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Research Article

Clay Impregnation on Strength of Red meranti Wood (*Shorea leprosula*)

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Abstract

Preservation of red meranti wood with clay material by vacuum-pressing called impregnation aims to improve its strength properties, especially flexural strength and stiffness Impregnation is the process of inserting certain materials into wood by vacuum-pressing, which is a full cell preservation process. The method of this research is to make a test sample of red meranti wood (*Shorea leprosula*) with a size of 5 cm x 5 cm x 76 cm which is impregnated with clay at a pressure of 60 psi for 2 hours in concentrations of 2.5%, 5%, and 7.5% and then tested for retention value and tested for flexural strength using a UTM machine. Research results showed that impregnation with clay at a pressure of 60 psi for 2 hours can produce retention in all three types of solution concentrations. While the strength does not decrease even from three kinds of clay solution, concentrations tend to show an increase in flexural strength and stiffness. Clay impregnation increases the strength class of red meranti wood from strength class 4 to strength class 3.

Keywords: clay, flexural, impregnation, red meranti, retention, stiffness

INTRODUCTION

One of the materials that are important for human life for various purposes such as construction materials, energy and other industries is wood. Wood as a construction material requires the knowledge properties of the wood so that its usage can be optimised both from a technical and economic perspective. One of the uses of wood is as a composite material and lamina board (Cross Laminated Timber) for residential and building construction (Choi et al. 2018). For the use of building wood, the wood needed is the one that has mechanical properties or strength properties and high durability properties. Strength properties and durability properties are classified into strong class and durable class (Winarni & Alex, 2022). The most important strength property of wood is the modulus of elasticity (Jung et al. 2029). Timber from natural forests with high strength and durability grades is very rare, while commercial timber species such as lime and red meranti are already in short supply, due to the rapid degradation of natural forests over the last 40 years.

Clay, also known as podzolic soil, is a nutrient-poor soil so it is called poor soil or acrisol. Loam soil contains a lot of iron, aluminum and silicate Foth, (1995). This soil can be one of high economic value if it is utilized as wood filler and environmentally friendly wood preservative. According to the Ministry of Environment and Forestry (2018), wood preservatives must be environmentally friendly. Wood preservatives on the market today are generally preservatives imported from abroad, the price is expensive which of course becomes uneconomical, and is not environmentally friendly (Primayuda et al.2022). Clay is a very fine soil and contains many metal particles that are toxic to plants (Amin et al. 2021). The use of clay as a wood filler which is also a wood preservative will provide many benefits. The obvious benefit is that it can increase the strength of wood. Another is that the material is widely available and easily obtained or excavated in the East Kalimantan region. The amount of availability makes it easy for the community to utilize it. Another advantage is that it comes from natural materials that are environmentally friendly (Arafat et al. 2023).

Red meranti wood (*Shorea leprosula*) is a fast growing species that grows widely in Indonesia and is a type of wood that is fast to harvest (Pujiastuti, 2018). Red meranti wood has been widely utilized as a construction material because the properties of wood, especially strength properties are very low, namely strength class IV. While the durability properties of these woods from wood destroyers are naturally low, because red meranti wood includes low durability properties, namely durable class V (Seng, 1990). Based on the results of the impregnation or durability test with a blue vitriol solution. Red meranti wood is wood that easily absorbs wood preservative chemical solutions. According to [Liu et al. 2019 and Eskani & Utamaningrat, 2019), the success of wood preservation is influenced by wood properties, preservatives and preservation methods. The indicator of high wood durability is the state of wood in a certain time and condition that is not easily attacked by wood destroyers (Alex et al. 2023). While (Alex et al. 2018) and (Alex et al. 2017) state that changes in wood shape can affect strength properties, especially the elastic modulus. To know that Red meranti wood has good strength properties, it is necessary to conduct research on the effect of clay impregnation on elastic modulus. The elastic modulus of wood is the most important strength property in wood construction (Song el al. 2018). This research focuses on the amount of clay solution concentration on increasing the elastic modulus of Red meranti wood.

2. RESEARCH METHODS

2.1. Preparation of Test Samples

Red meranti wood measuring (SNI 03-3959-1995) 5 cm x 5 cm x 76 cm that has been dried until the moisture content reaches 15% should be prepared. Before the wood is put into the impregnation tube, their volume was measured and weighed, with the aim of getting the retention value. The wood was then impregnated with clay solution at concentrations of 2.5%, 5% and 7.5%. The number of wood test samples used for each concentration and control were 10 pieces, so the number of wood test samples were 40 pieces.

2.2. *Preparation of Clay Solution*

The clay solution was made as much as 20 liters for each concentration. The method for making a 2.5% concentration is 500 grams of clay plus water to 20 liters, for a 5% concentration is 1000 grams of clay plus water to 20 liters and for a 7.5% concentration is 1500 grams of clay plus 20 liters of water.

2.3. Vacuum Press Procedure

Woods with known weight were put into the preserving tube and then the tube was sealed. The initial vacuum is carried out for 15 minutes with a vacuum amount of 10 cm Hg. The initial vacuum was completed and clay was put into the tube until it was full. Pressure impregnation was carried out for 2 hours with a pressure level of 60 psi. The solution was removed from the tube with an initial vacuum and a final vacuum of 10 cm Hg each for 15 minutes, then the wood was removed from the tube and weighed again to find the final weight value, and then the retention value is calculated. Woods are dried again in a drying oven at 80° Celsius until it reached a moisture content on the moisture meter of 15%.

2.4. Sample Testing

All wood samples or samples that have been impregnated with clay soil are calculated for their retention value using the formula:

$$R = (W1-Wo/V) \times C$$

Desc: R: Retention value, W1: Wood weight after impregnation, Wo: Wood weight before impregnation and V: Wood volume, C: Solution concentration

Tested for strength using a Universal Testing Machine (UTM) wood tester or machine. The data obtained are stiffness (Modulus of Elasticity/MoE) and flexural (modulus of rupture/MoR). The increase in wood strength is the relationship between retention value and modulus of elasticity.

3. Results and Discussion

3.1. Wood Strength

The strength of red meranti wood impregnated with clay with three different concentrations is shown in the following table with the modulus of rupture (MoR) and modulus of elasticity (MoE) values

Table 1. Average Strength of Red meranti Wood Impregnated with Clay Soil

Concentration (%)	MoR	MoE
Non Impreg	432.84	53124,25
2,5	704,12	75996,02
5	729,46	75679,81
7,5	712,46	79118,15

Based on the table, for the static bending strength value at the proportion limit there is a tendency to increase as the concentration of the solution increases. This also applies to the value of the modulus of fracture, with an increase in clay concentration actually increases the value of the modulus of fracture, when compared to wood without impregnation, the wood with clay impregnation treatment shows very high increase. While the value of modulus of elasticity (MoE) varies, namely at a concentration of 2.5% the MoE value is higher than the concentration of 5% and control, but the MoE value at a concentration of 5% is lower than the concentration of 7.5%, but overall the MoE value with impregnation is still higher than without impregnation. According to (Nandika et al. 2023) mentioned that preserved wood will increase its strength properties.

3.3. Retention Value

The retention values of red meranti wood impregnated with clay with three different concentration measures are listed in the following table.

Table 2. Average Retention Value of Clay Soil in Red meranti Wood

Concentration (%)	**Retention (kg/m^3)**
2,5	13,25
5	27,78
7,5	32,06

Based on the retention and penetration values of clay soil listed in the table, the retention value at a high concentration of clay soil solution gives a high concentration value, while at a low concentration it will produce a low retention value, with the pressure process is 60 psi in a time of two hours. As has been done by (Seta et al. 2023) and (Alex & Winarni, 2023) that retention is a manifestation of wood durability. High retention values illustrate that wood durability considered as easy (Nandika et al. 2023).

3.2. F-Value of MOE and Retention

Based on the analysis of variance on MOE, the calculated F value is compared with the F table at the 0.05 (95%) confidence level, and the calculated F value of retention is compared with the F table at the 0.01 (99%) level presented in the following table

Table 3. F-Value Count of MoE and Retention

Analysis of Variance	F-Value Count	Trust
MOE MOR	43,17** 20,48**	3,01 (0,01
Retention	95,77**	

Comparison of the calculated F value of MOE at the 0.05 confidence level shows that the concentration of clay has a significant effect on the MOE value. Impregnation of clay in red meranti wood can increase strength, especially the elastic modulus. This is in accordance with (Damayanti et al. 2020) that impregnation and combination of preservatives can increase wood strength. While the calculated F value of retention compared with the 0.01 confidence level shows a very significant difference, the higher the concentration of clay impregnated in red meranti wood, the higher the retention value obtained. In line with (Lee & Choi, 2018) who said that the high concentration of wood preservatives resulted in high retention values.

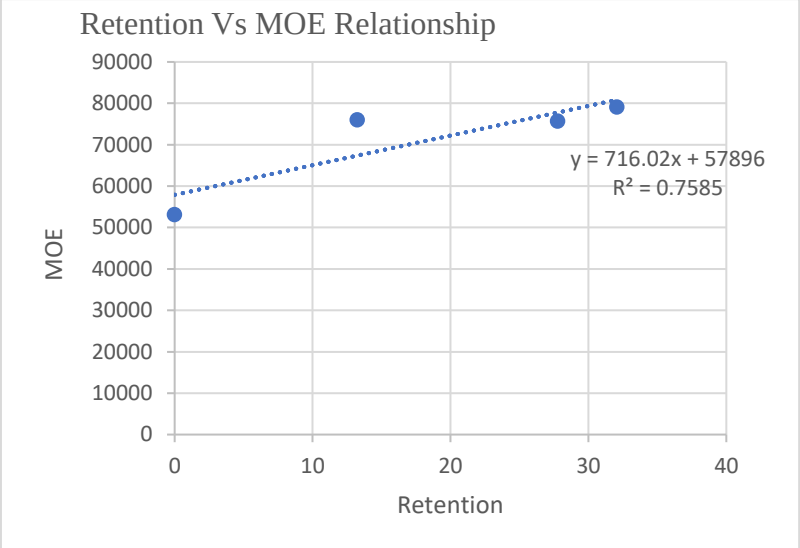
3.4. Relationship between Retention and Modulus of Elasticity

The relationship between the retention value and MoE of Red meranti wood impregnated with clay with three different concentration measures are listed in the following table.

Table 4. Relationship between Retention and Modulus of Elasticity

Concentration (%)	Retention (kg/m3)	MoE (kg/cm^2)
Non Impreg	0	53124,25
2,5	13,25	75996,02
5	27,78	75679,81
7,5	32,06	79118,15

Referring to Table 4 about the relationship between retention and modulus of elasticity (MoE) there is a relationship, namely low retention results in low MoE and high retention results in high MoE as well. So, it can be mentioned that the higher the retention of clay soil in red meranti wood, the higher the strength of red meranti wood, especially the MoE value. The relationship between retention and MoE can be seen in the regression value of 0.8709. For more details, see the following regression line image. The coefficient of determination value of 0.7585 with the equation Y = 57896 + 716,02X.



The regression value indicates that the relationship between retention and MoE is very strong and the coefficient of determination indicates that 75.85% of the increase in MoE value is determined by clay retention. Based on the regression value *r*, the *t* test was carried out and obtained a value of *t* = 8.348 compared to the value of *t* table = 4.303 for 0.05 confidence which indicates a significant positive relationship. This is in accordance with the opinion of (Rabbi et al. 2015) which states that impregnation of clay nanoparticles can increase wood strength.

4.CONCLUSIONS

Based on the research results, it can be concluded that:

1. Red meranti wood is a wood that has a low modulus of elasticity, but its elastic modulus property can be increased by impregnating it with clay from strong class IV strength level to strong class III.
2. Red meranti wood belongs to a group of wood that is easily preserved, based on the impregnation with clay at a concentration of 2.5%, a retention value of 13.25 kg/m^3 was obtained.

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