African Journal of Agricultural Research Vol. 6(22), pp. 5181-5191, 12 October, 2011
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR11.514
ISSN 1991-637X ©2011 Academic Journals

Full Length Research Paper

Strand properties of *Leucaena leucocephala* (Lam.) de wit wood

Wan-Mohd-Nazri W. A. R.[1], Jamaludin, K.[1], Rahim, S.[2], Nor Yuziah, M. Y.[3] and Hazandy Abdul-Hamid[4]*

[1]Universiti Teknologi MARA, 26400 Jengka, Pahang, Malaysia.
[2]Forest Research Institute Malaysia, 52109 Kepong, Selangor, Malaysia.
[3]Malayan Adhesive and Chemicals Sd. Bhd., 40200 Shah Alam, Selangor, Malaysia.
[4]Institute of Tropical Forestry and Forest Products, Universiti Putra Malaysia, 43400 Serdang, Malaysia.

Accepted 5 July, 2011

***Leucaena leucocephala* (Lam.) de Wit, locally known as "petai belalang", is widely used in Malaysia as livestock forage, reforestation material, as well as furniture and construction timber. This study investigated the properties of strand from *L. leucocephala* wood. Beside no study has been carried out on the strand properties of this species to date. Strand properties help to support the suitability and effective use of raw materials in wood composite. The main objective was to determine the strand properties of *L. leucocephala* as a raw material in the manufacturing of oriented strand board (OSB) under laboratory conditions. The study also aimed to determine the recovery and effect of age and strand size on bulk density, and to evaluate the effects of age and tree portion on strand properties of *L. leucocephala* from eight and sixteen-year-old trees. A total of 28 trees used in this study were randomly selected. Stranding process separated the fines and sorted the strands into 4 sizes; S0 (25 to 3.2 mm), S1 (19 to 12.7 mm), S2 (12.7 to 6.3 mm) and S3 (6.3 to 3.2 mm). Strand sizes of more than 25 mm and below 3.2 mm were rejected. Results showed that the recovery of strands from eight and sixteen-year-old wood was approximately 75.01 and 70.15%, respectively. Age and strand size were found to affect bulk density significantly. Strand size of S3 from sixteen-year-old gave the highest bulk density (436 g/L) while the lowest bulk density (321 g/L) was shown by strand size of S1 from eight-year-old. The correlation analysis revealed that bulk density showed a positive correlation with increase in age (r = 0.69*). Bulk density also showed a positive correlation with decrease in strand size from S0 to S3 (r = 0.43*). On average, strands from eight-year-old wood (65.90 mm) are longer than that of sixteen-year-old wood (57.64 mm). The average strand thickness from eight and sixteen-year-old wood was 0.90 and 1.00 mm, respectively. The interaction effects of age and strand size also showed significant interaction in area, rectangularity, slenderness ratio and aspect ratio.**

Key words: Wood properties, mechanical properties, wood composites, bulk density.

INTRODUCTION

The strength of boards largely depend on the mechanical properties of individual strands (Rowell and Banks, 1987; Wu, 2003). Strand properties have been used to predict strength properties of structural wood composite material Barnes, 2000; 2001; Lee and Wu, 2003), such as (oriented strand board (OSB). Most of the research work revealed that the increase of strand length resulted in the increase of the strength of wood composite products (Post, 1958; Brumbaugh, 1960; Badejo, 1988; Barnes, 2000). In wood industry, the use of fast growing species such as *Leucaena leucocephala* (Lam.) de Wit may be an alternative way of not only extending wood supply, but also to preserve natural resources from over-exploitation. *L. leucocephala* is a multipurpose fast

*Corresponding author. E-mail: hazandy@gmail.com.

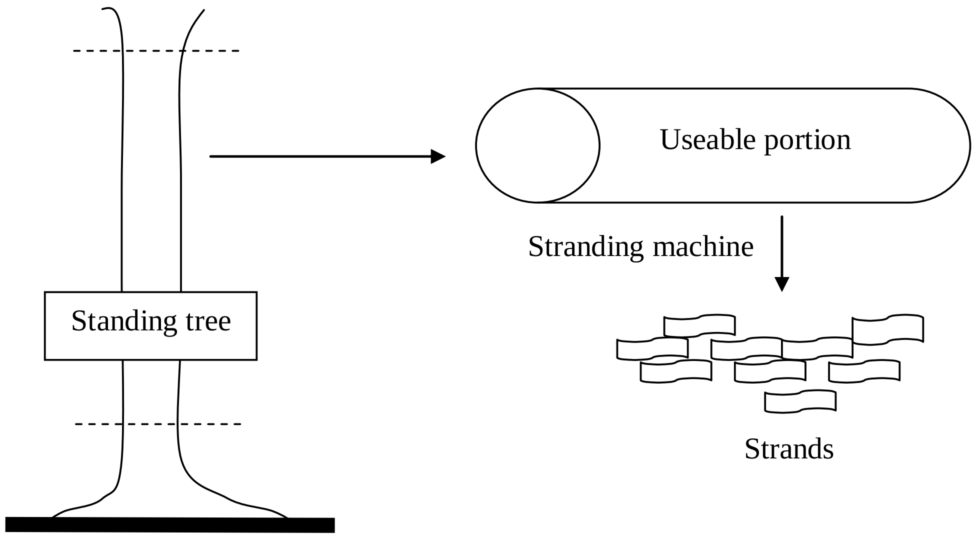

Figure 1. Usable portion from standing tree.

growing species from leguminous shrub of great importance in the tropic region (Vietmeyer et al., 1977). In Malaysia, it is locally known as “petai belalang”. *L. leucocephala* is widely used as livestock forage, fuel-wood, reforestation material and green manure.

Its uses have also been expanded to gum production, furniture and construction timber, pole wood, pulpwood, shade and support plants in agroforestry systems. In Southeast Asia, large growing trees are used for shading coffee and cocoa plantations (NAS, 1979; Brewbaker, 1987; Diaz et al., 2007). Studies on *L. leucocephala* leaves, seeds and roots were carried out by Ram et al. (1994) and Gupta and Atreja (1999 but no study has been done on strand properties of this species to date. Strand properties support the suitability and effective use of raw materials in wood composite. In order to use OSB products efficiently, it is important to understand the material and manufacturing variables that affect properties of boards. Hence, this study investigated the properties of strand from *L. leucocephala* wood.

The main objective of the study was to determine the strand properties of *L. leucocephala* as a raw material in the manufacturing of OSB under laboratory conditions. The specific objectives of the study were, 1) to determine the recovery and effect of age and strand size on bulk density, and 2) to evaluate the effects of age and tree portion on strand properties of *L. leucocephala* from eight-year-old and sixteen-year-old trees.

MATERIALS AND METHODS

Sampling of materials

Wood samples of *L. leucocephala* were obtained from the Malaysian Agricultural Research Development Institute (MARDI) station at Jeram Pasu, Pasir Putih, Kelantan. Basically, *L. leucocephala* is used as a shading tree of fruit plant at the station and normally discarded when the fruit tree attained maturity. The eight and sixteen-year-old *L. leucocephala* wood used in the study were randomly selected with a total of 28 trees. Figure 1 shows usable portion of wood to manufacture OSB board from the log sections of *L. leucocephala* which consisted approximately 80% of the total height of standing tree.

L. leucocephala logs

L. leucocephala logs of eight and sixteen-year-old trees were subjected to cut into small billets. The diameter of logs used was more than 14 cm. The logs were cut into halves along the length, they were cross-cut to about half of the original length, and cut about 18 to 22 cm in length to fit the width of strander platform. These billets were later fed into the disc strander to produce strands of consistent thickness.

Debarking and soaking

Manual debarking was carried out by a machete and the billet was then soaked in water for one to two days prior to the stranding process. The objective of the soaking was to soften the logs, reduce borer attack and also to reduce fines or dust during the stranding process.

Stranding

Stranding was done with a disk strander (a series of knives fixed in a rotating disk) by slicing the billet in the long grain direction. The billets were fed manually to the disc strander with the gap between the knife and the disc wall at 1.0 mm. Samples were collected as the strands dropped from the strander out feed. After stranding process, all the strands were left under a covered open area to dry to a moisture content of around 17 to 20% before further process. After the pre-drying process, a dust extractor with a centrifugal fan was used to split the strands into smaller width in order to minimize curling of the strands prior to screening process. It was observed

Table 1. Classification of strands.

No.	Strand type	Strand width (mm)
1	S0	25 to 3.2
2	S1	19 to 12.7
3	S2	12.7 to 6.3
4	S3	6.3 to 3.2

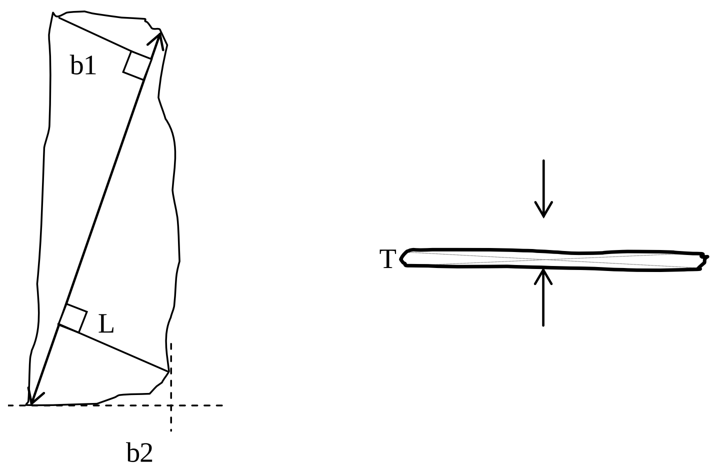

Figure 2. Strand measurement.

that, prior to the splitting process eighty percent (80%) of the strands would curl. However, after going through the splitting process, the degree of curled strands had been reduced to an almost flat surface. During stranding process, a total of 10 billets for each stage of age were carried out to determine the strand recovery. The weight of each billets were recorded before and after processing.

Screening

Screening of strands was carried out using a strand classifier which separated the fines and sorted the strands into 4 sizes. The strand classifier had 5 metal sieves with hole diameters of 25, 19, 12.7, 6.3 and 3.2 mm respectively. To establish the strand size distribution of wood strands, they were sieved through a range of sieve sizes. The amount retained on each screen was divided by the total weight of the sample to give a percentage for screening recovery output. The strands, averaging 1.0 x 20 x 75 mm were screened and those passing through 25 mm and retained on a 3.2 mm opening screen diameter was used in the study.

Strand sizes of more than 25 mm and below 3.2 mm were rejected. The strands were classified into four (4) categories as shown in Table 1 and prior to the treatments of Phase I, II and III. The recovery of strands was measured as wood strand collected after flaking process from a single billet. The recovery of strand is expressed as percentage using the equation shown below. Ten measurements were made for each sample:

$$\text{Recovery} = \frac{W1 - W2}{W1} \times 100\,\%$$

where; *W1* = weight of billet (g); *W2* = weight of billet after flaking (g).

Bulk density

Strand bulk density was determined by free falling strands into a 1 L container and followed by weighing (Anonymous, 1985). The weight of strands collected in the container was taken as bulk density over 1000 cm^3 volume or 1 L. The bulk density of strand is expressed as the weight per unit volume of strand, usually in gram (g) per liter (L*)* loose volume. Six measurements were made for each sample using the following equation:

$$\text{Bulk density} = \frac{Wg}{Vl}$$

where; *Wg* = weight of strands (g), *Vl* = Volume of oven dry sample (l).

Strands analysis

Strands were classified into three types (S1, S2 and S3) using sieve shaker. Determination of strand size and shape was made manually using a hundred (100) strands of each type. The thickness of strands was measured using a micrometer and digital caliper for length and width (Figure 2). Strand shapes were measured by area, aspect ratio, rectangularity and slenderness ratio (Dai and Steiner, 1997). Measurement dimension of strand size and shape were calculated based on the following equations:

Table 2. Disc strander and screening recovery and strand size.

Age	Disc strander recovery output (%)	Strand Size and Screening Recovery Output (%)					Strand Size (g/l)				
		S1	S2	S3	Total	Fines	S0	S1	S2	S3	Avg.
		(19.1-12.7 mm)	(12.7-6.3 mm)	(6.3–3.1 mm)	S1+S2+S3						
8	75.01	41.97	16.72	30.55	89.24	10.8	326	321	326	332	326
16	70.15	32.45	7.45	39.99	79.9	20.1	362	344	355	436	378

Values are average of three determinations.

Table 3. Bulk density.

Strand size	S0	S1	S2	S3	Avg.
Age	(g/L)				
8	326.00	321.00	326.22	332.05	326.42
16	362.47	344.12	354.70	436.47	378.43

Breadth (B) $= \frac{b1+b2}{2}$

Aspect Ratio $= \frac{L}{B}$

Rectangularity $= \frac{A}{L \times B}$

Slenderness Ratio $= \frac{L}{T}$

Where *b1* = Upper breadth perpendicular to length; *b2* = Bottom breadth perpendicular to length; *L* = Length; *B* = Breadth; *A* = Area; *T* = Thickness

RESULTS AND DISCUSSION

Strand recovery

The stranding process started from fresh log billets. A total of 10 billets for each stage of age were carried out to determine the strand recovery. The weight of each billets were recorded before and after processing. Table 2 shows the strand recovery output. The recovery of strands from eight and sixteen-year-old was approximately 75.01 and 70.15%, respectively. It was observed that the low recovery at stranding process was due to the limited capacity of disc strander machine to strand the entire wood billet. In this study, the limited capacity of the machine had to be accepted for safety purposes. The losses in recovery of approximately 25 to 30% can be solved by using other machine such as drum strander. According to Stiglbauer et al. (2006), stranding is an interaction between a knife edge (that is prone to edge wear) and the wood itself (which varies in mechanical properties due to growth ring construction, juvenile/ mature wood, etc.), so when logs are stranded, it is inevitable that an assortment of sizes is formed.

The results also show the recovery yield of wood strand was more than 70% for both eight and sixteen-year-old wood. For eight-year-old wood, screening yielded 41.97% for strand size of S1, 16.72% for strand size of S2 and 30.55% for strand size of S3. Strand size of S1 and S2 from the eight-year-old wood showed higher screening recovery output and lower percentage of fines (10.79%). Lower basic density of eight-year-old wood had contributed to easier flaking process. According to Jones and Fox (2007) low density and green moisture content (MC) improve wood processing. Screening of sixteen-year-old wood produced 32.45% strand size of S1, 7.45% strand size of S2 and 39.99% strand size of S3. Strand size of S3 constituted 40% of the sixteen-year-old strands weight proportion. During stranding process of sixteen-year-old wood, a large percentage of fines was produced (20.10%). This was due to the higher wood density which contributed to the brittleness of the wood which consisted 80% of heartwood. According to Stiglbauer et al. (2006) fines generated during stranding of wood for OSB production are especially prone to over drying on account of their higher surface: volume ratio.

Bulk density

The value of bulk density in unit gram per liter of the strands from the stranding processes is given in Table 3. Strand size of S3 from sixteen-year-old gave the highest bulk density which implied that lesser amount of strands would be required to produce OSB board. The lowest bulk density (321 g/L) was shown by strand size of S1 from eight-year-old. Generally, average bulk density of the sixteen-year-old strand is higher than those from eight- year-old and bigger strand size shows lower bulk density.

Statistical significance

The analysis of variance (ANOVA) of the effects of age and strand size and their interactions on the bulk density

Table 4. Summary of the ANOVA on strand parameters.

SOV	Df	Bulk density	Area	Rectangularity	Slenderness ratio	Aspect ratio
Age	1	1122.05*	157.60*	74.12*	34.40*	77.32*
Strand size	3	247.11*	217.88*	108.17*	35.63*	136.26*
Age × strand size	3	166.79*	22.85*	17.59*	10.51*	25.39*

SOV= Source of variance; Df = degree of freedom; *significant at p<0.05.

Table 5. Mean effects of age and strand size on bulk density and strand parameter.

Parameter	Age		Strand Size (mm)			
	8	16	S0 (25.0 - 3.2)	S1 (19.0 - 12.7)	S2 (12.7 - 6.3)	S3 (6.3 - 3.2)
Bulk density (g/L)	326.27^{a}	374.43^{b}	339.67^{b}	332.56^{c}	340.46^{b}	384.26^{a}
Rectangularity			797.41^{b}	1117.55^{a}	625.07^{c}	325.74^{d}
Area			0.18^{c}	0.31^{a}	0.12^{b}	0.04^{d}
Slenderness ratio			114.03^{a}	80.81^{b}	70.46^{b}	75.07^{b}
Aspect ratio			6.93^{b}	4.15^{c}	7.13^{b}	15.02^{a}

Means with the same letter down the column are not significantly different at p < 0.05.

Table 6. Correlation coefficients of the effects of age and strand size.

SOV	Bulk density	Area	Rectangularity	Slenderness ratio	Aspect ratio
Age	0.69*	-0.25*	-0.21*	-0.16*	0.15*
Strand Size	0.43*	-0.44*	-0.34*	-0.27*	0.37*

*Significant at p<0.05.

Table 7. Effects of strand size on bulk density.

Strand size (mm)	Bulk density (g/L)
S0 (25.0 to 3.2)	339.67^{b}
S1 (19.0 to 12.7)	332.56^{c}
S2 (12.7 to 6.3)	340.46^{b}
S3 (6.3 to 3.2)	384.26^{a}

Means with the same letter down the column are not significantly different at p < 0.05.

is shown in Table 4. All the main factors of age and strand size were found to affect bulk density significantly. The interaction effects of age and strand size also showed a significant interaction on bulk density.

Effects of age

Table 5 shows the effects of age on bulk density. Based on the statistical analysis, there is significant difference between the eight and sixteen-year-old wood strands. The correlation analysis further revealed that bulk density showed a positive correlation with increase in age (r = 0.69*) as shown in Table 6. This is due to the fact that sixteen-year old consist of more percentage of heartwood as compared to the eight-year-old. Higher bulk density in sixteen-year-old will lead to lesser use of strands to manufacture OSB board as compared to the eight-year-old. Zombori et al. (2004) showed that strand density may have a significant effect on the wood composite.

Effects of strand size

The effects of strand size on bulk density are given in Table 7. Based on the statistical analysis, there is significant difference between all strand sizes. The correlation analysis further revealed that bulk density showed a positive correlation with decrease in strand size from S0 to S3 (r = 0.43*). However, higher bulk density would increase the resin usage because smaller strand size with high amount of strands gave a bigger total strand area per volume. As strand area per volume increases, the amount of resin required to transfer stress to adjacent strands also increases (Bekhta and Hiziroglu,

Table 8. Measurement and determination of strand size and shape.

Age (year)	SS	L (mm)	T (mm)	b1 (mm)	b2 (mm)	B (b1+b2)/2	ASR (L/B)	A(mm^2) (BxL)	R [A/L(B)]	SR (L/T)
	S0	66.31	0.73	12.01	12.14	12.07	6.76	793	0.18	114
	S1	64.94	0.92	20.02	19.36	19.8	3.55	1276	0.42	81.6
8	S2	67.94	0.92	13.1	13.05	13.07	5.71	864	0.91	89
	S3	64.43	0.89	6.93	6.91	6.92	11.4	441	0.05	90.9
	Avg.	65.9	0.9	13.02	12.87	12.97	6.86	844	0.39	93.9
	S0	68.28	0.76	11.96	12.07	12.01	7.11	801	0.18	114
	S1	66.33	0.98	14.48	14.26	14.37	4.76	950	0.21	80
16	S2	56	1.19	7.03	6.96	7	8.56	385	0.05	51.7
	S3	39.96	1.07	2.12	2.6	2.36	22.26	94	0.01	43.5
	Avg.	57.64	1	8.9	8.97	8.94	10.67	557	0.11	72.3

SS: Strand size; L: length; T: thickness; B: width; ASR: aspect ratio; R: rectangularity; SR: slenderness ratio.

2002). Kruse et al. (2000) reported that fines affect the standard deviation of horizontal distribution of board density and mechanical properties.

Strand analysis

Table 8 shows measurement and determination of strand sizes and shapes from eight and sixteen-year-old wood. Screen analysis is a common tool to investigate strand geometry. Determination of aspect ratio, rectangularity and slenderness ratio is an indication of strand size and shape. According to Carll (1998) strands are the basic elements for composing strand-based composites. Their mechanical and physical properties are significantly influenced by strand parameters. Table 8 shows that strands from eight-year-olds were longer than 60 mm in length. Strand sizes of S2 (56.00 mm) and S3 (39.96 mm) from sixteen-year-olds were lower than 60 mm. In average, strands from eight-year-old recorded are longer than that of sixteen-year-old. Strand size of S2 from the sixteen-year-old wood recorded the thickest strand with 1.19 mm. Average strand thickness from eight-year-old wood recorded was 0.90 mm and average strand thickness from sixteen-year-old is slightly thicker with 1.00 mm. Strand size from eighth-year-old wood (12.97 mm) recorded wider strand than sixteen-year-old (8.94 mm). Wider strand size contributes to a bigger area of the strand and strand size from eight-year-old which recorded higher area with an average of 844 mm^2 compared to sixteen-year-old wood (557 mm^2).

The strands were categorized into four types of strand sizes (S0, S1, S2 and S3) as a function of aspect ratio, strand area, rectangularity and slenderness ratio. Figures 3 and 4 show the relation between aspect ratio and area of the strand. It is observed that bigger strand area show lower aspect ratios and smaller strands had higher aspect ratios for strands from both eight and sixteen-year-old wood. Strand sizes of S0, S2 and S3 overlapped the position at an area of 500 mm^2. However, only strand size of S0 and S2 overlapped the position at an area of 500 mm^2. The results also showed that the smallest strand size of S3 of eight and sixteen-year-old strands had a trend of higher aspect ratio and lower area, switch the values to the left in position on the figures. Moreover, Figure 3 shows that the value of aspect ratio for strand size for S3 at eight-year-old is slightly lower than sixteen-year-old and distribute in the area of 500 mm^2.

Figure 5 shows the relationship between strand width and rectangularity. The shapes in the histograms are all close to normal distributions. In general, strand shapes were observed to be mostly rectangular and there was also a wide variation in strand dimensions. Strand types of S0, S1 and S2 were longer and wider than S3 strands. It was observed that bigger strand width increased rectangularity. The rectangularity of strands from eight and sixteen-year-old increased almost proportionately with strand width increase. The rate of increase in rectangularity could be represented by a straight line. Effects of strand thickness have generally been examined in terms of strand length over strand thickness or slenderness ratio. In this study, higher slenderness ratio was observed from the eight-year-old wood (93.90) compared with the sixteen-year-old wood (78.28). Figure 6 shows lower strand thickness contributing to higher slenderness ratio. It also recorded that almost 80% of the strands had values of less than 100 for slenderness ratio.

Statistical significance

The analysis of variance (ANOVA) on the effects of age and strand size and their interactions on the strand parameters are shown in Table 9. All the main factors of

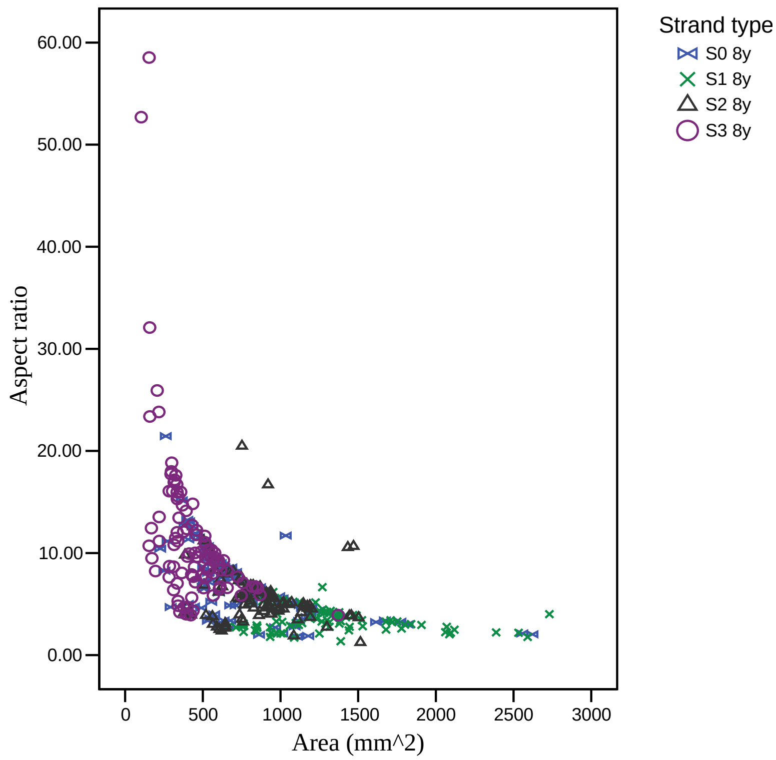

Figure 3. Relations between aspect ratio and area of the strand from eight-year-old sample.

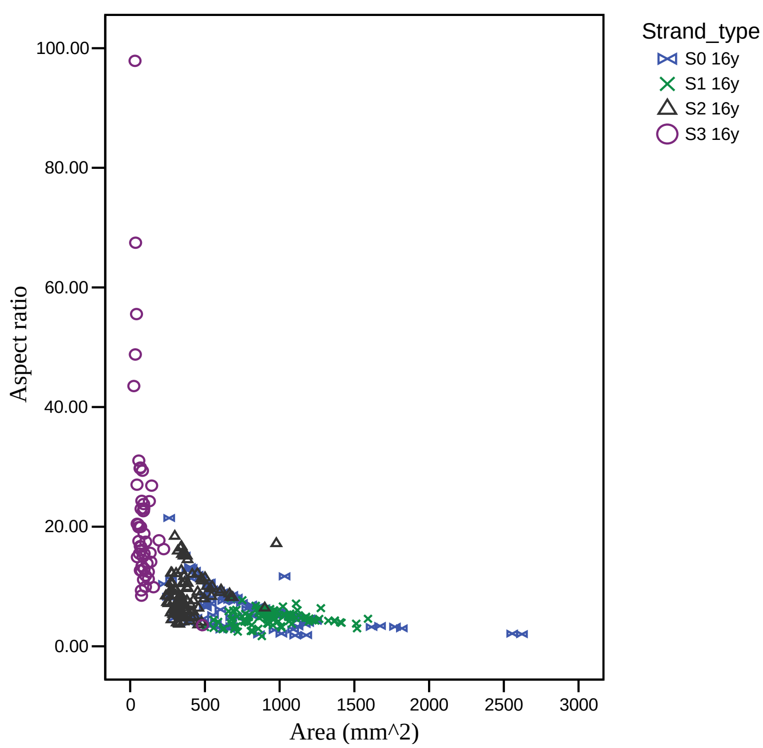

Figure 4. Relations between aspect ratio and area of the strand from sixteen-year-old sample.

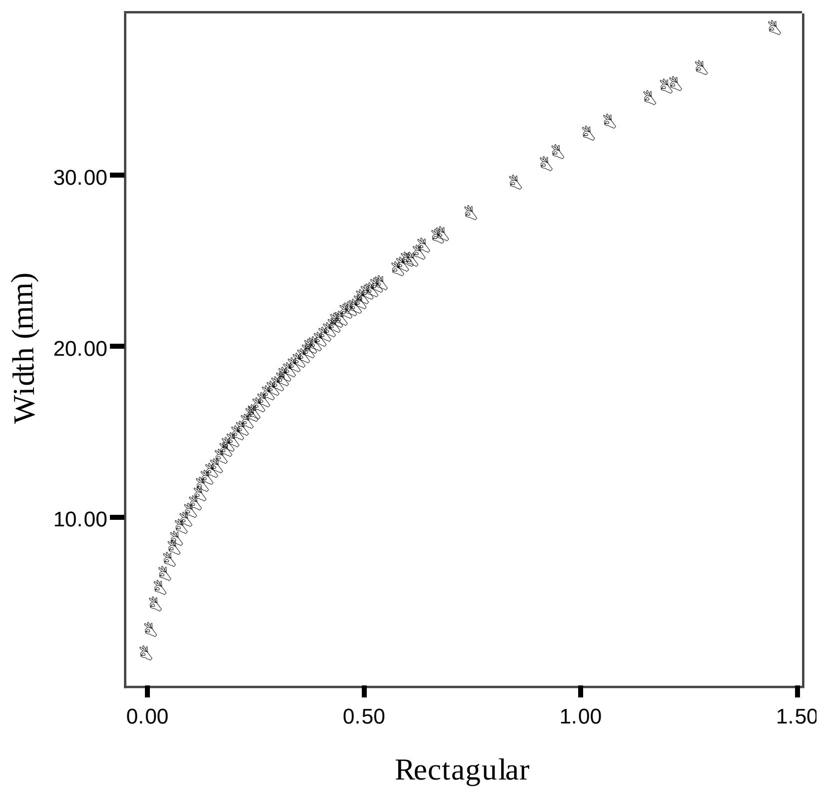

Figure 5. Width and rectangularity of eight and sixteen-year-old wood strands.

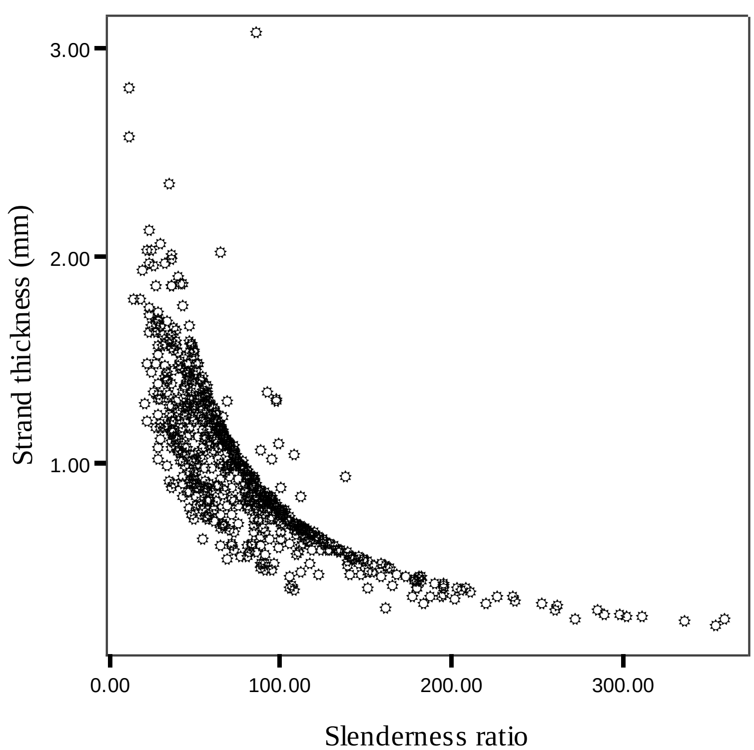

Figure 6. Relations between strand thickness and slenderness ratio for eight and sixteen-year-old.

Table 9. Summary of the ANOVA on strand parameters.

SOV	Df	Area	Rectangularity	Slenderness ratio	Aspect ratio
Age	1	157.60*	74.12*	34.40*	77.32*
Strand size	3	217.88*	108.17*	35.63*	136.26*
Age × strand size	3	22.85*	17.59*	10.51*	25.39*

SOV= Source of variance; Df = degree of freedom,*significant at $p<0.05$.

Table 10. Summary of t-test on the effects of age on strand analysis.

Age	Area	Rectangularity	Slenderness ratio	Aspect ratio
8	844.95^{a}	0.21^{a}	93.91^{a}	6.86^{b}
16	623.98^{b}	0.13^{b}	76.47^{b}	9.02^{a}

Means with the same letter down the column are not significantly different at $p < 0.05$.

Table 11. Correlation coefficients of the effects of age and strand size.

SOV	Area	Rectangularity	Slenderness ratio	Aspect ratio
Age	-0.25*	-0.21*	-0.16*	0.15*
Strand size	-0.44*	-0.34*	-0.27*	0.37*

SOV= Source of variance; *significant at $p<0.05$.

age and strand size were found to affect strand parameters significantly. The interaction effects of age and strand size also showed significant interaction in area, rectangularity, slenderness ratio and aspect ratio.

Effects of age

Table 10 shows the effects of age on strand parameters of *L. leucocephala* wood. The statistical analysis showed significant differences in all strand parameters imposed by the effects of age. However, the age of the tree was found to significantly affect strand area, rectangularity, slenderness ratio and aspect ratio. The eight-year-old wood had significantly bigger strand area than the sixteen-year-old wood. The correlation analysis (Table 11), further revealed that the strand area showed a negative correlation with age (r = -0.25*). The rectangularity decreased significantly with the increase of tree age due to higher wood density, which influenced the stranding process. The correlation analysis further revealed that the rectangularity showed a negative correlation with age (r = -0.21*). Xu and Suchland (1998) reported that age of the tree and wood density have been considered as a major variable in wood composite manufacturing.

Slenderness ratio showed a significant difference between strands from eight and sixteen-year-old. Higher slenderness ratio in eight-year-old wood was due to the low density of wood and easiness of stranding, producing a thinner strand. Pugel et al. (2004) have demonstrated that the use of juvenile wood in composite materials can improve manufacturing variables, such as strands geometry and strands compression. Bigger and wider strand directly contributed to lower aspect ratio. Lower aspect ratio was recorded in eight-year-old wood strand which was significantly different from sixteen-year-old wood strand (Table 10). This difference was mainly due to the width and consistency in width from eight-year-old wood strand. The correlation analysis (Table 11) further revealed that the aspect ratio showed a positive correlation with age (r = 0.15*).

Effects of strand size

The Duncan's multiple range test (DMRT) for effects of strand size on strand parameters is shown in Table 12. A significant difference was observed in strand area as affected by strand size. The correlation analysis (Table 11) further revealed that the strand area showed a negative correlation (r = -0.44*) with decrease in strand size (S0 to S3). Rectangularity also recorded similar trends. According to Barnes (2001), inherent wood characteristics such as rot and angled grain, and machine variables such as blunt knives, poor adjustment,

Table 12. Effects of strand size on the strand parameters.

Strand size	Area	Rectangularity	Slenderness ratio	Aspect ratio
S0	797.41[b]	0.18[c]	114.03[a]	6.93[b]
S1	1117.55[a]	0.31[a]	80.81[b]	4.15[c]
S2	625.07[c]	0.12[b]	70.46[b]	7.13[b]
S3	325.74[d]	0.04[d]	75.07[b]	15.02[a]

Means with the same letter down the column are not significantly different at $p < 0.05$.

and angle of logs in the infeed mechanism will generate variations from the nominal strand length. Strands are further damaged by each processing step such as drying, transportation, glue application, forming and orientation.

For slenderness ratio, there was no significant effect between strand size of S1, S2 and S3 (Table 12). However, the slenderness ratio of S0 is significantly higher than the other strand sizes. The correlation analysis (Table 11) further revealed that the slenderness ratio showed a negative correlation with decrease in strand size (r = -0.27*). Higher slenderness ratio contributes to a better strand alignment and compaction during forming and hot pressing process. Thinner strands are more flexible and thus easily fill spaces during pressing, as well as provide a smoother surface. Simpson (1977) indicated that increasing the length/thickness (L/t) ratio results in an initial increase in tensile strength which then began to level off at higher ratios. Post (1958) and Suchsland (1968) both found that the modulus of rupture of flakeboard increases with increase of the slenderness ratio.

The lowest aspect ratio was recorded by strand size of S1 and the highest by strand size of S3. Aspect ratio was significantly affected by strand size. The correlation analysis (Table 11) further revealed that the aspect ratio showed a positive correlation with decrease in strand size (r = 0.37*). Normally, a bigger area of strand is related to a lower value of aspect ratio because of the bigger width of the strand. Nishimura et al. (2004) also recorded the same trend.

ACKNOWLEDGEMENT

This study was financially supported by the Malaysian Timber Industry Board under Trial Plot Study of *L. leucocephala* as a plantation species project (MTIB 100-RMI/GOV 16/6/2 (64/2010)).

REFERENCES

Anonymous (1985). Physikaishe Bestimmungen Zun Qualitask-Onnlle Von Span-Faser-und osb-platten, Bison Bahre and Greten, 85 20/02/21.4pp.

Badejo SOO (1988). Effect of Flake geometry on Properties of cement-bonded particleboard from mixed tropical hardwoods, Wood Sci. Technol., 22(4), 357-370. DOI: 10.1007/BF00353325.

Barnes D (2000). An integrated model for the effect of processing parameters on the strength properties of oriented strand wood products. For. Prod. J., 50(11/12): 33-42. http://www.encyclopedia.com/doc/1G1-71325060.html.

Barnes D (2001). A model of the effect of strand length and strand thickness on the strength properties of oriented wood composites. For. Prod. J., 51(2): 36-46. http://www.cababstractsplus.org/abstracts/Abstract.aspx?AcNo=20013031740.

Bekhta P, Hiziroglu S (2002). Theoretical approach on specific surface area of wood particles. For. Prod. J., 52(4): 72-76. http://www.encyclopedia.com/doc/1G1-85250751.html.

Brewbaker JL (1987). *Species in the genus Leucaena*. Res. Rep., 7(2): 7-20. Hawaii. http://www.cababstractsplus.org/abstracts/Abstract.aspx?AcNo=19861648966.

Brumbaugh J (1960). Effect of Flake Dimension on Properties of Particle Boards. For. Prod. J., 10(5): 243-246.

Carll C (1998). *F*lake Storage Effects on properties of laboratory made Flakeboards. USDA Forest Service. Forest Products Lab., Madison. (Res. Note FPL-RN-267 pp.10). Madison, Wisconsin. http://www.treesearch.fs.fed.us/pubs/5676.

Dai C, Steiner PR (1997). Horizontal density variation in randomly-formed short fibre wood composite boards. Composites, Part A, 28A, 57-64.

Diaz MJ, Garcia MM, Tapias R, Fernandez M, Lopez F (2007). Variations in Fiber Length and Some Pulp Chemical Properties of *Leucaena* Varieties. Ind. Crop Prod., 26(2): 142-150. DOI: 10.1016/j.indcrop.2007.02.003

Gupta HK, Atreja PP (1999). Influence of feeding increasing levels of luecaena leaf meal on the performance of milk goats and metabolism of Mimosine and 3-hydroxy-4 (1H) pyridine. Anim. Feed Sci. Technol., 78: 159-167. ISSN 0377-8401.

Jones PD, Fox TR (2007). Wood density in Pinus taeda × Pinus rigida and response 10 years after thinning in Virginia. Forest Prod. J., 57(12): 70-74. ISSN 0015-7473.

Kruse K, Dai C, Pielasch A (2000). An analysis of strand and horizontal density distributions in oriented strand board (OSB). Holz als Roh-und Werkstoff, 58: 270-277. ISSN 0018-3768.

Lee JN, Wu Q (2003). Continuum modeling of engineering constants of oriented strandboard. Wood Fiber Sci., 35(1): 24-40. ISSN 0735-6161

National Academy of Sciences (NAS) (1979). Tropical legumes: resource for the future. Board on Science and Technology. (pp.67).Washington, D.C.: National Academy Press. ISBN-10: 0894991922.

Nishimura T, Amin J, Ansell MP (2004). Image analysis and bending properties of model OSB panels as a function of strand distribution, shape and size. Wood Sci. Technol., 38: 297-309.

Post PW (1958). Effect of Particle Geometry and Resin Content on Bending Strength of Oak Flake Board, Forest Prod. J*.*, 8(10): 317-322.

Pugel A, Price E, Hse C, Shupe T (2004). Composites from southern pine juvenile wood. Part 3, Juvenile and mature wood furnish mixtures. Forest Prod. J., 54(1): 47-52. http://www.encyclopedia.com/doc/1G1-112987102.html.

Ram JJ, Atreja PP, Chopra RC, Chhbra A (1994). Mimosine

Degradation in Calves Fed a Sole Diet of *Leucaena leucocephala* in Indian. Trop. Anim. Health Prod., 26, 199-206. DOI: 10.1007/BF02240380
Rowell RM, Banks WB (1987). Tensile strength and toughness of acetylated pine and line flakes. Brit. Polym. J., 19: 478-482.
Simpson WT (1977). Model for tensile strength of oriented flakeboard. Wood Sci., 10(2): 68-71.
Stiglbauer P, Conners TE, Banerjee S (2006). Influence of knife angle and ambient temperature on fines generation from flakers. Forest Prod. J., 56(10): 86-90. ISSN 0015-7473.
Suchsland O (1968). Particle-board from Southern Pine. Southern Lumberman. Decmber, 1968, pp. 139-144.
Vietmeyer N, Cotton B, Ruskin FR (1977). Leucaena promising forage and tree crop for the tropics. p. 80. U.S. National Academy of Science. Washington, D.C. http://www.cababstractsplus.org/abstracts/Abstract.aspx?AcNo=19776719163
Wu Q (2003). *Comparative linear expansion properties of commercial OSB*. (Technical Report School of Reviewable Natural Resource, p.8), Louisiana State University, Agricultural Center, Baton Rouge, LA.
Xu W, Suchsland O (1998). Modulus of elasticity of wood composite panels with a uniform density profile: A model. Wood Fiber Sci., 30(3): 293-300. ISSN 0735-6161
Zombori BG, Kamke FA, Watson LT (2004). Sensitivity analysis of internal mat environment during hot pressing. Wood Fiber Sci., 36(2): 195-209. http://www.cababstractsplus.org/abstracts/Abstract.aspx?AcNo=20043084054.