Strength and Durability of Six Fast-Growing Timber Against Marine Biota as an Alternative to Hull Materials

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Abstract. Ship hulls are vulnerable to attack by marine animals (barnacles and sea worms). The current scarcity of natural forest wood supplies has a negative impact on the fulfillment of good quality wood raw materials for wooden hull, especially types of Meranti batu (Shorea platyclados). The research aims to test the strength and durability of six fast-growing wood species as an alternative material for ship hulls. The method used is a laboratory test and field test. Flexural strength test based on SNI ISO 16978-2010, wood durability test based on SNI 01-7207-2006. The field test was carried out by submerging the specimens for six months in sea water, Kubu District, Rokan Hilir, Riau Province, Indonesia. Six types of wood tested were: Acacia (Acacia Mangium), Geronggang (Cratoxylon arborencens), Trembesi (Samanea saman), Eucalyptus (Eucalyptus), Mahang (Macaranga gigantea Mull.Arg), and Jabon (Anthocephalus cadamba (Miq)). Sea water immersion test results obtained that the wood Jabon, Acacia Mangium, Eukaliptus, and Geronggang not significantly different. The results of research on the flexural strength, Acacia Mangium wood and eucalyptus have strength equivalent to Meranti batu wood, so that it has the potential as an alternative material for hull material.

1. Introduction

Decreasing the quantity and quality of forest resources causes environmental damage, economic losses and social impacts that have led to alarming levels, this has implications for the decline in supply and types of high-quality timber. Deforestation and forest degradation are crucial issues facing the forestry sector today. Commitment to sustainable forest resource management has been many stated by various parties. In fact, until recently there are still many weaknesses that cause the decline quantity and quality of forest resources. As a result, there was damage environmental, economic losses and social impacts [1]. The mushrooming of the forestry industry in Riau Province has become one of the causes of the degradation of natural forests increasingly out of control.

The impact of scarcity of good quality wood has implications for the sustainability of the remaining shipyard business. The types of wood that are still used for ship building are Malas (Parastenon sp), Laban (Vitex sp), Meranti batu (Shorea platyclados), Meranti merah (Shorea acuminata), Meranti putih (Shorea lanellata) and Kempas (Kompassia malacensis) [2]. Laban wood (Vitex sp.), suitable for attaching ship walls. Meranti (Shorea sp.) is suitable for use as a ship hull wall, because it is flexible so that it is easily shaped according to the conditions of the ship's construction [3]. However, the availability of these wood species in the future will be increasingly difficult due to the reduced supply of wood from natural forests. The availability of wooden ship transportation modes is a vital tool for
the daily lives of fishermen, especially small fishermen, to earn a living to support their families. The impact of the scarcity of wood has implications for the increasingly high prices of raw materials for ship components, the ones who feel the direct result are the small fishermen who are constrained to replace damaged ship components or buy new vessels.

The potential of fast-growing timber is widely available in residential areas and sourced from community forests [3]. Timber originating from community forests is generally young, small in diameter (less than 25 cm), and of low quality, but because the supply of wood from major sources (natural forest/plantations) decreases and almost runs out, long-time wood users tend to choose the wood. Based on the results of research that has been achieved lately, wood originating from forests / folk plants can basically be used for various purposes both for carpentry and building materials. But in its use, technology needs to improve the properties of wood, and technical data from each type of wood is also needed. The results of the Regional Research and Development Agency for Riau Province study in 2016 [4] to find alternative solutions to anticipate the scarcity of natural forest wood supply, obtained results that alternative technologies that can be developed to anticipate the scarcity of wood materials are composite wood technology to minimize the use of wood materials at present, alternative wood utilization from local potential, the use of fast growing species, composite wood technology based on laminated wood and composite technology as a solution offered for the sustainability of shipping technology in the coastal Riau region in the future. The Indonesian Classification Bureau (BKJ) provides criteria for ship wood components based on the specific gravity (BJ) of wood for the hull part of the vessel used having a minimum BJ of 500 kg/m³.

Marine biota in the form of barnacles, fungi, and sea worms is an element of marine biofouling that attaches to the hull of the ship, has a very detrimental effect on fishermen. Ships' hulls can contain thousands of aquatic species, ranging from bacteria and other microbial organisms to microalgae and plant and animal species at various stages of development. The hull fouling increases the hull roughness, which increases its total water resistance and thereby results in additional fuel usage [5]. The influence of barnacles attached to the hull of the ship besides polluting the hull of the ship will also affect the slowing down of ship movements up to 86%. The excess will have a significant impact on increasing greenhouse gas emissions [6]. Laboratory test results on the effect of marine fouling on wood show that polluting organisms dominate by Balanus amphitrite, Bankia sp. and Ligia occidentalis. The immersion period has a significant meaning effect on the abundance of spoilage organisms [7]. Based on the criteria for the percentage of sea worm attack according to SNI 01-7207-2006 as shown in Table 1.

| Strength Class | Attack Intensity (%) | Classification |
|----------------|----------------------|----------------|
| I              | < 7.3                | Very Durable   |
| II             | 7.3 – 27.1           | Durable        |
| III            | 27.1 – 54.8          | Moderate       |
| IV             | 54.8 – 79.1          | Bad            |
| V              | >79.1                | Very Bad       |

The aim of the study was to test the strength and resistance of six potential local wood species from fast growing species to the attack of marine biota as an alternative raw material for ship components to provide solutions to the availability of sustainable raw materials for ship components. It is expected that fast-growing timber species will be able to become alternative wood raw materials to ensure the availability of wood supply to fulfill the raw material components of wooden vessels for the manufacture of new ships and maintenance of wooden vessels for fishermen in the future.

2. Research Methods
The raw material in the form of six types of fast-growing wood consists of Akasia (Acacia mangium), Trembesi (Samanea saman MERR), Ekaliptus (Eucalyptus), Mahang (Macarangan gigantea Mull. Arg), Geronggang (Cratoxylon arborencens), and Jabon (Anthocephalus cadamba (Miq)). As a
comparison, Meranti batu (*Shorea platyclados*) is a type of raw material used for hull wood used by the community today.

The methods used are laboratory tests and field tests on the strength and durability of six types of fast-growing wood. Strength test is carried out by means of flexural strength testing based on SNI ISO 16978-2010, Test of wood resistance to destructive organisms based on SNI 01-7207-2006. The location of field testing was carried out in the Kubu Subdistrict area, Rokan Hilir Regency by immersing the test sample in seawater for six months. The test results were analyzed statistically to determine the difference in results obtained between immersion test samples with no immersion.

3. Results And Discussion

The wood density test results obtained that Meranti stone has a density of 650 kg/m$^3$. The results of the density test on fast growing wood species *Acacia mangium* and *Eucalyptus* can match the density of Meranti stone wood, while the other four wood species are still below the density of Meranti stone wood as shown in Figure 1.

![Figure 1. Comparison of Fast-Growing Timber Density](image)

The results of the flexural strength test of Acacia and Ecliptus wood fast growing species can match the flexural strength of Meranti stone, while the other four types of wood are still under the flexural strength of Meranti batu as shown in Figure 2.

![Figure 2. Comparison of Strong Wood Bending Fast Growing](image)
The results of the wood immersion test were fast growing against the barnacles attachment as shown in Figure 3. The test results showed that all solid wood test samples suffered attacks almost evenly on all wood surfaces, this indicates that the wood species are vulnerable to barnacle attacks. Sticking barnacles on the surface of the wood does not damage the structure of the inner wood and can be removed by removing the wood surface.

![Figure 3. Barnacles attachment to the fast-growing wood surface](image)

The results of testing the effect of wood immersion in seawater on the resistance of marine biota obtained data as shown in Table 2. The results of statistical tests on the average comparison obtained is that the effect of six months immersion on Mahang and Trembesi wood has a significant effect on the level of confidence 95%, while other types of wood are not significantly different. Based on the results of the splitting test results by visual observation, it was found that damage to the interior of Mahang wood due to the attack of sea worms was very close to 70% of the inside of the wood (Figure 4). Even though there is a significant decrease in trembesi wood, but visually the sea worm attack that occurs is only seen on the outer surface of the wood in the form of black spots, but there is no visible colony hole due to the attack of sea worms that penetrate the inside of the wood.

| No. | Wood Species | t count | p count | t count > t table | p count < 0.05 | Explanation |
|-----|--------------|---------|---------|-----------------|---------------|-------------|
| 1   | Jabon        | 0.226   | 0.827   | No              | No            |             |
| 2   | Akasia       | 1.440   | 0.188   | No              | No            |             |
| 3   | Ekaliptus    | 0.788   | 0.453   | No              | No            | t table = 1.86 |
| 4   | Geronggang   | -0.172  | 0.867   | No              | No            |             |
| 5   | Trembesi     | 2.743   | 0.025   | Yes             | Yes           |             |
| 6   | Mahang       | 6.179   | 0.000   | Yes             | Yes           |             |
Based on the results of tests on borer (sea worm) attacks, it was found that six types of wood had resilience that met the criteria of class I wood (very resistant), while mahang wood included criteria for class IV wood (poor) as shown in Table 3.

**Table 3. Intensity of the Attack on Biota of Sea Hookers and Criteria for Wood Class**

| Wood Species | Attack Intensity | Criteria | Classификация |
|--------------|------------------|----------|----------------|
| Jabon        | 0%               | I        | Very Durable   |
| Akasia       | 0%               | I        | Very Durable   |
| Ekaliptus    | 0%               | I        | Very Durable   |
| Geronggang   | 0%               | I        | Very Durable   |
| Trembesi     | 0%               | I        | Very Durable   |
| Mahang       | 70%              | IV       | Poor           |
4. Conclusion
The results of the study can be concluded as follows:
1. Ekliptus and Acacia mangium wood species based on physical properties (density) and mechanical properties (bending test) meet the specifications set by the Indonesian Classification Bureau.
2. The immersion test results obtained decreased weight of Jabon wood, Acacia Mangium, and Eucalyptus, obtained not significantly different from the 95% confidence level, while Trembesi and Mahang wood species obtained a significant decrease in weight after immersion.
3. Based on the intensity of the attack on sea borer biota obtained for Mahang wood has a poor criterion (class IV), while for other wood has a very resistant criterion (class I).
4. Based on the results of the strength and endurance test of fast-growing wood species, it can be stated that the wood potential of Akasia Mangium, and Eucalyptus has criteria that meet the requirements as an alternative to wooden hull material replacing Meranti stone species.

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