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Tensile shear strength of natural wood decorative plywood from lesser known Sungkai (*Peronema canescens*) tree

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Abstract. Sungkai (*Peronema canescens*) small logs has been harvested from a private sungkai plantation (Sabahpuri Nursery Sdn Bhd) in Telipok, Sabah. The logs were then rotary peeled to 0.6mm thick and made into 4' x 4', 3 plies Urea Formaldehyde (UF) plywood with Acacia Hybrid wood used as the core veneer (1.2 mm thick) at a local plywood facility; Cymao Plywood Sdn Bhd in Sandakan. Remaining dried veneer were brought back to University Malaysia Sabah for further study. Laboratory scale 3 plies plywood (Sungkai-Acacia, Sungkai-Seraya) were made using the same source of UF resin and veneer, and used for comparison studies. Commercial 3 plies Nyatoh plywood were also used as control samples. The samples were then tested according to Japanese Agricultural Standard for Plywood 2003 (amended: 2008) *Tensile Shear Strength of Type II Natural Wood Decorative Plywood*. All of the samples pass the Tensile Shear Strength (TSS) minimum standard of 0.7 N/mm^2 in untreated condition or even after hot and cold water immersion treatment. The untreated mill samples of Sungkai-Acacia plywood perform the best with mean TSS = 1.74 N/mm^2, SE = 0.05 while Nyatoh shows the lowest mean tensile shear strength with 1.06 N/mm^2, SE = 0.07. Further statistical analysis shows there was no significance difference between Sungkai mixed plywood group samples. However, Sungkai mixed plywood samples shows a significant difference ($p < 0.05$) with superior strength when compared to commercial Nyatoh plywood samples. If these criteria met the final requirement for the end use of the veneer, then the potential of Sungkai as an alternative or supplemental raw material is something worth given due consideration.

1. Introduction

Malaysian timber industry is one of the top 3 largest commodity based nation export earner with total exports value amount of RM 21.86 billion in year 2016. Veneer and plywood seconded the largest timber product export list with 23 %. Japan was the largest importer of Malaysian plywood to date with United states comes in second [1].

The competition on Malaysian commercial tropical tree for the use as timber industry raw material has long been acknowledged. The depleting resources from the primary forest to produce high quality veneer for the production of plywood has been the effects from high demand for other uses of timber based products. The nation is in its efforts to be more systematic and finds sustainable way to maintain timber resources. Forest plantation has widely been implemented throughout the country and

the searches on suitable tree species for plantation purpose are still continuing until today. There are plenty species that has been planted more than 15 years and already reached maturity in Malaysia. Two dominant species were Rubberwood (*Hevea brasiliensis*) and *Acacia mangium*. Other species that has been considered under the plantation programme includes Teak (*Tectona grandis*); Sentang (*Azadirachta excelsa*); Khaya (*Khaya ivorensis/ Khaya senegalensis*); Kelempayan/Laran (*Neolamarckia cadamba*); Batai (*Paraserianthes falcataria*); Binuang (*Octomeles sumatrana*); and *Eucalyptus spp*.

Looking at the two primary plantation species. *Acacia mangium* species were found unable to produce high quality face veneer. The high volume of knots on its wood prevent it from being selected to be used as face veneer [2]. The current commercial use of mangium species is more towards the production for general purpose plywood and pulp production. Meanwhile Rubber tree has long been acknowledged as the prime source of solid wood for furniture production. More suitable or appropriate plantation tree species has to be studied to address the issue so that it can add more alternatives or supplement the current raw material shortage in the timber industry.

Sungkai tree is one of the lesser known tree species that has yet been fully explored and utilised by the Malaysian timber industry at the current state. The high survival character and the ability to grow far from the usual habitat are the strong trait of Sungkai *(Peronema canescens)* which is similar to other species from the Verbenaceae family. Highly significant differences in height, DBH growth and survival were observed among growth sites and between tree clones [3]. Sungkai tree are very much suitable to be planted for agroforestry and also to rejuvenate low productivity land such as shifting cultivation area and scrubland. A harvest cycle of 15 years is said to be economic [4]. Young leaf observed to have been sprouting out from the dislocated trunk in several days/weak after it has been cut from its stump. This shows a magnificent adaptability and survivability of the wood to grow in severe condition.

Matured Sungkai trees has the ability to survive and endure several wild fire during the dry season and quickly rejuvenate and sprout its leaves when the season back to normal or raining. It is in that condition which the tree adapting to dry and rainy season creates a beautiful ring porous structure within the wood. Sungkai is considered one among a few tropical tree with a distinct growth ring feature.

The wood is cream-coloured with bits of light yellow, light pink or light brown colour. The timber closely resembles teak wood with brighter shades of colour. Because of the bright colour, it sometimes being referred as white teak in the commercial trade. The tree is also known as Jati londo, Jati sabrang, Kurus and Sungkai (Indonesia); and Khoeilai, Sakae and Sangkae (Thailand).

The wood radial and surface texture is attractive and beautiful. Wood texture is moderately fine to moderately coarse and uneven. Grain is straight to wavy. It has a certain character that can be manipulate to be used as face veneer in decorative plywood production and further to be used for the furniture industry. Sungkai wood is moderately hard and medium in weight with a density of 520-730 kg/m^3 air dry [5].

Difference in veneer grade quality from a single species does not significantly affects density, bending strength and elasticity of a plywood [6]. However there are difference in wood characteristic between different species. So there might be a chance where there are differences for plywood properties of combined species. The effect of ageing process, wood species, glue type and drying temperature on bonding strength were said to be statistically significant [7].

The objectives of the study were to determine whether sungkai as face veneer can pass Article 7 in Japanese Agricultural Standard for Plywood minimum tensile shear strength requirement.

2. Materials and Method

2.1 Materials

The Sungkai wood used in this research was received from Sabahpuri Nursery Sdn Bhd which has an individual plantation plot at Telipok, Kota Kinabalu, Sabah. Raw materials used for the study was 13 years old Sungkai (*Peronema canescens*). 11 small logs from 6 different 13 years old trees with an average length of 137 cm each with average DBH of 22 cm were collected from the plot. It was felled and transferred with the permission of Sabah Forestry Department to the veneer peeling facilities at Cymao Plywood Sdn Bhd mill in Sandakan, Sabah and processed into 0.6 mm veneer. 12 Acacia hybrid small logs were collected from Sabah Forestry Development Authority (SAFODA) plantation plot at Ulu Kukut, kota Belud a day before being transported together with Sungkai logs to Sandakan. Acacia logs were peeled to 1.2 mm thick to be used as core veneer for the 3 plies plywood production process. Meanwhile the actual Cymao Plywood mill production samples of natural forest Seraya 1.2 mm veneer were requested and collected from the manufacturing facility to be used for comparison study. Commercial Nyatoh 3 plies plywood were also acquired as a control sample for the study. UF resin used throughout the study were compliments from Cymao Plywood Sdn Bhd.

2.2 Plywood production.

There were 12 piece Sungkai-Acacia plywood 1200 mm (width) x 1200 mm (length) x 2.4 mm (thick) which were made using the mill facilities**.** Sungkai 0.6mm veneer was used as face and back meanwhile 1.2 mm acacia veneer were used as the core veneer to produce the samples. At the University, 10 samples of 300mm (width) x 300mm (length) x 2.4 mm (thick) Sungkai-Acacia and Sungkai-Seraya plywoods were made from the same veneer and resin source acquired at Cymao Plywood Sdn Bhd earlier. This time the university facilities are being used to produce the laboratory scale samples for comparison study. The average adhesive consumption was 250 g/m^2 in double glue line. Assembly time was 25 min. The boards were pre-pressed at room temperature for 5 min. The hot press conditions were: Temperature, 135 °C; pressure, 1.2 MPa and time, 5 min.

2.3 Samples preparation

Samples from each group of plywood were cut according to the Japanese Agricultural Standard for Plywood 2003 (amended: 2008) *Tensile Shear Strength of Type II Natural Wood Decorative Plywood.* [8] Each plywood type was divided into two sub group which are the normal untreated group and the 3hr hot water immersion treatment group. At least 30 replicates for each group for every plywood types tested towards the JAS standard requirements.

2.4 Sample testing

Sample testing were done at UMS forestry complex, using Gotech universal testing machine (Model AI-7000 L10). The dimension of each sample shown in Figure 1 are in millimetres (mm). Normal untreated replicates will go directly for testing according to their respective types of plywood. Treated samples will undergo 3-hour water immersion in water bath with 60 ± 3 °C and later on immersed in water of room temperature until the samples cool down before being test for tensile shear strength.

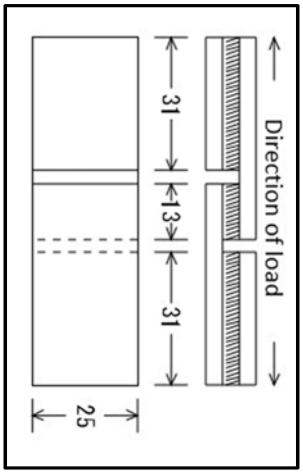

Figure 1. Test specimens dimension (mm)

Figure 2. test specimen grip position

The test specimens will be gripped vertically on the upper and lower part of the test specimens as shown in figure 2. Tensile force of 5mm/min will be loaded according to the direction load shown in figure 1.

3. Results and Discussion

All data collected were recorded and transferred into IBM SPSS 20 Statistical Analysis Program. One-way ANOVA were used followed by Duncan Mean Range Test (DMRT) to check the significance of the mean tensile shear strength statistically.

Table 1. Mean tensile shear strength of sample plywood.

Samples	Mean ± Standard error	
	Normal	3hr Hot Water Immersion
Sungkai Acacia B mill	1.74 ± 0.05 [a]	1.44 ± 0.07 [a]
Sungkai Acacia B lab	1.64 ± 0.09 [a]	1.59 ± 0.09 [a]
Sungkai Seraya B lab	1.59 ± 0.11 [a]	1.56 ± 0.09 [a]
Sungkai Acacia A mill	1.05 ± 0.03 [b]	1.19 ± 0.04 [b]
Nyatoh Commercial	1.06 ± 0.07 [b]	0.53 ± 0.05 [c]

Note: Data is expressed as means ± standard error; the means value is in N/mm2 unit, a different set of samples used for each treatment condition. Values with the same letter are not significantly different after one-way ANOVA followed by the Duncan post hoc test ($p < 0.05$).

As the result shown in Table 1. There was no significance difference between samples made at the mill and samples made at the laboratory for Sungkai-Acacia B and Sungkai-Seraya plywood. Highest mean tensile shear strength value was shown by mill sample Sungkai-Acacia B for normal condition samples with 1.74 ± 0.05 N/mm^2. 3-hours hot water immersion was done as an accelerated stress/ageing to the bonds between veneers. Laboratory sample of Sungkai-Acacia and Sungkai-Seraya plywood showed better mean tensile shear strength of compare to other samples with 1.59 ± 0.09 N/mm^2 and 1.59 ± 0.09 N/mm^2, respectively.

Sungkai-Acacia A mill and shows a significant difference compare to previous Sungkai-Acacia B and Sungkai-seraya B with 1.05 ± 0.03 N/mm^2 in normal condition and 1.19 ± 0.04 N/mm^2 after 3-hour Hot water immersion treatment. This may the result of type A sample has longer length (25mm) in the centre of the test specimens. Nyatoh commercial samples also exhibit no significant difference with Sungkai-Acacia A for normal condition samples but showed a significant difference with lower mean tensile shear strength value of 0.53 ± 0.05 N/mm^2. A further investigation is proposed and new

Type B replicates of Nyatoh Commercial should be done to clarify the reason there is a significant drop on mean tensile shear strength.

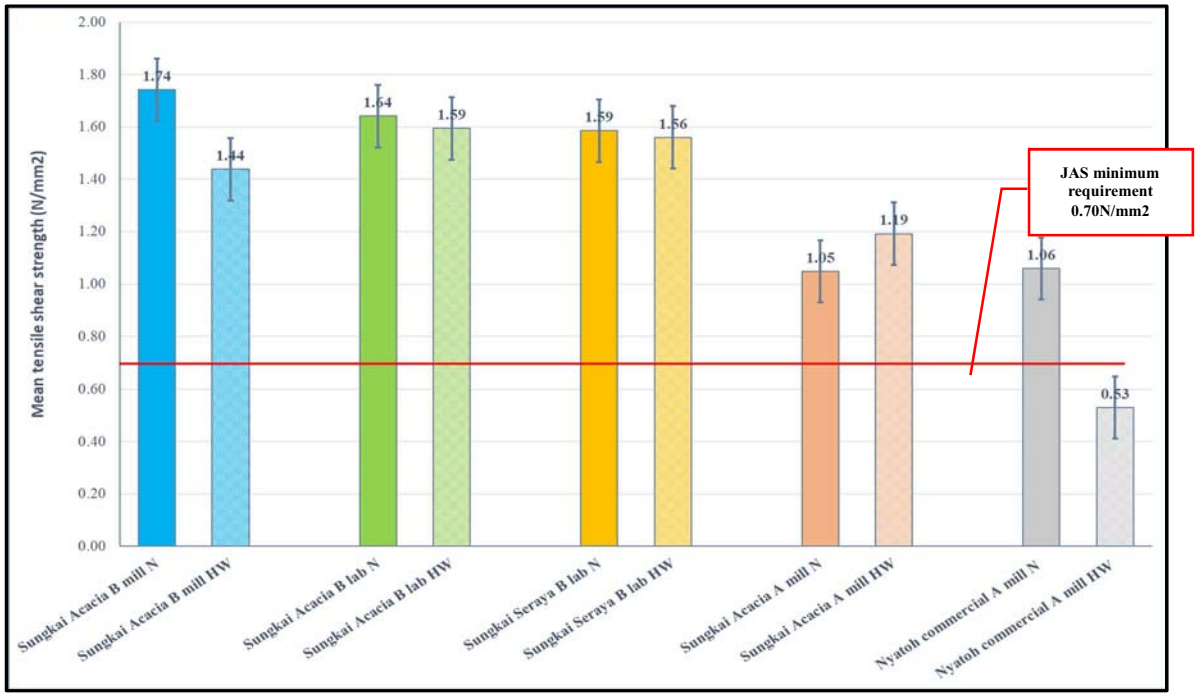

Figure 3. Mean tensile shear strength and standard error.

Overall, normal untreated condition samples show no significant difference when compared with treated 3-hour hot water immersion. It is interesting that Sungkai plywood were able to withstand the Type II accelerated stress/ageing test and come up with mean tensile shear strength with no significant difference from the normal condition samples and surpass the minimum JAS standard requirements of 0.7N/mm2 for tropical hardwood plywood. On top of that Sungkai plywood were also significantly better than the control Nyatoh commercial sample in normal condition and even in treated condition.

4. Conclusion

Based on the experimental results, it can be concluded that sungkai wood veneer offers attractive potential as an alternative or supplement raw material to produce good face veneer. It shows great result when used together with another potential plantation species and also with a current commercial natural forest species. It even surpasses the strength of a sample of current commercial species significantly. This finding should add more knowledge on the wood itself. If these criteria met the final requirement for the end use of the veneer, then the potential of Sungkai as an alternative or supplemental raw material is something worth given due consideration.

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