Properties of Oriented Strand Board (OSB) from Mixed Species of Mahang and Lundai

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ABSTRACT

Efficient and economical utilisation of various bio-based materials is an effective way to improve forest management. Oriented strand board (OSB) from fast growing and lesser-known tropical species in this study seems to have good potential for various structural and exterior applications. However, this potential will depend on further research and improvements in the physical and mechanical properties of the OSB. The main objective of the study is to develop and determine the properties of oriented strand board from mixed tropical species (lesser-known and fast growing) as a raw material in the manufacturing of OSB. Species like Ludai and Mahang were found in this study to be a suitable alternative raw material since the results showed that most of the treatments met the minimum requirements of mechanical and physical properties. It can be deduced from this study, that mixing Ludai and Mahang from fast growing tropical species had improved the board performance as compared to their single species. All of the mechanical and physical properties evaluated met the requirements of EN 310:1994, EN 317:1994 and EN 319:1994 for general purpose OSB.

Keywords: *Lundai, Mahang, oriented strand board (OSB), properties*

Introduction

Environmental and economic concerns combined with an increasing demand for wood products have led the forest products industry to maximise the use of wood residues. With the demand for forest products continuing to be strong and the available land base for timber production decreasing, the utilisation of small diameter and whole trees has become more important. Therefore, due to some of the constraints and changes in wood utilisation technology, fast growing tropical species have assumed greater potential as components of wood composite products. Furthermore, in view of the changing trend of available wood resources, wood composite products in general will become increasingly important in meeting the demand for wood products. Wood composites which make up a family of materials distinct from solid wood are composed of wooden elements of varying sizes (including fibres), held together by an adhesive bond. The bonding agent is either natural or synthetic in origin (Razali & Mohd. Hamami, 1993). According to Seibel (2004), the possibility of using timber from low commercial value and the local supply of fast growing wood species from planted sustainable forests are the main reasons to establish information and studies on the properties and utilization of wood species from planted forest for the OSB production.

Currently, the wood industry has contributed significantly towards the socio-economic development of Malaysia. OSB is significantly cheaper to produce as small diameter and low quality logs can be used unlike plywood, which requires good quality, and larger diameter logs. Generally, OSB is used in almost similar application to plywood, the panel being comparable with plywood in terms of strength and versatility (Breyer, 1993). Mohd. Nor and Hore (1997) reported that OSB from rubberwood was successfully manufactured in the Forest Research Institute Malaysia (FRIM) laboratory for the first time in 1996. The rubberwood OSB has high strength properties and has exceeded the minimum requirements of the Japanese Standards.

According to Douglas (1997), plywood manufacturing will decline across the Asia-Pacific region as the supply of peeler-quality logs declines and consumers adopt reconstituted panels. Based on the forecast made by ITTO (1996), plywood exports from Asia-Pacific region will drop by 60% while imports by the main consumer countries will decline by 80% by the year 2010 (Figure 1).

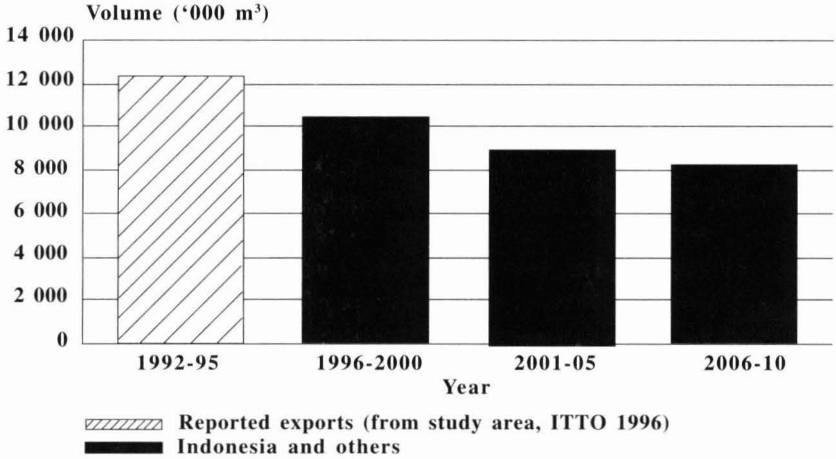

Figure 1: Forecast of Plywood/Veneer Exports by 2010

Therefore, researchers in Malaysia need to explore new types of wood composite products in order to replace the conventional type (plywood) which is higher in production cost. OSB is the most recent development in wood-based panel products and ready to replace the more traditional plywood in construction and industrial applications where this product is engineered to have strength and stiffness equivalent to plywood. In North America, OSB has been widely used to replace plywood as sheathing panels for walls, roofs and floors (Anon., 2000).

Problem Statement

Wood, as raw materials for the industries, has many diversified uses. Currently, wood product manufacturers in Malaysia are facing problems in getting the supply of wood. Wood composites are the direct result of declining availability of large diameter logs. Manufacturers tend to use alternative materials such as rubberwood, which is smaller in diameter. However, the wood industry sector in Malaysia are facing a declining supply of rubberwood logs and they are now trying to shift to Acacia wood which has fast growing characteristics as raw materials. Fast growing species like Acacia need to be introduced in order to sustain the wood industry sector in Malaysia. In Malaysia, there are several lesser-known tropical species, which have the potentials to be developed as materials with fast growing characteristics. Ludai and Mahang are fast growing tropical species, which are widely regarded as lead trees after logging activities or land clearing. Presently, these species are normally cut and burned or left to endure the degradable process during land clearing activities.

Studies on the performance of OSB made of species from temperate countries have been carried out and specifications on the appropriate use of this material have been established (Illston, 2002). Since OSB is a new wood composite in Malaysia, there is a lack of published information on OSB made from tropical species and no study on OSB from Ludai, Mahang and Petai belalang has been conducted.

Objectives

The main objective of the study is to determine the properties of oriented strand board from mixed tropical species (lesser-known and fast growing) as a raw material in the manufacturing of OSB. The specific objectives of the study are listed below:

i. to assess the feasibility of using Ludai and Mahang for the manufacturing of OSB.
ii. to evaluate the effects of manufacturing variables by mixing two species on the physical and mechanical properties of OSB.

Materials and Methods

In this study, Mahang and Ludai were harvested from UiTM Pahang forest reserve. Phenol formaldehyde (PF) resin used in the study is commercially available and supplied by a local adhesive company with 2 levels of resin content (5% and 7%). The board dimensions were 380 mm x 380 mm with 12 mm thick. Logs were cut into small billets to produce strands by using a high speed disk flaker. The strands, averaging 1.0 x 20 x 75 mm were screened and those passed through 20 mm and retain on a 5 mm opening screen diameter (S1: 20 mm to 5 mm, S2: 20 mm to 10 mm and S3: 10 mm to 5mm) were used in this study.

Three boards were produced for each treatment with a target density of 600 kg/m^3 (Mahang and Ludai). The boards measuring 380 x 380 x 12 mm, were conditioned at 21°C and 65% of relative humidity, to reach the equilibrium moisture content of 12 ± 2%.

For this study, OSB was formed in three layers; the top and bottom layers have their strands oriented towards the length of the panel to optimise strength, stiffness, and spanning ability. The middle layer has its strands aligned across the board. Mats were manually formed using a specially designed forming box with slots to control the strand alignment.

Manufacturing of OSB Board and Testing

In general, the manufacturing process for OSB starts from debarked logs which are then sliced into thin wood elements. The strands are dried, blended with resin, and formed into thick, loosely consolidated mats that are pressed under heat and pressurised into boards or panels. Figure 2 shows the flow process of OSB board making.

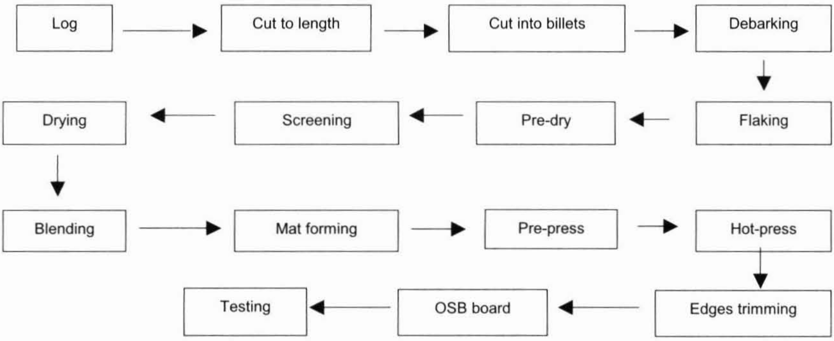

Figure 2: OSB Board Making Process

In this study, OSB boards were hand-formed into three layers (face to core ratio of 1:2), aligned in the same direction of orientation and the core was aligned in an angle of 90 degrees. Prepressing was done in order to compact the mat. All mats are pressed within heated press platens at 180°C for 6 min with varying pressure of 1200 psi, 1000 psi and 700 psi respectively.

Physical and Mechanical Testing on OSB Board

The properties tested include modulus of rupture (MOR), modulus of elasticity (MOE), thickness swelling (TS) and internal bond (IB). Tests were conducted according to the European Standard (EN 310; 1994 and EN 319; 1994) and flow process of testing as in Figure 3. Sampling and cutting of test specimens were carried out according to EN 317:1993.

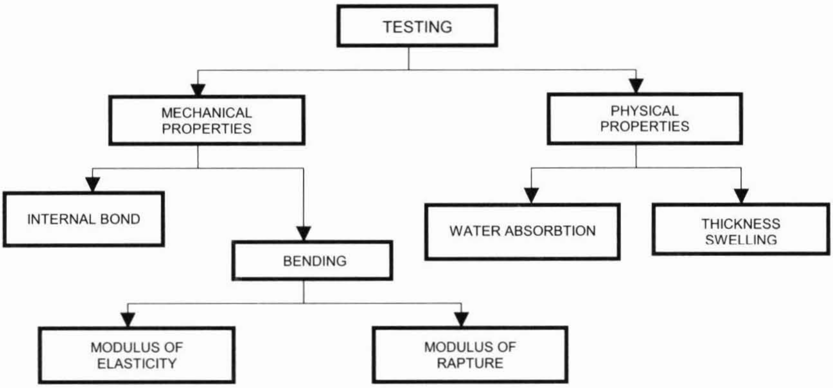

Figure 3: Flow of Testing

Statistical analyses were performed using ANOVA and the differences among varieties were compared using paired sample T-test.

Results and Discussion

Before OSB can be efficiently and safely used in any applications, proper studies on physical and mechanical properties need to be made based upon the strength values of the OSB. The main strength values that determine the structural integrity and stability of OSB are the MOR and MOE. The MOR values are needed to estimate the dimensions and the strength capacity while the MOE values are needed to estimate the stiffness and elasticity of the OSB. These two values are the main material properties needed by the engineers, architects or designers before the material can be specified for safe use as a building component.

OSB is mostly a 3-layer structure with surface layers oriented in direction of production and a core layer oriented cross to these. The alignment of strand gives OSB boards improved strength along board directions as compared to other wood composites.

Performance of OSB board from Mahang and Ludai

Mahang and Ludai are lesser-known tropical species with fast growing characteristics. According to Nazri and Akso (2006), Mahang and Ludai are among the fast growing species in UiTM Pahang forest reserve. Exploring new species and mixing with other species can improve the understanding of using lesser-known species which are able to show relationship between species, layer density, compaction, water exposure time, etc. Results from single wood species (Mahang and Ludai wood) in this study were used as control samples.

Table 1: Performance of OSB from Mahang and Ludai Wood

OSB/1: General purpose	EN 310: 1994	EN 310: 1994	EN 319: 1994	EN 310: 1994
Minimum requirement	18 MPa	2500 MPa	0.28 MPa	25%
Treatment: 600/5%	MOR/Major	MOE/Major	IB	T/S
Mahang	28.60	5289	0.37	29.50
Ludai	28.41	5739	0.34	39.50
Treatment: 600/7%	MOR/Major	MOE/Major	IB	T/S
Mahang	39.4	6079	0.52	12.16
Ludai	37.2	6317	0.43	20.32

Table 1 shows the performance of OSB board from Mahang and Ludai wood with the target density of 600 kgm^{-3}. There were two levels of phenol formaldehyde resin used (5% and 7%). Normally, 7% resin content performs better than 5% resin content. Presence of more amount of resin content contributes to this performance.

Properties of MOR and MOE

The results of the physical and mechanical properties of OSB panels from Mahang and Ludai at 5% and 7% resin contents are presented in Table 1. All mechanical properties evaluated met the requirements of EN 310:1994 for the general purpose of OSB. With regards to the modulus of rupture (MOR), the values were 36.6% to 37.0% higher in the major direction (parallel) as compared to the standard. The modulus of elasticity (MOE) in the major or lengthwise direction of boards was 52.7% higher than the minimum requirements for Mahang wood and 56.4% higher for the Ludai wood. However, the MOE between 5% and 7% resin content for Ludai was not significantly different (Table 2).

Overall, an increase of about 27% for the MOR value and 13% for MOE were observed when the resin content was increased from 5% to 7% for both Mahang and Ludai. This increase in strength was due to the better bonding of the strands in the presence of more resin. Similar

Table 2: Paired Samples Test for Ludai Wood

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	MORLu_5 - MORLu_7	-8.54656	11.6503	3.88345	-17.50180	.40869	-2.201	8	0.050*
Pair 2	MOELu_5 - MOELu_7	-499.338	1615.974	538.65803	-1741.4865	742.80876	-.927	8	0.381 ns
Pair 3	IBLu_5 - IBLu_7	-.15525	.1202	.04251	-.25576	-.05474	-3.652	7	0.008*
Pair 4	TSLu_5 - TSLu_7	24.0150	7.7827	3.17727	15.84756	32.18244	7.558	5	0.001*

Note: '*' indicates significant difference at $p \leq 0.05$;
'ns' indicates no significant difference

observation on board properties-resin content relationship was also reported on wood particleboard (Talbott & Maloney, 1957).

Internal Bond

Internal Bond (IB) is defined as the mechanical property that shows the tensile strength between raw material (wood) and adhesive. Both values of IB for Mahang (0.37 MPa) and Ludai (0.34 MPa) wood passed the minimum requirements (0.28 MPa). It indicates good adhesion or sufficient bonding, as well as efficient resin spread and fine atomisation. Sufficient bonding strength necessitates intimate contact between wood elements, which is obtained by a high degree of mat consolidation.

Physical Properties

The values of dimensional stability were higher than the minimum requirements. A poor performance in Thickness Swelling (T/S) for treatment 600/5% was due to the low density of wood (Mahang and Ludai) and less resin content. Mahang and Ludai wood had bigger vessel diameter characteristic and contributed to the high water intake during soaking process. An improvement has to be attained in order to reduce water uptake and thickness swelling. Two actions can be taken to increase the dimensional stability: adding wax in the blending machine during manufacturing process and reducing the panels density to decrease 'springback' effect.

Performance of OSB Board from Mixed Species of Mahang and Ludai

Table 3 shows the performance of OSB with different species used as face and core layers (OSB mix). Comparing the results from single species (Table 1), the mechanical and physical properties of the OSB mix showed overall improvement by the combination between Ludai and Mahang wood. The high-density surface layer of Mahang wood contributed 9.5% higher MOR values as compared to Ludai wood surface layer. The contribution of mixed-species shows better performance compared to single species.

Table 3: Performance of OSB Mix: Mahang and Ludai

OSB/1: General purpose	EN 310: 1994	EN 310: 1994	EN 310: 1994	EN 310: 1994	EN 319: 1994	EN 310: 1994
Minimum requirement	18 MPa	9 MPa	2500 MPa	1200 MPa	0.28 MPa	25%
Treatment: 600/5%	MOR/Major	MOR/Minor	MOE/Major	MOE/Minor	IB	T/S
Ludai;face/Mahang;core	38.12	18.91	5644	1896	0.29	23.33
Mahang;face/Ludai;core	42.14	20.10	7175	1887	0.34	23.47
Treatment: 600/7%	MOR/Major	MOR/Minor	MOE/Major	MOE/Minor	IB	T/S
Ludai;face/Mahang;core	38.15	26.17	5250	2682	0.48	15.04
Mahang;face/Ludai;core	45.27	18.30	7493	1880	0.53	18.77

Properties of MOR and MOE

Both MOE (stiffness) and MOR (strength) describe the mechanical performance of wood composite. According to Chugg (1964) and Schodek (1998), there are three types of stresses, which occur in static bending tests. These stresses are tension, compression and shear. The MOE was computed by assuming that the deflection of all of the specimens arises from flexural deformations. Table 3.3 shows the properties of MOR at different resin content. MOE and MOR showed moderate positive increase when the resin content was increased from 5% to 7%. Avramidis (1989) gave similar conclusions based on his tests on OSB specimens.

In minor axis, performance of MOR and MOE values are lower than in major axis. This is due to the longer strand alignment at face and bottom in major axis which is able to resist the load. According to Maloney, (1994), there are two main forms of OSB: one form of OSB has all the particles aligned in one direction, providing many of the strength properties found in solid timber such as high lengthwise strength. However, it is the widthwise strength is lower.

Internal Bond

The Internal Bond (IB) values were observed to increase with the amount of resin used (Table 3.3). It was observed that for an increase from 5% to 7%, an increase of about 39% in IB was noted. This is an exceptional increase in strength. This increase in IB is due to the resin being available at higher resin content to give better bonding among the strands. Avramidis (1989) reported IB and tensile strength of OSB improve as resin content increases.

Physical Properties

The values of Thickness Swelling (TS) of mixed-species board recorded lower water intake compared to single species treatment (Mahang and Ludai) after 24-hour water soak. This indicates that the density of the species layer affected TS values. As shown in Table 3, the TS value of the mixed-species decreased when the resin content increased from 5% to 7%. This improvement is due to the effective bonding between the flakes, thus, enabling the flakes to resist the uptake of water during the

24-hour soaking test. Gatchell, Heebink et al. (1966) concluded that the resin level was the most important single variable for controlling swelling and durability of exterior grade wood composites. The thickness swelling ranged from 16.4% to 11.6% for the change from oven dry to 90% relative humidity, using a range of phenolic resin content from 2% to 10%.

Conclusion

The development of lesser-known tropical species for OSB can provide tools to help forester to preserve virgin forest area and restore native eco-systems. OSB from fast growing and lesser-known tropical species in this study seems to have good potential for various structural and exterior applications. However, this potential will depend on further research and improvements in physical and mechanical properties of the OSB. Species like Ludai and Mahang were found in this study to be a suitable alternative raw material since the results showed that most of the treatments met the minimum requirements of mechanical and physical properties.

The results of this study lead to the following conclusions:

i. All samples from Mahang and Ludai at 5% and 7% resin content for mechanical properties met the requirements of EN 310:1994 for general purpose OSB. However, poor performance in thickness swelling (physical properties) for these treatments were observed.
ii. It can be deduced from this study, that mixing Ludai and Mahang had improved board performance as compared to the single species. All mechanical and physical properties evaluated met the requirements of EN 310:1994, EN 317:1994 and EN 319:1994 for general purpose OSB.

For further studies, other types of OSB such as those of five or seven layers and different board densities need to be developed. OSB from other tropical lesser-known species could be manufactured if for further research to be done-especially in order to determine the optimum density and resin content of the board.

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