

Effect of Strand Orientation on Physical and Mechanical Properties of Rubberwood Oriented Strandboard

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ABSTRACT

The effect of strand orientation on the physical and mechanical properties of rubberwood oriented strandboard (OSB) was investigated. The properties of OSB were evaluated by JIS A 5908-1994. Results suggest that face strands alignments significantly improve bending strength and stiffness in the aligned direction. The strand orientation only had a slight effect on the thickness swelling and internal bonding.

Keywords: Strand orientation, physical and mechanical properties, oriented strandboard

INTRODUCTION

Rubberwood (*Hevea brasiliensis* Muell. Arg.) is a dicotyledon plant in the Euphorbiaceae Family [1]. It originates in South America being native to Brazil and is now cultivated in Asia particularly in South East Asia (SEA). SEA countries have become the world's largest rubberwood producers because SEA has a suitable habitat for cultivation [2]. Thailand contains about 2 millions hectares of plantations, distributed in the South, East and North-east regions [3]. When rubberwood trees reach approximately 25 to 30 years of ages the quality of latex significantly decreases. At this time, rubberwood logs are harvested for wood industries. The plantation residues such as branches and tops are used as raw materials for low cost charcoal production. However, the value of plantation residues can be increased by new utilization of rubberwood as OSB.

OSB is a panel made from compressed strands lined up (oriented) and arranged in layers [4]. In 1982, the first OSB panel was produced in Canada. OSB is evolved from the original waferboard production. The structure of OSB is usually in layers. The strands of each layer are aligned parallel to one another, but perpendicular to those in adjacent layers. During 1998 in North America, OSB comprised about 49 % of the market share of industrial and construction (structural) panels. Most OSB mills are located in North America but the plants in Asia and Australia under construction will likely use rubberwood and eucalyptus [5,6]. Although a great deal of research has been conducted on OSB in North America, little research in Asia has focused on the layered structure and strand orientation of OSB. Further studies on OSB are necessary for both researchers and manufacturers for planning and constructing OSB mills.

The objective of this research is to investigate the effect of strand orientation on the physical and mechanical properties of rubberwood oriented strandboard.

MATERIALS AND METHODS

Preparation of strands

Strands were made from rubberwood veneer with an average thickness of 0.5 - 1.0 mm, width 12.5 mm and length 75 mm. Strands were dried to an approximately moisture content 0 % before glue spreading.

Board manufacturing

The following 4 types of board were fabricated in this experiment.

UD: Uni-directionally oriented homogeneous board

RD: Randomly oriented homogeneous board

OC: Cross orient three-layer board with cross core layer

OR: Oriented three-layer board with random core layer

The layer construction with a face: core: face ratio of OC and OR types were fabricated 25:50:25.

Manufacturing specifications for the boards were the following.

Board size: 350 mm × 350 mm × 16 mm
Target density: 0.85 g/cm³ in air-dried conditions
Resin: liquid pMDI resin
Resin content: 5 % on the oven-dried weight of strands
Pressing condition:
 Temperature 150 °C
 Specific pressure 75 kg/cm²
 Time 18 min

Physical and mechanical properties testing

The fabricated boards were cut to size for testing Modulus of rupture (MOR) and Modulus of elasticity (MOE) in lengthwise and widthwise directions under dry and wet conditions, Internal bonding (IB), Thickness swelling (TS). Density and moisture content were also determined according to Japanese Industrial Standards (JIS A 5908-1994) [7].

Data analysis

Data calculation and analysis according to the experimental plan with three replications for each plane were done. The data were executed by the analysis of variance (ANOVA) computer program and compared mean values with Duncan's multiple range test method.

RESULTS AND DISCUSSION

Bending properties

The most important mechanical properties of OSB are MOR and MOE, these properties are an indication of the overall board quality. Average MOR and MOE values for all panel types from dry and wet condition bending tests are shown in **Table 1**. The effect of strand orientation on MOR of OSB, comparing the mean values, for all types is shown in **Figure 1**. The MOR of UD board was highest in the parallel direction, whereas it was lowest in the perpendicular direction. The bending properties (MOR and MOE) in the parallel direction of three-layer boards (OC and OR) revealed no significant difference, which could be due to the fact that the surface layer properties dominated the bending properties of the board. On the other hand, the strength in the perpendicular direction of the OC board was slightly higher than that of the OR board, which may be attributed to the high strength of the aligned core layer of the cross-oriented board. The MOE obtained under the same conditions as MOR is shown in **Figure 2**.

Table 1 Physical and mechanical properties of OSB

Properties	Unit	Strand orientation			
		UD	RD	OC	OR
Modulus of rupture (dry conditions)					
Lengthwise (//)	N/mm ²	92.74 ^(a)	38.73 ^(c)	72.58 ^(b)	80.15 ^(b)
Widthwise (⊥)	N/mm ²	13.37 ^(c)	42.73 ^(a)	42.84 ^(a)	26.82 ^(b)
Modulus of elasticity (dry conditions)					
Lengthwise (//)	N/mm ²	7,576.71 ^(a)	2,934.28 ^(c)	6,139.37 ^(b)	6,736.68 ^(b)
Widthwise (⊥)	N/mm ²	869.00 ^(d)	3,407.13 ^(a)	2,350.37 ^(b)	1,526.51 ^(c)
Modulus of rupture (wet conditions)					
Lengthwise (//)	N/mm ²	29.72 ^(a)	5.80 ^(d)	15.30 ^(c)	21.84 ^(b)
Widthwise (⊥)	N/mm ²	2.82 ^(c)	7.17 ^(b)	14.99 ^(a)	9.03 ^(b)
Modulus of elasticity (wet conditions)					
Lengthwise (//)	N/mm ²	1,990.71 ^(a)	346.05 ^(c)	1,022.35 ^(b)	1,445.45 ^(b)
Widthwise (⊥)	N/mm ²	169.96 ^(c)	471.29 ^(b)	850.97 ^(a)	460.91 ^(b)
Internal bonding	N/mm ²	1.35 ^(a)	0.84 ^(a)	1.42 ^(a)	1.23 ^(a)
Thickness swelling	%	26.06 ^(a)	41.92 ^(a)	28.23 ^(a)	29.46 ^(a)
Moisture content	%	5.28 ^(a)	4.87 ^(a)	4.98 ^(a)	4.49 ^(a)
Density	g/cm ³	0.86 ^(a)	0.84 ^(a)	0.86 ^(a)	0.87 ^(a)

Note: Means with the same letter are not significantly different at $\alpha < 0.05$ by Duncan's multiple range test.

Strand orientation is a major factor affecting composite properties. It is measured for OSB as the angle between strand grain direction and the panel axis. The angle is used to describe orientation within a board. Values of MOR and MOE in the parallel board direction increase with higher levels of orientation. The Hankinson's equation that shown in Eq. (1) is an empirical formula used to transform parallel and transverse stiffness properties to some arbitrary angle. This equation was used with an off-axis orientation [8,9].

$$N = \frac{PQ}{P \sin^n \phi + Q \cos^n \phi} \quad (1)$$

where N is strength at angle ϕ from fiber direction
 Q is strength perpendicular to grain
 P is strength parallel to grain
 n is an empirically determined constant

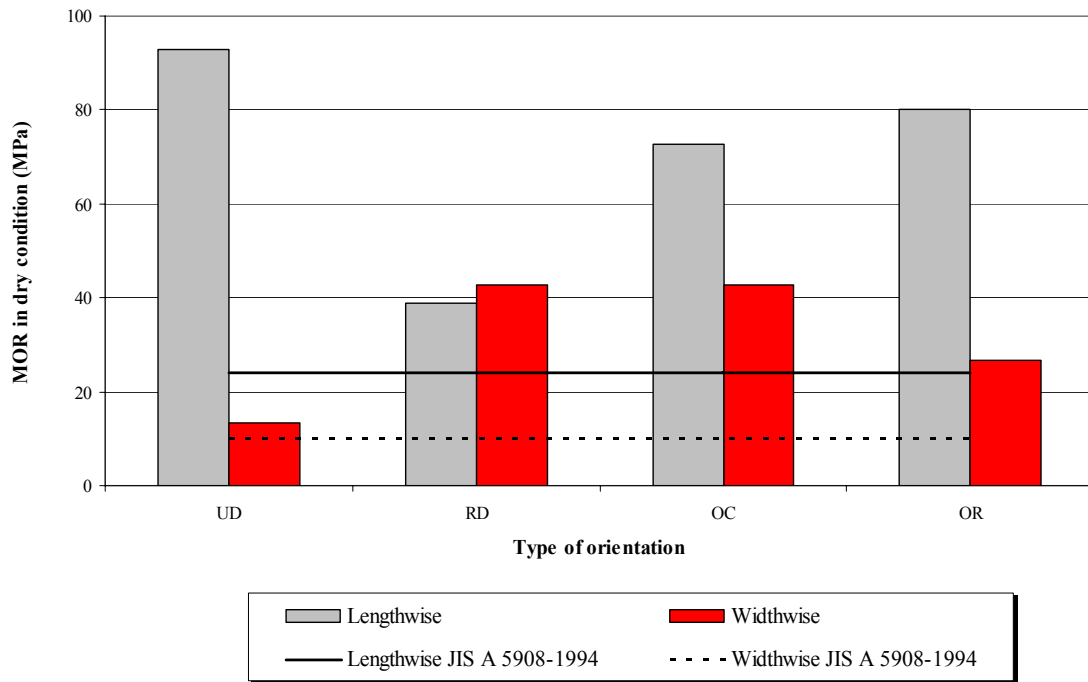


Figure 1 Effect of types of orientation on MOR in dry conditions.

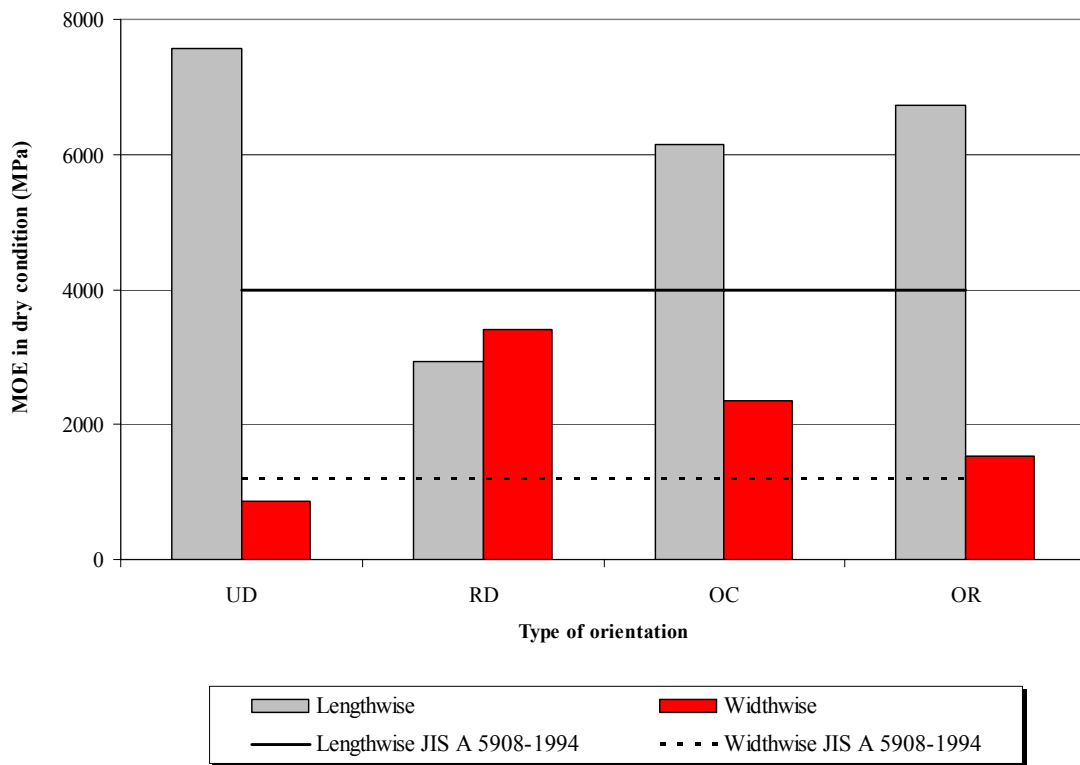


Figure 2 Effect of types of orientation on MOE in dry conditions.

Internal bonding

IB is the best single measure of the quality of manufacture because it indicates the strength of bonds between strands. The IB values should be discussed in reference to the resin content because it strongly depends on the amount of resin applied. The results showed that rubberwood OSB bonded with 5 % pMDI resin satisfied the JIS requirement of 0.3 MPa. Internal bond strength (IB) of boards that shown in **Figure 3** range from 0.8 to 1.4 MPa, and no significant difference was found between the board-types tested.

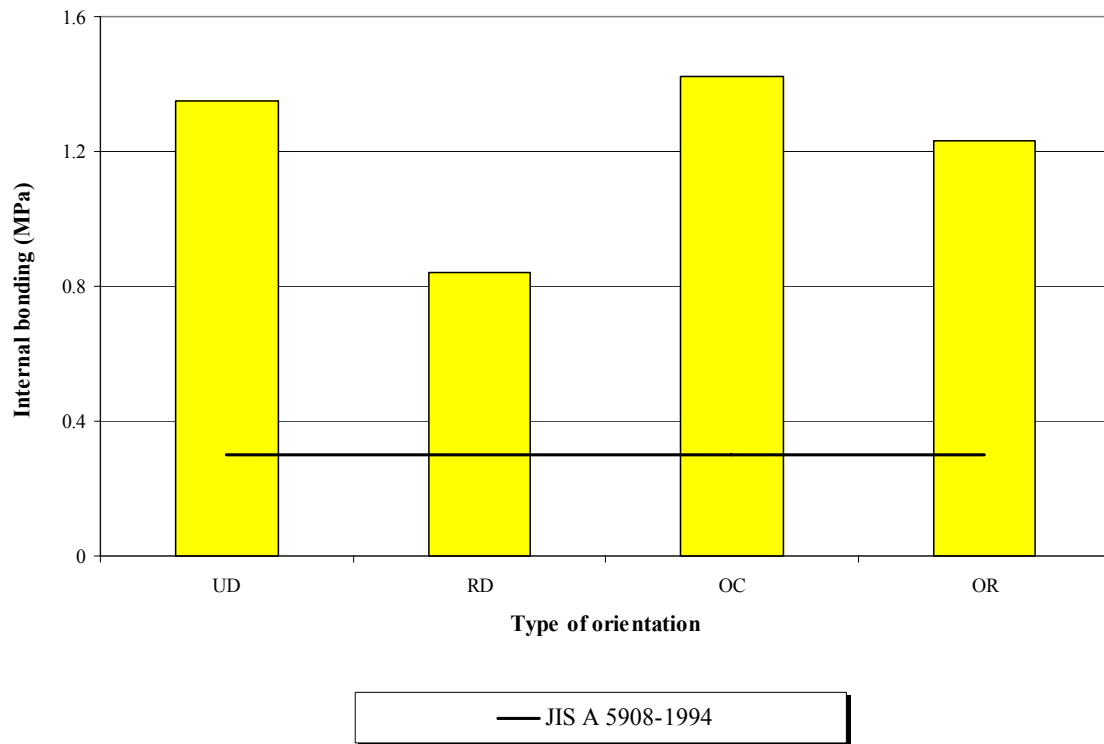


Figure 3 Effect of types of orientation on the internal bonding of rubberwood OSB.

Thickness swelling

TS value at 24 h water-soak that shown in **Figures 4** TS were not affected by strand orientation. All average values ranged from 26.0 to 41.9 %. For RD type, the TS value is greater than other types because the differential swelling potential due to in-plane density variation and abnormal thickness strands in this experiment lead to over compression stress released in the pressing operation.

The results showed that rubberwood OSB bonded with 5 % pMDI resin did not pass the JIS requirement of 20 %.

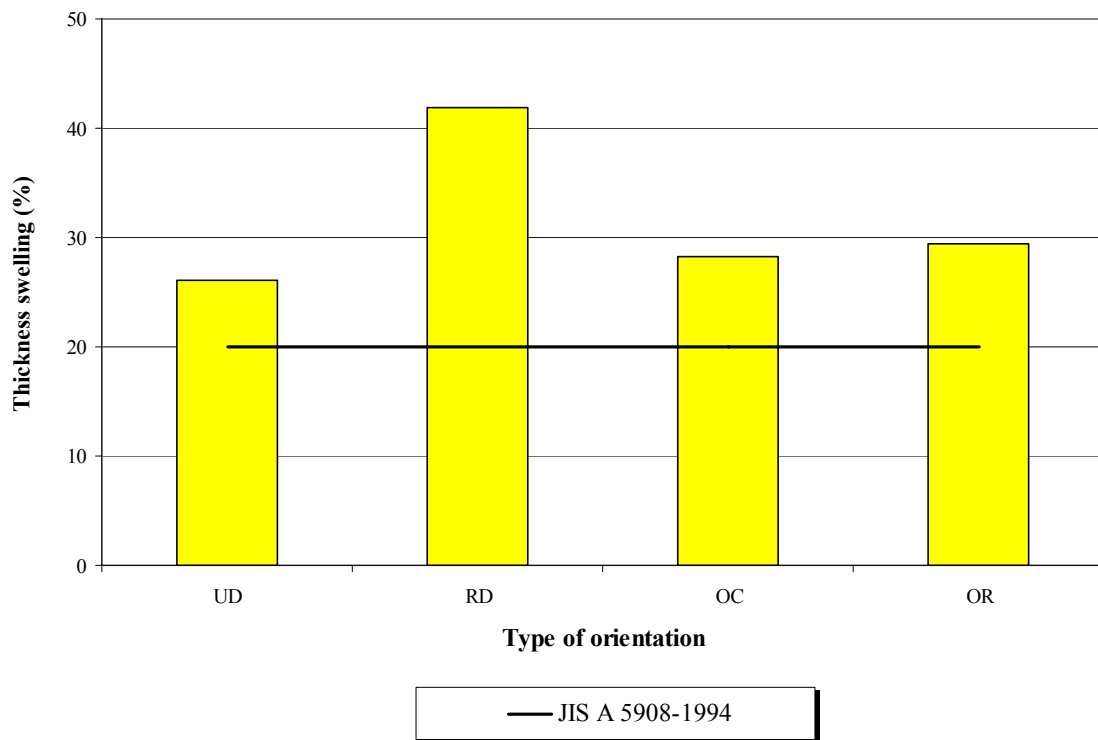


Figure 4 Effect of types of orientation on thickness swelling of rubberwood OSB.

CONCLUSIONS

In conclusions, alignment of strands improved the bending strength and stiffness of OSB in the direction of alignment but caused a corresponding reduction in the direction perpendicular to the alignment under dry and wet conditions. Secondly, alignment of face strands improved the bending strength and stiffness of OSB in the lengthwise direction. Cross alignment of core strands also improved the bending strength and stiffness of OSB in the widthwise direction. Thirdly, the strand orientation has no effect on the internal bonding and thickness swelling. Finally, strand alignment in the manufacture of OSB is advantageous in performance properties, particularly when the panel bending parallel to strand alignment is involved.

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บทคัดย่อ

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อิทธิพลของทิศทางการเรียงแถบไม้ที่มีต่อสมบัติทางกายภาพและเชิงกลของแผ่นแถบไม้อัดเรียงเส้น

งานวิจัยนี้ได้ทำการศึกษาอิทธิพลของทิศทางการเรียงตัวของแถบไม้ (Strand) ที่มีต่อสมบัติทางกายภาพและเชิงกลของแผ่นแถบไม้อัดเรียงเส้น (Oriented strandboard; OSB) ที่ผลิตจากไม้ยางพารา โดยทดสอบสมบัติต่างๆ ตามมาตรฐาน JIS A 5908-1994 ผลการทดสอบแสดงให้เห็นว่าการเรียงแถบไม้ที่ชันผิวไปในทิศทางเดียวกันจะทำให้ค่าโมดูลัสแตกหัก (Modulus of rupture) และโมดูลัสยืดหยุ่น (Modulus of elasticity) เพิ่มสูงขึ้น แต่ปัจจัยดังกล่าวจะมีผลกระทบเล็กน้อยต่อค่าการพองตัวทางความหนาหลังการแช่น้ำ (Thickness swelling) และค่าการยึดติดภายในแผ่น (Internal bonding)

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