# Impact Test Value of Asphalt Composite with Bamboo Fiber Apus (*Gigantochloa apus*)

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***Abstract*— The use of Fibrous Reinforced Plastic material with fiberglass reinforcement materials is considered to impact the environment and human health, giving rise to the idea of developing asphalt composite materials with fiber apus (*Gigantochloa apus*), which assessed can be the correct answer as an environmentally friendly material. Asphalt composite material with bamboo fiber apus is tested using the Charpy type impact test method by referring to ASTM to determine the substantial value of its impact. The value of the material impact test results is analyzed using the ANOVA method and compared to the impact test value of Bamboo Reinforced Plastic. The impact test results obtained that the highest value of the strong material impact of 5.9 J/cm² and the lowest by 0.1 J/cm², based on the results of the impact test, asphalt composite material with bamboo fiber content has not been able to exceed the highest value of bamboo reinforced plastic impact strength.**

*Keywords*— Asphalt, Bamboo Smear, Composite, Impact Test.

## I. INTRODUCTION

The use of composite materials as materials in shipbuilding is dominated by the use of Fibrous Reinforced Plastic material with reinforcement materials in the form of glass fibers or fiberglass. The use of composite materials has several advantages, such as materials that are easily formed as desired and do not require experts in shipbuilding from Fibrous Reinforced Plastic materials. Still, synthetic materials such as a combination of plastic and glass fibers can cause serious problems. According to Usha [1], the emergence of several environmental issues occurred due to the presence of plastic waste, for example, water blockage, damaged the soil for agriculture and caused adverse effects on the ecosystem. It has an impact that is considered dangerous on the environment and living things around it, especially on the environment and biota that live in the sea. [2]. In addition to this, the impact to watch out for is from the remaining glass fibers that have health risks which according to Palar [3], from a toxicology point of view, heavy metals containing copper (Cu), iron (Fe) contained in blasting sand, plasma crust and fiberglass residue cause human health effects. It is clearly explained by Ichtiakhiri dan Sudarmaji [4] that the heavy metal will be bound in the body so that it blocks the work of enzymes and then decides the body's metabolic processes and further the heavy metal causes allergies such as skin irritation, teratogen or carcinogenic to the body.

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The advantages of using organic fiber when compared to synthetic fibers include: the potential is significant enough, cheap, and easily degraded (high biodegradable) so that it does not pollute the environment [5]. Thus in this research will use bamboo apus (*Gigantochloa apus*) or also commonly called bamboo rope. Bamboo apus has a wide distribution, especially in the area of Java Island and Bali Island. This type of bamboo also has durability against powder attacks, in line with what has been revealed by Jasni and Sumarni in Widnyana [6] that bamboo apus / rope (*Gigantochloa apus*) is relatively resistant to powder attacks.

Asphalt is a product of refining operations where residues are treated with a gust of air or solvent to produce products that match road/highway construction specifications and other uses [7]. As we all know, asphalt has been used as an aggregate adhesive in road construction, but in addition, asphalt has been used since 5000 years ago for bed, waterproof coatings, jewelry adhesives, and mastic for construction purposes. Some of the advantages of asphalt are that asphalt has good binding power, asphalt has waterproof properties, asphalt can fill cavities from aggregates, and asphalt prices are lower when compared to epoxy resin. When a ship is in operation, some styles work on the boat where the working force can come from inside the vessel or outside the boat. The power from inside the vessel can be construction weight, machining weight, and cargo weight. At the same time, the external force can be caused due to hydrostatic pressure on the ship's body, waves, and wind so that it can be classified into two types of forces, namely static force, which is the difference in weight with buoyancy along the body of the ship, and the dynamic pressure caused by the movement of the boat and the working of waves and wind. In bad weather, the ship experiences perpendicular motion up and down (heaving) and rotational motion with a perpendicular rotary axis of the ship's hull (pitching) so that the ship's bow or forward end experiences in and out of the water with a slimming effect [8]. At the time of

slamming, the impact will, of course, result in collisions - collisions between sea waves and the ship's body to pose a risk of rupture or tearing on the vessel's skin if the material used is not able to withstand the load during slamming effect.

Therefore, in this study, the asphalt composite with apus bamboo fiber will be tested for impact, where further will compare it to the impact test value of bamboo reinforced plastic that has been studied by Nugroho et al. [9]. The results of this study are expected to provide benefits in the form of knowing the mechanical properties of asphalt composites with bamboo fiber apus, especially the value of impact test strength as an illustration of the quality of materials receiving shock loads and references for the development of composite material building methods with optimal and efficient bamboo fiber content, and help to reduce environmental pollution, especially in the environment and marine ecosystems. The purpose of this study is to find out the value of impact test strength of asphalt composites with apus bamboo fiber and find out the mechanical properties of asphalt composites with apus bamboo fiber, especially the value of impact test strength as an illustration of the quality of the material to receive shock loads.

## II. METHOD

### *A. Materials and Instruments*

A literature study will precede this study to get information and data about the problem to be studied. The main ingredients used in this study are asphalt and fiber bamboo apus (*Gigantochloa apus*). Tools used in the form of Markers, Ruler, Scissors, Balance Sheet, Stove, Thermometer, Mold, Brush, Cutter, and Metal Ruler, and Impact Test Machine.

### *B. Method and Procedure*

1) Preparation Stage

   This stage begins by preparing primary materials which is asphalt will be heated up to 200°C and bamboo apus woven mat will be cut into square with the size 30 $Cm^2$.

2) Stage of Composite Material Manufacturing

   This Stage combines asphalt binding material with reinforcement material in the form of woven bamboo weaved apus fiber into the composite material.

3) Stage of Manufacture Of Test Objects (Specimen)

   The American Standards of Testing Materials (ASTM) has determined the dimension size of each object to be tested so that the sheet of asphalt composite material with bamboo fiber needs to be adjusted again. Impact testing aims to determine the impact toughness value of a material in which the material is represented by several specimens to be tested for impact.

The process of data analysis using the ANOVA method or Analysis of Variance is a comparative test to test the average data of several groups with the help of SPSS software; from the test results will be analyzed the influence of the thickness of each specimen on the impact toughness value of the material so that later it can determine the conclusion of how the substantial impact test value of asphalt composite material with fiber apus (*Gigantochloa apus*) as a small shipbuilding material.

## III. RESULTS AND DISCUSSION

In this study, asphalt composite material with bamboo fiber is divided into three variants, namely:

1) The first variant (V1) of composite material with one layer of woven bamboo fiber smear as a reinforcement.
2) The second variant (V2) of composite material with three layers of woven bamboo fiber as a reinforcement.
3) The third variant (V3) of composite material with five layers of woven bamboo fiber reinforcement.

### *A. Impact Test Results*

The impact test results of each variant in the form of impact toughness values are values obtained through material damage tests using the ASTM D 256 standard conducted at the Material Laboratory of the Faculty of Engineering and Marine Sciences - Hang Tuah University Surabaya. The impact toughness values in a row ranging from variant one (V1) to variant three (V3) are as follows:

TABLE 1.
IMPACT TEST VARIANT ONE RESULT

| Value of Variant One Test Results (V1) | | |
|---|---|---|
| Specimen | Impact thoughness ($J/cm^2$) | Absorbed energy (Joule) |
| *Specimen* 1 | 0,3 | 0,2 |
| *Specimen* 2 | 0,5 | 0,4 |
| *Specimen* 3 | 0,1 | 0,1 |
| *Specimen* 4 | 0,4 | 0,3 |
| *Specimen* 5 | 0,5 | 0,4 |
| Average | 0,36 | 0,28 |

TABLE 2.
IMPACT TEST RESULT VARIANT TWO

| Value of Variant Two Test Results (V2) | | |
|---|---|---|
| Specimen | Impact toughness (J/cm$^2$) | Absorbed energy (Joule) |
| *Specimen* 1 | 3,1 | 2,5 |
| *Specimen* 2 | 2,8 | 2,2 |
| *Specimen* 3 | 3,1 | 2,5 |
| *Specimen* 4 | 5,9 | 4,7 |
| *Specimen* 5 | 5,1 | 4,0 |
| Average | 4,0 | 3.18 |

The impact toughness invariant one (V1) of the five test objects obtained the highest value is 0,5 J / cm$^2$, and the lowest value is 0,1 J / cm$^2$, while the deal of energy absorbed in the material received the highest value is 0,4 Joule, and the lowest amount of energy absorbed is 0,1 Joule. The impact toughness value of the test results of each test object on one consecutive variant from specimen 1 to specimen 5 is 0,3; 0,5; 0,1; 0,4; and 0,5.

Invariant two (V2) of the five test objects obtained the highest impact toughness value is 5,9 J / cm$^2$, and the lowest impact toughness value is 2,8 J / cm$^2$, while the value of absorbed energy in the material obtained the highest value is 4,7 Joule, and the lowest value of absorbed energy is 2,2 Joule. The impact toughness value of the test results of each test object on two consecutive variants (V2) from specimen 1 to specimen 5 is 3,1; 2,8; 3,1; 5,9; and 5,1.

Invariant three (V3), the impact toughness value shows the highest value of the five test objects is 5,1 J / cm$^2$, and the lowest impact toughness value is 4 J / cm$^2$, while the highest value absorbed energy or energy absorbed in the material is 4,1 Joule, and the lowest value is 3,2 Joule. As for the impact toughness value of the test results of each test object on three consecutive variants (V3) from specimen 1, specimen 2, specimen 3, then specimen 5 is 4,3 Joule; 4,0 Joule; 4,6 Joule; 5,1 Joule, and 4,1 Joule.

TABLE 3.
RESULTS IN IMPACT TEST VARIANT THREE

| Value of Variant Three Test Results (V3) | | |
|---|---|---|
| Specimen | Impact toughness (J/cm$^2$) | Absorbed energy (Joule) |
| *Specimen* 1 | 4,3 | 3,5 |
| *Specimen* 2 | 4,0 | 3,2 |
| *Specimen* 3 | 4,6 | 3,7 |
| *Specimen* 4 | 5,1 | 4,1 |
| *Specimen* 5 | 4,1 | 3,3 |
| Average | 4,42 | 3,56 |

### *B. Interpretation of ANOVA Test*

From the data - impact test results data in the form of impact toughness values have then analyzed the effect of the number of booster layers in the form of woven bamboo fiber apus against the impact toughness value of asphalt composite material with apus bamboo fiber through the ANOVA test using the help of *Statistica Product and Service Solution* (SPSS) software.

Based on normality tests using the Kolmogorov-Smirnov method stated by the significant value of the impact toughness value of variant one (V1) with one layer of apus bamboo fiber amplifier is 0,200 while the significance data value of the impact toughness value of variant two (V2) with three layers of apus bamboo fiber amplifier is 0,061. The significance value of the impact value of variant two (V3) with five layers of apus bamboo fiber amplifier is 0,200. Thus, the significance value of the data impacts toughness value or substantial value of impact more significant than 0,05, which becomes the probability value, in other words, typical data distribution pattern.

The normality test that uses the Shapiro-Wilk method of significance value data of variant one (V1) with one layer of apus bamboo fiber amplifier is 0,314. While the significance value of variant two (V2) with three layers of apus bamboo fiber amplifier is 0,118, and the significance value of variant three (V3) with five layers of apus bamboo fiber is 0,535. Thus it is not much different from the data normality test conducted using the Kolmogorov-Smirnov method, namely the data significance value greater than 0,05, which becomes the probability value and has a regular data distribution pattern.

Impact toughness value data from variant one, variant two, and variant three have a distribution pattern, or pattern of standard data collected meets basic assumptions to be used in parametric statistical analysis. The belief that the impact toughness value data of variant one (V1), variant two (V2), and variant three (V3) has a normal distribution after the normality test needs to be done because, according to Oktaviani and Notobroto [10], statistics try to maintain that the data taken has results that are at an average value or that can be called reasonableness.

TABLE 4.
ANOVA ONE-WAY TEST RESULTS

| | *Sum of Squares* | *df* | *Mean Square* | *F* | *Sig.* |
|---|---|---|---|---|---|
| *Between Groups* | 49,849 | 2 | 24,925 | 34,066 | 0,000 |
| *Within Groups* | 8,780 | 12 | 0,732 | | |
| *Total* | 58,629 | 14 | | | |

The overall homogeneity test result of each variant through the Levene test shows the significance value is 0,000, which means that the value is less than the value of 0,05, the probability value. Thus the values can be interpreted that the three group variants in this study are not the same. In this case, researchers can continue the hypothesis test using the ANOVA one-way test, but for a further different test using an alternative test that uses the other test next Games-Howell test [11].

Based on the results of the ANOVA test, one factor shown in the table above, the number of difference values between groups is 49,849 demonstrated in the Sum of Squares column, the number of different values in the group is 8,780. The average difference between groups of variant one (V1), variant two (V2), and variant three (V3) is 24,925, while the average value of the difference in the group of the entire variant group is 0.732. From the number's value of differences and the average difference between groups and in the above groups. It is known that the number's value of differences and the average value of differences between groups is greater than the value of the number of differences and the average value of differences in groups. Based on the results of the ANOVA test, one factor is also known that the significance value is 0,000 where the value is smaller than the probability value (0,05). So it can be interpreted that there is a meaningful influence caused by different treatments were in this study in the form of differences in the number of Reinforcement layers in each variant, generating a diverse group.

Based on the results of follow-up tests using the Games-Howell method that has been shown through table 5 above, the average difference value of variant one (V1) with one layer of bamboo fiber Reinforcement smear against variant two (V2) with three layers of apus bamboo fiber amplifier is -3,640 with a significance value of 0,009. In comparison, the average difference value of variant one (V1) against variant three (V3) with five layers of bamboo fiber Reinforcement is -4,06 with a significance value of 0,000. Comparison of the value of the difference of the average of the three variants (V3) against variant one (V1) is 3,640 with a significance value of 0,09; while the ratio of the average difference value to variant three (V3) is -0,420 with a significance value of 0,807. Furthermore, in the comparison of variant three (V3) to variant one (V1) obtained the average difference value is 4,060 and significance value 0,000; while the comparison of variant three (V3) to variant three (V3), the average difference value is 0,420 with a significance value of 0,807.

From the results of follow-up testing data through the Games-Howell method, when viewed from significance values that compared variant one (V1) to variant two (V2), significance values less than 0,05 or $p < 0,05$ can be interpreted that invariant one (V1) when compared to variant two (V2) there is a significant difference from variants' treatments of the layers' number of the bamboo apus' fiber reinforcement. In the comparison of variant one (V1) to variant three (V3), the significance value obtained is 0,000 where it can interpret that value is not different from the significance value of variant one (V1) to variant two (V2) that there is a significant difference or meaningful influence of the treatment of groups of variants in the form of differences in the number of layers of apus bamboo fiber reinforcement.

Significance value if variant two (V2) compared to variant one (V1) then found significance value less than 0,05 or $p < 0,05$ if interpreted from that value invariant group two (V2) there is a significant difference or significant effect of the treatment received by variant group two (V2) when compared to variant one (V1). (V2) to variant three (V3) is above the probability value where $p > 0,05$, and it can be interpreted that between variant two (V2) and variant three (V3), there is no significant difference or no significant influence on the treatment received by each variant group, wherein this study each variant group has several different layers of bamboo fiber as reinforcement.

TABLE 5.
ADVANCED TESTING RESULTS IN THE FORM OF MULTIPLE COMPARISON WITH GAMES-HOWELL METHOD

| (I) Many Layers of Reinforcement | (J) Many Layers of Reinforcement | *Mean Difference (I- J)* | *Std. Error* | *Sig.* |
|---|---|---|---|---|
| 1 Layer Reinforcement | 3 Layers of Reinforcements | -3,64000* | 0,63214 | 0,009 |
| | 5 Layers of Reinforcements | -4,06000* | 0,21213 | 0,000 |
| 3 Layers of Reinforcements | 1 Layer of Reinforcement | 3,64000* | 0,63214 | 0,009 |
| | 5 Layers of Reinforcements | -0,42000 | 0,65833 | 0,807 |
| 5 Layers of Reinforcements | 1 Layer of Reinforcement | 4,06000* | 0,21213 | 0,000 |
| | 3 Layers of Reinforcements | 0,42000 | 0,65833 | 0,807 |

TABLE 5.
IMPACT VALUE TOUGHNESS OF PLASTIC COMPOSITE MATERIAL WITH BAMBOO FIBER APUS ACCORDING TO NUGROHO ET AL. [5]

| Impact Value Toughness of Plastic Composite Material with Bamboo Fiber Apus | | |
|---|---|---|
| Reinforcements Variations | Fiber Cut | *Impact toughness* (KJ/m²) |
| Woven | Radial | 186,22 |
| Unwoven | Radial | 56,1 |
| Woven | Tangential | 186,61 |
| Unwoven | Tangential | 54,33 |
| Random Fiber | - | 41,34 |

Significant values invariant three (V3) compared to variant one (V1) of the advanced test results obtained significance values less than probability values or $p < 0,05$ where it can be interpreted that between variant three (V3) and variant one (V1), there is a significant difference or there is a considerable influence due to the treatment received in the variant group. Furthermore, when variant three (V3) is compared to variant two (V2), the significance value obtained is greater than the probability value or $p > 0,05$ with the interpretation that there is no meaningful difference between variant three (V3) with variant two (V2).

comparison, the interpretation of apus bamboo fiber that is not incorporated with the same fiber cutting demand has an impact toughness value of 54,33 kJ / m².

The impact toughness value in the table 6 is the highest value of each variation of asphalt composite material reinforced by bamboo fiber if the value is compared to the impact toughness value of the plastic composite material with apus bamboo fiber which is also the highest impact toughness value of each variation of the existing group. The lowest impact toughness value of asphalt composite material with apus bamboo fiber is 0,5 J/cm² or equal to 5 kJ/m², and the highest toughness impact value is 5,9 J/cm² or similar to 59 kJ/m².

TABLE 6.
THE HIGHEST IMPACT VALUE TOUGHNESS OF ASPHALT COMPOSITE MATERIAL WITH APUS BAMBOO FIBER

| Impact Value Toughness of Asphalt Composite Material with Apus Bamboo Fiber | | |
|---|---|---|
| Reinforcements Variations | *Impact toughness* J/cm² | KJ/m² |
| 1 Layes | 0,5 | 5 |
| 3 Layers | 5,9 | 59 |
| 5 Layers | 5,1 | 51 |

### *C. Bamboo Reinforced Plastic & Bamboo Reinforced Asphalt*

On this occasion, researchers compared bamboo reinforced plastic and bamboo reinforced asphalt that uses reinforcement in the form of bamboo fiber. From the study results obtained, the highest value of impact toughness of bamboo reinforced plastic is 186,61 kJ / m², where the weight is found in variations of apus bamboo fiber woven with tangential fiber cutting direction. In

Based on the highest value data from each group of variants, both bamboo reinforced plastic (BRP) and from bamboo reinforced asphalt (BRA), the highest value of impact toughness BRP is still far from the highest value of impact toughness BRA which is by a difference of 127 kJ / m². Adrift is higher than the variation of BRP whose reinforcing fiber is not served, namely with a distinction of 3 - 5 kJ / m², and is above the variation in the impact toughness value of BRP with random fiber, which is 18 kJ / m².

## IV. CONCLUSION

From the analysis and results above, it can be concluded that 1) asphalt composite material with bamboo fiber apus has the highest impact toughness value of 5,9 J / cm² or equivalent to 59 kJ / m² and has the lowest impact toughness value of 0,1 J / cm² or equivalent to 1 kJ / m², and 2) the value of the impact of asphalt composite material with bamboo fiber has been able to exceed the impact value of bamboo reinforced plastic with variations of reinforcement that is not woven.

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