Mechanical and Physical Properties of Oriented Strand Board from Kelempayan Wood

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Abstract

This study used Kelempayan wood as a raw material in manufacture of oriented strand board (OSB). This tree is naturally grow in Malaysia. Currently rubberwood supply is getting depleting and limited in resources. The objectives of this study were to determine mechanical and physical properties of OSB and effect of resin content. Target board density was 600 kg/m³, then phenol formaldehyde (PF) and urea formaldehyde resin (UF) were use as a binder. The quality of the boards were evaluated by determine of bending properties including modulus of elasticity (MOE), modulus of rupture (MOR), internal bond (IB) strength, thickness swelling(TS) and screw withdrawal. Generally, the mechanical strength increase with an increase in percentage of resin and OSB board from phenol formaldehyde resin is better than those boards from urea formaldehyde resin.

Keywords: *Modulus of rupture, modulus of elasticity, internal bond, thickness swelling, screw withdrawal.*

INTRODUCTION

With increasing population pressure, large areas of forest have been destroying in order to supply land for agriculture and raw material for wood industries. Increasing demand for wood and limited wood supply have prompted investigations into the potential of fast-growing species as a new source of material. Due to depleting supply of rubberwood, Kelempayan wood seem like be another alternative tropical wood for our wood-based industry. In this study Kelempayan wood. use to study their suitability as a substitute raw material in the manufacture of oriented strand board (OSB) because Kelempayan tree grows widely in Malaysia. Kelempayan in name of species called *Anthocephalus chinensis*. According to Choo *et al*., (1999), Kelempayan wood is classification as light hardwoods wood with density range from 370 kg/m^3 – 450 kg/m^3 air dry. Drying and relative movement are air-drying of 15 mm and 40 mm boards taken 2.5 and 3.5 m month respectively. Machining Properties of Kelempayan is easy to ripsaw and crosscut. Planing is easy and the planed surface produced is smooth. However, durability of Kelempayan is non-durable but can improve or upgraded to more strength durable in wood composite. Kelempayan is very easy to treat and the strength group of this timber is D. Kelempayan is suitable for plywood manufacture, packing case, wooden sandals, and toys, disposable of chopsticks and possibly as a short-fibred pulp (Choo, *et al.*, 1999). Performance and durability of furniture depends on the strength of joints used in its construction. Many researchers (Smardzewski and Prekrad, 2002) have studied factors affecting joint strength. The resistance to withdrawal of different types of fasteners in five wood species (Eckelman and Cassens, 1985) in particleboards, medium-density fiberboard and oriented strand board (Erdel and Eckelman, 2001) had been study. Fortunately, one of the main advantages of wood and its composite products as a structural material is that structural elements can easily connected with a wide range of fasteners (different type of adhesives and mechanical fasteners). Generally, there are two types of fasteners such as dowel type (bolt, lag screw, wood screw, nail) and bearing type (split ring, shear plate) (Soltis and Ritter, 1997). Wood screws are dowel type fasteners that attract more attention than fasteners like nails because of their better performance regarding vibration and withdrawal forces (Williamson, 2002). The objectives of this study were to determine mechanical and physical properties of OSB from Kelempayan wood and effects of resin content.

MATERIALS AND METHODS

In this study, Kelempayan wood (*Anthocephalus chinensis*) is the primary raw material in oriented strand board manufacturing. Several Kelempayan trees were harvested from Universiti Technologi MARA Pahang reserve forest. Trees were select based on the tree age or tree diameter (diameter breast height) according to what is required for this study. The trees were felled using chainsaw and transported to matau using a backhoe. The rest of logs are converting into sawn timber for strand preparation. The woods converted into flake and chip using wood flakers machine and chipper machine to produce the small strand with various sized. The particles were dried using an oven dried to make sure the moisture content of particles below 5%. The average moisture content of oriented strand board used for the preparation of test specimens was determined as 5% according to TS 2471 (1976). A temperature commonly used in the process of drying is 70-90°C, and take about 1-2 days to dry completely. After the entire strand is dried, the strands that were use are screened particles. The purpose of screening process is randomly strand size. Process mixing strands with resin will proceed and amounts of resin based on the board requirement. In this study, OSB boards are hand formed into three layers aligned in the same direction of orientation and core is aligning in an angle 90 degrees. All mats are press within heated press platens at 180°C for 6 minutes with varying pressure of 1200 psi for 180 sec, followed by a pressure of 1000 psi for 120 sec and lastly 800 psi for 60 sec respectively. The board will be produced in treatment with target density of 600 kg/m^3. The board measuring 380x380x12 mm will be condition at 21°C and 65% of relative humidity, to reach the equilibrium moisture content below 5%. The board will be test according to EN Standard. The adhesives used were phenol formaldehyde (PF) and urea formaldehyde (UF). Resin content of phenol formaldehyde used was at 5%, 7 %, and 9 %. For urea formaldehyde resin, three level of resin content were also used (8 %, 10 % and 12 %). The strands that were use are screened particles. The purpose of screening process is randomly strand size. All the processes to prepare of materials carried out in the Wood Industry workshop.

RESULTS AND DISCUSSIONS

Mechanical and Physical Properties

Oriented strand boards, or OSB panels, are a relatively a new kind of wood-based panels that the European standard (EN-300-97, 1997) classifies within the group consisting of particleboards.

Table 1: Properties of OSB from Kelempayan

Target Board Density (kgm^{-3})	Resin	Resin Content (%)	MOR (MPa)	MOE (MPa)	IB (MPa)	TS (%)	Screw
600	PF	5	20.43	3243	1.25	12.99	0.75
600	PF	7	22.16	3448	1.51	9.88	0.90
600	PF	9	27.39	4242	2.25	7.37	0.97
600	UF	8	23.27	4400	0.82	35.77	0.65
600	UF	10	28.12	4847	1.11	32.19	0.75
600	UF	12	34.23	5501	1.39	27.14	0.90
			18.00	2500	0.28	25.00	
Type OSB/1: General purpose EN Standard			EN 310: 1994	EN 310 1994	EN 319: 1994	EN 317: 1994	

Table 1 shows the average result of mechanical and physical properties on oriented strand board from Kelempayan according to PF and UF resin with three levels at resin content. The highest MOR value is 34.23 MPa, OSB that content 12 % of UF resin. Moreover, the lowest MOR is 20.43 MPa, OSB that content 5 % of PF resin. The highest MOE is 5501 MPa, OSB that content 12 % of UF resin. The lowest of MOE value is 3243 MPa, which resin content 5% of PF resin. OSB with resin content 9 % of PF and thicknesses 12mm have high value in IB, 2.25 MPa. The lowest of IB value is 0.82 MPa, which resin content 8 % of UF. Next, the highest of screw withdrawal value is 0.97 MPa, which 9 % of PF resin content. The lowest of screw withdrawal value is 0.65 MPa, from 8 % of UF resin content. The physical properties of resin content 9 % of PF and thicknesses 12 mm give the lowest value of thickness swelling with 7.37 %. All treatments for MOR, MOE, IB, SW, and TS were meet the requirement of the standard, except for those treatments using UF resin for thickness swelling do not meet the maximum requirement of the standard.

Effects of Phenol formaldehyde Resin

Bending Properties

The effect of phenol formaldehyde resin on bending properties shows in Figure 1. The effect of phenol formaldehyde resin on bending properties shows that MOR values show no significant difference between 5 % and 7 %, but significantly difference at 9 %. This was because of higher resin content give better bending properties between wood strands. According to Goroyias and Hale (2004) studied that higher of resin contents would marginally improve the MOR values. The MOE value from treatment of 9 % was higher than those treatments of 5 % and 7 %. However, analysis of variant shows the MOE values were no significant differences between treatment of 5 % and 7 % but at 9 % have significant difference. This probably due to the MOE values increase accordance to increasing of resin content (Andi Hermawan, *et al.*, 2006). Based on the strength value, all samples meet the minimum requirements of standard.

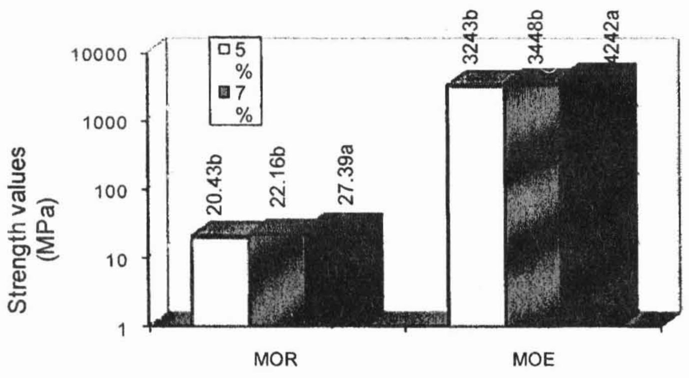

Figure 1: Effects of Phenol Formaldehyde Resin on Bending Properties

Internal Bond and Thickness Swelling

Figure 2 shows the effect of phenol formaldehyde resin on internal bond and thickness swelling. The internal bond of phenol formaldehyde resin show that values were no significant difference between treatment 5 % and 7 % but for treatment of 9 % shows significant difference. The highest value of internal bond was from treatment of 9 % and the lowest value was from treatment of 5 %. The internal bond strength showed a tendency to increase when the resin content also increase (Andi Hermawan, Takeshi Ohuchi, et al, 2006). The thickness swelling values were significant difference. The highest of thickness swelling value was from treatment of 5 %. Decreasing of resin content effected compaction of the board and created more void spaces, but all specimens still below 25 % of maximum EN standard (Eckelmen, 1998).

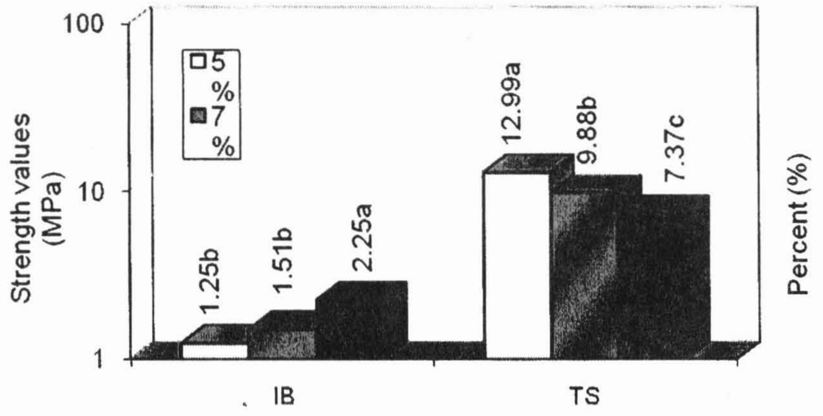

Figure 2: Effects of Phenol Formaldehyde Resin on Internal Bond and Thickness Swelling

Screw Withdrawal

Figure 3 shows the effect of phenol formaldehyde resin on screw withdrawal. The highest of screw withdrawal value was from treatment of 9 % resin content of phenol formaldehyde, while the lowest value was from treatment of 5 %. The screw withdrawal values show no significant difference between 5 %, 7 %, and 9 %. Maybe screw withdrawal was not affect by increasing of resin content. The results show that the withdrawal resistance of wood screw was not affects on increasing resin content (Mohammad Ali Taj, 2009).

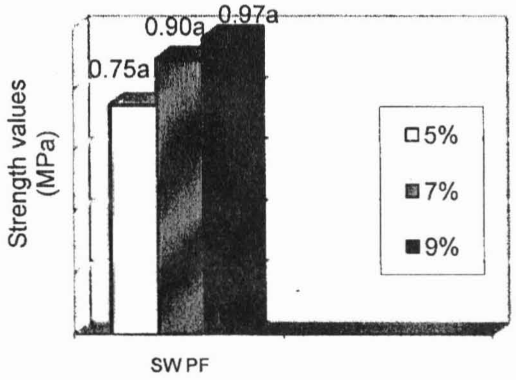

Figure 3: Effects of Phenol Formaldehyde Resin on Screw Withdrawal

Effects of Urea formaldehyde Resin

Bending Properties

The effect of urea formaldehyde resin on bending properties shows in Figure 4. The effect of urea formaldehyde resin on bending properties shows the highest of MOR value is 12 % of resin content. The MOR value was significant difference. The trend increase may affected by increasing percentage of resin content. The lowest of MOE value is 8 % of resin content. The MOE values also showed similar trends to increase those for MOR that affected by increasing percentage of resin content but due of value still above the standard requirement. In short and as a conclusion to these experiments, it could be state that the main advantage of increasing resin content that give high values of MOE and MOR (Manuel et al., 2005).

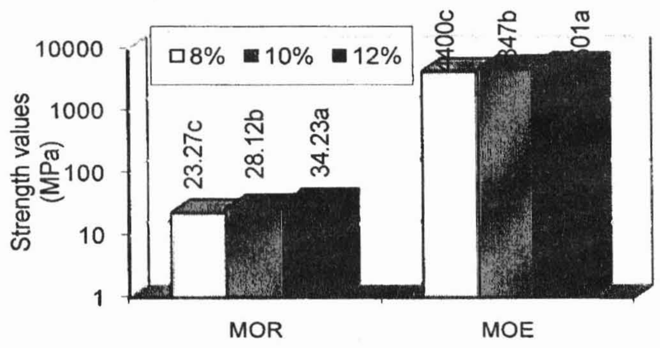

Figure 4: Effects of Urea Formaldehyde Resin on Bending Properties

Internal Bond and Thickness Swelling

Figure 5 shows that effect of urea formaldehyde resin on internal bond and thickness swelling. The highest of internal bond value was 12 % of urea formaldehyde resin. The internal bond strength was significant difference that showed a tendency to increase when the resin content also increase (Parviz, 2002). The highest of thickness swelling value was 8 % of resin content of urea formaldehyde resin. This cause the sample has more void area, so the samples become easier to absorb more water. Thickness swelling decreased significantly with increasing percentage of resin content. Next, to reduce the resulting of thickness swelling, increasing of resin content is required for applying board, since it can see that increasing in resin content enables to obtain more performance of resulting (Manuel et al., 2005). Therefore, all still passes the requirement of the standard need but only thickness swelling of urea formaldehyde is not passing.

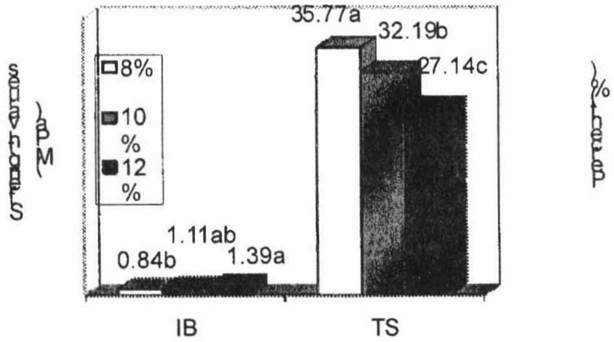

Figure 5: Effects of Urea Formaldehyde Resin on Internal Bond and Thickness Swelling

Screw Withdrawal

The effect of urea formaldehyde resin on screw withdrawal is show in figure 6. The effect of urea formaldehyde resin on screw withdrawal is show that screw withdrawal also has significant difference. The highest of screw withdrawal value is 12 % of resin content and the lowest value is 8 %. Urea formaldehyde resin of 12 % show boards are more compacted board than 8 % and 10 %. The results show that the ultimate withdrawal resistance of wood screw in increasing of resin content can get high of result (Mohammad Ali Taj, 2009).

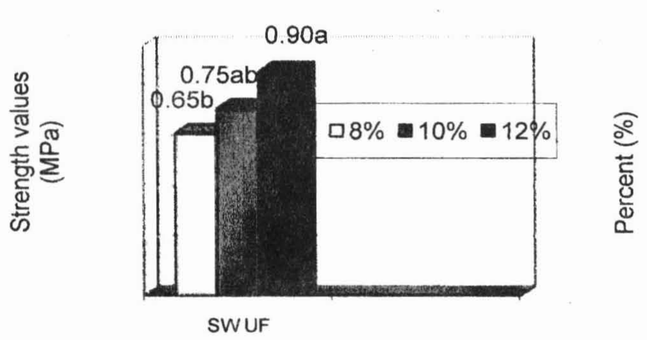

Figure 6: Effects of Resin Content of Urea Formaldehyde on Screw Withdrawal

CONCLUSIONS

From the result, the fast growing species especially for Kelempayan (*Anthocephalus chinensis*) shows a suitability to substitute species from virgin forest. This species is environmentally friendly and more economical to produce wood composite product. Kelempayan tree is widely regarded as a lead tree because of its fast growth compare to the other commercial tropical tree. Generally, the mechanical strength increase with an increase in resin content and decrease with decrease percentage of resin content. All mechanical properties of the board meet the minimum requirement of standard EN 300 OSB/1. The thickness swelling increase because decrease percentage of resin content, but still below the maximum requirement of 25 % for all board treatment except from resin content with 8 %, 10 % and 12 % of urea formaldehyde resin. In conclusion of this study, treatment with 5 % of phenol formaldehyde resin from Kelempayan wood has a potential for OSB manufacturer because based on the result that all meet the standard of requirement.

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