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WOOD QUALITY OF *PARASERIANTHES FALCATARIA* L. NIELSEN SYN WOOD FROM THREE YEAR ROTATION OF HARVESTING FOR CONSTRUCTION APPLICATION

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ABSTRACT

Paraserianthes falcataria is fast growing species that considered being potential lumber for construction application. The aim was to evaluate the effect of year rotation of harvesting on quality of *Paraserianthes falcataria* wood for construction application. Nine trees of *Paraserianthes falcataria* with harvesting rotation of 5, 7, and 9 years, were harvested from the private forest. Moisture content, specific gravity, shrinkage, MOE, MOR, and compressive strength parallel to grain were measured for wood quality parameters in accordance to JIS Z 2101. Durability test were conducted against dry wood termite (*Criptotermes cynocephalus* Light). The results showed that year harvesting of *Paraserianthes falcataria* influence significantly on specific gravity, and compressive strength parallels to grain. *Paraserianthes falcataria* wood is classified into strength class III-IV, which is properly used for light construction. To obtain optimum quality for construction purposes, *Paraserianthes falcataria* tree is recommended to be harvested in minimum harvesting rotation of 7 years.

KEYWORDS: Construction, *Paraserianthes falcataria*, rotation, properties.

INTRODUCTION

As construction purposes, wood shows several advantages, such as its appearance, its easy working and re-working, its high strength/weight ratio, its better insulation properties and somehow very low cost (Stalnaker and Harris 1989). To fulfill material for a construction, such as housing and other light constructions, wood is remain preferred in Indonesia. However, a gap between supply and demand of high-quality timber has been widening due to massive forest exploitation in the previous period in Java, Indonesia since 1998. Extensive clearing of Indonesian forest reached 47,600 ha per year from 2009-2012 (Margono et al. 2014). On the other hand, the number population and residential housing are increasing, which lead to growing demand for wood products, especially for construction. Therefore, it is essential to explore substituted potential timber for construction use. Providing an alternative fast growing species, which also able to grow in various type of soil and acceptable quality for construction, has been a significant concern in Indonesia.

Paraserianthes falcataria L. Nielsen syn wood is one of the fast-growing species that has been widely planted in Indonesia. Smallholder has traditionally planted *Paraserianthes falcataria* on private or community land in a multi-cropping system due to their ability to fix nitrogen, and fodder production (Sorieanegara and Lemmens 1993). *Paraserianthes falcataria* is also well planted in almost all type of soil and elevation in Indonesia (Krisnawati et al. 2011). This species is a fairly large tree that can grow up to 30 m with straight bole-height up to 20 m. The growth rate of this species is also good, which is shown by a mean annual increment (MAI) can reach 30-40 m^3/ha in 8-12 years of harvesting rotation (Sorieanegara and Lemmens 1993). *Paraserianthes falcataria* have been utilized mainly for plywood and harvested based on a diameter that important in plywood production. Planting *Paraserianthes falcataria* is provide more routine income, which is shown by Benefit-Cost Ratio (B/C Ratio) of more than one (Siregar et al. 2007). Therefore, *Paraserianthes falcataria* is considered to be a potential alternative lumber for construction purposes in Indonesia.

Farmer is often lack of information related to proper time to harvest trees in optimum quality based on year rotation. Regarding to the volume of growth, *Paraserianthes falcataria* is usually harvested after ten years old and tends to decrease up to 8 years old (Siregar et al. 2007). Kurinobu, et al. (2007) observed that *Paraserianthes falcataria* are planted by well-managed forest company in the year rotation of 8 years. A shorter rotation of harvesting was reported by Nemoto et al. (2002) who stated that *Paraserianthes falcataria* can be used for industrial purposes at six year rotation. Regarding wood quality, there is not enough information related to a proper time of year rotation of harvesting. Wood quality is affected by many factors including silvicultural treatments such as rotation age (Goncalves et al. 2004, Listyanto and Nichols 2009). Shorter rotation in fast growing species tends to have a high proportion of juvenile (Bao et al., 2001, Rahayu et al. 2014). The decrease of year rotation of harvesting may influence on wood quality by increasing the proportion of juvenile wood and sapwood, which lead to a decrease of strength properties (Bao et al. 2001). The increasing proportion of sapwood may also influence on average a durability of lumber. As a result, prolonging harvesting rotation may not significantly influence on growth and quality improvement. There are more parameters, such as moisture content (m.c.), density, shrinkage, mechanical properties, and durability that should be investigated to support farmer or wood industries to select the proper time to harvest *Paraserianthes falcataria*.

The aim of this study was to evaluate the effect of year rotation of harvesting on the quality of *Paraserianthes falcataria* wood for construction purposes. Moisture content, specific gravity, shrinkage, modulus of elasticity (MOE), modulus of rupture (MOR), compressive strength parallel to grain, termite mortality, and mass losses of the samples were measured to determine the quality of *Paraserianthes falcataria* wood for construction use.

MATERIALS AND METHODS

Nine trees of *Paraserianthes falcataria* from three different year rotation, which were 5, 7, and 9 years old, were harvested from the private forest (07.53.180 S and 110.03.982 E) in Yogyakarta. Three trees on each year rotation were taken for sample. Each tree was cut into logs with the length of 2000 mm (Fig. 1). A total of 3 short logs 400 mm in thickness were collected from the bottom, middle, and top part of each tree (Fig. 1a). Disks with the thickness of 20 mm were cross-cut in the bottom part of each log with the dimension of 20 x 20 x 20 mm to create sample of m. c. and specific gravity (Fig. 1 b-c). Samples for shrinkage measurement were prepared with the dimension of 20 x 20 x 40 mm (Fig. 1d). Sample with the dimension of 20 x 20 x 300 mm were prepared for measurement of modulus of elasticity (MOE) and modulus of rupture (MOR). Sample for compressive strength parallel to grain were made with the dimension of 20 x 20 x 60 mm. Moisture content, specific gravity, shrinkage, MOE, MOR, and compressive strength parallel to grain were measured in accordance JIS Z 2101-2117 (2009). Durability test were conducted by preparing the sample with the dimension of 50 x 50 x 50 mm. All samples were conditioned to obtain m.c of 12% and tested against dry wood termite (*Criptotermes cynocephalus* Light). Termite mortality and mass losses of the samples were calculated after 28 days observation.

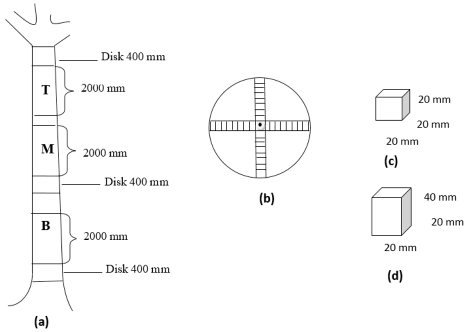

Fig. 1: Schematic drawing of preparing sample. (a) Log and disk cutting. (b) Transversally schematic diagram of preparing sample of moisture content, density, and shrinkage measurement. (c) Preparing sample for moisture content and density measurement. (d) Preparing sample for shrinkage measurement.

Analyses of variance with the significance level (α) of 0.05 were conducted to analyse the effect of year rotation of harvesting on m. c., specific gravity, shrinkage, modulus of elasticity (MOE), modulus of rupture (MOR), compressive strength parallel to grain, termite mortality and mass losses of the samples. Tukey`s honestly significant different (HSD) was used to determine the difference among the year rotation of harvesting.

RESULTS AND DISCUSSIONS

Green m. c. of *Paraserianthes falcataria* varied between 111%-146%. The average of a green moisture content of each year rotation is presented in Tab. 1. This value of green m.c. is relatively high. The effects of m.c. has to be understood and considered in the wood construction (Kretschmann 2010). Moisture content influence significantly on strength properties of lumber. Gerhards (1982) stated that a significant effect implies a greater change in mechanical properties because of a given change in m.c. Therefore proper drying should be applied, otherwise strength properties is decreasing due to higher given m.c. Incising as pre-treatment with combined by microwave and steam drying could be considered to be applied for proper drying method to reduce greater m.c. with minimum defects (Listyanto et.al. 2016a, Listyanto et.al. 2016b, Listyanto et.al. 2013). Analysis of varian showed that there was no significant different

(P – value > 0.05) on green m. c. among three different year rotation. This means farmer can harvest *Paraserianthes falcataria* start from 5 year rotation.

Tab. 1: Average of green moisture content, radial and tangential shrinkage, and tangential and radial shrinkage ratio.

Age	Green Moisture Content (%)	Shrinkage to oven dry (%)		T/R ratio
		Radial	Tangential	
5	131	2.59	4.56	1.8
7	123	2.75	4.57	1.7
9	139	3.21	6.11	1.9

Tangential and radial shrinkage ratio varied between 1.8 and 1.9. The average of T/R shrinkage ratio is shown in Tab. 1. There was no significant different (P – value > 0.05) on T/R shrinkage ratio among three year rotation. It is important to consider that this ratio is classified into medium and high, which may cause some significant warping after sawing. Shrinkage is a parameter of wood dimensional stabilization. The effects of tangential and radial shrinkage ratio (T/R ratio) can cause wood warping and checks during drying below fiber saturation point. Checks across one surface to the opposite one may influence the strength properties (Kretschmann, 2010). Therefore, it should be considered during sawing and drying process. Heavy sticker or clamp should be well prepared before proper drying.

Interestingly, significant difference (P – value > 0.05) was found in the parameter of specific gravity. Wood from harvesting rotation of seven and nine year-old showed a higher average of specific gravity than that of five years one (Fig. 2).

Fig. 2: The Average specific gravity of Paraserianthes falcataria wood from three different rotation age of tree.

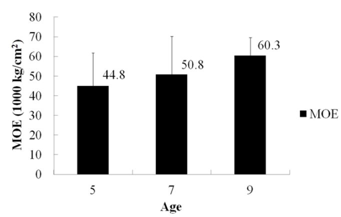

Fig. 3: Average modules of elasticity (MoE) of Paraserianthes falcataria wood from three different age of tree.

The difference of specific gravity between 5 years old and 7-9 years is seemed to be caused by transition line between juvenile and mature part (Gartner 2005). This result is also supported by Rahayu et al. (2014) that 5-6 years falcataria is dominated by juvenile wood. *Paraserianthes falcataria* at seven years or more is expected to be dominated by mature wood. Specific gravity also shows strong correlation with mechanical properties, such as compressive strength properties (Gerhards 1982, Kollman and Cote 1984). The structural Young's modulus and the flexural stiffness of the stem are affected by the distribution of adult and juvenile wood within the stem affects (Bruechert et al. 2000). Consequently, harvesting *Paraserianthes falcataria* in the age of 7-9 years are more recommended.

The average value of strength properties at m.c. 12% are shown in Fig. 3-5. Modulus of rupture (MOR) were in the range of 536 $kg{\cdot}cm^{-2}$ - 541 $kg{\cdot}cm^{-2}$ while modulus of elasticity (MOE) varied between 44.827 x 1000 $kg{\cdot}cm^{-2}$ and 60.314 x 1000 $kg{\cdot}cm^{-2}$. This results slightly higher than that reported by Martawijaya et al. (2005) that MOR values of *Paraserianthes falcataria* were 526 $kg{\cdot}cm^{-2}$.

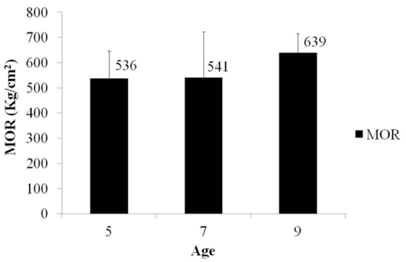

Fig. 4: Average modules of rupture (MOR) of Paraserianthes falcataria wood from three different age of tree.

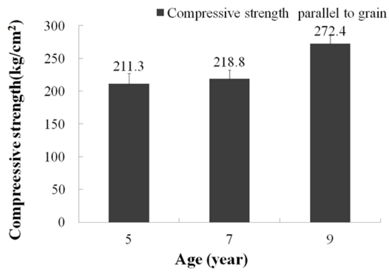

Fig. 5: Average compressive strength perpendicular to grain of Paraserianthes falcataria wood from three different age of tree.

There were no significant different (P – value > 0.05) on MOR and MOE among those three year rotation of harvesting. Significant difference was found in compressive strength parallels to grain. Compressive strength parallel to grain of year rotation 7 and 9 year were higher than that of 5 year one. Strength property based on MOR is classified into strength class II-IV, which means suitable for light construction. Considering its specific gravity and strength properties, *Paraserianthes falcataria* shows better properties on strength-weight ratio, which is important in construction application (Breyer et al. 2003). Therefore, it is recommended to harvest *Paraserianthes falcataria* in the year rotation of 7-9.

Termite mortality and mass losses were investigated as a parameter to indicate the durability of the samples. Termite mortality was in the range between 37 and 42%, while mass losses after 28 days against dry wood termite varied between 1.6 % and 1.2 %. The average mortality and mass losses of *Paraserianthes falcataria* wood from three different harvesting rotation against dry wood termite can be seen in Fig. 6.

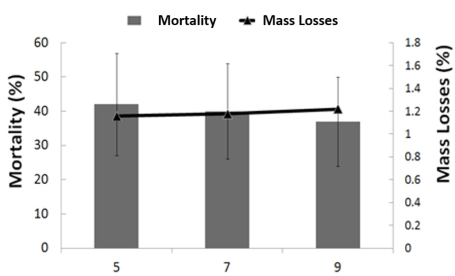

Fig. 6: The average mortality and mass losses of Paraserianthes falcataria wood from three different age of tree against drywood termite.

This result indicates that *Paraserianthes falcataria* has a low resistance against dry wood termite. This result is similar with report by Martawijaya et al. (2005) that *Paraserianthes falcataria* can be classified into durability class IV. There was no significant different on durability (P – value > 0.05) among three year rotation *Paraserianthes falcataria* trees. Therefore, it is recommended to preserve all *Paraserianthes falcataria* wood from rotation of 5-9 year before using as construction use.

CONCLUSIONS

It can be concluded that year rotation influence significantly on specific gravity and compressive strength parallel to grain. *Paraserianthes falcataria* wood is classified into strength class III-IV., which is suitable for light construction purposes. *Paraserianthes falcataria* is recommended to be harvested in the minimum harvesting rotation of 7 years-old, which is properly used for light construction. It is important to preserve *Paraserianthes falcataria* wood before utilising for construction application.

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