EFFECT OF METAL PLATE CONNECTED JOINTS ON STRENGTH PROPERTIES OF RUBBERWOOD LAMINATED VENEER LUMBER

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Summary

The effect of metal plate connected joints on strength properties of rubberwood (*hevea braziliensis*) laminated veneer lumber (LVL) is presented to study on the possible use of rubberwood LVL for structural purposes in the context of its strength performance. The making of the rubberwood LVL was carefully designed, selected and monitored in order to produce good quality LVL. Defect-free solid rubberwood was tested as control. Comparison is also made with studies carried out by Gupta in evaluating test results from various sources. Results of different tests on strength properties and joints with metal plate connected rubberwood LVL are presented, including direct comparisons with similar experimental results on selected solid rubberwood. Preliminary studies indicated that the teeth of the metal plate connector causes a certain degree of damage to the outer layer of the LVL and weaken the strength properties. However, it is concluded that this research has merit and requires further investigation on the surface lamination of the LVL and the teeth configuration of the metal plate connector.

Keywords: Metal plate connected joint, rubberwood, laminated veneer lumber, basic working load.

1. Introduction

To date, structural laminated veneer lumber (LVL) has yet to be used vastly for construction in Malaysia due to lack of demand in the market as a result of limited awareness of the potential of the engineered material. Sawn timbers are widely utilized as metal plate connected roof trusses in Malaysia for more than a decade. However, little works have been done locally to establish the use of structural LVL. In view of that, the objective of this paper is to investigate the effect of metal plate on the strength properties of rubberwood (*hevea braziliensis*) LVL. Simple parallel and perpendicular tension joint tests were carried out and the evaluated parameters were the basic working loads and mode of failures. This preliminary study uses rubberwood for making LVL because rubberwood is found to be with easy working qualities with respect to sawing and machining [1]. In the last decade rubberwood has been accepted as a valuable timber by the wood based industry. This has led to it being utilized for a wide variety of uses [2].

The strength properties of LVL are consequently superior to those of glued laminated timber or stress graded timber. The average of most strength properties is higher and the variation is significantly lower when compared to solid wood. LVL is a high-quality product that is more uniform and exhibit improved structural properties over sawn timber. The modulus of elasticity of LVL is 10 % higher than that of Douglas fir, the design strength in bending and tension is more than fifty % higher. LVL is dimensionally precise, straight; it does not warp but can cup, and has minor changes due to humidity. Every other veneer sheet in the veneer lay up is placed tight side up or down to ensure that the final product will not wrap or twist [3]. Related research on the strength properties of rubberwood LVL has found that the modulus of elasticity is 21.2 % greater than that of rubberwood sawn timber. Strength properties tests have proven that rubberwood LVL exhibited an encouraging consistent strength values as compared to the solid rubberwood [4].

2. Experimental Methodology

All rubberwood laminated veneer lumber were manufactured in a factory environment in such that the strength-reducing characteristics of the rubberwood were dispersed or removed. The sawn rubberwood were taken from the similar batch of logs to ensure uniformity. All samples were conditioned to 12 % moisture content prior to experimental tests. Metal plate connectors of size 50 mm x 100 mm, hot-dipped zinc coated and a minimum corrosion resistance of 300 g/m^2 of zinc were used. The plate has 0.0124 teeth per square mm or 8 teeth per square inch. The selected MN series plate has staggered teeth and is 1.0 mm thick. Parallel and perpendicular simple tension tests were carried out on 80 test samples each from LVL and solid rubberwood. The tests were conducted in accordance to AS 1649 – Australian Standard for Timber – Method of Test for Mechanical Fasteners and Connectors – Basic Working Loads and Characteristics Strength. The basic working loads(BWL) were derived at a 5 % lower probability limit as given in equation (1).

$$BWL = \frac{X - kSD}{3.5N} \tag{1}$$

where, X = average load

k = "t" value at 5% lower probability limit, i.e 1.87 for n = 12

n = number of test specimen

SD = standard deviation

N = total number of single shear units (nails/teeth) acting in one member of the joint, i.e. 32 x 2 = 64

Concurrently with this project, rubberwood LVL trusses were fabricated and used to construct a research station near the university site (see Fig. 1). The trusses were treated with light organic solvent preservatives and to date the integrity of the trusses are being monitored.

Fig. 1 Rubberwood LVL trusses for a research station

3. Results and Discussion

A summary result of the basic working loads is tabulated Tables 1 and 2, where the Hankinson formula as given in equation (2) was used to calculate the BWL at their corresponding angle of load to grain.

$$BWL_{\theta} = \frac{(BWL_{//})(BWL_{\perp})}{BWL_{//}\sin^2\theta + BWL_{\perp}\cos^2\theta} \quad (2)$$

Sample type	Angle of load to grain (°)			
	0	30	60	90
LVL rubberwood	68.94	58.88	45.59	40.96
Solid rubberwood	58.07	51.96	42.92	39.49

Table 1 Basic working load (N/tooth) for plate parallel to load direction

Sample type	Angle of load to grain (°)			
	0	30	60	90
LVL rubberwood	42.6	23.47	12.37	10
Solid rubberwood	46.46	43.43	38.42	36.32

Table 2 Basic working load (N/tooth) for plate perpendicular to load direction

Preliminary studies indicated that the teeth of the metal plate connectors causes a certain degree of damage to the outer layer of the LVL and thus weakens the strength properties. However, it is found that the BWL of LVL rubberwood is comparatively higher by 18.7 % to that of solid rubberwood when the plate is placed parallel to the load direction (see Table 1). On the contrary, when the plate is perpendicular to the load direction, the BWL of the LVL rubberwood is found to be much lesser than that of solid rubberwood especially at the 90º angle of load to grain (see Table 2). This is perhaps caused by the tearing of the surface lamination and a weaker fibre-grip at a perpendicular orientation. Such type of failure is similar to that suggested by Gupta [5] where wood fibre tearing occasionally happens in perpendicular joints as a result of loading crossing the grain direction. Nevertheless, the most common mode of failure recorded was tooth withdrawal (see Fig. 2).

It is observed that the first row of teeth closest to the gap was critical due to the axial force that is transferred through the effective section of the plate. As the loading progressed, it is found that the first row of teeth starts to bend losing its grip of the wood fibre. Hence withdrawal begins from the end of the plate. LVL rubberwood exhibited similar failure modes in that some of the surface laminations are withdrawn together with the plate showing a relatively strong grip due to a better density in the LVL rubberwood. The density of timber is still one of the major governing factors of such joint where the LVL rubberwood specific gravity is 0.69 while the solid rubberwood ranges from 0.58 to 0.60.

Fig. 2 Teeth withdrawal failure in rubberwood LVL

4. Conclusions

This study has shown that there is no negative effect on the strength of LVL as compared to their equivalent species of sawn timber in metal plate connected joints. In fact there is an 18.7 % increment of BWL in parallel joints due to higher density in LVL. However, perpendicular joints in LVL were found to be inferior to that of solid timber of which requires further study into the surface lamination effect and teeth configuration. The density parameter is still the main strength influencing criteria even in LVL.

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6. References

[1] Hong, Lay Thong and Sim, Heok Choh, *Rubberwood, Processing and Utilisation*, 1999, Kepong, Kuala Lumpur: Forest Research Institute Malaysia (FRIM). pp. 43-47.

[2] Hong, Lay Thong and Sim, Heok Choh, *Products from Rubberwood-An Overview.* Kepong, Kuala Lumpur: Forest Research Institute Malaysia (FRIM). pp. 177-186.

[3] Neuvonen, E., Salminen, M., Heiskanen, J., Hochstrate, M. and Weber, M., *Overview of the Product, Manufacturing and Market Situation*. 1998, http://www.hochstrate.de/micha/reports/replvl.html.

[4] Diana Malini and Yeoh, E.C., David, *Derivation of Mechanical Properties of Rubberwood Laminated Veneer Lumber*, KUiTTHO, 2003, pp. 72-76

[5] Gupta, R. & Waguer, B., *Effect of Metal Connector Plates on the Bending strength of Solid Sawn Lumber and LVL: A Pilot Study*. Journal of Forest Product. 2002 Vol. 52, No.10, 71-74.