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Comparison of Properties between Solid and Laminated Mahang Wood

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Abstract: Processing solid wood into laminate wood is an effective way to improve the poor properties of fast growing wood species especially its density and strength. In this study, Mahang wood (*Macaranga sp.*) was chosen to be processed into laminated wood. The comparison were made between solid Mahang wood and laminated Mahang wood in terms of its physical and mechanical properties. Comparison were also been done between different age, portion and wood type for each of the wood samples. The physical properties that were tested are basic density, thickness swelling and water absorption while strength properties were observed through modulus of rupture (MOR) and modulus of elasticity (MOE). It was found that, heartwood, matured wood and top portion of the wood have the outstanding properties compared to sapwood, young and wood from other portion due to the cell and fiber loading. The laminated process increase the basic density of Mahang wood and decreased the thickness swelling and water absorption. In terms of strength, the laminated process have greatly increased the MOR and MOE of the Mahang wood.

Key words: *Mahang. Macaranga sp., lesser-known species, laminated wood, wood portion, wood maturation*

INTRODUCTION

The growth and demands of wood products are driven by a number of factors, most notably are population, economic growth and changes in demographic, technological and also environmental issues [1]. Malaysia is one of the major timber producer since 1970s and the industry was grown and shifted into higher value-added products which this industry provide more return in terms of profit. However, due to increase in environmental concerns, Malaysia committed to achieve sustainable forest management (SFM) which led to declining supply of the timber [2]. In return, manufacturers are tempted to use low density wood species from plantation for example rubberwood, or *Acacia mangium* as alternative to the raw materials [3]. However, wood from plantation are usually low in strength properties and non-durable that limit their final applications [4]. Nonetheless, there are some wood species from secondary forest that can be utilized but still less concerned by the wood based industries.

Mahang, Sesenduk and Terap are among lesser known species (LKS) that emerged in large quantity in secondary forest are potential to become alternative supply of raw materials for wood based industries. Mahang (*Macaranga* sp.) wood is a pioneer tree species and light density hard wood which emerge in sizeable quantity in logged over forest in Southeast Asia [5]. It is a fast growing plant thus it can be harvested at the early ages where at ae of four years old, the diameter at breast height (DBH) can reach 50 cm. While, six years old Acacia mangium the DBH is *only 45 cm and rubberwood might take five to ten* years to reach that size [6].

However, most of the wood-based industries in Malaysia are reluctant to use LKS due to its poor properties. These poor properties of LKS for instance dimensional instability, inferior mechanical strength and low durability can be improved by wood treatment with or without changing the nature of the wood chemically or by processing the wood into value-added products which may increase the properties of the wood.

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In this present study, to overcome the inferior quality of Mahang wood, the wood was processed into laminated product. Laminate is a process to produce engineered wood by bonding together wood plies using adhesive and it is a good technique that can be implemented to improve the strength properties. To access the success of laminated Mahang wood compared to the solid Mahang wood, the wood was tested with few tests namely physical and mechanical testing.

MATERIALS AND METHOD

Sample Preparation

Mahang wood was obtained from Agro Park of Universiti Malaysia Kelantan Jeli Campus. The trees were cut at their breast height and a spray paint was used to cover the surface of the wood at the cutting edge to prevent loss of moisture. There were two age categories of the wood which are mature (6 to 8 years old) and young (3 to 4 years old). Later, the wood were divided into three portion which are bottom, middle and top. There were also two wood types which are heartwood and sapwood.

Laminating Process

In this research, parallel lamination was chosen as lamination process because it is easier to be fabricate. Two-layer of wood lamination was used in this research and polyvinyl acetate (PVA) was used as adhesive to combine the layers. PVA was used because it is non-toxic, inexpensive and performed stronger bonds according to the cellulose polymers.

Physical Properties Evaluation

For physical properties evaluation, the samples were prepared in blocks (2 cm x 2 cm x 2 cm) for both solid and laminated wood. The process of evaluation are as follows:

1. Basic density

Both of the solid and laminated wood were put into the oven overnight. After 24 hours, the mahang wood are weight again and the basic density are calculated using the following formula.

Density (g/cm3) = (oven dry mass)/(green volume)

2. Water absorption

All the samples were immersed in distilled water for 24 hours. After 24 hours the samples were weight and the water absorption are calculated using the following formula.

Water absorption (%) = (M1-M0)/M0 x 100

3. Thickness swelling

The samples are measured using venier calipers at tangential, longitudinal and radial surface before immersed in distilled water for 24 hours. After 24 hours, the measurement were retaken at the same surface.

Mechanical Properties Evaluation

The bending test was done using Universal Testing Machine (UTM) to test the strength of the Mahang wood samples. Both Modulus of Rupture (MOR) and Modulus of Elasticity (MOE) following ASTM D143 with modification.

RESULT AND DISCUSSION

Basic density is the determination of cell wall material in the wood. It is also very important because it affect the moisture content of the wood which high moisture content will lead to high susceptible to attack by bio-deterioration agent. The basic density of wood depends on the thickness of the wall fiber and related to the ratio of vessel fiber [7]. Figure 1 shows the basic density in solid and laminated Mahang wood according to the variety of wood samples. For both sample types, maturity and relative position of the wood are important source of variation in basic density. The higher basic density can be found in matured wood compared to young Mahang wood is associated with the thicker wall fiber in matured wood. While, for the portion of wood, top portion have slightly higher basic density than [8].

Besides, to compare between sample types which are solid and laminates Mahang wood, the laminated Mahang wood have higher basic density. The basic density value of solid Mahang wood is comparable with balsa and bamboo which are very lightweight material. However, when the Mahang wood is processed into laminates, the basic density is increased and comparable

with eucalyptus which is one of the wood species widely use in furniture industry.

This is because, the weight of laminated wood are higher than the solid wood. When weight is increase, value of basic density also were increased. Other than that, there are significant dispersion of wood density within the glued elements, disruption of the grain due to the many wood layers and the use of glue to hold the layers all contributes to the increment of basic density [9].

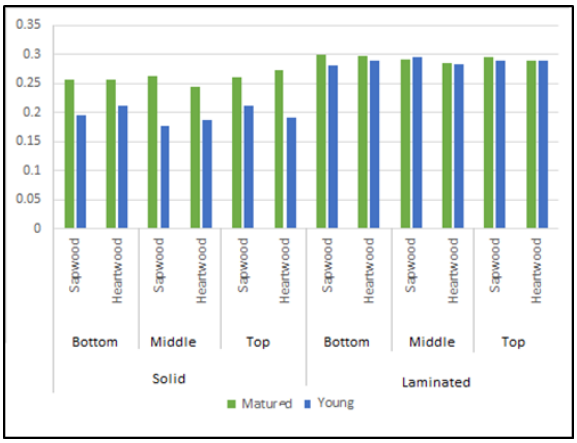

Figure 1: The basic density of solid and laminated Mahang wood

For the shrinkage and swelling test, the research was conducted on the wood generally without dividing it into portion. By referring to Figure 2, the swelling in tangential and radial are obviously higher than the longitudinal swelling. Longitudinal swelling did not really effected due to its structure. The longitudinal shrinkage and swelling is only 0.1 to 0.3% in contrast to the transverse shrinkage and swelling which is between 2 to 10%. Tangential shrinkage is often about twice as great as in radial direction although in some species it is as much as five times higher. According to Walker, 1993, the usual shrinkage is about 5 to 10% in the tangential direction and about 2 to 6% in the radial direction.

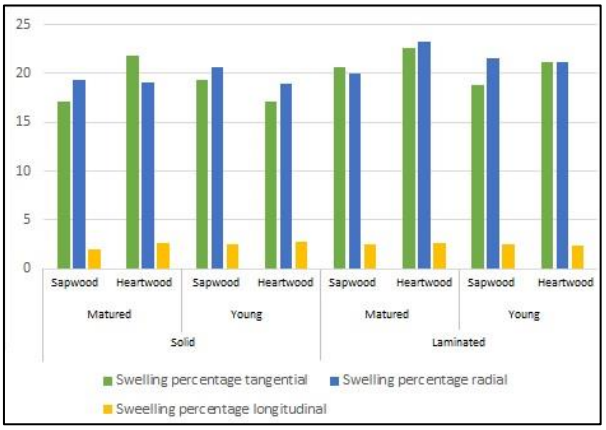

Figure 2: The percentage of shrinkage and swelling test for solid and laminated Mahang wood

Figure 3 shows the value of water absorption capability of matured and young samples from solid and laminated Mahang wood. Generally, heartwood absorbs less water than the sapwood. This is due to the heartwood that loss its transport function compared to sapwood [10]. However, it can be see that in young Mahang wood, the heartwood absorbs more water than sapwood because transforming into heartwood is an ongoing process and the wood may not fully developed its heartwood properties and thus it absorbs more water. There are also differences in terms of the maturity of the samples. The young samples can absorb more water than the matured samples. This can be explained through the maturity factor of the wood where when maturity increase, the rate of water absorption decrease [11].

Whereas, the water absorption in solid wood are higher than laminated wood due to the absorption capability rate in biological structure of solid wood [12]. This would conclude that with lower water absorption, laminate Mahang wood can be considered as a stable wood product. It is because high water absorption can cause changes in shape, debonding or loss of strength in products with regular exposed to the moisture [13].

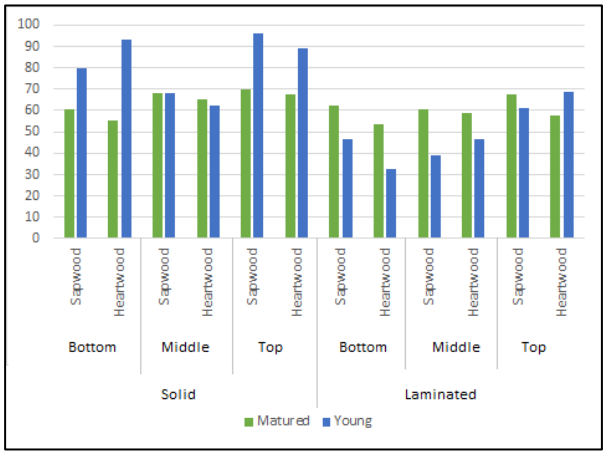

Figure 3: The percentage of water absorption for solid and laminated Mahang wood

MOR and MOE are important parameters for the use to be utilized as structural material [14]. As can be observed from Figure 4 and 5, the MOR and MOE of laminated wood are obviously higher than the solid Mahang wood. For MOR, the highest improvement are almost 600% for the sapwood middle part of Mahang wood while for MOE the major increment was almost 500% of the heartwood bottom part. This proved that by implementing the lamination process, the strength of this light hard wood can be greatly increase and can be further used. One of the reason why laminated wood is stronger than the solid wood is that the wood layers added flexibility that reduce stress-cracking. There are many other factors that might affect the mechanical properties of laminated wood such as compression ratio, size, wood species, binding agent, wood defects, growth ring characteristic and density of wood [15].

As observed in Figure 4 and 5, all the above characteristic did affect the improvement in strength of laminated wood. Wood with higher fiber loading and thickness of fiber which is the matured Mahang wood have better MOE and MOR. The strength properties directly related with the physical properties of the wood.

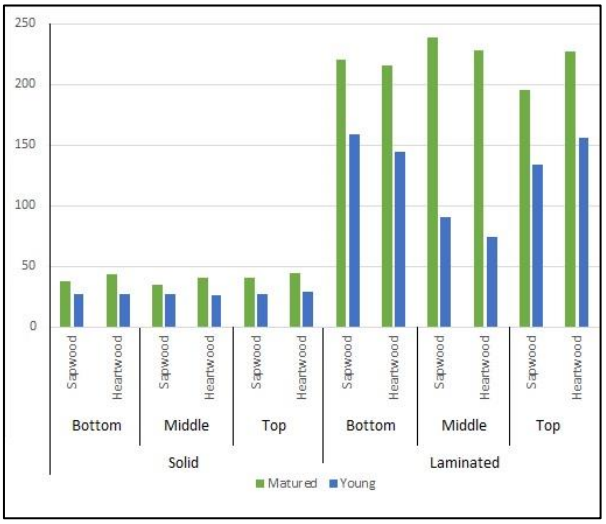

Figure 4: MOR of solid and laminated Mahang wood

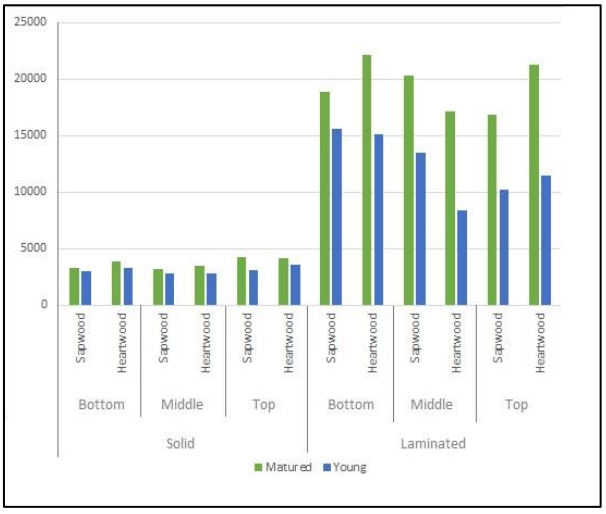

Figure 5: MOE of solid and laminated Mahang wood

CONCLUSION

In conclusion, laminating process can be used to process solid Mahang wood into laminated Mahang wood which this process would improve the physical properties and strength properties of Mahang wood. The physical properties especially the density definitely related with the strength properties of the wood. It is advised to use matured wood, above 8 years to gain more satisfactory Mahang wood laminates. This wood laminates can be used for as construction materials or households products especially furniture since the strength is greatly improved. Continuous research should be carry out on Mahang wood to promote the use of this wood species for example the use of different layers of different laminating process.

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