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TENSILE STRENGTH BEHAVIOR OF LAMINATED VENEER LUMBER

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ABSTRACT

*Tensile strength behavior of laminated veneer lumber (LVL) manufactured from Malaysian tropical timber was evaluated. The 50 mm thick LVL panels were manufactured using 13 and 17 layers veneers. The tensile strength test was carried out using in-grade size specimens. In order to carry out this test, a special tensile grip was fabricated using the model suggested in ASTM D198. The LVL comprised Kedondong (*Canarium,*spp), Keruing (*Dipterocarpus , *spp) and Bintagor (*Calophyllum, *spp). Tests were conducted according to ASTM D198 (Static Test of Lumber in Structural Size). The tensile strength properties evaluated include tensile strength, modulus of elasticity and Poisson ratio. Effect of timber species and the number of veneer layers on the tensile strength properties were analysed statistically. In this study it was found that the species has more dominant effect on the tensile strength of LVL.*

Keyword: *tensile strength, LVL, modulus of elasticity, Poisson ratio, Malaysian tropical timber*

INTRODUCTION

In Malaysia, woods are primarily used for esthetic function such as floor panel or furniture and as structural members mainly in roof trusses application. The introduction of many new wood technology products with outstanding capabilities changes the engineering scenario dramatically. One of them is Laminated Veneer Lumber (LVL). In Malaysia, LVL is mostly used as nonstructural application, and not yet to be used as structural member because of insufficient data available even though LVL has been in production since 1980s. The production of LVL is mainly for exports i.e to Japan, South Korea and America.

LVL is used primarily as structural framing for residential and commercial construction and is well suited to applications where open web steel joists and light steel beams might be considered. LVL has been type-approved in several countries in Europe, Japan and North America and it is used in loading – bearing constructions. LVL are very suitable for applications where the dimensions and sawn woods will not suffice. LVL can offer components of ideal size for each application. In dwelling houses, LVL is commonly used in the roof structures. With its high flexural, tension and compression values, LVL enables manufacturing of inclined ceilings without truss structures. The use as header beams of wide windows and garage doors is also a common application. Since LVL is straight and accurate in dimensions, it is used as a major component in prefab houses. Other uses include scaffold planking and as flange members for some proprietary prefabricated wood I-joists. LVL has also been used as distribution a transmission cross arms in utility structure box shaped roadway signposts, and as trucked decking with hardwood face veneers.

To sufficient apply the LVL on the mentioned above structural component, the tension properties of the laminated veneer lumber are particularly important. Tensile properties is one of the required information for design those of structural component system. The tensile strength parallel to grain is the highest strength property of wood (1) Because of sensitivity to irregularities of grain, edge knots, notches, and other stress risers, it is difficult to realize this superior strength in structural members of commercial lumber if only based on the data available from small clear specimen. The need for precise design criteria for the tensile strength of structural timber and composite lumber is attaining increasing importance for the effective design and utilization of wood. It is therefore important to have direct measurements of the actual tensile strength of the lumber especially for LVL as the necked-down shape tensile specimens cannot be prepared due to the lamination process. Tensile strength data from in-grade testing, either for solid or composite lumber for Malaysian timber is not yet available due to the difficulty of making the end-fastening device. The device must have the end fastening secure enough for the full tensile strength to be brought into play before the fastening shear off longitudinally. Therefore in this study a special tensile grip has been fabricated in accordance to the method set forth in ASTM D198(2) as shown in Figure 1.0. This study is part of a broad research program in investigating the mechanical properties of LVL.

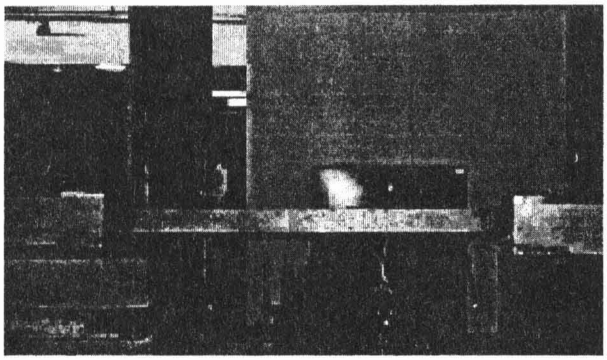


Fig. 1.0: Test set-up for tensile test

The work has been carried out in collaboration between Civil Engineering Faculty, University Technology Mara and the Faculty of Forestry, University Putra, Malaysia. The objective of the present study has been to establish tensile strength properties of LVL made from Malaysian tropical hardwood species. The effect of veneer thickness and species on the tensile strength of the LVL was also examined.

MATERIALS AND METHODS

Three tropical hardwood species were selected according their peelability, availability and gluability for making plywood i.e., Keruing (*Dipterocarpus spp.*), Kedondong (*Canarium spp.*) and Bintagor (*Calophyllum spp.*). LVL of 15-ply and 17-ply panels were manufactured using the tropical hardwood species, respectively. The logs were peeled into 3.2 mm (to make 17-ply LVL) and 4.0 mm (to make 13-ply LVL) thick veneers. The veneers were kiln-dried to approximately 7% moisture content. Panels size of 1200 mm width x 2400 mm long x 50 mm thick size, were manufactured in a commercial plywood mill. Phenol Formaldehyde (41.5% solids) resin was used a binder. The LVL panels were then cut to size according to the AS/NZS 4357: Structural Laminated Veneer Lumber (3).

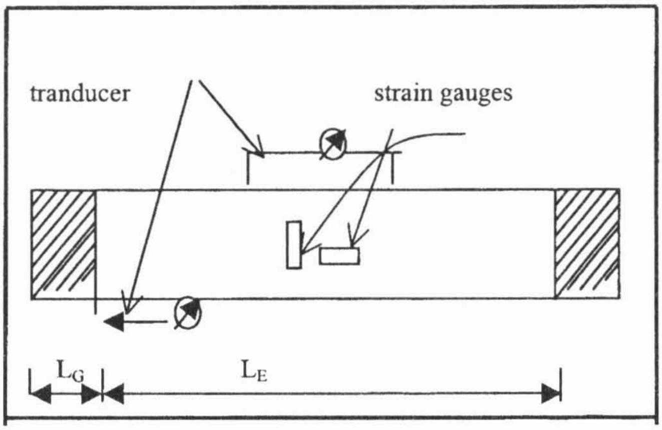
Ten panels were manufactured for each treatment. Fifteen specimens of 50 mm width x 50 mm thick x 1500 mm length sized for each treatment were cut from those LVL panels. The specimens were destructively tested in tension according to AS/NZS 4357:1995 Structural Laminated Veneer Lumber (1995) (3) as shown in Figure 2.0.

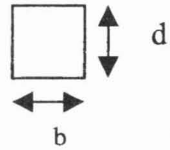
The density and moisture content for each of the tested bending specimen were determined after the testing. The tension strength, Modulus of elastic and Poisson's Ratio were calculated from this test. The Poisson's ratio, modulus of elasticity and tensile strength were calculated by using the equation below:

(i)Poisson's Ratio $= \dfrac{\varepsilon_{lateral}}{\varepsilon_{longitudinal}}$

(ii)The Modulus of Elasticity = slope of the stress-strain graph.

(iii) Tensile strength = optimum value of stress-strain graph.





$L_{specimen}$ = 1500mm b = d = 50mm

L_E = 900mm (According to AS/NZ 4063: 1992 (ASTM D198) L_E must not greater than 30d

L_G = 300mm

Figure 2.0: Schematic diagram for Test setup for tension parallel to grain test

RESULTS AND DISCUSSION

Failure characteristics

It was found that the test set-up has been able to produce tension failure as shown in Figure 3.0(a) and Figure 3.0 (b). Most of LVL from Keruing fails along the glue line. This can be explained by the fact that Keruing is difficult to be glued. A study done by **Wellons and Kramer (1973)**(4) also agreed that keruing has many occurrence failures in glue line. LVL from Kedondong and Bintagor has shown a good tension failure. Cracking of the specimen followed the joint between veneers. This indicates that this joint is the weak zone. Therefore the failure of the specimens is not entirely because of the fibres has reached its maximum stretching but because of the veneers jointing is weak.

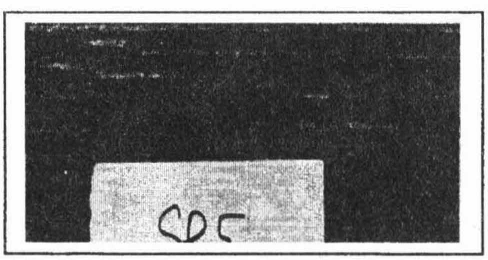


Figure 3.0(a) : Showing pull out effect on Keruing

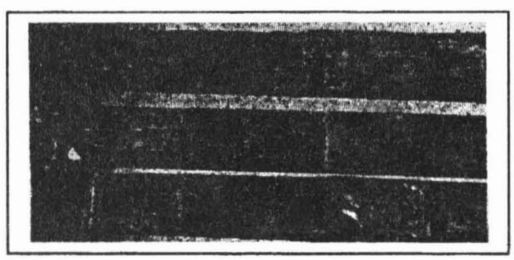


Figure 3.0(b): Showing cracks along the scarf joint.

Tensile strength

A summary of the test results is given in Table 1.0 and these values have been calculated in accordance with ASTM D198. The test result in Table 1.0 provides all the mean LVL properties in response to number of plies and species. Preceding the result, as there are three different species and two different number of plies, the tensile strength may be affected by both factors, therefore 2-Way ANOVA was performed to determine which experimental factors: number of plies, species type and interaction was of significant difference.

From the ANOVA analysis, the F-test indicates that there is interaction effect between number of plies and species types at 5% significant level [p-value = 0.027]. This means that the tensile strength was affected by both number of plies and type of species together. Therefore separate analysis cannot be done, as their result is not consistent.

By looking at pearson correlation coefficient, it was found that species types have more dominant effect on tensile strength therefore an analysis of variance (ANOVA) was performed to determine if there were differences in tensile strength for the different species tested. The ANOVA indicate the significant species effect (p value = 0.000). Since only two numbers of plies used, the mean of 17 plies was compared with 13 plies. From figure 2.0, the tensile strength comparison between numbers of ply, explained that LVL made from Kedondong, the 17-ply is 48% higher than 13-ply. For Bintagor, the 17-ply is 38.6% higher than 13-ply and for Keruing, the 17-ply is 13% higher than 13-ply. Therefore, the tensile strength of 17-ply for all species gave higher tensile strength compared to 13-ply. This indicates that as the number of plies increases, the tensile strength increases. This observation is also found by (**Wang et al.,1990; Sasaki et all.,1990**) (5) which conclude that laminated products with higher number of ply per unit thickness demonstrate better mechanical strength with improved uniformity due to the greater dispersion of defects all over the whole piece. **Preston (1950)** (6) investigated that by decreasing the veneer thickness the strength would be increased. **Leicester (1969)** (7) suggested that the use of sufficiently thin laminates could result in strength approaching those of defects free wood. Higher mechanical properties could be obtained by using thinner veneers.

Table 1.0: The mean tensile strength and MOE for all species.

SPECIES	NO. OF PLY	Tensile strength (MPa)	Modulus of elasticity (GPa)	Poisson's ratio
KEDONDONG	**13**	16.90	11.96	0.5810
	17	32.7	11.75	0.6564
BINTAGOR	**13**	17.2	16.01	0.4806
	17	28.0	18.49	0.4524
KERUING	**13**	24.7	21.74	0.8356
	17	28.4	21.52	0.8249

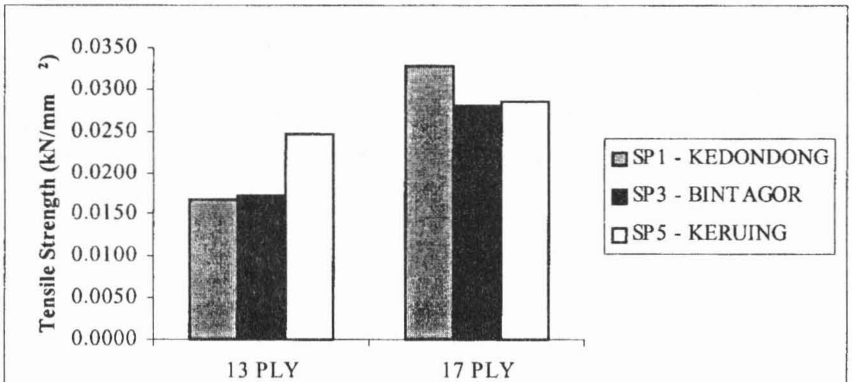


Figure 4.0: Tensile strength of LVL for different species

As the tensile strength for 17 plies is higher than 13 plies for all species, the strength for 17 plies was evaluated further. It was found that tensile strength for Kedondong is higher than Keruing and Bintagor even though for 13 ply keruing has higher tensile strength than the others. This may indicate that Kedondong has a better glue-bond compared to keruing which allow maximum stretching of the fibers. As in solid timber, keruing is higher than kedondong and bintagor even though they are in the strength group SG 5[8]. In this investigation, direct comparison with solid timber in structural size was not performed. However it's expected to be higher.

According to **Killmann.F.F.P et al, 1984**, (9) the tensile strength of solid wood parallel to the grain is extremely high and the tensile strength of separated wood fibres(such as LVL) is even higher and may vary up to 4 times higher.
It was also found that the coefficient of variation for the tensile strength properties of LVL is within 20 to 25 percent in comparison with values of 25 to 35 percent reported for visually graded lumber. This indicates that the properties of LVL are generally more uniform than for solid wood.

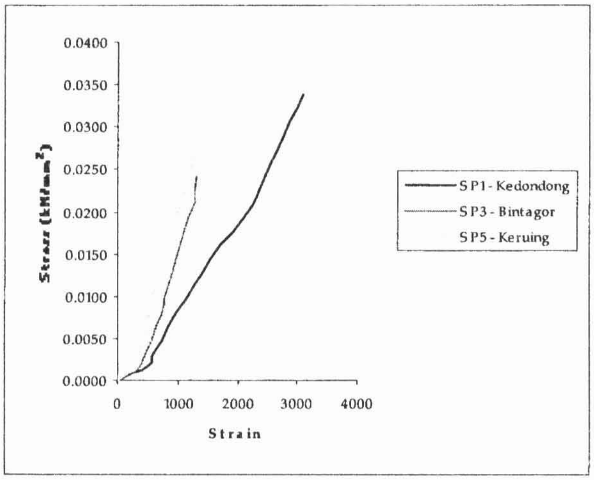


Figure 3.0: Stress – strain of LVL for 17 ply from 3 types of species

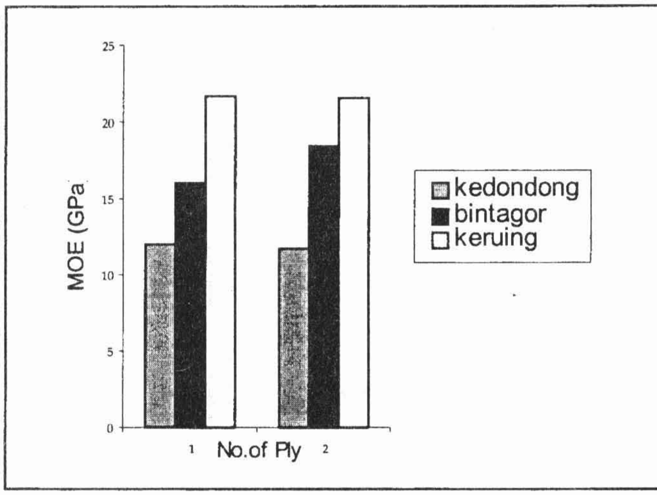


Figure 4.0: Modulus of Elasticity of LVL for different species

Modulus of elasticity (MOE)

An ANOVA test was also applied to MOE. From the F-test, there is no significant interaction between species type and number of ply (p-value = 0.062) at 5% significant level which means that MOE is consistent as can be seen from Fig. 4.0. There is significant effect for species type on the Modulus of Elasticity (p-value = 0.000) but there is no significant effect for number of ply on the MOE (p-value = 0.061). Keruing has the highest MOE but at the same time has quite low tensile strength as can be seen from higher slope of the load deflection graph in Fig. 3.0. This is attributed to the ability of fiber for not be able to reach its maximum stretching because of the veneers jointing is weak and also the problems in the glue bond.

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REFERENCES

1. Fahterty K.F., Williamson,T.G., (1999). "Wood Engineering and Construction Handbook", Mc Graw Hill, Inc.,USA. Pp. 27-28.

2.ASTM D 198-197 (1998). Standard Test Methods of Static Tests of Lumber in Structural Sizes. Annual Book of ASTM Standards Vol. 04.10

3. AS/NZ 4063: 1992 AS/NZS 4357:1995 Structural Laminated Veneer Lumber (1995)

4. Steven M. Cramer et.al, 1988. " Exploring the relationship between local grain angle and initial fracture in lumber subject to tensile load", Proceedings International Conference on Timber Engineering, September 19-22, Seattle, Washington,USA. Pp. 566.

5. Wang Q.Sasaki, H., S. Kawai and Razali Abdul Kader (1990). Utilization of Thinningsfrom Sabah (Malaysia) Hardwood Plantation: Properties of Laminated Veneer Lumbersand the Application to Flanges of Composite Beams with a Particleboard Web.Conference on Processing and Utilization of Low-grade Hardwoods and InternationalTrade of Forest-Related Products; 11-13 June 1990.

6. Preston, S. B (1950). Effect of Fundamental Glue – Line Properties on the Strength of Thin Laminates. For. Prod. Res. Soc. Proceedings Vol. 4: 228-246.

7. Leicester, R. H. and Bunker, P. C (1969). Fracture at Butt Joints in Laminated Pine. Proceedings the 1988 International Conference on Timber Engineering", September 19-22 1988, Seattle, Washington.

8. MS 544. Part 2 – 2001. Malaysia Standard. Code of Practice for Structural Use of Timber: Part 2: Permissible Stress Design of Solid Timber.