegradable [3].

The nature of Tana Toraja is sufficient to provide a variety of plants, including the abundant petung bamboo, but its use is still limited to parties for the dead and handicrafts such as souvenirs. Petung bamboo has good innate mechanical properties, which is strongly influenced by the chemical composition contained therein. One of the important mechanical properties of petung bamboo is tensile strength. Research conducted by [4] with the title characteristics of the tensile properties of petung bamboo fibers (Dendrocalamus asper). Research conducted by [5]

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entitled optimization of hot sulfur water immersion on the mechanical and physical properties of petung bamboo strips (Dendrocalamus asper). Research by (Frans R.B. 2019) with the title analysis of bending stress and microstructure of petung bamboo strips (Dendrocalamus asper) due to cold sulfur water immersion treatment. Research that uses petung bamboo strips as a composite reinforcement is the analysis of the strength of petung bamboo (Dendrocalamus asper) reinforced composites conducted by [6]. [7] Conducting research on local Toraja bamboo species such as wulung bamboo, petung bamboo andapus bamboo to be used as fuel in the form of briquettes produced bamboo petung charcoal briquettes which are the most superior in terms of calorific value and thermal efficiency of 5176.33 cal/gram and 56, 91%.

For this reason, it is necessary to take steps to improve the surface properties of petung bamboo so that its use in composite materials can be improved so that its mechanical properties can be improved. Based on this background, the writer will conduct research entitled: analysis of mechanical properties and physical properties of composites reinforced with petung bamboo strips (Dendrocalamus asper).

This research is important because knowing the chemical composition and mechanical properties of strips through brackish water treatment allows revealing the extent of the effect of brackish water treatment in improving the mechanical properties of strips which in turn can improve the mechanical properties of petung bamboo strips.

2. BASIC THEORY

Engineering materials are the application and improvement of the properties of a material with the process, design, and formation of the material. Engineering materials help humans learn the basic relationship between the structure and properties of materials and then design these materials' structures to get the desired properties

There are three main classes of engineering materials, namely metals, ceramics, and polymers. Then there is one more addition, namely composite materials. In the industrial world, you are often faced with a situation where you have to choose a material to be used, many considerations will be made but generally will choose the best or closest material to be applied. Therefore, understanding engineering materials is an absolute must for an engineer or scientist [3] and [4]

Composite is a material formed from a combination of two or more constituent materials through an inhomogeneous mixture, where the mechanical properties of each constituent material are different [8] and [9]. A composite with mechanical properties and characteristics that are superior to its constituent materials will be produced from this mixture.

Composites and alloys have differences in the way they are combined, namely when the composites are combined macroscopically so that the strip and matrix are still visible (strip composites) while the alloys or alloys are combined microscopically so that the supporting elements are no longer visible.

The properties of the combined materials are expected to complement each other's weaknesses in each of the constituent materials. Renewable properties include [10]:

a) Strength is the ability of a material to withstand loads without fracture.

b) Stiffness, which is something that cannot be separated from a material. Many rigid materials have a low density to resist deformation from mounting, gravity and vibration during operation.

c) Corrosion Resistance, that is, it does not rust quickly so it has a long service life,

d) Weight is the weight of the material that can be turned into a lightweight without reducing its elements.

e) Fatigue Life is a phenomenon of material damage due to repeated loading. When a material is subjected to repeated stresses, it will fracture at a stress much lower than the stress required to cause fracture under static loads.

f) Heat Conductivity, which increases the rate of heat propagation in solids by flowing from high temperature to low temperature.

In general, composite properties are determined by several factors, including[11]:

a) Types of constituent materials, namely strip materials to be used such as coconut fiber strips, fibers, pineapple strips, banana strips, bamboo, and others.

b) The geometric shape and structure of the constituent materials, namely the shape of the strips, sets, and the structure of the constituent materials in the manufacture of composite materials.

c) Comparison ratio of constituent materials, namely the ratio of materials to be used to produce new and good composite materials.

d) Adhesion between constituent materials, is the ability of the strip to bind to each other between the constituent materials.

e) The manufacturing process, in this process, it is necessary to pay attention to the steps in making new materials so that good materials are obtained and in accordance with standards.

Composites reinforced with natural materials have features such as renewable, environmentally friendly (degraded), and low prices. Meanwhile, synthetic strips are difficult to degrade, producing CO and dust that are harmful

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to health if recycled. Polymer-based materials have high corrosion resistance in acidic (chlorine) environments. However, polymeric materials have relatively low mechanical strength, so strips (fiber) are needed as composite reinforcement.

The high corrosion resistance properties of polymers combined with the mechanical strength of the strip (fiber) are one of the selling points of polymer matrix composite materials. While the strip as a reinforcing element greatly determines the mechanical properties of the composite because it continues the load distributed by the matrix. Factors that affect the mechanical properties of the lamina include orientation, size, and strip shape. Natural strip combined with resin as a matrix will produce alternative composites by varying the orientation of the natural strip (Figure-2.1) so that it is expected to obtain maximum composite mechanical strength results.

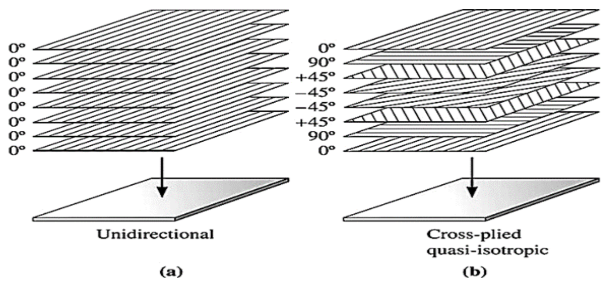


Figure-1. The direction of orientation in FRP composites, unidirectional and (b) quasi isotropic. Source: [12]

Composite is a macroscopic joining of two or more materials between strip and matrix. Macroscopically it shows that the constituent materials in the composite still look like the original, in contrast to the incorporation in the alloy through a homogeneous smelting solidification process, in which the constituent materials are no longer visible. The purpose of the combination is not only to obtain the addictive properties of the constituent materials but especially to obtain synergistic properties [12]

Strip serves to strengthen the matrix because generally, the strip is much stronger than the matrix. The matrix serves to protect the strip from environmental influences and impact damage. Meanwhile, in general, there are three types of fiber-reinforced polymer (FRP) composites based on the strips used (Figure-2.2). Strip composites (fibrous composites) consist of one lamina (layer) that uses reinforcement in the form of strips (fiber) which are arranged randomly or with certain orientations, even in more complex shapes such as woven. Particulate composites use particles (powder) as reinforcement and are evenly distributed in the matrix. And laminated composites are composite types consisting of two or more layers that are combined into one and each layer has its own characteristics.

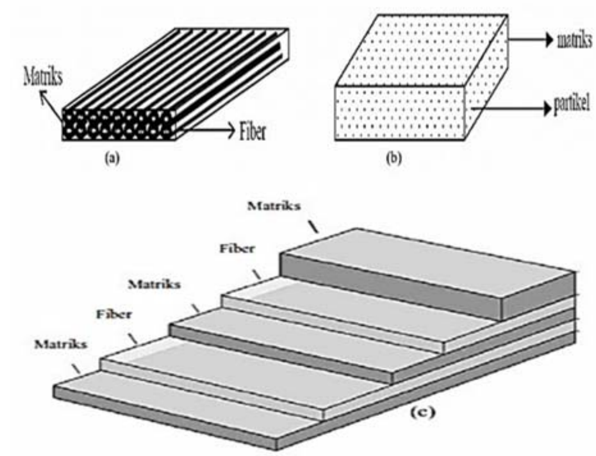


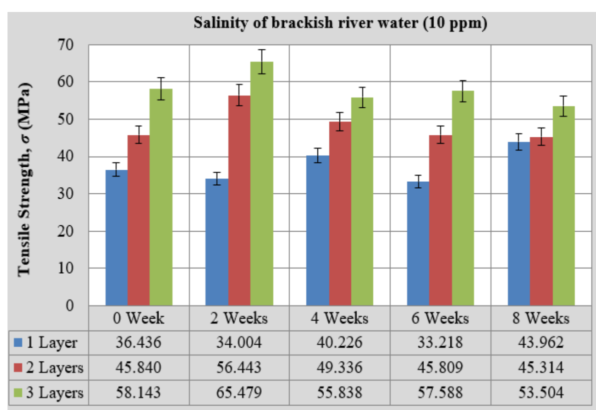
Figure-2. Types of composites (a) strip composites, particle composites, and (c) laminated composites Source: [13]

3. RESULTS AND DISCUSSIONS

A. Tensile Strength Test

The data used in this study is the average value of the tensile strength of each sample in each layer of petung bamboo strip woven, either treated or without immersion or normal. The test was conducted to determine the optimal value that occurs in the petung bamboo strip reinforced composite by immersing in brackish water media with salinities of 10, 20, 30 parts per million (ppm) and variations in immersion time of 0, 2, 4, 6, and 8 weeks.

The average tensile strength value resulting from testing composite samples reinforced with petung bamboo strips, either normal or untreated or subjected to immersion, is presented below in the graphic form.



	0 Week	2 Weeks	4 Weeks	6 Weeks	8 Weeks
1 Layer	36.436	34.004	40.226	33.218	43.962
2 Layers	45.840	56.443	49.336	45.809	45.314
3 Layers	58.143	65.479	55.838	57.588	53.504

Figure-3. Graph of the effect of immersion time on tensile strength in 10 ppm. brackish water salinity.

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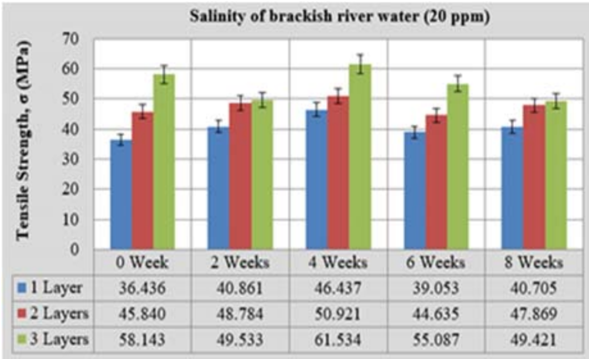

Figure-4. Graph of the effect of immersion time on tensile strength in brackish water salinity of20 ppm.

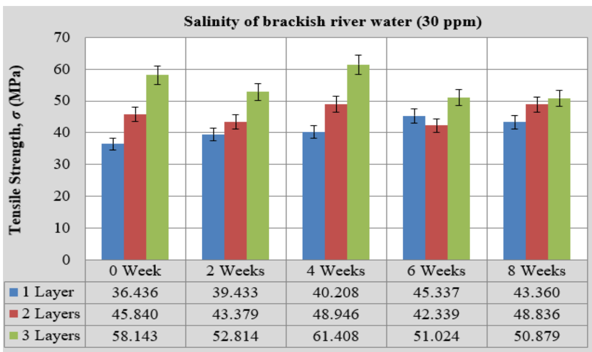

Figure-5. Graph of the effect of immersion time on tensile strength in brackish water salinity of 30 ppm.

B. Testing of Physical Properties

The physical properties in the form of microstructures obtained in this study are the results of the Scanning Electron Microscope (SEM) conducted at the Agency for the Assessment and Application of Technology (BPPT) Serpong, South Tangerang City, Banten Province, Indonesia. From several samples as representative samples in each layer of petung bamboo strip woven, both those that were treated and without soaking or were normal. The test was carried out to determine which conditions were effective for a petung bamboo strip reinforced composite by immersing in brackish water media with salinities of 10, 20, 30 parts per million (ppm) and variations in immersion time of 0, 2, 4, 6, and 8 weeks.

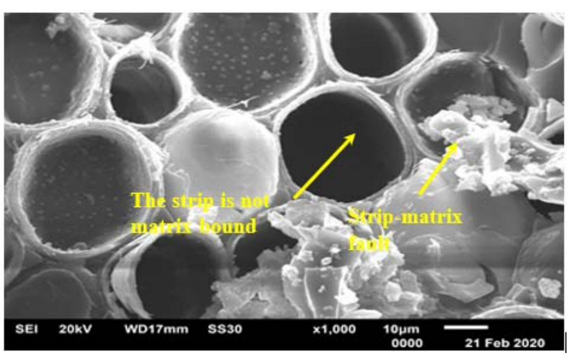

Figure-6. SEM photos of composites reinforced with normal petung bamboo strips.

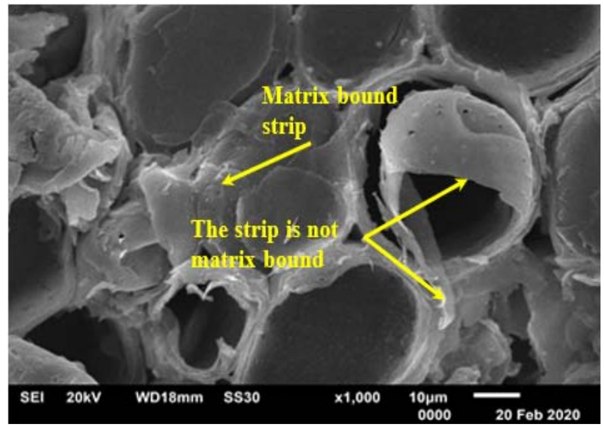

Figure-7. SEM photo of composite reinforced with petungbamboo strips soaked for 4 weeks.

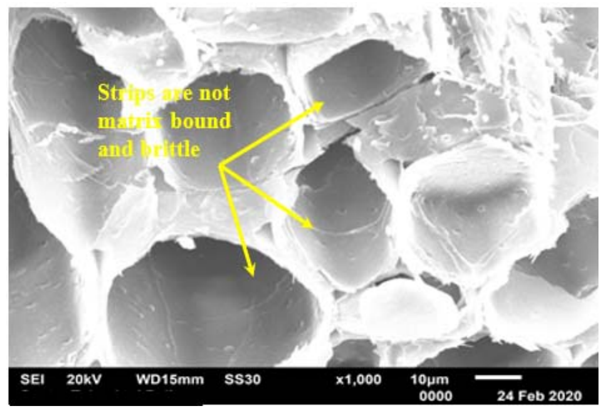

Figure-8. SEM photo of composite reinforced with petung bamboo strips soaked for 8 weeks.

C. Discussion of Research Results

Figure-3.1 shows that variations in immersion time with brackish water media (0, 2, 4, 6, 8 weeks) at salinity (10 ppm) have an effect on changes in the optimal average tensile strength of epoxy resin composites reinforced with woven bamboo strips. petung. The optimal average tensile strength of petung bamboo strip reinforced composite without immersion is 1 layer (36,436 MPa), 2 layers (45.840 MPa), and 3 layers (58,143 MPa). Furthermore, this value is used as a comparison for the value of the optimal tensile strength of the composite reinforced with petung bamboo strips that have been immersed.

In the composite reinforced with 1 layer of petung bamboo strips with brackish water immersion at 10 ppm salinity, the optimal tensile strength value was obtained at 8 weeks of immersion of 43,962 MPa. While the tensile strength at 0 weeks of immersion was 36,436 MPa with a difference of 17.119%. For composites reinforced with petung bamboo strips reinforced with 2 layers at 10 ppm the optimal tensile strength of the composite was obtained at 2 weeks of immersion of 56,443 MPa, and the tensile strength of 0 weeks of immersion was 45,840 MPa with a difference of 18,785%. In a composite reinforced with 3-layer petung bamboo strips with brackish water immersion at 10 ppm salinity, the optimal tensile strength value of the composite was obtained at 2 weeks of immersion of 65,479 MPa, while the tensile strength of 0 weeks of immersion was 58,143 MPa with a difference of 11.204%.

Figure-3.2 shows that variations in immersion time with brackish water media (0, 2, 4, 6, 8 weeks) at salinity (20 ppm) have an effect on changes in the optimal average tensile strength of epoxy resin composites reinforced with woven bamboo strips. petung.

The optimal average tensile strength of petung bamboo strip reinforced composite without immersion is 1 layer (36,436 MPa), 2 layers (45.840 MPa), and 3 layers (58,143 MPa). Furthermore, this value is used as a comparison for the value of the optimal tensile strength of the composite reinforced with petung bamboo strips that have been immersed.

In the composite reinforced with 1 layer of petung bamboo strips with brackish water immersion at 20 ppm salinity, the optimal tensile strength value obtained at 4 weeks immersion was 46,437 MPa, while the tensile strength at 0 weeks immersion was 36,436 MPa with a difference of 21,537%. For composites reinforced with petung bamboo strips reinforced with 2 layers at 20 ppm, the optimal tensile strength of the composite was obtained at 4 weeks of immersion of 50.921 MPa, and tensile strength of 0 weeks of immersion with a tensile strength of 45.840 MPa with a difference of 9.978 %. In a composite reinforced with 3-layer petung bamboo strips with brackish water immersion at 20 ppm salinity, the optimal tensile strength value of the composite obtained at 4 weeks of immersion was 61,534 MPa and the tensile strength obtained at 0 weeks of immersion was 58,143 MPa with a difference of 5,511. %.

Figure-3.3 shows that variations in immersion time with brackish water media (0, 2, 4, 6, 8 weeks) at salinity (20 ppm) have an effect on changes in the optimal average tensile strength of epoxy resin composites reinforced with woven bamboo strips. petung.

The optimal average tensile strength of petung bamboo strip reinforced composite without immersion is 1 layer (36,436 MPa), 2 layers (45.840 MPa), and 3 layers (58,143 MPa). Furthermore, this value is used as a comparison for the value of the optimal tensile strength of the composite reinforced with petung bamboo strips that have been immersed.

In the composite reinforced with 1layer petung bamboo strips with brackish water immersion with 30 ppm salinity, the optimal tensile strength value obtained at 6 weeks of immersion was 45.337 MPa and tensile strength at 0 weeks of immersion was 36.436 MPa, the difference was 19.633%. For composites reinforced with petung bamboo strips reinforced with 2 layers at 20 ppm, the optimal tensile strength of the composite obtained at 4 weeks of immersion was 48.946 MPa, and the tensile strength of 0 weeks of immersion was 45,840 MPa with a difference of 6.346%. In a composite reinforced with 3-layer petung bamboo strips with brackish water immersion at 30 ppm salinity, the optimal tensile strength value of the composite obtained at 4 weeks of immersion was 61,408 MPa and the tensile strength at 0 weeks of immersion was 58,143 MPa with a difference of 5.317%.

Figure-3.4 shows that the SEM results of the reinforced epoxy resin composite with normal or without soaking petung bamboo strips show a coarse fracture microstructure and between the matrix and the petung bamboo strips do not bond together. This is because the pores on the surface of the petung bamboo strip have not been opened due to immersion and if it is related to the results of the tensile strength test, it can be said that there is a significant correlation between the microstructures because normal woven reinforced composites have relatively lower average tensile strength. When compared with the woven strips of bamboo petung that experienced immersion.

Figure-3.5 shows that the microstructure of the SEM result of the epoxy resin composite reinforced with petung bamboo strips soaked in brackish water for 4 weeks can be seen in certain parts of the petung bamboo strips, bonding has occurred between the epoxy resin and the mat, but it has not yet been completely whole. Thus, it is clear that the shape of the fracture in the SEM results is that it is ductile but there is also a brittle or brittle fracture. If it is correlated with the results of the tensile strength test, there are already several samples of composites reinforced with petung bamboo strips that have been immersed for 4 weeks have relatively more optimal tensile strength.

Figure-3.6 shows that the SEM results of an epoxy resin composite reinforced with petung bamboo strips with 8 weeks of immersion show that the fracture microstructure is coarser than that of 4 weeks and the matrix and petung bamboo strips do not bond together. This is due to the fact that the pores on the surface of the petung bamboo strip have not been opened due to immersion and if it is related to the results of the tensile strength test, it can be said that there is a significant correlation between the microstructure because the woven reinforced composite with 8 weeks of immersion has a relatively average tensile strength. Lower than that of petung bamboo strips that had been soaked for 4 weeks but were still above normal.

4. CONCLUSIONS

The mechanical and physical properties of the petung bamboo strip reinforced composite are described as follows. The optimal tensile strength of the petung bamboo strip-reinforced composite without immersion was 1 layer (36,436 MPa), 2 layers (45.840 MPa), and 3 layers (58,143 MPa).

a) The optimal tensile strength of the composite with 1 ply petung bamboo strip woven, 10 ppm, and an immersion time of 8 weeks (43.962 MPa) increased (17,119%). The optimal tensile strength of the composite with 2 layers of petung bamboo strips, 10 ppm, 2 weeks immersion time (56.443 MPa) increased (18.785%). The optimal tensile strength of the composite with 3 layers of petung bamboo strips, 10 ppm, and 2 weeks soaking time (65,479 MPa) increased (11, 204%).

b) The optimum tensile strength of the composite with 1 layer of 20 ppm of 20 ppm petung bamboo strips and 4 weeks of immersion time (46.437 MPa) increased (21.537 %). The optimal tensile strength of the composite with 2 layers of 20 ppm of 20 ppm petung bamboo strip, and 4 weeks of immersion time (50,921) increased (9.978 %). The optimal tensile strength of the composite with 3 layers of 20 ppm 20 ppm of petung bamboo strips for 4 weeks (61,534) increased (5,511%).

c) The optimal tensile strength of the composite with 1 ply petung bamboo strip woven, 30 ppm, and an immersion time of 6 weeks (45.337 MPa) increased (6.851 %). The optimal tensile strength of the composite with 2 ply petung bamboo strips, 30 ppm, and 4 weeks immersion time (48.946 MPa) increased (6.346 %). The optimal tensile strength of the composite with 3 layers of petung bamboo strips, 30 ppm, and 4 weeks immersion time (61.408 MPa) increased (5.317%). By paying attention to the changes that occur in each layer and treatment, it can be stated that the most significant increase in tensile strength was at 4 weeks immersion at 20 ppm salinity and 1 layer woven, which increased (21.537 %).

d) The effect of immersion time on the physical properties of the petung bamboo strip reinforced composite, as illustrated by the Scanning Electron Microscope (SEM) results as follows. Based on the SEM results of the composite microstructure reinforced with petung bamboo strips in each layer, it can be seen that between the matrix and the petung bamboo strips, there are some parts of the surface that do not seem to bind each other. This is due to the length of immersion so that the petung bamboo strip woven shows damage, especially on the surface.

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