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IMPACT STRENGTH OF HORIZONTAL BAMBOO FIBER AND IRON SAND WITH EPOXY MATRIX

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Abstract

Composite is a material composed of 2 materials, namely matrix and filler. Natural fibers, especially bamboo fibers and iron sand that are waste in Indonesia, have the potential to be developed as engineering materials for composite materials reinforced with natural materials. Therefore, the researcher used bamboo fiber and iron sand as a filler and epoxy resin as a matrix. The method used in this research is experimental. Impact test aims to determine the mechanical properties of the composite to be tested. In the manufacture of composite specimens, researchers used the hand lay-up method in accordance with the ASTM D 6110-10 standard. Meanwhile, to see the physical properties, researchers used macro photos to see the difference in composite fractures after impact testing. This study aims to determine the impact strength of horizontal bamboo fiber composites and iron sand with an epoxy matrix. The composite was made with fraction 1 (50% epoxy matrix and 50% horizontal bamboo fiber), fraction 2 (50% epoxy matrix and 50% iron sand), fraction 3 (50% epoxy matrix, 20% horizontal bamboo fiber and 30% iron sand). The results of the charpy impact test showed that the impact strength of the composite fraction 1 was 50 KJ/m². for the composite test fraction 2 has an impact strength is 23 KJ/m². Meanwhile, fraction 3 produces an impact strength is 30 KJ/m². It can be seen from the results of the macro photo that the specimens of fractions 1 and 3 have fiber pull-outs, while for fraction 2 it can be seen that the sand grains absorb resin well.

Keywords: *composite, epoxy matrix, horizontal bamboo fiber, iron sand, impact test*

Introduction

Currently, the need for composite materials, especially bamboo fiber and iron sand is very important. Composite materials are materials that are formed from a mixture of two or more materials that produce composite materials with different characteristics and mechanical properties (Wahyudi and Yuono 2017). With the different properties of each material, there are many methods to test what properties a material has.

The choice of bamboo fiber as research material is because bamboo fiber has the ability to strengthen composites. Bamboo has a stem shape consisting of long and segmented fibers that help the bamboo stand upright. Natural fiber, especially bamboo which is a waste in Indonesia, has the potential to be developed as an engineering material by designing bamboo fiber reinforced composite materials. Natural fibers have several advantages over synthetic fibers, are non-abrasive, low density, cheaper, environmentally friendly and harmless to health (Wahyudi and Yuono 2017).

Iron sand is a type of sand with a grayish black color, tends to be slightly black and has a high content. commonly used as the main raw material and useful for several industrial fields. One of them is an additional material to make a test object between horizontal bamboo fiber and iron sand by using epoxy resin as a binder.

The epoxy matrix contains an epoxy or oxide structure. This resin is in the form of a thick or almost solid liquid that is used to solidify the material. The advantage of an epoxy resin matrix is that it is more resistant to corrosion than polyester when wet. In addition, the epoxy matrix shows excellent mechanical properties and dimensional stability (Tauvana and Subekti 2020). The matrix in this study was used as a mixture of materials in the manufacture of horizontal bamboo fiber specimens and iron sand.

Impact test is one of the methods used to determine the fiber strength, stiffness and ductility of the

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material. Therefore, impact testing is widely used in the field of testing the mechanical properties of materials. To evaluate the resistance of the composite material to horizontal bamboo fiber and iron sand, it is necessary to test and consider the factors that influence it by conducting an impact test. Impact testing is an attempt to simulate the operating conditions of materials commonly encountered in drone equipment, where loads can come suddenly (Yopi Handoyo 2013).

Theoretical basis

Composite

Composite materials are materials made from a mixture of two or more, resulting in composite materials with different mechanical properties and characteristics. In general, composite materials consist of 2 main components, namely the matrix (binder) and filler (filler). A filler is a filler material used in the manufacture of composites, usually in the form of fibers or powders. From the above understanding, it can be concluded that composite materials are materials composed of two different materials (Wahyudi and Yuono 2017). Two types of composite forming materials consist of Reinforcement (Reinforcement) and matrix.

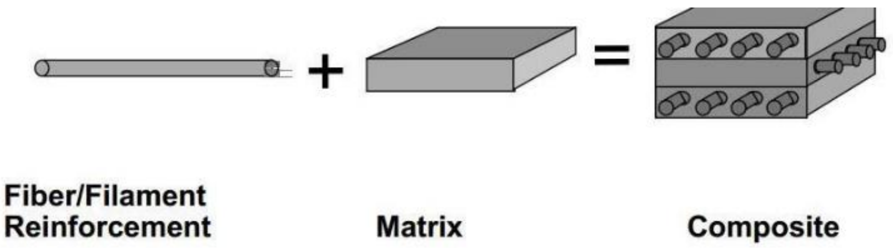

Figure 1. Composite Composition

Composite Manufacturing Method

In the manufacture of composites, there are several methods, namely the Hand Lay Up, Spray Up, and Filament Winding Methods. In this study I used the Hand Lay Up method because this method is the simplest and easiest method in making a composite specimen.

Bamboo Fiber

Bamboo fiber has the ability to strengthen the structure of polymer composites. Bamboo is one type of grass that is famous for its hard stems, some types have a cross-sectional diameter of more than 10 cm, and several meters in height. Bamboo rods are used in many types of building structures, from scaffolding to furniture. One of the limitations of bamboo rods for direct use in design systems is their cylindrical shape. Therefore, bamboo fiber separated from the stem was investigated as a reinforcing material for polymer composites (Glória et al. 2015). In this study, the bamboo fiber used was apus bamboo. Because bamboo apus has about 50% parenchyma, 40% fiber and 10% connective cells.

Table 1. Mechanical Properties of Bamboo Fiber

	Bambu (across the fiber)	Bambu (Along the fibers)
Density (103 kg/m³)	0,802	0,802
Tensile Strength M/Nm² (CoV)	8,6 (±1,02)	200,5 (±7,08)
Initial Tensile M/Nm² (CoV)		19,60 (±2,09)
Flexural Strength M/Nm² (CoV)	9,4 (±0,3)	230,09 (±9,060)
Impact Strength KJ/m² (CoV)	3,02 (±1,08)	63,54 (±4,63)

Sumber : (Yuwanda 2017)

Iron Sand

Iron sand has been widely used as a building material even though the sand in this sand contains magnetic mineral material in iron sand deposits with the main mineral composition being iron oxide with varying levels in each region, magnetic minerals are the basis for developing tools in modern life (Karbeka, Koly, and Tellu 2020). Iron sand that has been separated from non-magnetic materials is widely used as an ingredient in steel mills, iron smelting materials and also a combination of cement (Setyo 2008).

Epoxy Matrix

The matrix is the phase in the composite that has the largest (dominant) part or volume fraction. The matrix is usually more ductile but has lower strength and rigidity. Epoxy resins, also known as polyepoxides, include reactive propolymer types and polymers containing epoxide groups. This resin has excellent chemical and heat resistance and is a fairly effective adhesive. Epoxy resins are good for use as laminates, adhesives, surface coatings, and vanes.

Table 2. Epoxy Matrix Mechanical Properties

Property	Unit	Value
Tensile Strength	Mpa	68-80
Deformation	%	5-7
Bending Strength	Mpa	110-130
Modulus of elasticity	Mpa	2,9-3,2
Pressure Strength	Mpa	110-130
Impact Charpy	KJ/m^2	30-50

Sumber: (Petrović et al. 2013)

Impact Test

Impact tests are used to determine the ductility of materials or materials under sudden loads. The way the impact test tool works is by hitting the strength of the object to be tested with a pendulum. Pull the pendulum to a certain height then loosen it, so that the pendulum hits the object being measured until it breaks (Dwipayana and Widi 2020). In general, impact testing is divided into 2 types, namely the Charpy method and the Izod method. The Charpy method is an impact test where the test object is placed in a horizontal / horizontal position on the holder and the direction of loading is opposite to the direction of the notch, while the Izod method is an impact test where the test object is placed on a pedestal with the position and direction of the load in the direction of the notch (Pramono 2016). In this case, the researcher chose the Charpy impact test because this test is easy to perform and prepare. In addition, the results of this test can be done cheaply and quickly.

Research methods

This research method was conducted at the Department of Mechanical and Industrial Engineering, Engineering Materials Laboratory, Gajah Mada University (UGM) Yogyakarta which includes a series of activities, namely:

Literature Review

the method used by researchers to obtain information that is relevant to the topic or problem that is the object of research. This research method was obtained from other references as a reference in the preparation of this research, which of course is related to the discussion that will be discussed.

Observation

The method used by researchers is by direct observation to obtain data based on facts in the field.

Experiment

This study uses an experimental method in which researchers make their own specimens and then test them in the form of an impact test to determine the quality of the strength of the composite material for each specimen. The design in this research model is described as follows:

Table 3. Composite Specimen Fraction

Composite Fraction	Epoxy matrix	Bamboo fiber	Iron Sand
Fraktion 1 (mixed fraction of the epoxy matrix and horizontal bamboo fiber)	50%	50%	-
Fraktion 2 (mixed fraction of the epoxy matrix and iron sand)	50%	-	50%
Fraction 3 (mixed fraction of the epoxy matrix, horizontal bamboo fiber and iron sand)	50%	20%	30%

Stages of Preparation of Tools and Materials

In this research process, it is necessary to prepare tools and materials before carrying out impact testing, including bamboo fiber, iron pair, epoxy resin, composite mold according to ASTM D 6110-10 standard, measuring cup, caliper, scales, brush, mirror glass, Miling, Miser triangle..

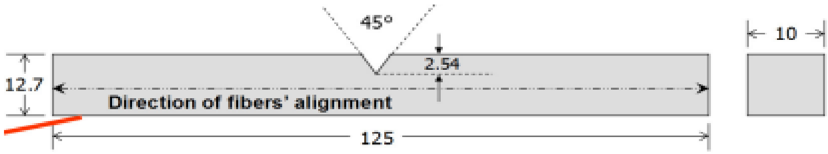

Figure 2. ASTM D 6110-10 Composite

Impact Test Specimen Manufacturing

The first step is to pour the resin into the measuring cup according to the predetermined calculation, then the resin mixture is poured into the mold sufficiently and leveled until the entire mold area is filled. A portion of the fiber is slowly pushed into the mold and then the fiber is rinsed with resin. Align and press the fibers with the stirrer to ensure even distribution of the fibers. Pour the remaining fiber into the mould. Then rinse the fibers again with the remaining resin. Align the fibers and distribute them evenly by pressing again with a stirrer. As for the iron sand mixture, it is just stirred together with the resin. After that wait up to 24 hours until the mold dries / hardens.

Composite Impact Strength Calculation

After performing mechanical testing in accordance with the ASTM D 6110-10 standard, the data will be obtained after which the calculation of the Charpy Impact Test according to (Yopi Handoyo 2013) is as follows:

$$E = m.g.R\,(\cos\beta - \cos\alpha)\ldots\ldots..(1)$$

$$HI = \frac{E}{A}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

Information :

m = Pendulum Weight (Kg)

g = Gravity 9.81 (m/s^2)

R = swing arm distance (m)

cos = Angle at the end of the pendulum
HI = impact strength (J/mm^2)
E = Impact Energy (J)
A = Cross-sectional area under the notch (mm^2)

Results and Discussion

Impact Test Results of 50% Epoxy Matrix Composite And 50% Horizontal Bamboo Fiber

Based on the results of research that has been carried out in accordance with the ASTM D 6110-10 standard, data such as table 4 is obtained. From the table, it can be seen that in the composite fraction a mixture of 50% epoxy matrix and bamboo fiber horizontally 50%, the specimen with the largest Impact Energy is 6,15 Joules and the biggest strength impact is 57 KJ/m^2 was found in specimens 1 and 4. While the lowest was found in specimen 2, namely 4,27 Joules and 40 KJ/m^2, it can be seen that there is a difference in the β angles in specimens 1,2,3,4, and 5 because in specimen making is still using the hand lay-up method so that the specimen can't be exactly the same. For Impact Energy the average obtained is 5,39 Joule, while the average Impact strength obtained is 50 KJ/m^2.

Table 4. The results of the impact test on the mixed fraction of the epoxy matrix and horizontal bamboo fiber

Specimen	α (°)	β (°)	Impact energy (J)	Impact Strenght (J/mm^2)
1	156	145	6,148635916	0,057463887
2	156	148	4,266393331	0,039872835
3	156	146	5,504708422	0,051445873
4	156	145	6,148635916	0,057463887
5	156	147	4,877230515	0,045581594
Average			**5,38912082**	**0,050365615**

It can be seen in Figure 3 that a fiber pull-out failure occurred because the fiber was pulled out of the matrix due to a shock load. This is because the bonding strength between the fiber and the matrix is not perfect so that when the test occurs, the fiber is separated from the matrix. In general, the composite material with fiber pull-out fracture type has the highest impact strength.

Figure 3. The results fracture of composite mixed matrix 50% epoxy and 50% horizontal bamboo fiber

Composite Impact Test Results 50% Epoxy Matrix Mix And 50% Iron Sand

In table 5, the results of the impact test of 50% Epoxy Matrix Mixed Composite and 50% Iron Sand have have the largest Impact Energy of 3,095 Joule and the largest Impact Strength of 29 KJ/m^2 is found in specimen 1 with β angle that is 150°. While the lowest is found in specimens 4 and 5 with β angle of which of 152° which produces an Impact Energy is 1,99 Joules and an Impact Strength is 19 KJ/m^2. And for Imapct Energy the Average obtained is 2,43 Joules and the Average Impact Strength obtained are 23 KJ/m^2

Table 5. The results of the impact test on the mixed fraction of the epoxy matrix and iron sand

Specimen	α (°)	β (°)	Impact energy (J)	Impact Strenght (J/mm²)
1	156	150	3,095380276	0,028928788
2	156	151	2,535561107	0,023696833
3	156	151	2,535561107	0,023696833
4	156	152	1,993095955	0,018627065
5	156	152	1,993095955	0,018627065
	Average		**2,43053888**	**0,022715317**

Then in Figure 4 it can be seen that the iron sand is still in the form of piled grains and the resin cannot absorb well all parts of the iron sand so that the specimen becomes brittle and porous.

Figure 4. The results fracture of composite mixed matrix 50% epoxy and 50% iron sand

Impact Test Results of 50% Epoxy Matrix Composite, 20% Horizontal Bamboo Fiber And 30% Iron Sand

From Table 6, it can be seen that in the 50% epoxy matrix composite fraction, 20% horizontal bamboo fiber and 30% iron sand, the specimen with the largest Impact Energy is 3,67 Joules and the Largest Impact Strength of 34 KJ/m² is found in the specimen 1 and 5. While the lowest was found in specimen 2, namely 2,54 Joules and 24 KJ/m². While for the Average Impact Energy and the Average Impact Strength obtained is 3,21 Joules and 30 KJ/m².

Table 6. The results of the analysis of the impact test on the mixed fraction of the epoxy matrix, horizontal bamboo fiber and iron sand

Specimen	α (°)	β (°)	Impact energy (J)	Impact Strenght (J/mm²)
1	156	149	3,672382938	0,034321336
2	156	151	2,535561107	0,023696833
3	156	150	3,095380276	0,028928788
4	156	150	3,095380276	0,028928788
5	156	149	3,672382938	0,034321336
	Average		**3,214217507**	**0,030039416**

Figure 5 has the same failure with a 50% epoxy matrix composite composite variation, 50%

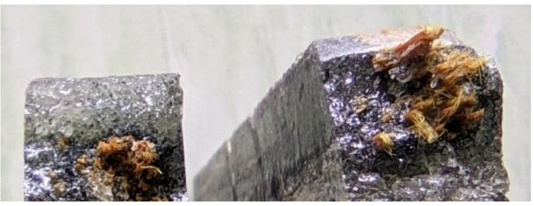

Figure 5. The results fracture of the composite matrix of 50% epoxy, 20% horizontal bamboo fiber and 30% iron sand

horizontal bamboo fiber which also occurs Fiber Pull-Out because this variation uses too much iron sand which makes it more porous and brittle so that this specimen has more ductility. lower than 50% epoxy matrix mixture composite, 50% horizontal bamboo fiber.

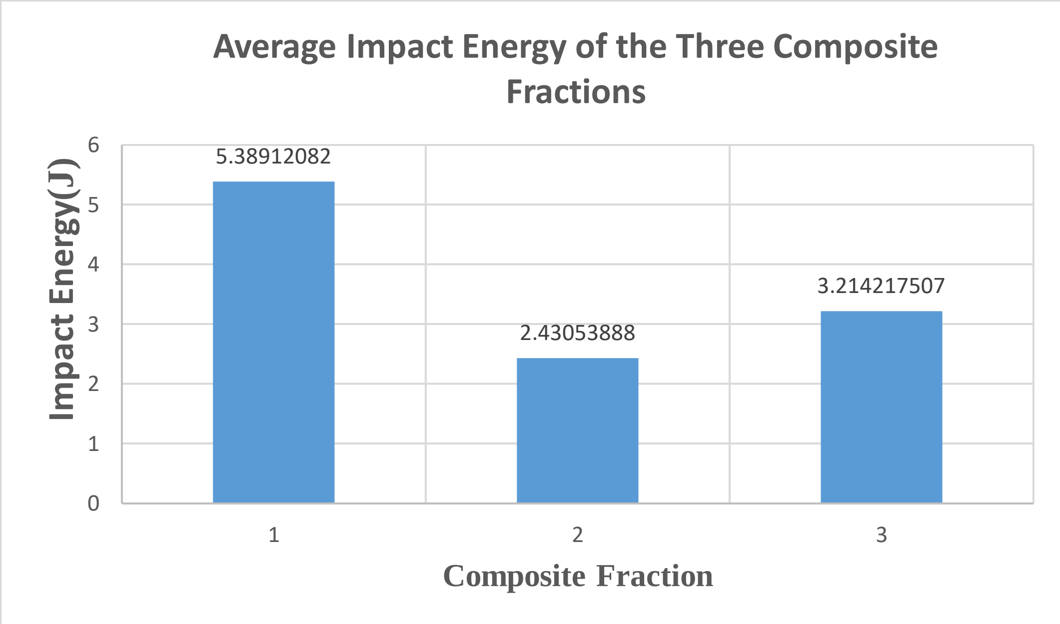

Figure 6. Average Impact Energy of the Three Composite Fractions

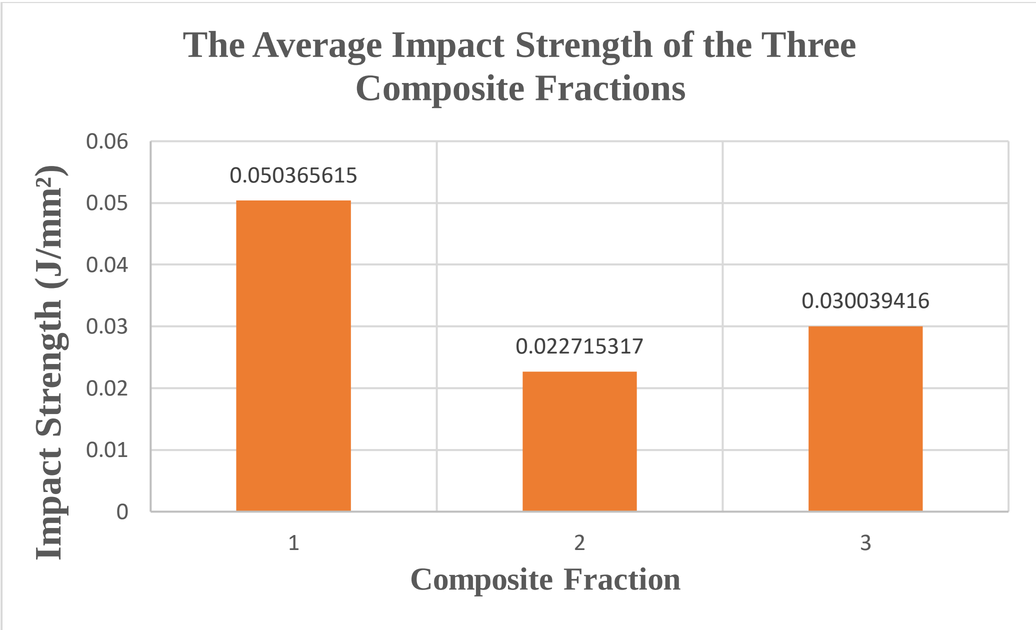

Figure 7. Average Impact Strength of the Three Composite Fractions

from Figure 6 and Figure 7 above, it can be concluded that the fraction the same volume of resin, does not always increase the Impact Energy and Impact Strength. it can be seen that fraction 1 is composite mixed matrix 50% epoxy and 50% horizontal bamboo fiber have the biggest Average Impact Energy and Average Impact Strength because it turns out that the more fiber used, the stronger it is as well as the resulting impact strength.

Conclusion

Based on the impact testing research that has been done, it can be concluded that:

1. Mixed composite test 50% epoxy matrix and 50% horizontal bamboo fiber produced an Average Impact Energy is 5,39 Joules and an Average Impact Strength of 50 KJ/m²
2. Mixed composite test 50% epoxy matrix and 50% iron sand produced an Average Impact Energy is 2,43 Joules and an Average Impact Strength is 23 KJ/m²
3. Mixed composite test 50% epoxy matrix, 20% horizontal bamboo fiber and 30% iron sand produced an Average Impact Energy is 3,21 Joules and an Average Impact Strength is 30 KJ/m²
4. Of the three composites that have been tested, the results obtained are mixed composites 50% epoxy matrix and 50% horizontal bamboo fiber had the best impact strength and ductility compared to the other 2 composite fractions.

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