

Proceeding of

The 4th

International Symposium of Indonesian Wood Research Society

**“Greening the Earth to
Continue the Wonderful
Use of Wood for Secure
Life”**

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Organized By:
Forestry Faculty of Hasanudin University &
Indonesian Wood Research Society (IWoRS)



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Research Society(IWoRS)

**“Greening the Earth to Continue the Wonderful Use of
Wood for Secure Life”**

Makassar, 6 – 7 November 2012

Editors

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2015

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PREFACE

After Bogor, Denpasar, and Yogyakarta became the previous hosts for the International Symposium of Indonesian Wood Research Society (IWoRS), the Forestry Faculty of Hasanuddin University in Makassar had been given an honour to be the host for the symposium in 2012. Makassar is one of the biggest city in the Eastern part of Indonesia. It is located in Sulawesi Island and has 1.3 million population. The island has multi-cultural ethnics and is famous with its endemic flora and fauna as it is positioned in Wallacea Line. Makassar city has also been known for its beautiful beaches.

The selected theme for this symposium was **“Greening the Earth to Continue the Wonderful Use of Wood for Secure Life”**. Greening the earth through tree plantations and enrichment has become an important issue to improving the quality of the environment and to continuously generating its intangible benefits. Sustainable and optimum development of wood utilization as a raw material for many purposes incorporated with sustainable development of tree plantations, emphasize the importance of ensuring the availability of wood for present needs without compromising life sustainability for future generations. As reforestation program is intensified, larger plantation resources will significantly contribute to sustainable wood supply which in turn will optimize wood utilization. Some efforts to developing sustainable wood supply and optimum wood utilization have been embarked upon by many scientists from various disciplines; especially in the field of wood science and technology; however, better understanding of wood need to be intensively explored.

On behalf of the editors, we would like to thank all of the authors who presented papers in the symposium. There were 29 full papers and 110 abstracts in this proceeding. The papers came from all over Indonesia and also overseas such as from Japan, South Korea, France, Iran, Nigeria, and Malaysia. We would like to extend our gratitude to DR. Iman Santoso, the Head of Research and Development Agency of Forestry Ministry, Prof. Nobuaki Hattori from Tokyo University of Agriculture and Technology as well as to Prof. Remy Marchal from Arts et Metiere Paris Tech. and CIRAD, France as our keynote speakers for the symposium. This proceeding is expected to be a medium for the dissemination of the latest research information to various countries in the field of wood science, other forest products, and forest management.

The Editors and committee would like to thank the Directorate General for Higher Education, Ministry of Education and Culture for the grant given for the symposium to the professional organization scheme. Our gratitude goes to the Rector of Hasanuddin University, the Dean of Forestry Faculty, and the Head of Indonesian Wood Research Society.

Makassar, June 2015

Editors

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INVITED PAPER

The Prospect for *Acacia mangium* Willd as a Raw Material of Pulp and Paper in Indonesia

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ABSTRACT

This paper shows the results of research on *Acacia mangium* Willd in the pulping process, wood chemistry, anatomical properties, physical properties and analysis of the elementary chlorine free bleaching using the KRAFT and ASAM (Alkali, Sulfite, Antraquinone and Methanol) process. The pulping process used KRAFT and ASAM methods determined by TAPPI and Zellcheming standards. The stages of elementary chlorine free bleaching with 6 combinations used bleaching process such as oxygen bleaching, sulfuric acid, Chlordioxide, Oxygen/hydrogen Peroxide-, second step of Chlordioxide and hydrogen Peroxide bleaching (O-A-D₁-OP-D₂-P). Analysis of wood chemistry component and wood anatomy were determined by TAPPI and IAWA Standards. The results of the Kraft pulping process on 8 year old *Acacia mangium* were 53.42% total yield; 0.01% wood reject; 16.45 Kappa number; 862 mg/l CED – Viscosities and 24.16% ISO brightness. Paper strengths properties at 30 °SR beating degree interpolation were 8.84 tensile strength km, 410 kPa bursting strength and 86,4 cN tearing strength. The 15 year old *Acacia mangium* has lower qualities in pulp and paper than 8 years old timber. The bleaching process used several stages; the first stage of bleaching used oxygen in an alkaline condition. It decreased the Kappa number from 16.5 – 27.5 to 4.2 – 11.1, as well as increased the brightness from 18.1 – 24,2 %ISO to 40.2–46.5 %ISO. Nevertheless, it also decreased 6–123 point pulp viscosity and showed 0,5–1,4% yield. The Chlordioxide was used for the second stage of the bleaching process and the hexauronic acid and other sugar that derived from hemicelluloses were not solved, only a part of them. It had an increased Kappa number of pulp. In order to dissolve this acid, a washing method can be used to reduce the Kappa number and give slightly increased brightness. The next stage was a combination process of Chlordioxide at the final stage, oxygen/peroxide, and Chlordioxide at the second stage and peroxide only at the end of stage. The results showed that the bleaching process with 6 combinations obtained 0.5–1.4 Kappa number, 571–863 ml/g viscosities and 89–90,9 %ISO brightness. The anatomical properties of fiber from *Acacia mangium* have 982-1027 µm length, 20.76-21.67 µm fiber diameters, 13.79-18.48 µm lumen diameters, and 3.42-3.58 µm thickness of fiber wall. The chemical properties were 27% lignin, and 1 - 5% extractive (soluble in hot water). The physical properties including moisture content of green wood were 94% - 111% with 0.45-0.49 g/cm³ wood density (oven dry).

Key words: acacia mangium, pulping, ECF Bleaching.

INTRODUCTION

The pulp and paper industry is one of the high capital industries that have tended to grow quickly in recent times. To become one of the 10 biggest producers in the world, we need many strategies, such as, planting fast growing species over large areas, as in Plantation forests. *Paraserianthes falcataria*, *Gmelina arborea*, *Acacia mangium*, *Eucalyptus deglupta* and other species were chosen to be planted in order to fulfill the raw material needs of pulp and paper factories.

Good planning in choosing species and accurate information were needed to avoid a great risk in this program. Based on these reasons, this research was conducted to determine the optimum condition for the Kraft-pulping process as well as the quality of pulp and paper, fiber anatomy, physical properties of wood and bleaching of plantation forest species, especially *Acacia mangium* Willd.

METHODOLOGY

Tools and Materials

The pulping process used *Acacia mangium* Willd (6, 7, 8, 9 and 15 years after being planted) from International Timber Corporation Indonesia Ltd., Co, NaOH, Na₂S, H₂SO₄, Antraquinone (AQ), Ethanol, KMnO₄, KI and Na₂S₂O₃, whereas for determining of Kappa Number, Sulfuric, Hydrogen Peroxide, Chlor dioxide, Oxygen etc. were used within the bleaching process.

Digester, refiner, screener, centrifugal, Yokromuhle, paper handset machine, and apparatus for the testing of tensile, tearing, and bursting strengths, beating degree, analytical balance were used in this experiment.

Procedures

Logs without bark were converted into chips in (20-30) x (15-20) x (2-6) mm dimensions. The chips were dried to ≤ 12% of moisture content, and stored in a constant room to determine the moisture factor before pulping; using the Kraft/sulphate and ASAM method.

The pulping conditions were regulated as follows:

- Active alkali : 12-18% Na₂O or 16-24% NaOH
- Sulfidities : 25% Na₂O or 40% NaOH
- Antraquinone : 0.0 - 0.1% per wood weight (oven dry)
- Pulping temperature (max.) : 170 - 175°C
- Pulping time (t-max.) : 1 - 2 hours
- Weight of chip : 300 - 800 gram (OD)
- Ratio of chip : liquor : 1 :
- 4

Table 1. The Testing Methods for Pulp and Paper

Type of Test	Methods of Merkblatt
- Screened yield, wood reject and total yield	No. 1/15/63
- Kappa number	No. IV/37/80
- Beating degree	No. V/7/51
- Paper making	No. V/8/76
- Weight, thickness and density of paper	No. V/11/57
- Strength of paper	No. V/12/57

Data Analysis

The data was analyzed within the average values, tabulated, and figured in simple graphics.

RESULTS AND DISCUSSION

A. Wood chemical component

Based on the results of wood chemical analysis (Table 2), *Acacia mangium* had medium to high extractives and lignin content. Mostly, tannin and other phenolic made up composed the wood extractives content from Plantation forest species.

Table 2. The Wood Chemical Composition of *Acacia mangium* Willd. at Different Ages.

Wood Chemical	Years			
	6	7	8	9
Wood extractives (%):				
Cold water solvent	1.28	1.46	1.64	1.15
Hot water solvent	2.26	4.77	3.09	1.07
Alcohol benzene solvent	-	-	3.03	-
1% NaOH solvent	10.12	12.80	15.95	15.60
Ash (%)	0.25	0.33	0.62	0.45
Lignin (%)	27.55	27.53	27.40	27.06
Holocellulose (%)	-	-	69.52	-

The ash content was extremely low, whereas holocellulose was at a medium to high content. Technically, *Acacia mangium* could be used as pulp raw material for pulp with a medium to high yield of pulp.

B. Fiber Anatomy

Table 3 shows that at each age, fiber dimension and derivatives of fiber dimension did not show different values. Fiber diameter was classified into middle class, thickness of fiber wall into thin class, fiber length into middle class, whereas the Coefficient of Rigidity, Muhlsteph Ratio, and Felting Power were classified into third class, Flexibility Ratio in the second class, and Runkel Ratio in the first class.

Table 3. Fiber Dimensions of *Acacia mangium*

Age of Tree (Years)	Fiber Diameter (µm)	Lumen Diameter (µm)	Thickness of Fiber Wall (µm)	Fiber Length (µm)	Fiber Proportion (%)	Axial Parenchyma Proportion (%)	Pore Proportion (%)
6	21.67	14.82	3.42	983.76	74.94	10.17	6.33
7	21.63	18.84	3.58	989.10	77.59	10.18	5.69
8	20.76	13.79	3.49	982.33	76.09	9.99	6.21
9	21.38	14.45	3.46	1027.29	76.13	10.85	5.40
Average	21.36	14.39	3.49	995.62	76.19	10.30	5.91

Age of Tree (Years)	Fiber Length (µm)	Ray Parenchyma Proportion (%)	Coefficient Of Rigidity	Muhlsteph Ratio (%)	Flexibility Ratio	Runkel Ratio	Felting Power
6	983.76.	8,56	0,160	53,53	0,677	0,501	47,02
7	989.10	6,53	0,169	55,49	0,662	0,540	47,12
8	982.33	7,73	0,172	56,27	0,656	0,551	48,85
9	1027.29	7,57	0,165	54,60	0,670	0,511	49,28
Average	995.62	7,60	0,167	54,97	0,666	0,526	48,07

C. Physical Properties

Table 4. Physical Properties of *Acacia mangium* Wild.

Physical Properties	Years				Average
	6	7	8	9	
DBH (cm)	14.58	19.99	21.10	21.74	19.35
MC green wood (%)	111.50	94.80	105.20	98.70	102.6
ρ green wood (g/cm ³)	0.87	0.89	0.91	0.88	0.88
ρ OD (g/cm ³)	0.45	0.49	0.47	0.47	0.47

Table 4 shows that at each age of the trees, the physical properties did not have different values.

D. Pulping Process

1. Preliminary Pulping Process

The pulping results of *Acacia mangium* can be seen in Table 5 (6 - 9 Years) and the physical and mechanical properties of pulp and paper in Table 6. The best quality of Pulp and Paper for *Acacia mangium* 6 - 9 years old obtained were more than 50% the Total Yield, below 20 Kappa Number, and above Quality Standard for the Mechanical properties of Paper.

Table 5. Physical Pulp and Physical Mechanical Paper Properties from *Acacia mangium* Wild. at Difference Age.

No.	Physical Properties of Pulp and Physical Mechanical of Paper	Years				Average
		6	7	8	9	
1.	Screened yield (%)	53.62	51.66	51.23	52.16	52.16
2.	Unscreened yield (%)	0.02	0.01	0.10	0.04	0.04
3.	Total yield (%)	53.64	51.67	51.33	52.20	52.21
4.	Kappa number	14.58	16.10	19.37	16.00	16.51
5.	Beating degree (°SR)	30	30	30	30	30
6.	Tensile strength (m)	6083	6263	7349	7295	6748
7.	Bursting strength (kPa)	349	377	368	432	382
8.	Tearing strength (cN)	56.9	57.5	73.8	55.7	68.0

Pulping Conditions: 16% Active alkali; 25% sulfidities; 175°C temperature; 1 hour pulping time and ratio of Liquor: Wood Chip = 4 : 1

Table 6. The Physical-Mechanical Properties of Pulp and Paper from *Acacia mangium* Wild.

Years	Gramatur (gr/cm ²)		Thickness of Paper (mm)		Density (gr/cm ³)	
	Unbeaten	30°SR	Unbeaten	30°SR	Unbeaten	30°SR
6	85.19	0.09	0.14	79.22	0.62	0.87
7	82.88	0.09	0.13	80.89	0.63	0.88
8	84.24	0.13	0.14	81.85	0.60	0.64
9	82.09	0.09	0.13	80.97	0.61	0.87
Average	83.60	0.10	0.14	80.73	0.62	0.82

Table 6. (to be continued)

Years	Tearing Strength (mN)		Bursting Strength (kPa)		Tensile Strength (m)	
	Unbeaten	30°SR	Unbeaten	30°SR	Unbeaten	30°SR
6	241.91	568.81	88.75	348.75	1257.26	6083
7	241.91	575.34	103.75	377.88	1548.43	6263
8	346.51	738.79	117.50	268.75	1361.53	7349
9	359.59	555.73	103.75	432.50	1323.06	7295
Average	297.48	609.67	103.44	356.97	1372.57	6747.5

Table 7. Kraft and ASAM Pulping Process of *Acacia mangium* in Different Age.

No	Descriptions	15 Years Old	15 Years Old	15 Years Old	15 Years Old	8 Years Old
		Acacia	Acacia	Acacia	Acacia	Acacia
A.	Method of Process	ASAM	ASAM	KRAFT	KRAFT	KRAFT
1.	Number	AM2	AM4	AM1	AM3	AM5
2.	Chip (g oven dry)	700	700	700	700	700
3.	Moisture Factor	0.9090	0.9090	0.9090	0.9090	0.8850
	Chemical:					
	• Active Alkali as NaOH (%)	25	25	22	22	22
	• Sulfidities (%)	-	-	40	40	40
	• Na ₂ SO ₃ : NaOH (%)	70 : 30	70 : 30	-	-	-
	• Methanol (%) volume)	20	20	-	-	-
	• Antraquinone (% Of wood)	0.1	0.1	0.0	0.1	0.1
4.	Ratio (Liquor : wood)	4 : 1	4 : 1	4 : 1	4 : 1	4 : 1
5.	Pre-hydrolysis (Min)	30	30	30	30	30
6.	Pulping Time (to T max, Min)	66	85	60	60	60
7.	Pulping Time (T max, Min)	120	120	120	120	120
8.	Pulping Temp. (T max, °C)	175	180	170	170	170
B.	Results					
1.	Screened Yield (%)	45.54	42.54	46.27	43.7	53.42
2.	Wood Reject (%)	2.89	3.52	0.56	0.71	0.01
3.	Total Yield (%)	48.43	46.06	46.83	44.41	53.43
4.	PH (End of Pulping)	10.6	10.5	12.6	12.5	12.5
5.	Moisture Factor	0.3302	0.3159	0.3121	0.3114	0.3140
6.	Kappa Number	30.6	28.2	28.2	27.5	16.45
7.	Brightness (%ISO)	18.11	21.38	22.27	18.82	24.16
8.	Viscosities (ml/g)	975	996	852	928	862
9.	Tensile Strength (Km), 30 °SR	9.89	9.10	8.67	8.42	8.84
10.	Bursting Strength 80 gr (kPa)	556	525	456	433	410
11.	Tearing Strength 100 gr (cN)	66.4	71.9	74.5	59.9	86.4
12.	Opacities 80g/m ³	99.4	99.7	99.8	99.7	99.3
13.	LSC (m ²)	15.6	20.1	22.1	19.8	20.6

Table 7 explains that the antraquinone addition of 0.1% raw material decreased the pulp yield by 2% - 4% and the Kappa number by 0.7 point, the strength of the paper as relatively stable for tensile strength and bursting strength, but the tearing strength decreased. The viscosities of Kraft pulp for *Acacia mangium* were lower than ASAM pulp at the same age.

2. Bleaching of Pulp

a. Reduction of Chlorine by Using Oxygen in Bleaching Process and Sulfuric Acid in Washing Treatment

The research conducted in Germany focused on reducing the use of Chlorine with Oxygen bleaching through arranging the NaOH concentration as a media of bleaching. The result showed that increasing the NaOH concentration also made pH and brightness of pulp increase, but decreased the Kappa Number and Viscosity. This research is based on Lehnen's experiments in 1993-1998 at Hamburg University, Germany.

After bleaching with oxygen, the pulp from tropical wood changed their hemicelluloses to become hexauronic acid and other sugars that derived from hemicelluloses, then it decreased brightness and viscosity and needed to be washed in a low concentration of sulfuric acid.

Table 8. Bleaching of Pulp with Alkali/Oxygen

Number	NaOH	pH		Kappa Number	GZV (ml/gr)	Brightness (% ISO)
		Initial pH	Final pH			
AM5	-	-	-	16.5	862	24.2
01	1.5	12.6	9.9	9.9	779	45.1
02	2.0	12.9	11.3	7.2	729	50.4
03	2.5	13.0	12.1	7.0	706	52.1
04	3.0	13.1	12.3	6.9	663	52.8

Remarks: - Unbleached of Pulp from AM5
 - Consistency: 15 %
 - Temp: 100 °C, and Time: 90 min
 - MgSO₄ = 0.3%
 - O₂ = 0.6 Bar

Table 9. Washing Treatment using Sulfuric Acid After Oxygen Bleaching (The Effect of Consistency)

Number	Consistencies (%)	PH		Kappa Number	GZV (ml/gr)	Brightness (% ISO)
		Initial pH	Final pH			
AM5	-	-	-	16.50	862	24.20
Oxygen	-	-	-	6.61	720	55.75
A1	3	2.52	3.2	3.83	685	55.92
A2	5	2.46	2.9	3.75	654	55.84
A3	7	2.40	3.1	3.63	635	55.74
A4	9	2.10	2.2	3.34	624	54.75
A5	11	1.90	2.0	3.22	617	53.69

Remarks: - Unbleached pulp from AM5
 - (0,50 N H₂SO₄ of Pulp OD)
 - Temp. : 95 °C, and Time: 90 min

Table 10. Washing Treatment Using Sulfuric Acid After Oxygen Bleaching on Normal Sulfuric Acid and pH

Code	H ₂ SO ₄ (N)	PH		Kappa Number	GZV (ml/gr)	Brightness (% ISO)
		Initial pH	Final pH			
AM5	-	-	-	16.50	862	24.20
Oxygen	-	-	-	11.93	1054	41.81
A6	0.2	4.3	7.3	11.33	978	43.97
A7	0.4	3.2	6.4	10.99	973	43.08
A8	0.5	3.0	4.1	10.55	970	41.54
A9	0.6	2.5	3.2	10.23	964	44.62
A10	0.7	2.3	3.0	9.75	953	44.82
A11	0.8	2.1	3.2	9.19	946	44.26

Remark: Unbleached Pulp from AM5; Consistency = 10 %; Temp = 95 °C, and Time = 90 minutes

b. Bleaching Combinations Using 6 Stages

Bleaching was conducted using a six stages combination. The numbers as shown in Table 9 are the bleaching results within optimum value. Tropical wood pulp after being bleached by oxygen, obtained hexauronic acid and other sugars, which were not able to completely remove in the chlordioxide stage. Based on references, acid and sugar could be solved in light hot sulfuric acid. The results indicated that *Acacia mangium* pulp needed to be washed in sulfuric acid after the oxygen bleaching stage. The sulfuric acid treatment was able to decrease the Kappa number of pulp effectively and it made the next bleaching stage easier, as well as achieving an extremely high increase in pulp brightness.

The next stage of pulp bleaching used the chlordioxide method. This method improved pulp brightness quality over unwashed pulp. Furthermore, the next stage of bleaching using oxygen/peroxide increased brightness. It was due to the relatively low lignin content that remained in the pulp. The second stage was bleaching using chlordioxide and it obtained an increase in brightness and a less reduction in the Kappa number.

The final stage was peroxide treatment; the paper obtained 89% – 90.9%ISO brightness, 0.9 – 1.4 Kappa number and 571 – 863 ml/g viscosities. The addition of 0.1% MgSO₄ and 0.05% DTMPA in the final stage extremely stabilized the peroxide, and caused very high peroxide consumption. The paper strength of *Acacia mangium* was in 20, 25, and 30 °SR beating degree interpolation as seen in Figure 1.

The unbleached paper had 3.9 – 9.89 km tensile strength, 162 - 556 kPa bursting strength, and 49 – 96 cN tearing strength. The bleaching process decreased the paper strength, due to changes in cellulose structure, as seen in the decrease of viscosities from the first to the last stage. Moreover, each stage has decreased the Kappa number and viscosity, increased paper brightness diversely, but as a whole, the final paper quality was of a good standard.

Table 11. The Combination of Pulp Bleaching using 6 Stages *Acacia mangium*

Bleaching	<i>Acacia mangium</i> (AM5)- Kraft				<i>Acacia mangium</i> (AM3)-Kraft				<i>Acacia mangium</i> (AM2) - ASAM			
	Kappa Number	Viscosities (ml/g)	Brightness %ISO	Yield (%)	Kappa Number	Viscosities (ml/g)	Brightness %ISO	Yield (%)	Kappa Number	Viscosities (ml/g)	Brightness % ISO	Yield (%)
Un	16.5	862	24.2	53.4	27.5	928	18.8	44.4	30.6	975	18.1	48.4
O	4.2	786	46.5	52.9	11.1	805	40.2	43.0	11.7	969	43.3	45.7
A	3.8	678	49.7	52.4	8.2	765	44.5	41.5	9.4	941	43.8	44.9
D ₁	1.4	658	68.0	51.7	5.1	787	57.8	41.0	5.7	930	54.5	44.7
OP	0.9	656	80.3	51.5	3.3	752	73.6	40.1	2.9	894	73.6	44.2
D ₂	0.6	645	87.5	51.3	2.1	749	84.9	40.0	1.1	804	86.8	44.1
P	0.5	571	89.9	50.3	1.4	701	90.9	39.9	0.9	863	89.0	44.0

Remarks:

Un = unbleached of Pulp *Acacia mangium* (Kraft and Asam method)

O = oxygen bleaching, 0.6 mPa, 2.5% NaOH for AM5, 3% NaOH for AM3 and AM2, 0.3% MgSO₄; 90 min, 15%consistency; 100°C.

A = Sulfuric Acid Washing 0,5 N H₂SO₄ Pulp, pH = 3.0, 120 min, consistency = 10%, 95°C.

D₁ = Chlordioxide bleaching = 0.5%, pH 1.6, 45 min, consistency = 10%, 60°C.

OP = Oxygen/Peroxide bleaching, 0.6 mPa O₂, 2% NaOH, 0.3% MgSO₄; 90 min; 12% consistency, 90°C.

D₂ = Chlordioxide bleaching = 0.4%, pH 4.2, 45 min, 10% consistency, 60°C

P = Peroxide bleaching, 1% H₂O₂, 1% NaOH, 0.1% MgSO₄, 0.05% DTMPA, 90 min, 12% consistency, 70 min

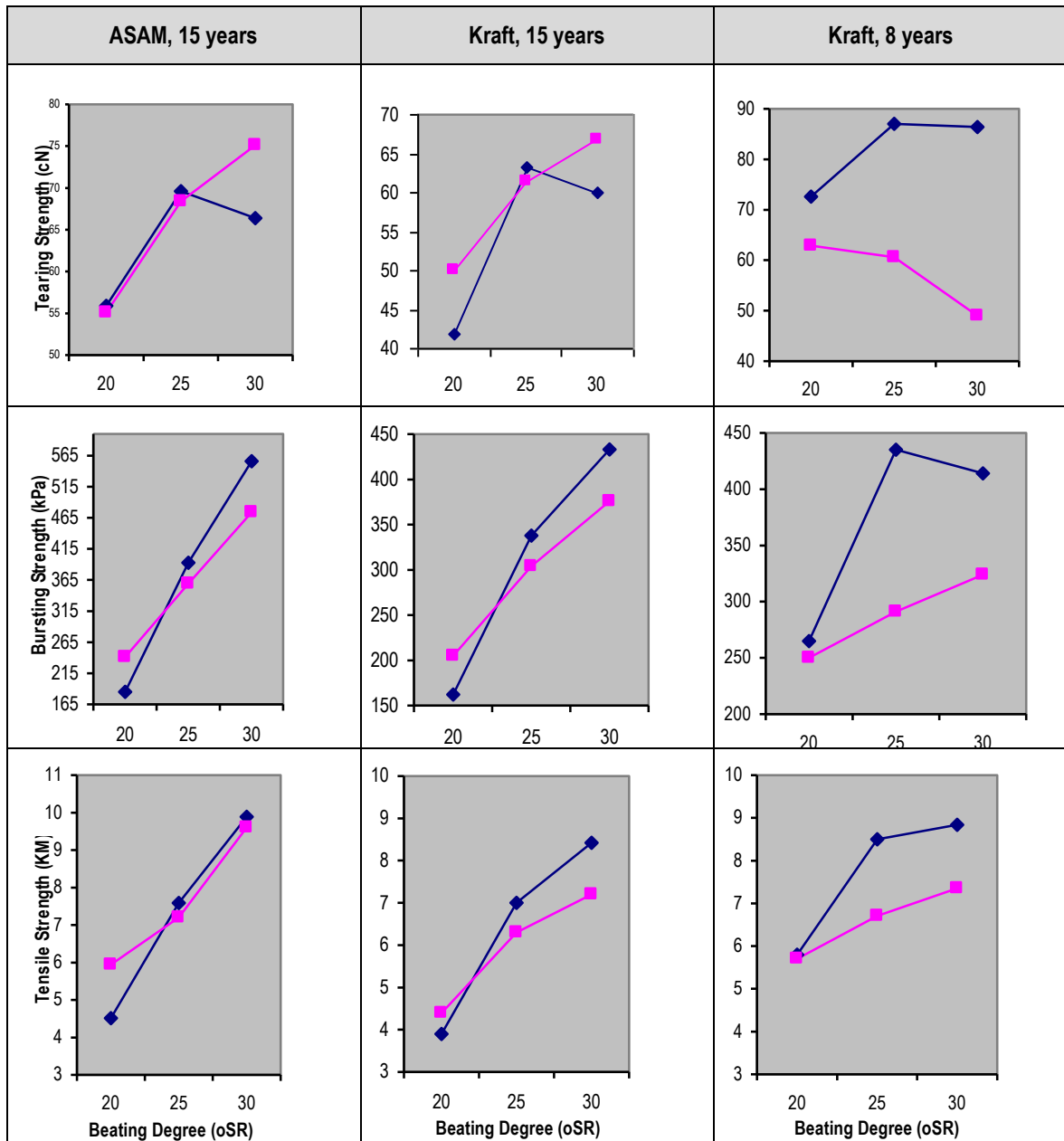


Figure 1. Relationship between Beating Degree and Strength of Bleached and Unbleached Paper

◆ Unbleached

■ Bleached

CONCLUSION

1. The best quality of Pulp and Paper from 6 - 9 years old *Acacia mangium* obtained more than 50% total Yield, below 20 Kappa Number, and above Quality Standard for mechanical properties of Paper.
2. The elementary chlorine free bleaching process using six stages combination had 90% ISO brightness.
3. Based on IAWA Standard, the quality of fiber was classified into II - III class.

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Temperature Distribution of Microwave Modified Wood

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ABSTRACT

Temperature distribution of timber after microwave modification is an important data to picture the microwave energy distribution. This paper is observes the temperature distribution of timber that was modified using applicator PC-1 and conventional applicator. Temperatures were measured on the wholes that have been prepared in four different distances from heating point and in four different depths. The result shows that the highest temperatures were recorded on the timber surfaces (88 – 98°C) after being modified by both PC-1 and conventional applicators. However, the temperature was higher in the inner part of the timber after modification using conventional applicators (60 – 68°C), while applicator PC-1 can only heat the inner part to about 32°C. The temperature distribution indicates microwave energy distribution after modification. After microwaving using PC-1 applicator, high temperature on the surfaces and lower temperature in the inner part shows that the applicator has succesfully heated the timber surfaces only, without neccesarily heating the inner part as the conventional did.

Keywords: Temperature, microwave energy, surface, PC-1, conventional

Cement Bonded Particleboard from Natural and Plantation of Red Meranti

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ABSTRACT

Cement bonded particleboard is a composite made from wood particles and bonded with portland cement. This product is water and fire resistant, termite resistant; and can be used for some purposes. Cement bonded particleboard was developed from natural and plantation of red meranti (*Shorea* spp.) obtained from PT Sari Bumi Kusuma, Pontianak. The purpose of this study was to compare the board properties made from natural and plantation woods. Log was processed into particles using ring flaker. Wood particles used were varied from 30, 40, and 50 % of cement weight. Water used was 60% of cement weight. Magnesium chloride (MgCl₂) was added at 2.5% of cement weight. Wood particles were sprayed with 40% of water used and kept for 24 hours. The particles then mixed with cement using mortar mixer and added with 60% of water left and MgCl₂. The mixture were matt formed and cold pressed for 24 hours. The size of board was 25cm x 25 cm x 1.2 cm with target density of 1.2 g/cm³. The boards were kept for 28 days before tested. Physical and mechanical tests were conducted in accordance with JIS A 5417. The properties tested were bending strength, screw withdrawal, thickness swelling, water absorption, moisture content, and density. Results showed that all boards properties met the JIS standard. Boards made from natural meranti have higher properties compared to those boards made from plantation meranti.

Keywords: Cement bonded particleboard, red meranti, natural, plantation

Resistance of Three Smoked Wood Species to Subterranean and Dry Wood Termites Attack

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ABSTRACT

Samples from sengon (*Paraserianthes falcataria*), pulai (*Alstonia* sp), and mindi (*Melia azedarach*) woods were smoked for 1- to 3-weeks using mangium wood (*Acacia mangium*), and untreated wood was also prepared. All of the wood specimens were exposed to subterranean termite (*Coptotermes curvignathus* Holmgren) and dry wood termite (*Cryptotermes cynocephalus* Light) under laboratory conditions regarding to Indonesian standard SNI 01.7207-2006 . The results showed that (1) the untreated sengon and pulai woods had resistance class V or very poor resistant and mindi wood had resistance class III or moderate resistance to subterranean termite attack. On the other hand, pulai had resistance class IV or poor resistant to dry wood termite, while sengon and mindi had resistance class III or moderate resistant based on the Indonesian standard (SNI, 2006); (2) Smoking treatment of the samples for 1 to 3 weeks resulted in resistance class I or very high resistant to subterranean and dry wood termites attack, it can be suggested therefore, that smoke treatment for one week was enough resulting in very resistant woods to both termites attack.

Keywords: Smoked wood, subterranean termite, dry wood termite, weight loss, resistance class.

Regeneration Strategy of Some Primary, Secondary, and Pioneer Tree Species in Burned Over Tropical Rain Forest Area at East Kalimantan

P. O. Ngakan, E. Suzuki, H. Simbolon, N. Watanabe, and Tamrin

ABSTRACT

Many studies have reported that revegetation process of heavily burned forest areas would be initiated by pioneer species. At Bukit Bengkirai East Kalimantan, however, some primary species were found to compete with pioneer ones in colonizing the heavily burned forest area. In order to reveal the regeneration strategy of such primary species, vegetation surveys were conducted in 2-ha burned forest and 1-ha unburned forests at Bukit Bengkirai from 2005 to 2007. In addition, sprouting experiments were also conducted in order to clarify the sprouting ability of both the secondary and primary species. Unburned forest plot was dominated by primary species (*Shorea laevis*), whilst burned forest plot was dominated by pioneer species (*Macaranga gigantea*), but some primary species (i.e. *Cotylelobium melanoxyton*) and secondary species (i.e. *Schima wallichii*) were frequently found. Data analyzed from the vegetation survey supported the conclusion that revegetation process of the severely burned forest area was initiated by the seedling of pioneer species that germinate from buried seed. *Cotylelobium melanoxyton* was a primary species capable of producing abundant vegetative sprouts from its remained-survive long taproot. The sprouts coexisted with pioneer species to initiate the revegetation process. The secondary species, *Schima wallichii*, invade the area later through the seedlings that germinate from seeds produced by the survived mother trees. Many mother trees of *Schima wallichii* survived the fire due to the thick fresh-bark they have. The colonization of *D. confertus* and *S. laevis* in the plot was caused by seed dispersal from outside the plot.

Keywords: Primary, secondary, pioneer, burned forest and unburned forest

FULL PAPERS

The Effect of Site Class, Tree –Age and Axial Direction on Adhesion Properties of Teakwood

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ABSTRACT

Teakwood is a well-known prime wood species in Indonesia. The teak forest had been managed well by PERHUTANI, a state forest company for a long time. In the teak forest the site quality has been classified according to land's capability to grow the teak plant. This site classification had been set up from the beginning of forest management and it has not been reviewed yet. This research's objectives are to know the effect of teak forest site quality class and axial direction on the adhesion properties of the teak wood. The research is conducted using Completely Randomized Design arranged in factorial experiment. The first experiment used site quality and axial direction factors, while the second experiment used tree's age and axial direction. The site quality factor consisted of three levels of site index III, III/IV and IV. The three levels of axial direction of the teak stem were butt, center and top. The tree's age consisted of three age class of 25, 35 and 45 years. Three teak trees are employed as replication. The adhesion properties parameter were wood specific gravity, adhesion compression shear test and wood failure in both dry and wet condition using block test. The first research result showed that no interaction factor affected the adhesion properties. The teak growing site-class influenced significantly the wood specific gravity and adhesion shear strength. The more fertile of teak growing site class, the lower wood specific gravity and adhesion strength. The site class of III, III/IV and IV revealed the average wood specific gravity of 0.54; 0.50 and 0.47 consecutively. The adhesion strength produced from the three site classes were 41.71; 32.56 and 23.52 kg/cm² consecutively. The axial direction (from the butt to the top) showed a decreasing trend of wood specific gravity and adhesion strength. The second research showed that tree age affected significantly the wood specific gravity. The wood specific gravity increased from 0.57 to 0.67 and 0.69 produced from tree age of 25, 35 and 45 year old consecutively.

Keywords: teak wood, site class, age, axial direction, adhesion strength

INTRODUCTION

Teak wood is considered a prime wood globally. It is also a prime wood in Indonesia and is used by highly ranked in social status among the Indonesian people. When someone has a house made of teak wood, this means the man is considered as rich and famous. This condition is caused by the very high price of teak wood. For that reason all Indonesian people are trying to build a house using teak wood.

Teak wood in Indonesia had been produced for quite a long time from natural teak forest found in Java since the Dutch occupation. The Dutch Company has employed a relatively good teak forest management. They had set up a normal teak wood standing volume per unit area of teak plantation. This table; that is called WvW table has been used up till now and it has not experienced a significant change. During the Political Reformation in 1998, the teak plantation had been suffering significant damages in such a way that a normal condition of the teak forest has altered (Anonymous, 1998). In this condition the teak forest has been receiving significant change in terms of the total number of teak trees per unit area and basal area of teak trees as well. This condition has been detected to affect the site quality whereon the teak trees had been planted (Aji, 2008).

In terms of teak silviculture, teak follows many stages of forest plantation namely, seedling in nursery, field planting in a close spacing, thinning, pruning and harvesting. After field planting, the teak forests are classified into tree age class of ten years. Teak seedlings are planted in a small compartment based on homogenous site quality index (SQI). *Marsono and Soeseno(1992) states the principles of silviculture in forest plantation in order to come to the big volume of wood at the end of rotation.*

Based on the above discussion, a research has been planned. The research used the site quality whereon the teak trees had been planted, that is called site quality index (SQI). The second factor used in the research was chosen from the tree ages.

MATERIALS AND METHODS

Materials

The teak trees were obtained from Kalibodri, Kendal Teak Management Unit of PERHUTANI. The teak trees were classified into three trees ages class namely 25 year old, 35 year old and 45 year old. Each tree age class was procured from three site quality index namely SQI III, SQI III/IV and SQI IV. Total of 9 trees were collected from the Kendal Teak Management Unit. The teak trees were sawn into radial sawn in Semarang and make samples for adhesion block test.

Research Design and Procedure

The research was conducted in two separate sub research or sub-experiment. The first sub-research used two factors namely site quality index (SQI) and axial position along the teak stem. The second sub-research used two factors namely tree age class and axial position along the teak stem. Those two sub-researches were designed using Completely Randomized Design with factorial experiment. Three replications were employed in each sub-research. Analysis of Variance was used to know the effect of interaction factors and individual factor on the adhesion properties. The separation of means used HSD-Tukey procedure based on the probability of factors involved in the research.

In the first sub-experiment, the teak stem from each site quality index (SQI III, SQI III/IV and SQI IV) was divided into three axial position namely butt, middle and top portion. From the axial position logs were then sawn into radial sawn type samples. Six wood radial type samples with dimension 2cm x 2cm x 30" were obtained from each axial position. They were glued by epoxy adhesive with 40#/MDGL in composing to three adhesion block test measuring 2cm x 2cm x 30cm (Prayitno 1994). The block tests were conditioned for a week before subjected to adhesion test sample cutting measuring 2cmx2cmx2cm. The adhesion test were the tested by compression stress according to British Standard 373 (Anonymous, 1957). Adhesion testing was conducted in dry condition and wet condition. Two adhesion parameters were adhesion strength and percentage of wood failure. Wood specific gravity of each adhesion samples were measured as well.

In the second sub-experiment, three teak trees age-classes was chosen, namely class of 25, 35 and 45 year-old. Teak logs obtained were then cut into three axial positions namely butt, middle and top portion. Each log was then sawn to obtain radial lumber. From these lumber, samples were prepared following the British Standard as stated in first sub-experiment procedure.

RESULTS AND DISCUSSION

The ANOVA of data obtained from first experiment showed that interaction factors of SQI and axial position did not affect the adhesion strength of teak wood. The single factor of axial position did not exert a significant effect on the adhesion strength as well. Site Quality Index (SQI), however, revealed the significant effect on the wet adhesion strength and high significant effect on wood specific gravity (Table 1). This means that SQI whereon teak tree grow has really affected its wood specific gravity (Figure 1) and dry and wet adhesion strength (Figure 2). The dry adhesion strength was affected by SQI at 90%, therefore it is not significant at 95% level. Site quality index (SQI) is a measure of fertility of the soil whereon the teak trees grow. More fertile the soil means more soil nutrient for teak to grow fast and healthy (Bermejo *et al.*, 2004). In this case teak trees has been supplied by enough chemical elements and water for making buds, growing hormones and faster cells division and enlargement. This condition has promoted the higher number of cells produced but having thinner cell wall. This condition consequently producing large diameter of teak trees but smaller wood specific gravity (Brown *et al.*, 1952; Kollmann *et al.*, 1975).

Site quality whereon plant grows really affects the wood properties (Dreschel *et al.*, 1990). Soil fertility reveals enough nutrient available for plant to grow such as Mg, K, Ca and other ion uptake by the plants. *Abod and Siddiqui (2002) measured the teak growth upon application of Nitrogen, phosphorous and potassium fertilizers.* For that reason the soil fertility represented by SQI in PERHUTANI has been proven to be the important factors that affect the growth of teak plantation (Kollert and Cherubini. 2010). Figure 1 showed that from SQI III, SQI III/IV to SQI IV (meaning from low fertile soil to more fertile soil), the

wood specific gravity has decreased from 0.54, 0.50 to 0.47. In addition Site quality reveals the faster growth of teak in Kerala for developing intrinsic growth to set a correction of growth model (Rugmini and Jayaraman, 2009). This constant decreasing trend of wood specific gravity has been observed in three axial position namely butt, middle and top portion of teak samples. Haygreen and Bowyer (1996) states that wood properties from butt to top portion of the stem have been observed following the same pattern.

Table 1. ANOVA of effect of site quality (SQI) and axial position on adhesion strength, wood failure and wood specific gravity

Research Variables	SQI	Axial Position	Interaction
Wood Specific Gravity	14,857**	1,852 ^{ns}	1,291 ^{ns}
Dry Shear Strength	2,630 ^{ns}	0,088 ^{ns}	0,676 ^{ns}
Wet Shear Strength	3,678*	0,437 ^{ns}	0,980 ^{ns}
Dry Percentage Wood Failure	3,192 ^{ns}	0,051 ^{ns}	0,802 ^{ns}
Wet Percentage Wood Failure	0,211 ^{ns}	0,836 ^{ns}	0,442 ^{ns}

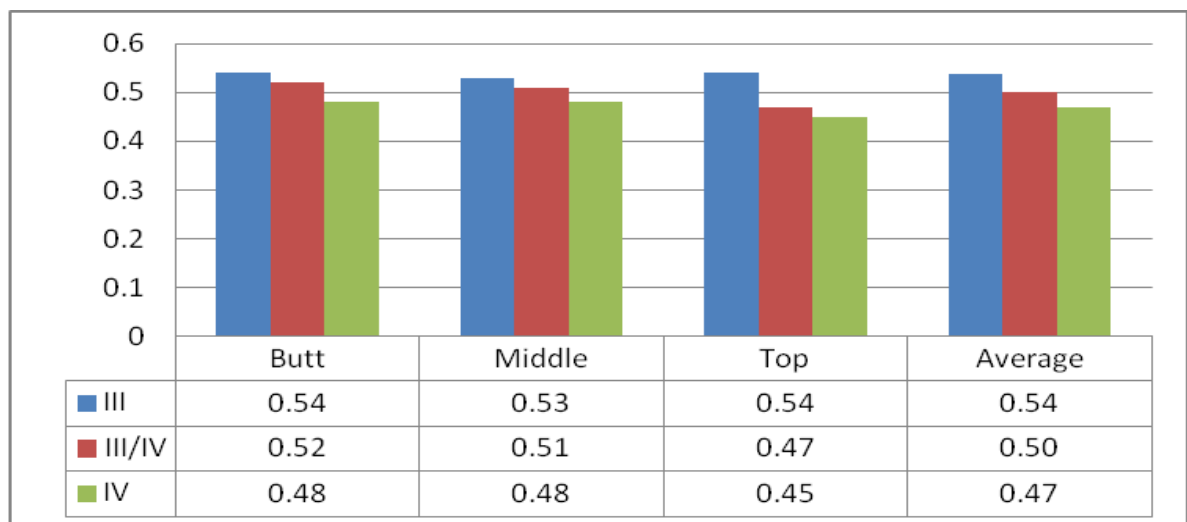


Figure 1. Wood specific gravity of teakwood affected by SQI

In terms of adhesion strength, the result of the first sub-experiment showed that wet adhesion strength was significantly affected by SQI. This could be true, since the adhesion strength has been observed to have a very close relationship with wood specific gravity. Prayitno (1997) states that wood specific gravity has parallel relationship with adhesion strength. Based on Freeman data of adhesion strength of American wood(1959), higher specific gravity up to 0.8 higher adhesion strength. Wood specific gravity above 0.8 did not significantly affect the adhesion strength (Prayitno, 1983). Dry adhesion strength is also affected by SQI at 90%level. Numerically, SQI has a decreasing effect on adhesion strength both at dry and wet condition (Figure 2). On the other hand, the factor of axial position did not exert a significant effect on adhesion strength (Table 1). Numerically, there is an actual decreasing trend of adhesion strength of samples obtained from butt, middle and top portion. Average of dry adhesion strength from butt, middle and top portion of teak stem are 48.86; 47.06 and 43.66 kg/cm² respectively. Wet adhesion strength from butt, middle and top portion of teak stem are 35.52; 32.99 and 29.29 kg/cm² respectively. Those adhesion strength data show a decreasing trend effect of axial position. This trend is parallel to the effect of axial position on wood specific gravity (Farida, 2005).

The second sub-experiment used two factors namely tree age class and axial position of the teak stem. The result of the research showed that interaction factors did not affect the adhesion strength. The single factor of the research, namely axial position has revealed a significant effect on wet adhesion strength and wet wood failure percentage at 95% level (Table 2). The axial position factor and tree age

class exerted high significant effect on wood specific gravity (99%). The single factor of tree age class only affected dry adhesion strength at 93%, but wet adhesion strength.

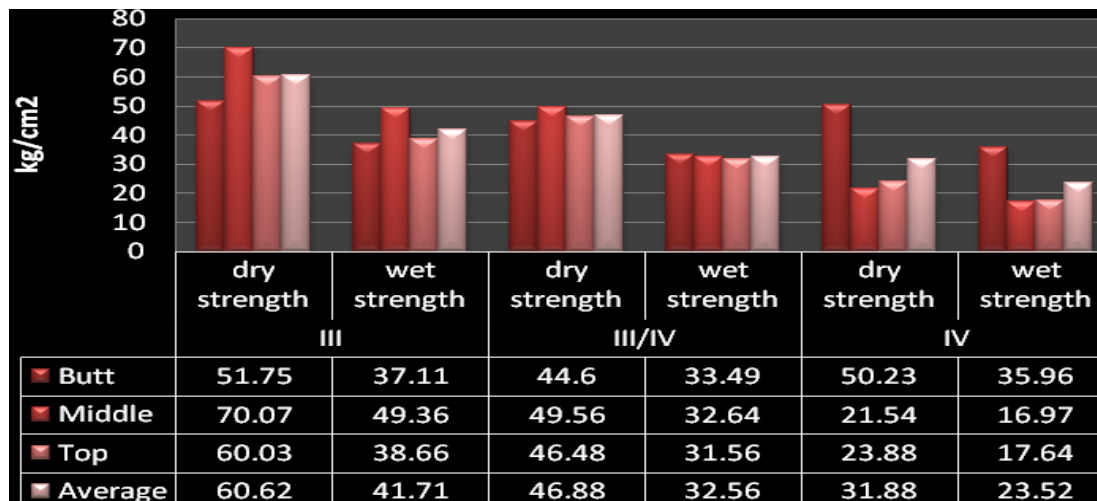


Figure 2. Variation of dry and wet adhesion strength of teak wood affected by SQI and axial position

Wood specific gravity of teak samples shows an increasing trend according to tree age class and axial position. Tree age class from 25 year-old, 35 year-old and 45 year-old produce wood specific gravity of 0.57; 0.67 and 0.69. Analogy, the tree axial position has parallel relationship with wood specific gravity as well. Average wood specific gravity of 0.69; 0.64 and 0.62 are shown by butt, middle and top position of the stem respectively (Figure 3). Tsoumis (1991) states that butt portion has a relatively bigger portion of heartwood, bigger percentage of mature wood thus produces high wood specific gravity consequently. Older tree reveals bigger diameter at breast height at the same site condition and upon observing its cross section resulting lower percentage of sapwood (Panshin and de Zeeuw, 1980). Farida (2005) has shown the same trend on wood specific gravity in *Acacia auriculiformis* affected by tree ages and axial position.

Table 2. ANOVA of effect of Tree age class and axial position on adhesion strength, wood failure and wood specific gravity

Variables Research	Tree Age	Axial Position	Interaction
Wood Specific Gravity	0,000**	0,004**	0,766 ^{ns}
Dry Adhesion Strength	0,087 ^{ns}	0,788 ^{ns}	0,995 ^{ns}
Wet Adhesion Strength	0,883 ^{ns}	0,042*	0,292 ^{ns}
Dry Percentage Wood Failure	0,143 ^{ns}	0,704 ^{ns}	0,758 ^{ns}
Wet Percentage Wood Failure	0,479 ^{ns}	0,040*	0,193 ^{ns}

In terms of wood adhesion properties, factor tree age class did not show a significant effect on dry and wet adhesion strength and wood failure in dry and wet condition as well (Figure 4 and 5). This results is very confusing. Numerically, dry adhesion strength, wet adhesion strength, wood failure at dry and wet condition show no specific pattern of data variation. Steel and Torrie (1981) states that a significant effect can be produced by high precision data. On the other hand a relatively scattered, random data will result low level of significant probability. Normally, variation of wood specific gravity will be followed by the adhesion properties. This means that high wood specific gravity will produce high adhesion strength. Low wood specific gravity will result in low adhesion strength respectively, as long as the range of wood specific gravity is still under 0.8 (Prayitno, 1996, 1997). The wood variation according to tree age class factor shows a significant increase from 25 year-old to 35 year-old, but little increase shown by 35 year old to 45 year old. This might be responsible for the higher variation of adhesion strength.

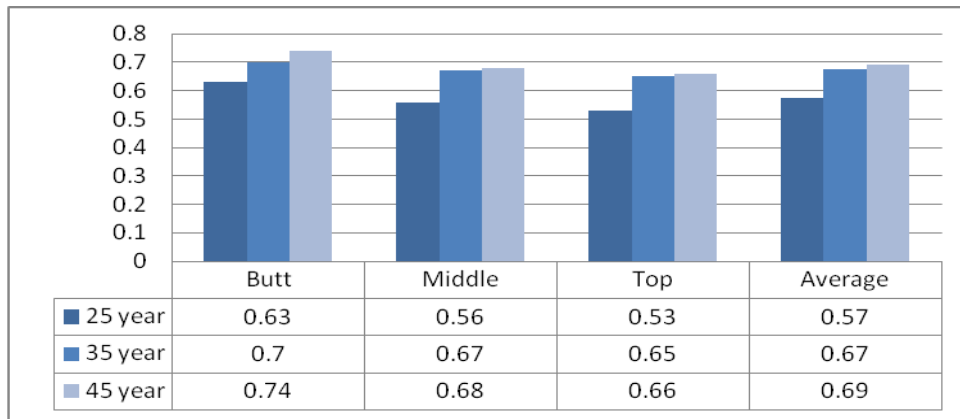


Figure 3. Wood specific gravity of teakwood affected by tree age class and axial position factors

The axial position factor shows a fixed decreasing trend of adhesion strength. The butt portion produces high adhesion strength than the middle and top portion. Vick (1999) states that butt portion of the stem produces high value wood specific gravity. This will produce high adhesion strength consequently. Upper portion of the stem usually shows a decrease of wood specific gravity, thus produces lower value of adhesion strength (Tsoumis, 1991).

The percentage of wood failure appears to follow the unidentified pattern of adhesion strength due to tree ages classes. On the other hand axial position factor has revealed specific decrease pattern of wood failure percentage. From butt to top portion of the teak stem, it shows a decreasing value of percentage of wood failure. Upon observation on the adhesion line, it shows difficulties to separate the epoxy glue from the wood fibers. This might increase the variation of wood failure (Putra *et al.*, 2007).

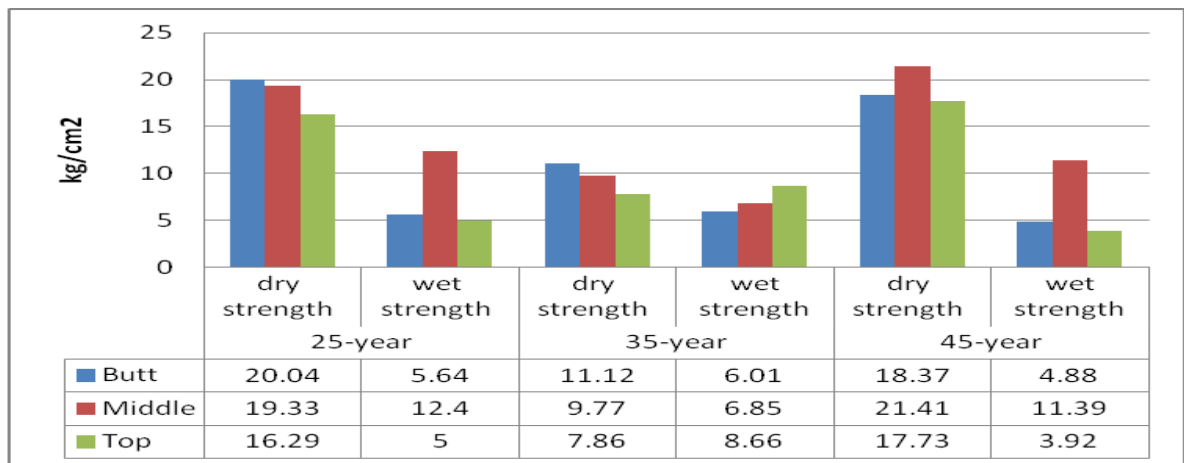


Figure 4. Adhesion strength of teakwood affected by tree age class and axial position factors

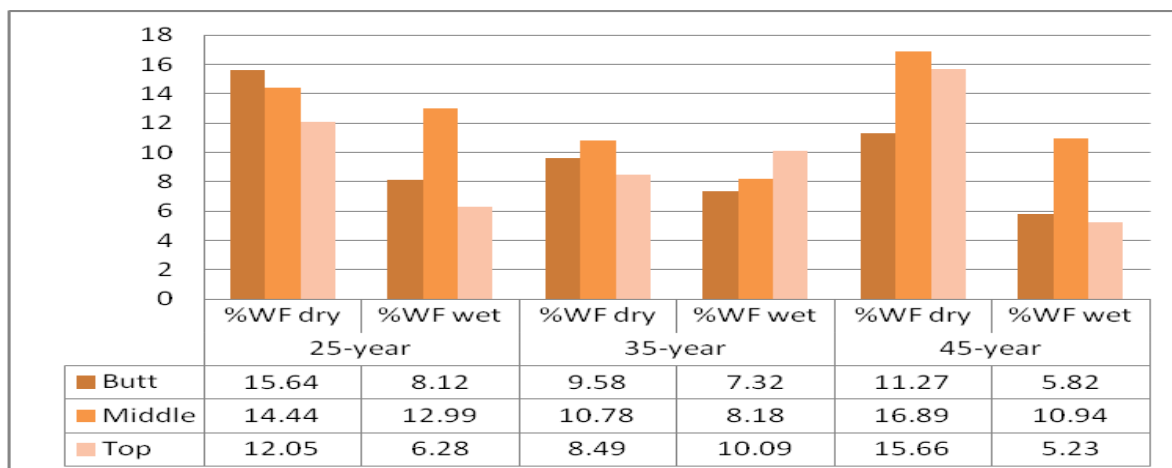


Figure 5. Percentage wood failure of teakwood affected by tree age class and axial position factors

CONCLUSION

The research on the effect of site quality index, tree age class and axial position has come to several conclusions as follows:

1. The research result showed that no interaction factor affected in adhesion properties and wood specific gravity. In the first experiment no interaction factors effect is observed in SQI and axial position and tree age class and axial position as well (second sub-experiment).
2. The teak growing site index (SQI) influenced significantly to the wood specific gravity and adhesion shear strength. The more fertile of teak growing site class (SQI), the lower wood specific gravity and adhesion strength. The site class of III, III/IV and IV revealed the average wood specific gravity of 0.54; 0.50 and 0.47 consecutively. The adhesion strength produced from the three site classes were 41.71; 32.56 and 23.52 kg/cm² consecutively.
3. The tree age class and axial position factors affected significantly the wood specific gravity. The wood specific gravity increased from 0.57 to 0.67 and 0.69 produced from tree age of 25, 35 and 45 year old consecutively.
4. The axial direction (from the butt to the top) showed a decreasing trend of wood specific gravity in both sub experiments. This factor did not show a homogenous effect on adhesion strength in both sub-experiments.

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Nondestructive testing of Near Infrared (NIR) Spectroscopy to Predict Physical Properties of *Acacia mangium*

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ABSTRACT

Near Infrared (NIR) spectroscopy have been used to predict of several properties of wood. This is one of nondestructive testing (NDT) method provides fast and reliable wood characterization analysis which can be applied in various manufacture industry, included forest sector, in control and process monitoring task. Moisture content and wood density is important properties related to strength properties. The aim of this study was to evaluate NIR technique in obtaining calibration models for determining moisture content and wood density of *Acacia mangium* in age 5, 6, 7 year. Solid and ground wood samples were used in measuring of NIR spectra. The laboratory values was correlated with the NIR spectra using multivariate analysis statistics of Partial Least Square (PLS). The best prediction result were determined by calibration validation model of those relationship evaluated by the coefficient of determination (R^2), root means square error of calibration (RMSEC) and prediction (RMSEP) values. A better accuracy was obtained by calibration model of ground wood compared with solid wood samples. In age of 7 year, the model were good using solid samples compared with ground wood samples, in contrast for the younger age in estimating of moisture content and wood density properties.

Keywords: near infrared (NIR), wood density, *Acacia mangium*, nondestructive testing (NDT), Partial Least Square (PLS)

INTRODUCTION

Near Infrared (NIR) is one of emerging technology which is already being utilized to evaluate the properties of wood and wood products. There are some advantages of NIR spectroscopy technology including more rapid analysis and the ability to operate in a number in-field or on-line/at-line environments. Some material properties analysis need destructive analyses, use specific equipments analysis, and require long time testing. NIR spectroscopy technique of non destructive testing is used as alternative method to assess material properties through fast and reliable analysis. NIR spectroscopy use electromagnetic spectrum region extend from wave length 780 nm to 2500 nm. In this region spectra may be characterized by band assignments of chemical components vibration as response of the absorption bands in NIR region. In wood, overtone and combination bands (stretching and deformation) of fundamental vibrations due to large force constants and low masses involve through C-H, O-H, and N-H bonds (So et al. 2004, Schwanniger et al. 2011). NIR spectroscopy has been widely applied in agricultural products such as cereal, beverages, dairy products, textiles, and pharmaceutical application (Burns and Ciurzak 2008). In forest products industry, NIR spectroscopy has been used at processing stage to control the product quality. It is as a rapid assessment tool to predict wood quality of chemical properties of wood, pulp and paper properties, density, moisture content, grain angle and surface roughness, anatomical properties, and mechanical properties (Schimleck et al. 2001a,b, So et al. 2004, Tsuchikawa 2007).

In analyzing of NIR spectroscopy to predict wood properties involve chemometric approach through multivariate data analysis. Partial Least Squares Projection to Latent Structured (PLS) and Principal Component Analysis (PCA) are two multivariate characterization data analysis which are commonly used (Antii 1999, Burns and Ciurzak 2008). In Indonesia, research of NIR spectroscopy to predict wood and

wood products is still limited. The aim of this study was to predict density and moisture content of *Acacia mangium* using NIR spectroscopy technology.

MATERIALS AND METHODS

The study used samples of *Acacia mangium* aged 5, 6, and 7 years old collected from plantation forest of Perum Pehutani at RPH Maribaya, BKPH Parung Panjang, West Java. Four trees were felled from each sample age. The samples were then cut into plank sortimen. The samples were processed using band saw for thickness, width, and length (3 x 10 x 25).

The NIR spectra were taken in solid and ground wood samples using NIRFlex N-500 fiber optic from Buchi® (Switzerland products) (Figure 1). Solid wood samples were tested by mounted a sensor into smooth and clean surface. The measurements were conducted using a contact, diffuse reflectance, fiber optic sensor on three sample surface. The ground samples were milled using a standard Wiley® mill which those retained in a 40-mesh sieve. Samples were held in a sample holder. All measurements were conducted using a noncontact, diffuse reflectance, fiber optic sensor. The spectra were collected at 0.4 nm interval over the wave length 1000-2500 nm. Three scans reading were collected for each sample. NIR diffuse reflectance spectra (R) were obtained from NIR scanning. The absorbance spectra were calculated as $\log(1/R)$.

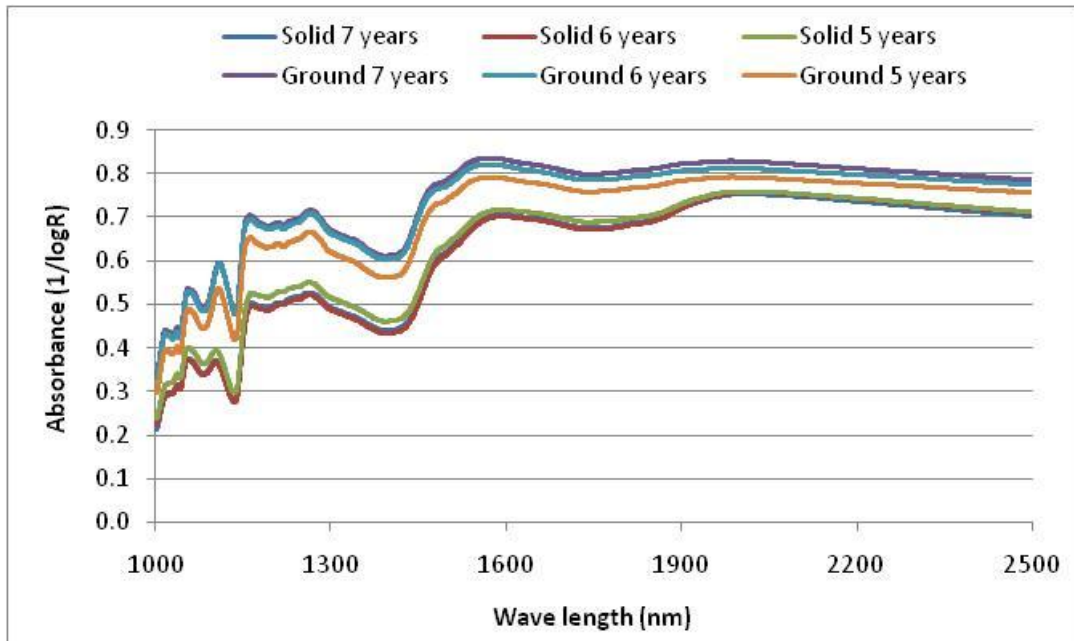


Gambar 1. NIR spectroscopy testing using NIRFlex N-500 fiber optic; solid wood sample, (b). ground wood sample

Chemometric analysis with multivariate analysis (MVA) was conducted using the Unscrambler®X10.2 trial version, CAMO software. A multivariate statistical tool was used to group the data and to develop prediction models (Antii 1999). Partial least squares (PLS) is a regression method that is used to near infrared spectra with referenced response variables of density and moisture content. The spectral data from each tests were handled as untreated data (raw), first derivatives and second derivatives. For the 1st and 2nd derivatives, the data were differentiated using Savitsky-Golay (S-G) algorithm method (20-point filter and a second order polynomial). The cross validation were used to identify following calibration parameters: the best pre-treatments, the number of latent variables, outlier samples. The accuracy and stability of models were evaluated by coefficient of determination (R^2) and root mean square error (RMSE), respectively. Four criteria for model selection as following: 1) higher correlation coefficient of cross validation, 2) higher ratio of deviation performance (RDP), 3) lower number of latent variables used in calibration, and 4) standard error of cross validation (Hein 2010). The root mean square error of cross validation (RMSECV) (determined from the residuals of each cross validation phases), the root mean square error of calibration (RMSEC) (determined from residuals of the final calibration) were used to assess calibration performance. The root mean square error of prediction (RMSEP) as external validation was used to give a measure of how well a calibration predicts the parameter of interest for a set of unknown samples that are different from the calibration set. RPD are the predictive ability of calibration was assessed by calculating ratio standard deviation of the reference value to the RMSEC or RMSEP. An RPD greater than 2.5 is considered satisfactory for screening (Jones et al. 2005).

RESULTS AND DISCUSSION

Near infrared spectra were collected for at least fifty samples with three scan readings over the range of 1000 to 2500 nm. The raw spectra for each of the individual sample age were averaged and are shown in Figure 2 for both solid and ground wood samples.



Gambar 2. Average value of raw absorbance NIR spectra from solid and ground wood samples of *A. mangium* (Source: Karlinasari et al. 2012)

There are some obvious visual differences between the absorbance spectra of solid and ground wood samples from one species, as it is noticeably shifted in upward for ground wood samples; however, little difference of absorbance values were quantitatively found between the individual spectra from each age. Surface roughness and fiber orientation response to radiation direction seemed influencing NIR absorbance spectra.

The descriptive statistic for the laboratory testing of density and moisture content of the samples are given in Table 1. The average value of moisture content were of 21.51%, 15.46%, and 18.93% for 7 year, 6 year, and 5 year samples, respectively. The wood density presented the highest value of 0.60 g/cm³ obtained by 7 year wood samples. The lower value resulted by 6 and 5 year wood samples with the same average values of 0.54 g/cm³.

Table 1. Results of moisture content and density of *Acacia mangium* wood

Age		Moisture content (%)	Density (g/cm ³)
7 year	Average	21.51 (8.89)	0.60 (0.06)
	n	50	50
6 year	rata-rata	15.46 (3.78)	0.54 (0.06)
	n	64	64
5 year	rata-rata	18.93 (2.28)	0.54 (0.11)
	n	76	76

n: number of samples, number in parentheses denotes standard deviation

Raw absorbance spectra data were analyzed as well as differentiated data to determine the smoothed value for each point. A valuable spectral pre-treatment method is the use of 1st or 2nd derivatives. Table 2. provide a summary of the partial least squares (PLS) analysis from the solid and ground wood samples.

Table 2. Summary of NIR calibration for each age of *Acacia mangium* in solid (SW) and ground wood (GW) sample

Age	Wood property	Sample type	Treatment	LV	Calibration sample set			Validation sample set			RPD
					n	R ² _{cal}	RMSEC	n	R ² _{val}	RMSEP	
5 year	Moisture content	GW	2d	7	140	85.4	0.944	10	52.9	1.707	5.21
		SW	1d	8	216	63.2	1.376	12	54	1.545	0.17
	Density	GW	1d	5	140	61.04	0.063	10	37.2	0.08	0.75
		SW	1d	10	216	42.1	0.082	12	13.9	0.099	1.65
6 year	Moisture content	GW	1d	7	140	87.6	1.240	10	73.1	1.839	2.06
		SW	0d	13	176	75.8	1.845	16	59.1	2.406	0.64
	Density	GW	0d	12	140	80.3	0.026	10	70.1	0.032	1.88
		SW	0d	13	176	48.7	0.039	16	4.79	0.054	0.90
7 year	Moisture content	GW	0d	12	126	73.4	4.533	9	57.4	5.767	0.39
		SW	2d	13	126	86.98	3.179	9	48.1	6.397	2.82
	Density	GW	0d	14	126	77.6	0.029	9	58.5	0.041	2.68
		SW	1d	15	126	85.6	0.024	9	51.3	0.044	0.40

GW: ground wood samples, SW: solid wood sample, n: number of sample, LV: latent variables, R²_{cal}: coefficient of determination calibration sample, R²_{val}: coefficient of determination validation sample, RMSEC: root mean square error calibration, RMSEP: root mean square error prediction, 0d: raw data, 1d: first derivatives, 2d: second derivatives, RPD: ratio of performance to deviation

Results in Table 2 indicate that there were variation of statistical variables between the use of original spectra and spectra after mathematical treatment. Second derivatives were used to determine moisture content in solid samples and ground samples for age of 5 and 7 year, respectively. In age of 5 and 6 year, moisture content and wood density presented strong calibration coefficient (R²_{cal}) in ground wood samples, while in age of 7 year the solid wood samples were the strong calibration as shown in Figure 2. This information allows knowing the use of ground wood samples to determine those properties in young age and solid wood samples for the older age tree.

According to Table 2 the PLS model provided R²_{cal} in range 0.42 to 0.876. For moisture content, the best model presented in ground wood samples for age of 5 year (R²_{cal} = 0.856 and RPD = 5.21) and 6 year (R²_{cal} = 0.876 and RPD 2.06), while for age of 7 year the best model was obtained by solid wood sample with R²_{cal} = 0.869 and RPD = 2.82. In the density properties of wood the best calibration model for age 5, 6, 7 year presented in ground wood with the values of R²_{cal} = 0.610, R²_{cal} = 0.803, R²_{cal} = 0.776, respectively, and RPD = 0.75, RPD = 1.88, RPD = 2.68, respectively. Previous study on basic density of temperate region species, *Picea abies* and *Eucalyptus*, by Thygesen (1994), Schimleck et al. (1999), Hein et al. (2009), Hein (2010) revealed that R²_{cal} values ranging from 0.384 to 0.87 using 5 to 11 latent variables. The latent variables of this study were in range 5 to 15 which LV of solid wood was higher than ground wood samples. This relates with ability of wave radiation to cover sample surface in ground wood samples.

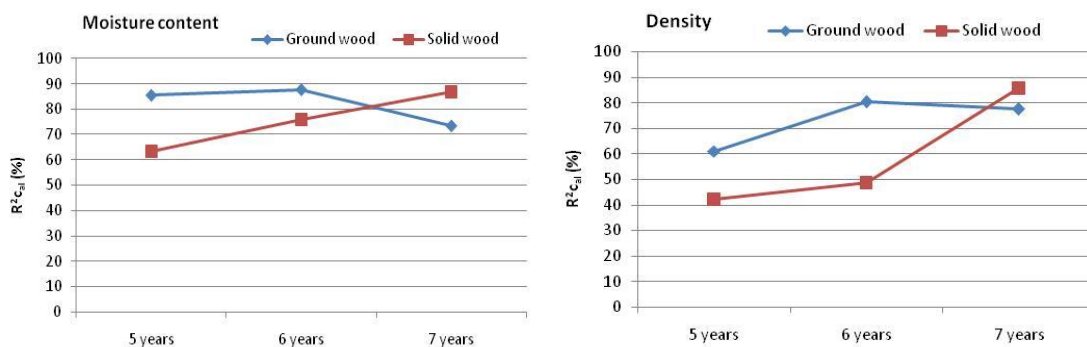


Figure 2. The value of coefficient determination calibration sample in solid and ground wood sample for moisture content and density properties

Using prediction set data determined by software, the coefficient determination of prediction (R^2_{val}) was noticeably lower than corresponding R^2_{cal} as well variables of RMSEP compared with RMSECV. R^2_{val} ranged from 0.481 to 0.731 for moisture content and 0.0479 to 0.701 for density woods. The large difference of statistical variable between calibration and prediction may be a consequence of the small number of prediction set data. Ideally the number of external validation or prediction set data was 1/3 from calibration set data.

RMSE indicated the stability of calibration or validation model. RMSEC values were lower than RMSEP values of predictive models from both moisture content and wood density properties. This indicated that better predictive stability of validation models for those wood properties. These are in line with study on prediction model of pulp yield of *Acacia mangium* (Zhang 2011), prediction of air-dry density of *Pinus taeda* (Schimleck et al. 2005), and estimation of wood stiffness of *E. delegatensis*, *P. radiata* (Schimleck et al. 2002).

CONCLUSIONS

1. NIR spectroscopy can be useful to predict moisture content and density of *Acacia mangium*'s wood
2. Estimates of moisture content and density wood were in better using ground wood samples in age 5 and 6 year, while in age of 7 year the good predicting of those properties was obtained by solid wood samples

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Creating Awareness on Harnessing the Potentials of Wood as a Sustainable Construction Material in Nigeria

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ABSTRACT

Emphasis on how to strategize the adaptation of developmental policies into the mainstream of Vision 2020:20 as proposed by the Nigerian Government, with the building sector having a greater potential to reducing CO₂ emission. Currently 40% of global resource consumption is as a result of the building construction. The main goal of this study is to optimize the environmental performance of a building using the life cycle approach, which most green building rating systems are also trying to adopt and incorporate as well; through a literature review of life cycles of various construction materials. The result shows that solid wood is a very energy efficient raw material. Solid wood processing is environmentally friendly and is relatively free of pollution. The energy efficiency of wood was confirmed by an American study (Koch 1992) that established that solid wood building products are ten to thirty times as energy efficient as the equivalent non-wood substitutes (steel, concrete, etc.). The paper concludes by emphasising on the need to creating awareness and establishing policies that would encourage the use of wood as a sustainable building materials against non-wood substitutes in Nigeria in order to continuing the greening of the earth.

Keywords; awareness, construction material, Nigeria, sustainability & wood

INTRODUCTION

There are environmental concerns that the atmospheric release of carbon from the use of fossil fuels will result in global warming. There are uncertainties about the size and life of the remaining reserves of fossil fuels (especially oil). Will the world's oil reserves last another 25, 50 or even 100 years? Although it is important commercially to know how long fossil fuels will last, there is no uncertainty that fossil fuels are a finite resource. Their continued use is unsustainable. Once used, it will be millions of years before fossil fuels are formed again. Wood - the World's Most Sustainable Raw Material - does require tree harvesting for its use, but it is possible to harvest trees in an environmentally responsible manner (Sutton, 2003). Sustainability concerns have led to efforts to reducing its consumption. However, consumption is a key driver of an economy.

Because economic growth requires increase in consumption, it is difficult for democratic Governments to act. Consumption is only a problem if the world consume unsustainable (finite) resources; consumption should not be a problem if the world consume renewable resources. Fossil fuel use results in permanent additions of atmospheric carbon. In contrast, wood use can result in no long term increase in atmospheric carbon - provided most of the world practice Sustainable Forest Management (SFM), the carbon released into the atmosphere by the use of wood is quickly requested for by the regenerating forest. SFM, in both naturally occurring and created (planted) forests, will ensure a continual and increasing harvest of wood. Wood should be increasingly promoted as a renewable and environmentally friendly raw material.

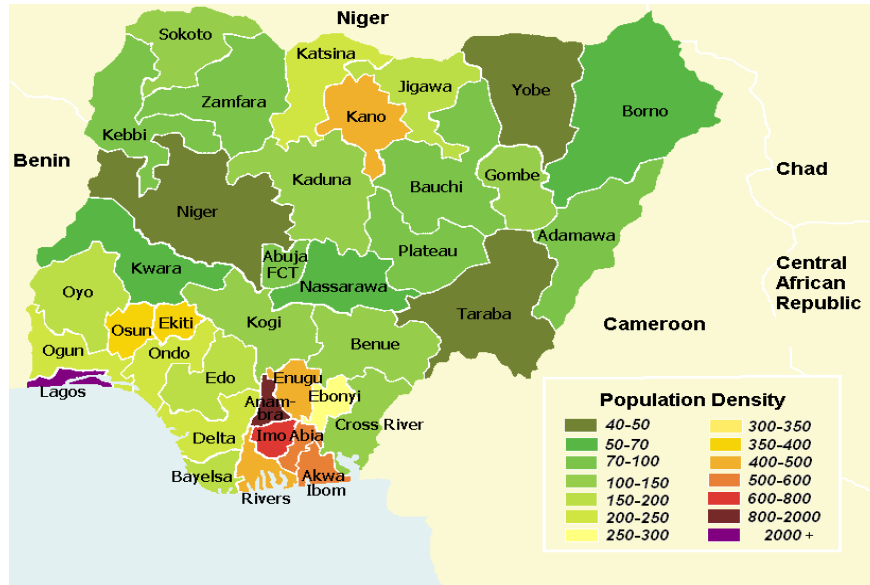


Figure 1. The Map of 36 states of Nigeria and the 6 geopolitical zones.

BACKGROUND

1. Sustainability

The UN, through UNESCO; which was active in helping to coin the concept of sustainable development in the 1980s, is now concerned more with promoting its dissemination. A recent key report entitled ‘Action Plan for the Human Environment’ has sought to influence governments by establishing an international programme on environmental education, encompassing all levels and all major stakeholders. The plan is based on the following key principles:

1.1 Sustainability and Sustainable Development

Sustainability involves two domains that should not be ignored or over simplified: economic/environmental on the one hand, and socio/cultural on the other hand. The question that should be raised at this point is: are architectural programs structured in a manner that is based on the above objectives of sustainability and sustainable development? The following section is devoted to this question.

1.2 Paradigm Change: Shifting Attitudes about the Environment

There has been a trend in the past decade to introduce a new paradigm of thinking about the manner in which architects, urban designers, and planners approach the design of built environments. This new paradigm places emphasis on the concept of sustainability, a concept that should become the focus and goal of architectural education worldwide.

2. How Sustainable is Wood Production?

To maintain (and hopefully improve) the average living standards, the world has no option than to increasingly shift from its dependence on fossil fuels to environmentally friendly and renewable energy sources. Earth's sustainable /renewable energy sources are:

- The sun - solar energy (includes hydro and wind),
- Geothermal - heat from the earth's inner core,
- Tidal - from the gravitational pull of the moon's rotation on the oceans, and
- Nuclear.

Nuclear energy as currently supplied (from the controlled breakdown of the unstable atomic nuclei of U 235) cannot really be regarded as a sustainable and renewable energy source,. The energy

efficiency of wood was confirmed by an American study (Koch 1992) that established that solid wood building products are ten to thirty times as energy efficient as the equivalent non-wood substitutes (steel, concrete, etc.). Solid wood is a very energy efficient raw material.

Solid wood processing is environmentally benign and should be relatively free of pollution. Because it takes energy to breakdown solid wood into wood chips or fibres and then to recombine them; reconstituted wood products such as wood pulping (especially mechanical pulp), particleboard, medium density fibreboard, etc. are not as energy efficient as solid wood. Especially in the last few decades, wood substitution has increased. Probably every one of 100,000 different products made from wood could be substituted by a metal, concrete, plastic or ceramic product. As all wood substitutes require more energy and involve a more polluting process, a greater use of wood would reduce both energy use and pollution.

3. Sustainable Construction Materials

Of all the points that a building project may earn under the U.S. Green Building Council's LEED rating system for construction, building, and design, perhaps none is more heavily contested than that for sustainable wood. From its first iteration in 2000, LEED has used one standard as a benchmark for allocating sustainable wood points, that of the Forest Stewardship Council (FSC), an independent, nongovernmental, not-for-profit organization with international offices in Germany. At present, if half of the cost of all wood-based materials and products in a building meets FSC criteria, that project can earn one LEED point. If 95 per cent or more of the wood is FSC certified, there is an opportunity to earn two points.

Table 1. The mainstream sustainable/green building rating tools

Comparisons items	The mainstream sustainable/green building rating tools					
	LEED	BREEAM	SBTool	CASBEE	GBI-Malaysia	ESGB
Version	V2.x	BREEAM-2008	SBTool-2007	Update to 2008	V2.0	ESGB-2006
Organization providing the rating tools	USGBC(nonprofit third party)	BRE (nonprofit third party)	li SBE (international non-profit collaboration)	JaGBC (joint of government, industry, academy)	Malaysian Green building Council (MGBC)	MHURD (dominated by national government)
Assessment issues	Sustainable sites, Water Efficiency, Energy & atmosphere, materials & Resources , Indoor Environmental Quality, Innovation & Design Process	Management, Energy, Transport, Pollution, Materials , Water, Land Use and Ecology, Health and Wellbeing, Pollution (Eco Homes only contains the former eight issues)	Site Selection, Project Planning and Development, Energy and Resource Consumption , Environmental loadings, Indoor Environmental Quality, Service Quality, Social and Economic aspects, Cultural and perceptual Aspects	Building environmental quality issues: Indoor Environment, Quality of Service, Outdoor Environment on site; Environmental Load issues: Energy. Resources & Materials , Off-site Environment	Energy Efficiency, Indoor Environmental Quality, Sustainable Site & Management, Materials & Resources , Water Efficiency, Innovation	Land saving & outdoor Environmental, Energy saving and usage, Water saving and usage, Material saving and usage , Indoor Environment Quality, Operational Management
Life cycle coverage (building phases)	Programming, Design, Construction, Operation	Programming, Design, Construction, Operation	Programming, Design, Construction, Operation	Programming (Tool-0, underdevelopment),	Programming, Design, Construction, Operation	Programming, Design, Construction, Operation

Source: adopted from (Xiaoping, Huimin and Qiming 2010)

3.1 Sustainable construction

This is the 'creation and management of healthy buildings based upon resource efficient and ecological principles' (BSRIA, 1996).

3.2 Sustainable materials

These are 'materials and construction products which are healthy, durable, resource efficient and manufactured with regard to minimizing environmental impact and maximizing recycling' (Edward, 2004).

Table 2. Green Building Index (GBI) Malaysia criteria for rating New and Old buildings

Part	Item	NRNC	NREB
1	Energy Efficiency (EE)	35	38
2	Indoor Environmental Quality (EQ)	21	21
3	Sustainable Site Planning & Management (SM)	16	10
4	Material & Resources (MR)	11	9
5	Water Efficiency (WE)	10	12
6	Innovation	7	10
	Total Score	100	100

Source: www.greenbuildingindex.org

In rating both New and old buildings in most of the rating system, points are awarded to building materials for almost all rating systems. This shows that the use of wood can be harnessed as the table has shown the importance of wood.

The table above shows an example of how points are allocated to the use of Materials and Resources; for Non Residential New Construction (NRNC) 11 points are awarded and for Non Residential Existing Buildings (NREB) 9 points are awarded. Likewise in the other aspects of the criteria in the rating systems, wood can find a place to enhance or assist in gaining points

4. The carbon question

The following discussion could imply that the atmospheric carbon from wood use is somehow different from the atmospheric carbon that comes from the use of fossil fuels. While there is no chemical difference, there is a major difference in the rate at which carbon is subsequently reabsorbed. In the last 100 years, the concentration of carbon dioxide in the atmosphere has increased. This increase is (and will) probably adversely affect the global climate. Because of the burning of fossil fuels, the manufacture of cement, the destruction of forests, etc. And other human activity has been the major contributor to the increase. Although both fossil fuels and wood essentially stored solar energy, they have different origins and their use has different effects on the net levels of atmospheric carbon.

Fossil fuels slowly accumulated over hundreds of millions of years in the crust of the earth. When the carbon in fossil fuels is released into the atmosphere, which carbon will effectively stay there for millions of years until it is requested? The carbon in wood was sequestered in the decades or centuries before the extraction of the mature tree. With sustainable forest management the fate of carbon released by the burning or decaying of wood should not be equated with carbon coming from fossil fuels.

METHOD

A case study of two prominent cities in Nigeria; Lagos and Abuja, were examined to its full potential in achieving one of the possible solution to climate change and reduction in carbon release to the atmosphere 'green building'.

RESULT AND DISCUSSION

Wood comes from trees. Most trees grow in forests. These forests can be natural (including managed natural forests) or deliberately created forests – planted forests. Is it possible to supply all the wood requirements of the world from planted forests? No, there is currently too small an area of planted forests. Estimates of the current supply of industrial wood that comes from existing planted forests vary from 20% (Sutton, 1999) estimates to 35% (ABARE, 1999).

The percentage of the world's saw logs that comes from planted forests (i.e. for the manufacture of solid wood products) is by estimate less than 10%. Over millions of years, many existing forest ecosystem has survived countless natural catastrophes - disease, fire, hurricanes, volcanic eruptions, tsunamis, and even thousands of years of ice ages and other climate changes.



The study of how forests survive and recover from even powerful natural disasters demonstrates the resilience of forest ecosystems. Where only a part of a forest is altered or damaged complete forest recovery is almost always possible.

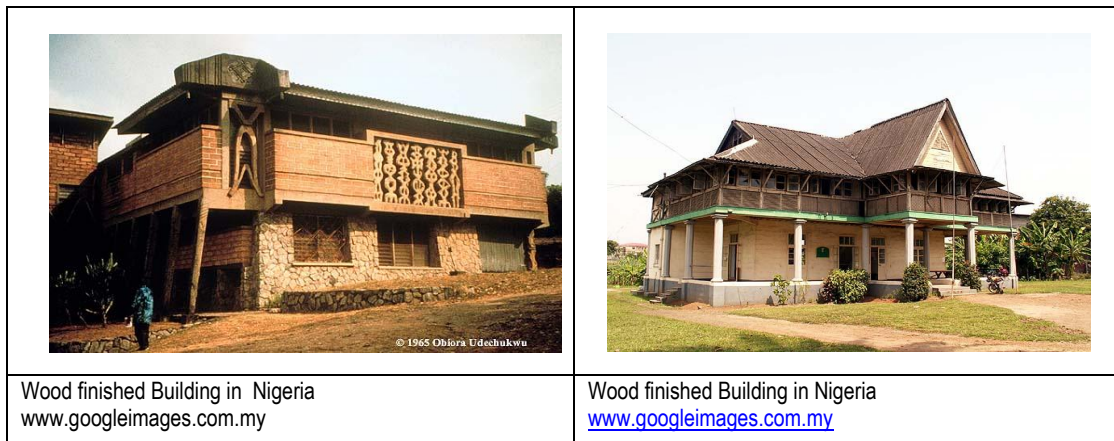
There are countless examples throughout the world of forest recovery following harvesting. It is doubtful if there is a single example of long-term permanent forest damage following any responsible harvesting operation.

Potentials of sustainable Buildings with wood in Nigeria

Nigeria is a country of huge potentials, with vast human and natural resources (especially wood and other materials that can supplement wood for construction purpose) with a huge deficit of over 2 million housing unit in both urban and rural areas and the need for major infrastructure to be put in place for its plan to be a developed nation. There is a great potential for the construction and establishing of green buildings where wood can be the major resource material for construction.

Table 2. Uses of wood in Buildings in various part of the world

	
<p>Wood finished Building in the USA Source ; Eichelkraut (2000) www.googleimages.com.my</p>	<p>Tsukuba International School is an IB World School in Tsukuba, Ibaraki, Japan www.googleimages.com.my</p>



Source; Google images

CONCLUSIONS

Energy is one of our largest resource needs. Of the sustainable energy resources the sun is by far the most important. An environmentally friendly alternative for capturing and storing solar energy is through photosynthesis and the growing of wood. Because it is a sustainable raw material, wood use will help us to maintain consumption and employment. Because of wood's sustainability and environmental friendliness there must be greater efforts to promote wood use.

There is also the need for more research and innovation in the development of new wood products. Wood is very versatile - being used for perhaps as many as 100,000 different products. Nigeria is yet to be at the forefront of climate change policy forum at both the regional and international levels despite the alarming effects of changing climate on lives and livelihoods across the 6 geo-political zones in the country.

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Curvature Factor of Curved Glulam Beam Made of Hardwoods

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ABSTRACT

In several design specifications, including the most recent National Design Specification for Wood Construction, curvature factor is used as adjustment of reference bending design values of curved glulam beam to account for the effects of the nonlinearity of bending stress and the presence of bending stress induced during the manufacturing process of the beam. In these codes, this factor depends on the ratio of the thickness of the lamination and the radius of curvature of inside face of lamination. In this paper, the applicability of the factor is investigated numerically by analyzing curved glulam beams of various radii of curvature made of hardwoods, namely red meranti (*shorea spp.*) and acacia mangium. Linear elastic finite element method has been used to analyze the beams. Glulam beams made of both one species and two species have been analyzed. The presence of bending stress induced during the manufacturing process of the beam is modeled as initial strain that varies throughout the beam. In the numerical model, each curved glulam beam is loaded by the failure load of a straight beam of the same length, cross section, and material properties of the curved glulam beam. The maximum bending stress in the curved glulam beam obtained numerically divided by the reference bending design value of the material is defined as numerical curvature factor. It is shown that the numerical curvature factors are very close to the curvature factors from the design specification with the difference of less than twopercent.

Keywords: curvature factor, curved glulam beam, reference bending design value

INTRODUCTION

Structural glued laminated timber, abbreviated as glulam, is an engineered wood product consisting of mechanically graded laminations with the grain of all pieces parallel to the longitudinal axis of the member. One of the advantages of using glulam is that it can be made a curved beam in order to increase its load carrying capacity and its stiffness. Another case that might need a curved beam is the necessity of higher space in a building. It is, of course, almost impossible to have a curved beam made of solid lumber, especially a curved beam with large ratio between rise and span (Suryoatmono and Bukhari 2010).

In the current USA design specification, the reference bending design value, denoted as F_b , needs to be adjusted by several adjustment factors (AWC 2012). For curved glulam beam, one of the adjustment factors is the curvature factor, C_c , that can be calculated using

$$C_c = 1 - 2000 \left(\frac{t}{R} \right)^2 \quad (1)$$

where t = thickness of laminations, mm, and R = radius of curvature of inside face of member, mm. This factor is used to account for the effects of the nonlinearity of bending stress and the presence of bending stress induced during the manufacturing process of the beam (ANSI/AF&PA NDS-2005). The curvature equation (Eq. 1) is based on the early tests (Wilson 1939) and is still used in the most recent wood construction specification in the USA (AWC 2012). In the specification, the limits on the ratio of lamination thickness to radius of curvature, t/R , of 1/100 for southern pine and hardwoods and 1/125 for other softwood species is intended to avoid overstressing or possible breaking of the laminations (AWC 2012). Red meranti and acacia mangium are hardwoods so the ratio of t/R of curved glulam beams made of these species may not exceed 1/100. As seen in Table 1, all beams analyzed in this paper satisfy this limitation.

Table 1. Glulam beam analyzed numerically using finite element method

Beam designation	Beam type	Laminations	End supports	Radius of curvature, R (m)	t/R
SU-HH	Straight	Uniform	Hinge-hinge	∞	0
CU1-HH	Curved	Uniform	Hinge-hinge	20	0.002
CU2-HH	Curved	Uniform	Hinge-hinge	10	0.004
CU3-HH	Curved	Uniform	Hinge-hinge	5	0.008
SN-HH	Straight	Nonuniform	Hinge-hinge	∞	0
CN1-HH	Curved	Nonuniform	Hinge-hinge	20	0.002
CN2-HH	Curved	Nonuniform	Hinge-hinge	10	0.004
CN3-HH	Curved	Nonuniform	Hinge-hinge	5	0.008
SU-HR	Straight	Uniform	Hinge-roller	∞	0
CU1-HR	Curved	Uniform	Hinge-roller	20	0.002
CU2-HR	Curved	Uniform	Hinge-roller	10	0.004
CU3-HR	Curved	Uniform	Hinge-roller	5	0.008
SN-HR	Straight	Nonuniform	Hinge-roller	∞	0
CN1-HR	Curved	Nonuniform	Hinge-roller	20	0.002
CN2-HR	Curved	Nonuniform	Hinge-roller	10	0.004
CN3-HR	Curved	Nonuniform	Hinge-roller	5	0.008

In this paper, the applicability of the curvature factor is investigated numerically by analyzing curved glulam beams of various radii of curvature made of hardwoods, namely red meranti (*shorea* spp.) and acacia mangium. To investigate if the uniformity of the laminations and the type of supports affect the curvature factor, two types of laminations (uniform and nonuniform) and two types of supports (hinge-hinge and hinge-roller) are analyzed as seen in Table 1. Each glulam beam has four pieces of lumber, each of which has thickness of 40 mm and width of 120 mm. The span of all glulam beams analyzed numerically in this paper is 1000 mm. Uniform beam consists of four pieces of lumber made of red meranti and nonuniform beam consists of two pieces of lumber of higher reference bending strength placed at outer side of the beam and two pieces of lower reference bending strength placed in the core of the beam (see Figure 1 and 2). The reference bending design values, F_b , used in this paper are 8.68 MPa and 20.74 MPa for red meranti and acacia mangium, respectively (Breyer et.al. 2007).

By assuming the glulam beam as a circular arc (see Figure 3), the radius of curvature of the beam is constant along the length. The glulam beam is loaded vertically (in the Y-Y direction) at midspan such that it bent with respect to the X-X axis (see Figure 4).

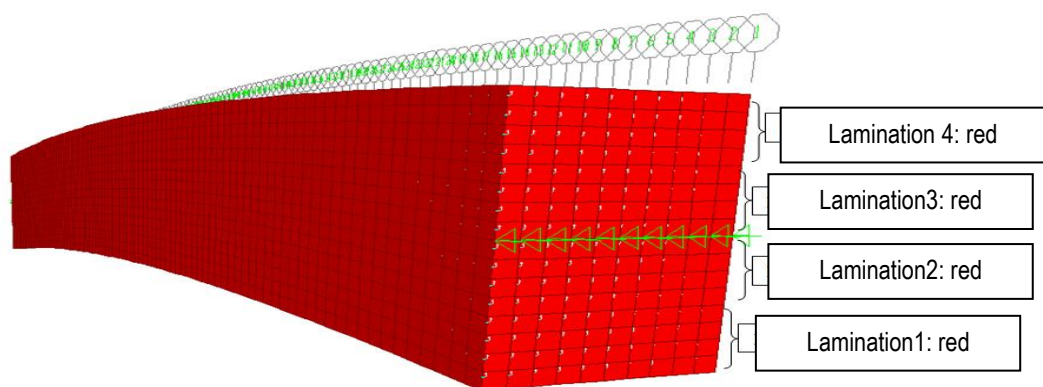


Figure 1. Finite element mesh of uniform curved glulam beam

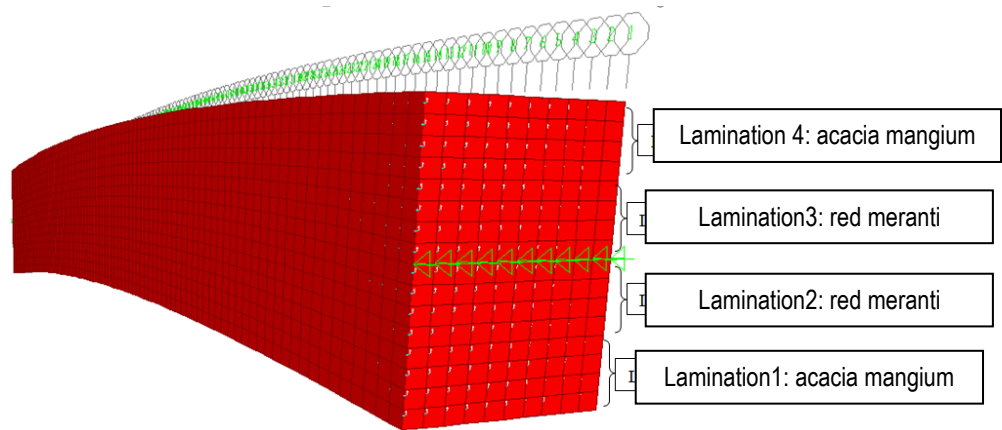


Figure 2. Finite element mesh of nonuniform curved glulam beam

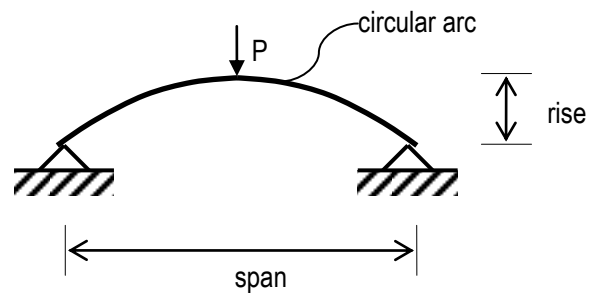


Figure 3. Concentrated load at midspan of a curved glulam beam

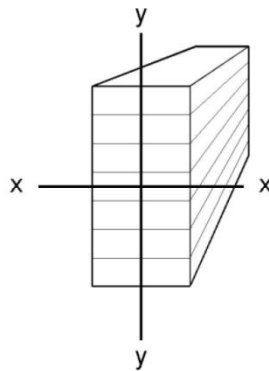


Figure 4. Axis orientation of the curved glulam beam (AWC 2012)

METHODS

As the name stands for, the curvature factor is to be used to adjust the reference bending design value F_b specified for straight glulam beam so that it is applicable for curved glulam beam. In other words,

$$(F_b)_{\text{curved}} = C_c \times F_b \quad (2)$$

The first step that needs to be done in order to obtain the curvature factor is to find the failure load, $P_{failure}$, of the straight glulam beam by applying a concentrated load of 1 kN at midspan of a straight glulam beam and using

$$P_{failure} = \frac{F_b}{\sigma_b} \times 1kN \quad (3)$$

where F_b is the reference bending design value of the outermost of the straight glulam beam, and σ_b is the normal bending stress at midspan at the outermost fiber due to the unit concentrated load. The next step is to apply $P_{failure}$ at midspan of curved glulam beam of the same configuration (supports and laminations) as the straight beam analyzed previously. Denoting the normal bending stress at midspan at the outermost fiber of the curved glulam beam as $(\sigma_b)_{curved}$, the curvature factor can be computed using

$$C_c = \frac{(\sigma_b)_{curved}}{F_b} \quad (4)$$

Both σ_b and $(\sigma_b)_{curved}$ are the results of the finite element analysis described below. In the above steps, it is assumed that the induced shear stress parallel to grain, compression perpendicular to grain, radial tension, and radial compression do not govern the strength of the curved glulam beam. Bending strength is assumed to be the governing limit state of the beam.

Finite Element Analysis

If wood is assumed as an orthotropic and elastic material with three mutually perpendicular material principle axes (longitudinal, radial, and tangential), then the constitutive relation between strain components and stress components can be expressed as (Bodig and Jayne 1993)

$$\begin{Bmatrix} \varepsilon_L \\ \varepsilon_R \\ \varepsilon_T \\ \gamma_{LR} \\ \gamma_{LT} \\ \gamma_{RT} \end{Bmatrix} = \begin{bmatrix} \frac{1}{E_L} & -\frac{\mu_{RL}}{E_R} & -\frac{\mu_{TL}}{E_T} & 0 & 0 & 0 \\ -\frac{\mu_{LR}}{E_L} & \frac{1}{E_R} & -\frac{\mu_{TR}}{E_T} & 0 & 0 & 0 \\ -\frac{\mu_{LT}}{E_L} & -\frac{\mu_{RT}}{E_R} & \frac{1}{E_T} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{G_{LR}} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{G_{LT}} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{1}{G_{RT}} \end{bmatrix} \begin{Bmatrix} \sigma_L \\ \sigma_R \\ \sigma_T \\ \tau_{LR} \\ \tau_{LT} \\ \tau_{RT} \end{Bmatrix} \quad (5)$$

where E_i are moduli of elasticity, μ_{ij} are Poisson's ratios, and G_{ij} are shear moduli, where $i = L, R,$ and T . It should be noted that the constitutive matrix is symmetric, so that the Poisson's ratio $\mu_{ij} = \mu_{ji} E_i / E_j$. The elastic properties of red meranti and acacia mangium used in the analysis are shown in Table 2. Eq. (1) can be written in a compact form as $\{\varepsilon\} = [S] \{\sigma\}$ where $[S]$ is the material constitutive matrix (Sadd 2009). The inverse relationship between stress and strain is

$$\{\sigma\} = [C] \{\varepsilon\} \quad (6)$$

where $[C] = [S]^{-1}$ is the material stiffness matrix.

Table 2. Orthotropic elastic properties used in the finite element analysis

Orthotropic Properties	Species	
	Red Meranti	Acacia Mangium
E_L (MPa)	5529 ³	10975 ³
E_R (MPa)	851 ¹	724 ⁵
E_T (MPa)	453 ¹	296 ⁵
μ_{LR}	0.172 ²	0.240 ²
μ_{LT}	0.324 ²	0.375 ²
μ_{RT}	0.560 ¹	0.912 ⁵
G_{LR} (MPa)	202.39 ⁴	614.58 ⁵
G_{LT} (MPa)	204.91 ⁴	504.85 ⁵
G_{RT} (MPa)	116.00 ¹	230.47 ^h

¹ Suryoatmono and Tjondro 2008

² Tjondro et.al. 2010

³ FPL 2010, assuming $E_L = 1.1E_{sb}$

⁴ Trienggar 2007

⁵ FPL 2010, assuming the same as the property of Basswood

⁶ FPL 2010, assuming the same as the property of Mahogany

In this paper, three, instead of two, dimensional finite element analysis chosen in order to anticipate future study of varying material properties and/or load across the width of the glulam. In the three dimensional finite element analysis, the type of element used is 8-node solid element with three translational degrees of freedom at each node. Example of finite element mesh in undeformed configurations is shown in Figure 1 and 2. The fiber direction of wood (the longitudinal axis of the material) is assumed to coincide with the tangential direction of the beam. The lamination plane is regarded as the longitudinal-tangential plane of the material. Compatibility between each lamination is assumed to be perfect, i.e. no slip occurs between laminas.

During the manufacturing process of a curved glulam beam, each lamination is bent to follow the intended curvature. This will induce residual stress in the lamination, the distribution of which is assumed to be linear, i.e. the material follows Euler-Bernoulli beam theory. By using Hooke's law, this residual stress can be converted into initial strain in the curved glulam beam. It should be noted that the relationship between stress and strain components used in the conversion has a minus sign, i.e.

$$\{\sigma\}_0 = -[C] \{\varepsilon\}_0 \quad (7)$$

where subscript "0" indicates initial condition (Cook et.al., 2002).

This initial strain is entered in the finite element model before the concentrated load at midspan of the beam is applied. Figure 5 shows the initial (residual) stress distribution due to manufacturing process of glulam beam. As seen in the figure, the initial stress in each lamination is linearly distributed across the thickness of the lamination. As expected, there is stress discontinuity on the interface between each lamination.

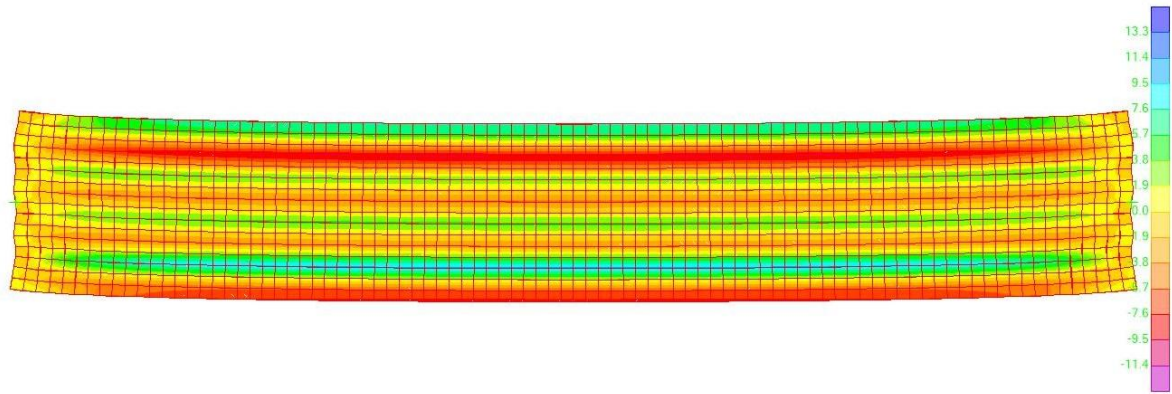


Figure 5. Initial (residual) stress distribution due to manufacturing process of glulam beam

Tangential and radial stress distribution throughout the curved glulam beam due to combined initial stress and applied concentrated load can be plotted using the finite element software. In Figure 6, tangential stress distribution is plotted in the deformed state of the beam. As seen in the figure, the vertical distribution of the tangential stress is no longer linear, as normally occurs in vertically loaded curved beam.

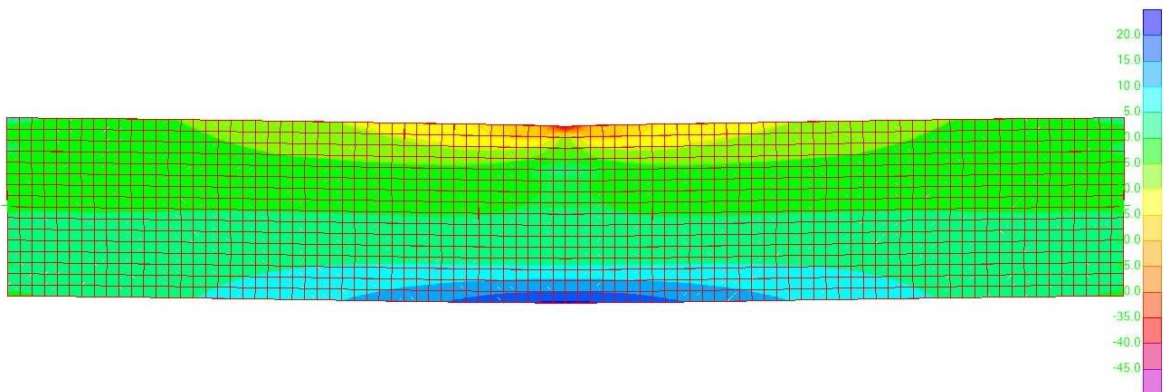


Figure 6. Typical tangential stress distribution due to combined initial stress and concentrated load at midspan of the glulam beam obtained from finite element analysis

Figure 7 shows the distribution of radial stress. It should be noted that the stress varies from tension and compression and the direction is perpendicular to grain. Although in the real design these type of stresses may govern the failure load of the curved glulam beam, in this paper bending strength is the only limit state considered because the objective of this paper is to investigate the curvature factor that applies only on reference bending design value, not on the radial tension perpendicular to grain design value nor the radial compression perpendicular to grain design value.

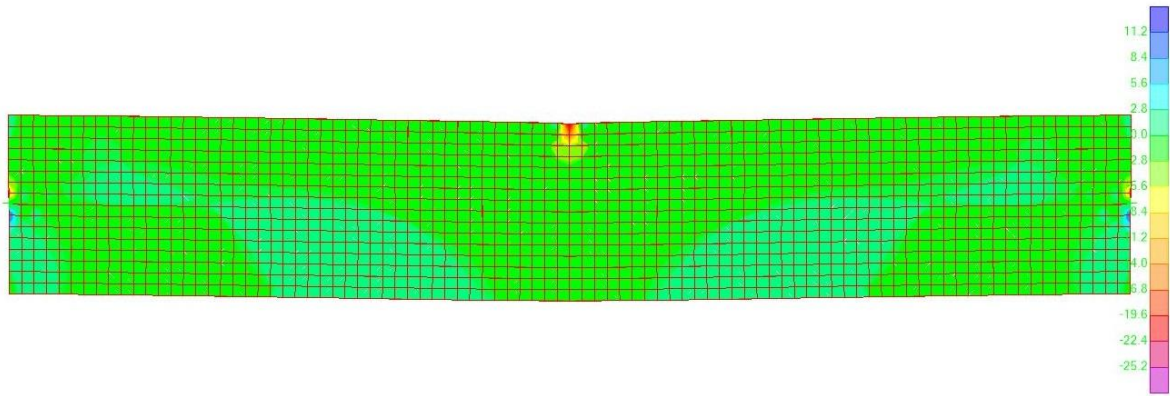


Figure 7. Typical radial stress distribution due to combined initial stress and concentrated load at midspan of the glulam beam obtained from finite element analysis

RESULTS AND DISCUSSION

Table 3 shows the curvature factor for each glulam beam obtained from finite element analysis described above. Curvature factor computed using Eq. 1 is also shown in Table 1. It is not surprising that curvature factor computed using Eq. 1 do not depend on the species of each lamination nor the type of supports. By definition, curvature factor for all straight beams is one. The difference between the two methods is also shown in the table. Note that the negative difference means that the current design specification in the USA (AWC 2012) is conservative. The maximum positive difference (1.21 %) can be considered very small, so it can be concluded that the curvature factor computed using Eq. 1 is conservative for all cases considered in this paper.

Table 3. Comparison of curvature factors between numerical (finite element analysis) results and Eq. 1

Beam designation	C_c (FEA)	C_c (Eq. 1)	Difference (%)
SU-HH	1	1	0
CU1-HH	0.990	0.992	0.202
CU2-HH	0.987	0.968	-1.960
CU3-HH	0.989	0.872	-13.417
SN-HH	1	1	0
CN1-HH	0.995	0.992	-0.302
CN2-HH	0.988	0.968	-2.066
CN3-HH	0.994	0.872	-13.990
SU-HR	1	1	0
CU1-HR	0.980	0.992	1.210
CU2-HR	0.962	0.968	0.620
CU3-HR	0.924	0.872	-5.963
SN-HR	1	1	0
CN1-HR	0.988	0.992	0.403
CN2-HR	0.972	0.968	-0.413
CN3-HR	0.955	0.872	-9.518

CONCLUSIONS AND SUGGESTIONS

A method for computing the curvature factor of curved glulam beam utilizing finite element method has been developed in this paper. The method has been used to analyze various curved glulam beam, i.e. various laminations (uniform and nonuniform), various end supports, and various radii of curvature, the results of which have been compared with the current design specification. Under the limitation of the cases studied herein, it can be concluded that the design equation for computing the curvature factor is safe, although it has been developed nearly seventy years ago.

It is suggested that the finite element method utilized in this paper be extended to include, but not limited to, other type of supports, lamination configurations, axis orientation, and loadings.

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Drying Deffects of the Oil Palm Trunk: a Preliminary Analysis

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ABSTRACT

Shortage of wood supply from natural and plantation forest is the main problem to ensure the existence of the timber industry in the near future. Various efforts have been done to use non-timber resources such as the oil palm trunk (OPT) as an alternative material, but OPTs are reported to be difficult to dry, not only because of its extremely high green moisture content, but also its drying defects. The objectives of this study are to characterize of drying defects in the OPT at different height (bottom to top) and layer of the trunk (bark to pith). To have different layer of trunk, the OPTs are sawn with polygon sawing pattern. Ninety samples size 25 mm thick x 100 mm wide x 200 mm long obtained from three palm trunk was dried using the Terazawa's Quick Drying Test (QDT) Method. Likert scale is used to rate the defect level of the sample with scale from 1 (free from a defect) to 5 (severe defect). Chi-squared independent test is conducted to determine the significant effect. The result showed a gradual increase in drying defect along the trunk height and depth, but only trunk depth show significantly different mean score at 1% significance level. It is concluded that the specific sawing pattern that allow the depth segregation of timber (polygon sawing) are necessary to ensure that the properties of boards produce similar across the wide of timber.

Key Words: Oil Palm trunk, Polygon sawing, drying defect, Likert scale, Chi-squared

INTRODUCTION

The oil palm is a monocot plant that produces edible oil used in food manufacturing, Oleo Chemical and other sources of palm based product. The oil palm plant are perennial crop, when planted will produce fruit economically until the age of 25 to 30 years.

As the second largest oil palm producer, Malaysia has 4.85 mil ha planted oil palm of different ages that have contributed to Malaysia socio-economy (Sulaiman et al., 2012). Upon replanting, there will be an abundant amount of biomass (Shuit, et al., 2009). This unutilized biomass must be developed into new products. It can further reduce the environmental impact of the unutilized biomasses and also to extract the potential material for the alternative of the traditional timber species that are fast depleting (Ghana, 2006). To explore the oil palm contribution, various efforts have been made to encourage, enhance and commercialize the usage of the unvalued material including the stem, which is the primary and largest waste (Ahmad et al., 2011). However, only 20% of the oil palm trunk is useable in the production of plywood and low grade lumber (Abdul Khalil et al., 2010).

There are technologies on hand to convert oil palm biomass to various types of value-added products such as Medium Density Fiberboard (Laemsak & Okuma, 2000), particleboard (Ahmad et al., 2011; Chew, 1987), fiber plastic composite (Shinoj et al., 2011), fiber-reinforced cement board (Abraham et al., 1998; Rahim et al., 1995), plywood (Anis et al., 2011), Laminated veneer lumber (Wahab et al., 2008) and compress lumber (Salim et al., 2012).

To any kind of products utilizing the oil palm biomass, the material must be dried first. However, variation of moisture content and density of the trunk inhibit its full utilization (Choo et al., 2011). This makes processing of these biomass resources has a considerable challenge, mainly from the trunk, which can have a green moisture content of up to 300% to 500% (Bakar et al., 2008) and density of 200 to 700 kg/m³ (Anis et al., 2007).

Oil palm trunk offers the best properties of wood as compared to that of other types of oil palm biomass viz-a-viz empty fruit bunch and oil palm frond (Bakar et al., 2008). The outer part of the trunk is higher in density, and 1/3 of the most outer part can be used as solid wood. The Polygon sawing pattern was reported as the best sawing pattern for this material that give higher recovery of the outer lumber with better quality (Bakar et al., 2006)

Due to its very high green moisture content and soft structure, especially in the central part, oil palm lumber (OPL) is difficult and takes a long time to dry. OPL is highly recommended using a special drying schedule and the drying method compared to others timber (Mohamad et al., 1989)

So far, there is no single company that has successfully developed an optimal drying method for OPL. On the other hand, comprehensive study to develop proper drying for OPL has yet been reported. Under current scenario, the company dries oil palm lumber using their own trial and error drying schedule. Some companies take 3 weeks' time of drying, while others use slightly shorter times, but produce excessive defects in the lumber (Ramli, 2012). This approach leads to uneconomic drying process that contributes to waste of time, energy and material.

The study on drying characteristics of OPL helps determine the most effective drying schedule for the material that shorter in drying time with minimal defects. This study conducted to identify the characteristics of drying defects in the OPL at different height (bottom to top) and layer of the trunk (bark to pith). This would inspire in determining suitable drying method of the material and identifying ways of avoiding the drying defect. Similar studies have been done by Bakar et al., (2000); Lim & Gan, (2005) and Anis et al., (2007), however, the impact of drying defect on OPL has not been proven statistically, and the relationship of tree height and layer in the formation of a defects has not been discussed.

MATERIALS AND METHODS

The material for the experiment obtained from 25 years-old *Elaeis guineensis* Jacq from Felda Jengka 25 Maran, located at 3°41'20.3"N, 102°25'9.4" E, at 63m altitude in Pahang state. Three trunks with diameter ranges over 43 - 55 cm were divided into 3 m long portions: bottom, middle, and top. The 6" band-head rig was used to saw the trunk to lumber size using polygon sawing method as described by Bakar et al. (2006) and a 4" band-resaw was used for further process that determines the final size 25 mm thick x 100 mm wide x 200 mm long (Figure 1).

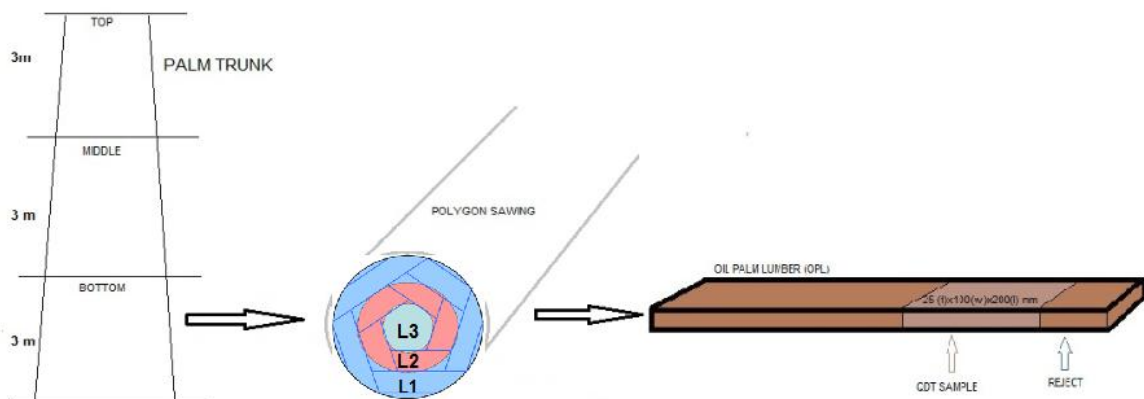


Figure 1: Sampling identification for QDT.

For drying, this research adopts a Terazawa's Quick Drying Test (QDT) Method (Terazawa & Tsutsumoto, 1976). The principle of QDT states that as small samples of wood exposed to severe drying condition, the drying defects is proportionate to the expected that was studied to predict the occurrence of collapse in *Eucalyptus* wood by Ilic and Hillis (1986).

Using the QDT method, the QDT samples were placed in the oven and the drying process took at least 72 hours at 103±2°C. The outcome of the samples on the end checks/splits, honeycomb, and deformation after the drying process were recorded and analyzed. Likert scale is used to rate the defect

level with scale 1 for samples free from a defect to scale 5 for severe defect samples. As for the type of defect, the samples are cross cut, and labeled as D1 for end checks/splits, D2 for honeycomb and D3 for deformation if the defect happen in the samples. Every parameter needs ten samples, thus a total of 90 samples were required for the analysis.

The number of defects on each trunk portion is obtained through the multiplication of the defect severity level, as weightage and the number of defects occurrences at each defect type.

RESULTS AND DISCUSSION

From this preliminary study it was found that the number of defect shows a gradual increase along the trunk height (Figure 2) and across the depth of the trunk (Figure 3).

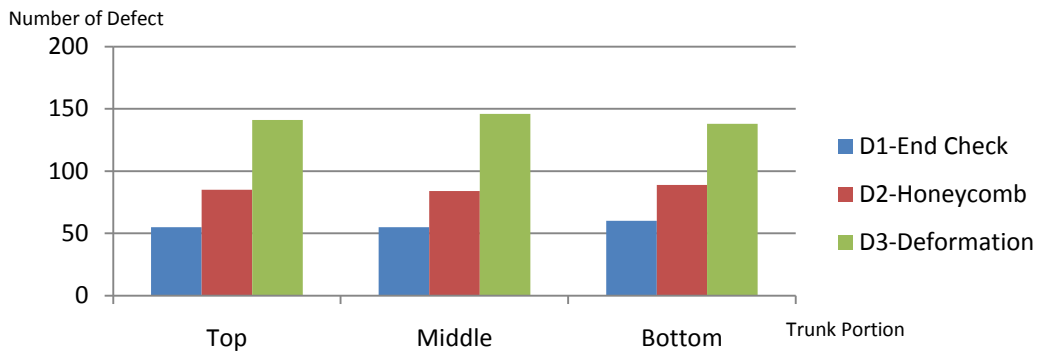


Figure 2: Drying defects along the trunk of oil palm from top to bottom

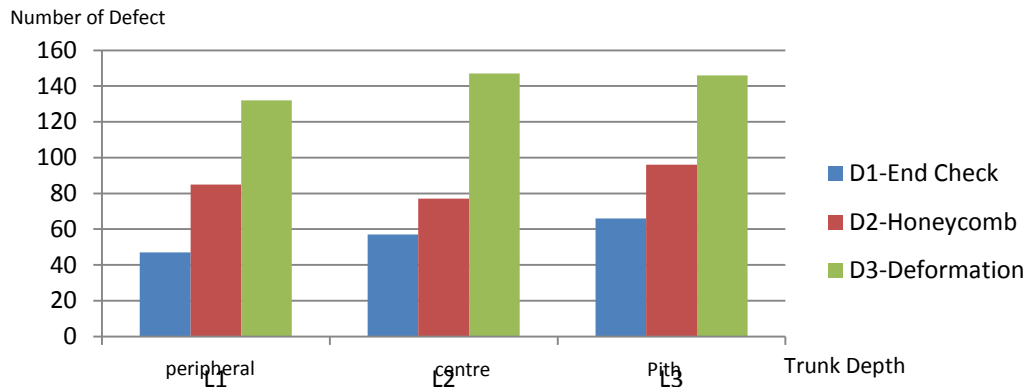


Figure 3: Drying defect of oil palm trunk from the bark to the center of the pith

The statistical test using the chi-square independent test between the trunk portion on the type of defect produced a p-value of 0.9625, indicated that no significant association between the parameters. These findings were in tandem with Lohet et al., (2010) that no association between the trunk portion and defect type due to homogeneity of density, while Jusoh et al., (1991) discover that the rate of shrinkage between radial and tangential are about similar that produces less drying defect and no significant effect on the longitudinal.

On the other hand, there is an increase in the number of defect in accordance to the layers. The statistical test showed a significant association between the layer of the trunk and the drying defect with a p-value of 0.000. This is expected to be related to the different amount of parenchyma cell and vascular bundle between the layer, where the peripheral zone (outer layer) is composed of a small amount of parenchyma cells and a large amount of vascular bundles which gave more stability in the mechanical properties of the palm trunk (Lim & Gan, 2005).

Conversely, the soft central region (pith) has a small amount of vascular bundles embedded within a large amount of parenchyma tissue that might be resulted a sorption properties during drying process (Zaihan et al., 2011). The distinctive moisture level in different layers of the oil palm trunk is expected to have different drying properties (Bakar et al., 1999, 1998; Choo et al., 2011). The peripheral region contains the lowest moisture content and increases progressively from the peripheral region to the pith or central region (Paridah & Anis, 2007). The differences also affected by variation of size, location, and distribution of vascular bundles along tree height and depth (Balfas, 2006; Lim & Khoo, 1986).

Furthermore Mohamad (1989) and Killmann (1983) suggested the core of oil palm trunk cannot be used because of its poor drying properties, and because of that he mentioned the necessity of OPL segregation according to the potential uses. Similarly, Feng et al., (2011) also recommended segregating veneer made from oil palm trunk by densities prior to plywood manufacturing.

CONCLUSIONS

It was observed that the drying defect was significantly increased toward the inner zone. The most occurred defect was "Deformation", followed by "Honeycomb", and "Check". Because of that, it is highly recommended to use the oil palm trunk separately based on its transverse section. The polygon sawing was seen as the most suitable sawing method that facilitates the trunk segregation. It was also evident that the outer and middle region of the trunk is possible to kiln dry with less defect as compared to the center region, producing a lumber with appropriate drying schedule.

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Effect of Hole's Existence in the Specimen Center and Convective Air Drying Condition on Drying Stress of Sugi (*Cryptomeria japonica* D. Don) Wood

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ABSTRACT

Sugi wood containing pith in the centre of wood is having a very difficult to dry and very easy to get drying defects. This research is the second phase of the serial studies. The first study was aimed to know the effect of hole's diameter concludes that hole's diameter of 6.15 cm on the centre of thin sample was the optimum hole's diameter because resulting the dried wood with no defects at all. This second study was aimed to determine the effect of drying conditions and the presence of a hole in diameter of 6.15 cm in the center of the thick sample on drying stress of sugi wood. Trunk of sugi trees grown artificially in Matsuyama forest district was cut longitudinally getting sample dimension of 12.3 x 12.3 x 1.5 cm (length) and two samples in dimension of 12.3 x 12.3 x 9 cm (length). Every three of samples were grouped in same groups. The first unit of sample in every group is intended to measure initial moisture content, while the second and the third sample are subjected to treat a hole in the center of sample with a diameter's dimension of 0 and 6.15 cm respectively. The first until the fifth of group of the samples were dried in convective dryer with temperature of 50°C and relative humidity of 80%, and the sixth until the tenth group were dried in temperature of 80°C and relative humidity of 87% and the eleventh until the fifteenth group were dried in temperature of 100°C and relative humidity of 83%, and the sixteenth until the eighteenth were dried naturally in room condition. Every stage of drying, each of samples was weighted and measured for moisture content. At the end of drying step, each of samples was measured it's drying stress on back and front sides of tangential surfaces using strain-gauge and micro-computer equipped with data logger. The study concludes four things. First, there are four pattern of drying stresses. Second, drying stresses values on the back side were always greater than found in the front side of wood. Third, the existence of hole in dimension of 6.15 cm causes the smaller drying stress than those of un-perforated samples. Fourth, the harder the drying condition produced a higher drying tension. Natural drying, low drying, medium drying and high drying condition produces tension in the range of 10 to -15 μ s, -600 μ s, 1000 to -1000 μ s, and 1500 to -1000 μ s respectively.

Key words: wood, drying condition, hole's diameter, drying stress

INTRODUCTION

Sugi trees (*Cryptomeria japonica* D. Don) is a dominant tree growing in forest area of Japan. This domination makes sugi wood is chosen as a main raw material to fulfill the need of wood industries, including wood construction and wood furniture industries in Japan. However, sugi wood also have some weaknesses, such as very high moisture content at green condition, very low of dry ability, and very easy to get drying defects (Hayashi *et al*, 1992).

To eliminate these weaknesses, some treatments had already been developed. Some of these treatments are as follows: incision on wood surface, steaming to wood, pressing and compact-ing of the wood, making a gap as long as the length dimension of the wood, and local explosion by pre-steaming. Result of these treatments had not yet satisfied in eliminating these weaknesses (Hayashi, 1999). This background inspired the writers to conduct a research in serial about the effect of perforations on wood centre and drying condition to drying properties of sugi wood.

The first study was aimed to know the effect of hole diameters and drying condition on the thin sample have been conducted. The first phase study concluded that hole's diameter of 6.15 cm on thin sample was the optimum ones, because resulting the dried wood with no defects at all. This first study recommend to do research on drying stress on the thicker sample and apply a hole in the wood centre with the greatest diameter and also apply a higher drying condition. The second phase of the study was aimed to investigate the effect of drying conditions and the presence of hole with diameter of 6.15 cm at the centre of a length of 9 cm sample to the character of drying stress.

Wood drying process is a process to evaporate moisture out from the wood. In this process, free moisture and bound moisture are evaporated to the surrounding air. Drying process requires driving force, namely moisture gradient between moisture in the wood and moisture in the surrounding air. Wood moisture must be higher compared to air moisture. The higher the moisture gradient, the faster the drying process, and led to the greater drying stress. (Haygreen and Bowyer, 1982)

Process of moisture evaporation is begun on the outer part of the wood, successively followed by the inner part of the wood. Rate of moisture movement from inner part to the outer part of the wood depends on relative humidity of the surrounding air, the steepness of the moisture gradient, and the temperature of the wood. The lower the relative humidity, the greater the capillary flow. In connection to the temperature, the higher the temperature of the wood, the faster the rate at which the moisture moves from the wetter interior to the drier surfaces. If the temperature is too high, dry wood tend to have high drying stress, and it is a trigger for the emergence of drying defects, in the form of deformation, collapse, cracks and split (Rasmussen, 1961).

MATERIALS AND METHODS

This research used three stems of thirty years old of sugi wood grown artificially at community forest district at Matsuyama prefecture, Japan. Each stem is in normal condition, healthy and as much as possible free of defect, include knot. Each stem was cut with double blades bend saw to rectangular shape in dimension of 12.3 x 12.3 cm. This rectangular shape of lumber was then cut again longitudinally with circular saw to obtain sample groups, each consisting of three samples, i.e 1.5, 9 and 9 cm in length dimension. Overall, a total of 18 groups of sample were obtained. The first unit sample in every group was intended to measure initial moisture content, while the second and third units were subjected to a treat with a circular hole in the centre of the sample with a diameter's dimension of 0 cm and 6.15 cm respectively.

Samples intended for measuring initial moisture content were weighted and then dried in an electric oven. Drying process was held continuously until the samples were free from moisture which was marked by the constant weight of the sample.

The first until the fifth of the group were dried in low drying condition with temperature of 50°C and relative humidity of 80%, and the sixth until tenth group were dried in medium drying condition with temperature of 80°C and relative humidity of 87% and the eleventh until fifteenth group were dried in high drying condition with temperature of 100°C and relative humidity of 83%, while the sixteenth until eighteenth group were dried in natural condition on laboratory room (temperature 15 °C and relative humidity 45%). Before drying process and every six hours duration of drying, each of the samples was weighted to determine the water content decreased and the end of each drying process which was marked by the constant weight of the sample. Equalizing step was applied at the end of each convective drying process. Measuring the drying stress was conducted on each dried wood sample. Measurements were performed using a micro-strain-gauge attached to sample surface and a set of tools for micro-computer equipped with data-logger software. Measurement of each sample performed at two positions, namely at the two opposite tangential surfaces.

The experiment on low, medium condition and natural drying were conducted at Laboratory of Wood Science and Technology, Forest Resources Department, College of Agriculture, Ehime University, Matsuyama. Meanwhile, experiment on high drying condition was conducted at Laboratory of Industrial Research Institute Hiroshima, Japan.

RESULTS AND DISCUSSION

Final moisture content measurement

Results of research on final moisture content at the end of drying is presented in Table 1. While result of analyses of variance in order to know the effect of hole's diameter and drying condition and interaction of these two factors is presented in Table 2 as follows.

Table 1. Final Moisture Content (%)

No	Drying Condition (Temperature & Relative Humidity)	Hole's Diameter Dimension (cm)		Mean
		0	6.15	
1	50°C & 80%	11.89	13.34	12.617
2	80°C & 87%	10.54	12.56	11.553
3	100°C & 83%	10.66	11.47	11.064
	Mean	11.031	12.459	11.745

Table 2. Analyses of Variance of Final Moisture Content (%)

Source of variation	Degree of Freedom	Sum of Square	Mean Square	Computed F	Probability
Treatment	5	29.7487	5.9497	1.58 NS	0.203
Drying condition	2	12.6100	6.3050	1.68 NS	0.208
Hole's diameter	1	15.2938	15.2938	4.06 NS	0.055
Interaction	2	1.8447	0.9223	0.25 NS	0.7845
Error	24	90.2998	3.7624		
Total	29	120.0485			

Note: ** is significant at 1% level, * is significant at 5% level, NS is not significant

Analysis of variance showed that drying factors and perforation at the wood centre has no significant effect on final moisture contents, so final moisture contents of sample is relatively same after equalizing process. This condition is a good starting point for drying stresses measurements

Drying Stresses measurements

Result of minimum and maximum values on drying stress in a measurement on the front side and back side of tangential surfaces are presented on Table 3 and 4 respectively.

Study on drying stress will be done gradually by phasing as follows. First, describe the drying stress pattern. Second, comparing the drying stresses on the front and back tangential surfaces of the samples. Third, comparing the drying stresses on holed samples and un-holed samples. Forth, study on the effect of drying condition on drying stresses.

Drying stress pattern is shown by an abscissa and ordinate frame. Abscissa shows a passage of time and ordinate shows size of drying stress. Strain has a positive value and negative value. Strains positive value means that outer portion of dry wood has a tension condition, where as negative strain means outer portion has a compression condition. Based on these criteria, it appears that the pattern of drying stress varies. There are four models of drying stress patterns.

Tabel 3. Minimum and maximum values of Drying stress (μs) on front side of tangential surface

Num	Treatment	Rep	Drying stress		Num	Treatment	Rep	Drying stress	
			Min	Max				Min	Max
1	D0H0	1	-5.04	0.03	17	D2H0	1	-2563	10
2		2	-19.86	0.09	18		2	-27	205
3		3	-16.38	-0.01	19		3	-9	1115
4	D0H4	1	0.09	294.26	20		4	-32	312
5		2	0.78	8.74	21		5	-25	431
6		3	-9.13	5.95	22	D2H4	1	-155	22
7	D1H0	1	-22	29366	23		2	-173	64
8		2	-654	-7	24		3	-190	23
9		3	-633	-1	25		4	-1355	-75
10		4	-1374	64	26		5	-566	45
11		5	-257	53	27	D3H0	1	2	1044
12	D1H4	1	-704	-16	28		2	-81	40
13		2	-629	-2	29		3	-5	815
14		3	-206	-1	30		4	-317	2006
15		4	-656	15	31		5	-118	1198
16		5	-545	30001	32	D3H4	1	-25	781
					33		2	-1089	5
					34		3	-5	99
					35		4	-32	30001
					36		5	-15	428

Note: D0: natural drying (15°C & 45%)
D1: low temperature drying (50°C & 80%)
D2: medium temperature drying (80°C & 87%)
D3: high temperature drying (100°C & 83%).
H0: hole diameter's dimension of 0 cm
H4: hole diameter's dimension of 6.15 cm

Tabel 4. Minimum and maximum values of drying stress (μs) on back side of tangential surface

Num	Treatment	Rep	Drying stress		Num	Treatment	Rep	Drying stress	
			Min	Max				Min	Max
1	D0H0	1	-5.04	0.03	17	D2H0	1	-237	23
2		2	-19.86	0.09	18		2	-5	241
3		3	-16.38	-0.01	19		3	-10	1434
4	D0H4	1	0.09	294.26	20		4	-12	584
5		2	0.78	8.74	21		5	-7	471
6		3	-9.13	5.95	22	D2H4	1	-377	18
7	D1H0	1	-1746	15	23		2	-4	394
8		2	-564	80	24		3	-7	114
9		3	0	714	25		4	-56	868
10		4	-407	74	26		5	-18	270
11		5	-1494	20	27	D3H0	1	-22	2543
12	D1H4	1	-762	12	28		2	-5	1824
13		2	-57	225	29		3	1	2024
14		3	-3	299	30		4	3	1866
15		4	-344	23	31		5	-5	1017
16		5	-599	18	32	D3H4	1	-17	537
					33		2	-7	564
					34		3	-118	149
					35		4	-15	181
					36		5	-247	211

Note is same as in Table 3

The first model is as follows. Drying stress in the form of tension and the greater the value until it reaches the peak, then gradually decreases until it reaches the neutral point, and the decline continues and enter the compression region. Compression is getting bigger until it reaches a maximum size, and then gradually decline and stabilize at a certain value in the state of compression. Length of time in the state of tension and compression is different and the peak value of tension and compression is also different. This first drying stress pattern is own by the second test replication of D0H0 sample, namely sample without hole which was dried at temperature of 15°C and relative humidity of 45% and by the fourth test replication of D1H0 sample, namely sample without hole which was dried at temperature of 50°C and relative humidity of 80%.

The third model is as follows. All parts of drying stress in the condition of tension. Since the beginning of the measurement, the value of the tension increases until it reaches a maximum point, and then becomes constant at that point. This third drying stress pattern is own by the majority of sample which was dried at temperature of 50°C and relative humidity of 80%.

The fourth pattern is the reverse of the third pattern. All parts of drying stress in the condition of compression. Since the beginning of the measurement, the compression value increases until it reaches a maximum point, and then becomes constant at that point. This third drying stress pattern is own by the majority of sample which was dried at temperature of 100°C and relative humidity of 83%.

The second study was aimed to compare the drying stresses on the front and back side of tangential surfaces of the samples. In general, comparison of the two pattern of drying stresses suggests that tension that occurs on the back side is always greater than found in the front ones, both on low, medium and high drying conditions.

Tension on the back side of the sample is greater than that on the front side is reasonable. In the process of drying, samples are always placed in chamber in the consistent position. The front side of sample is always facing the kiln door (to the front of the dry kiln). In contrast, the back side of sample is always facing the back side of dry kiln. Thus, the back side is always getting a chance to the beginning of air circulation, while the front side is always getting a chance to the end of air circulation. Because of the air is hot and dry at beginning of entering the chamber, the back side of sample will always have exposure to the air dryer and hotter than the front side of the samples. Thus, the drying process on the back side of the sample to be more intensive than that the front side. This reality led to the tension value on the back side is higher than on the front side. This reality is in accordance with the theory of Rasmussen (1961) that the dry and hot air surrounding the timber, the faster wood dry and the greater drying stress.

The third study was aimed to compare the drying stresses on perforated sample (H4) and un-perforated one (H0). In general, comparison of the two pattern of drying stresses suggests that tension or compression that occurs on perforated samples is always smaller than that on un-perforated samples, both on back and front side measurement. This phenomenon occurs in all drying condition. This is caused by the presence of the holes in the sample will provide additional space for shrinkage expression, so that the perforated sample can express it's shrinkage more freely compare to the un-perforated sample. In addition, un-perforated sample will have more wood substance than perforated sample. The more wood substance will also led to a greater drying stress due to drying stress magnitude is a function of wood substance. This assumption proposed by Soenardi (1976) that the amount of wood substance determines the shrinkage and other physical properties of wood.

The fourth study was aimed to compare the effect of drying condition on drying stresses. In general, comparison of the four pattern of drying stresses suggests that the average tension or compression that occurs in samples increases in line with the increase drying condition of D0 (temperature of 15°C and relative humidity of 45%) led to D1 (temperature of 50°C and relative humidity of 80%), D2 (temperature of 80°C and relative humidity of 87%) and D3 (temperature of 100°C and relative humidity of 83%). Measurement on the front side of sample, natural drying condition (D0) produces tension in the range of 10 to -15 μs , low drying condition (D1) produces tension in the range of -600 μs , medium drying condition (D2) produces tension in the range of 1000 to -1000 μs , and high drying condition (D3) produces tension in the range of 1500 to -1000 μs . The harder the drying condition produced a higher tension. This is due to the higher drying conditions led to the steep gradient of moisture that occurs on wood surface and the faster the drying process takes place in the wood. The higher and the more rapid drying process resulting the greater drying stress on the wood.

CONCLUSIONS

1. There are four pattern of drying stresses on sugi dry wood.
2. The drying stresses values on the wood back side were always greater than found in the front side ones.
3. Hole made in the centre of sugi wood influence the values of drying stress. The existence of hole in dimension of 6.15 cm causes the smaller drying stress than those of un-perforated samples.
4. Drying condition influence the values of drying stress of dry wood. The harder the drying condition produced a higher drying tension. Natural drying, low drying, medium drying and high drying condition produces tension in the range of 10 to -15 μs , -600 μs , 1000 to -1000 μs , and 1500 to -1000 μs respectively.

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Eco-Friendly Board from Oil Palm Frond and Citric Acid

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ABSTRACT

The utilization of non-wood lignocellulosic as composite board raw material has developed due to the declining of wood supply. Among of non-wood lignocellulosic, by product from oil palm plantation such as oil palm fronds would be the economically lignocellulosic resources. Nowadays, commercial particle boards using urea formaldehyde as binder. However, the boards release formaldehyde emission that harmful for human health during application. Therefore, it is necessary to find natural binder agent for board production. Currently, citric acid is used as natural adhesive on the wood-based moldings. Citric acid has carboxylic acid functional group that can react with hydroxyl functional group from cellulose by esterification reaction. This paper would explain about the production of board from oil palm frond and citric acid, then elaborate their physical and mechanical properties.

Keywords : board physical mechanical properties, oil palm fronds, esterification

INTRODUCTION

The demand for particleboard products continues to increase, meanwhile due to government restriction; wildlife protection, and other environmental concerns, the availability of these raw materials, particularly from wood has been decreasing, leaving an increasing gap between raw materials and products demand. Researchers are finding alternatives to fill this gap. Oil palm fronds are renewable agricultural by-product from oil palm plantation would be the economically lignocellulosic resources.

Indonesia is the largest producer of oil palm (*Elaeis guineensis*) in the world. In 2009 Indonesia oil palm plantations was covering an area of 7,508,023 hectares and increased to 7,824,623 hectares in 2010 (Directorate General of Plantation 2010). During the production period, the fronds of oil palm trees need to be trimmed when harvesting oil palm fruit bunches. In a palm tree age from 3 to 4 years, the number of fronds can reach 30 to 40 stalks, and then decreased between 18 to 25 stalks. Within a year, every single hectare of oil palm plantations produce as much as 10.4 tons of oil palm fronds based on dry weight, averagely (Husin 2004). With a total plantation area in 2010 amounted to 7.82 million hectares, there will be oil palm fronds as by product up to 81.32 million tons per year. Such a large amount of oil palm fronds need to be well managed for environmental sustainability.

According to Thole and Hora (2003) referred in Jonoobi *et al.* (2011), more than 90% of the oil palm empty fruit bunches can be converted into fibers, while the part of the oil palm trunk and fronds that can be converted into fibers, respectively, were 25% and 50%. Wan Rosli *et al.* (2004) stated that the oil palm fronds contains 14.81% lignin, 86.53% holocellulose, 62.34% α -cellulose and 1.8% extractives. Therefore, the oil palm fronds are potential to be processed as source of cellulose.

Commercial particle board production apply urea formaldehyde or phenol formaldehyde as adhesive to bind wood particles. The emission of carcinogenic formaldehyde in the production and during application of particleboard has generated an urgent need for development a formaldehyde-free wood adhesive for making particleboards.

There has been reports regarding natural adhesives, binderless boards and chemical surface activation of wood, for alternatives of eco-friendly board production. In this research, we paid attention in citric acid which is a natural organic polycarboxylic acid containing three carboxyl groups. Citric acid is widely used in foods, beverages and pharmaceuticals. The utilization of citric acid as a cross-linking agent to improve the physical and mechanical properties of wood had been reported by Vukusic *et al.* (2006). Additionally, Umemura *et al.* (2012) had researched the application of citric acid as a main material of wood adhesive. In this study, citric acid was applied as a natural adhesive for oil palm fronds board production.

MATERIALS AND METHODS

Materials

Oil palm fronds were obtained from oil palm plantation in West Java, Indonesia. The leaves were cut off from oil palm fronds, then the fronds were processed with ring flaker to produce particles with 1 ~ 5 cm length. The particles were washed and sun-dried until the moisture content reached 6%. Citric acid was produced by PT. Budi Acid Jaya, Lampung. Citric acid solution was obtained by stirring 700 g citric acid in 1000 ml water.

Board production

Oil palm fronds particles were sprayed with citric acid solution. The weight of citric acid were 10%, 15% and 20% based on oil palm fronds dry weight. Details regarding the formulations are shown in Table 1. Boards were produced with dimensions 25 cm x 25 cm x 0.8 cm with density target of 0.6 g/cm³. The hot pressing temperatures were vary at 140 °C, 160 °C, 180°C, and 200 °C. The pressing condition was pressure at 1N/mm² for 10 minutes. Boards were produced in randomly particles arrangement.

Table 1. Formulation of boards

Citric acid content (wt%)	Weight ratios of OPF to citric acid	Oven-dried Oil palm fronds (g)	Citric acid (g)
10	5 : 1	272,7	27,3
15	7 : 1	260.9	39.1
20	10: 1	250.0	50.0

Evaluations of boards.

The specimens of 200 x 50 x 8 mm were prepared for static bending test. The static three-point bending test was carried out under air-dry condition according to JIS A5908-2003. The effective span and loading speed were 120 mm and 5 mm/min, respectively. The modulus of rupture (MOR) and modulus of elasticity (MOE) of composites were calculated. Internal bond and screw withdrawal test were also performed according to JIS A 5908-2003. For thickness swelling properties testing, water immersion treatment for 24 h was performed using a square specimens (50 x 50 mm). After the treatment, thickness changes were measured under wet condition.

Results and Discussion

Naturally oil palm fronds particles' color were light brown. Due to hot pressing at 140-200°C, boards of oil palm fronds's color change to be dark brown (Figure 1). The obtained board densities ranged from 0.44 to 0.67 g/cm³.



Figure 1. Oil palm frond board

Effects of citric acid content on composite physical properties

The thickness swelling of oil palm frond board bonded with citric acid is shown in Figure 2. After 2 hours immersion, the board thickness swelling with 10 wt% citric acid and 140°C pressing temperature, showed the highest value which was 46,03%. While board with 20 wt% citric acid and 200°C pressing temperature, had the lowest value (0,56%). After 24 hours immersion, the board thickness swelling with 10 wt% citric acid and 140°C pressing temperature, showed the highest value which was 57.34%. While

board with 20 wt% citric acid and 200°C pressing temperature, had the lowest value (2.53%). The increasing of citric acid content and pressing temperature lead to the better performance of boards' thickness swelling properties.

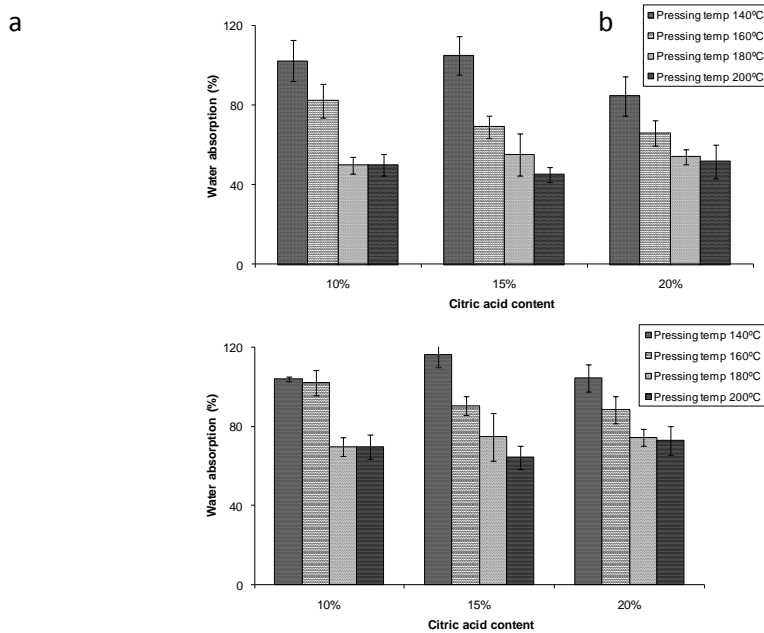


Figure 2. Oil palm fronds board thickness swelling after (a) 2 hours immersion, (b) 24 hours immersion.

The chemical composition of oil palm frond strands was 14.81% lignin, 86.53% holocellulose, 62.34% α -cellulose, and 1.8% extractives, on an oven-dry weight basis (Wan Rosli *et al.* 2004). The polycarboxylic acids react with hydroxyl groups of cellulose after high-temperature drying or curing, and drive the formation of ester cross-links in cellulosic or lignocellulosic. A covalent bonding is expected in the adhesion mechanism, as the boards have some resistance to swelling. The reaction between carboxyl groups from citric acid and hydroxyl groups from cellulose is given in Figure 3.

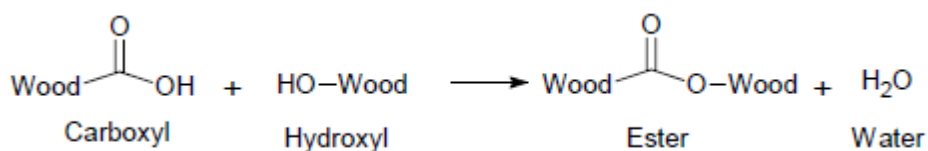


Figure 3. Esterification reaction of carboxyl groups from citric acid and hydroxyl groups from cellulose

Effects of citric acid content on composite mechanical properties.

Effects of citric acid content on the boards' modulus of rupture (MOR) is presented in Figure 4. The maximum MOR value of oil palm fronds boards in this study was 5.85 N/mm², which produced from 15 wt% citric acid and 200°C pressing temperature. Higher pressing temperature applied during boards production, improved the boards' modulus of rupture properties.

Citric acid (CA) can be functionalized as particles adhesive by the present of covalent bonding between carboxyl groups from citric acid and hydroxyl groups from cellulose which was effective for development of good bending properties. Although oil palm fronds board with 15 wt% citric acid content which pressed at 200°C (5.85 N/mm²) did not fulfilled the JIS standard for particle board type 8, MOR of oil palm fronds board was higher than sisal fiber board or vetiver root board at the same citric acid content. According to Syamani *et al.* (2010), MOR of sisal fiber board with 15 wt% and 20 wt% citric acid were 1.67 and 1.52 N/mm², respectively. While MOR of vetiver root board with 15 wt% and 20 wt% citric acid were 1.96 N/mm² and 2.53 N/mm², respectively (Syamani *et al.* 2012).

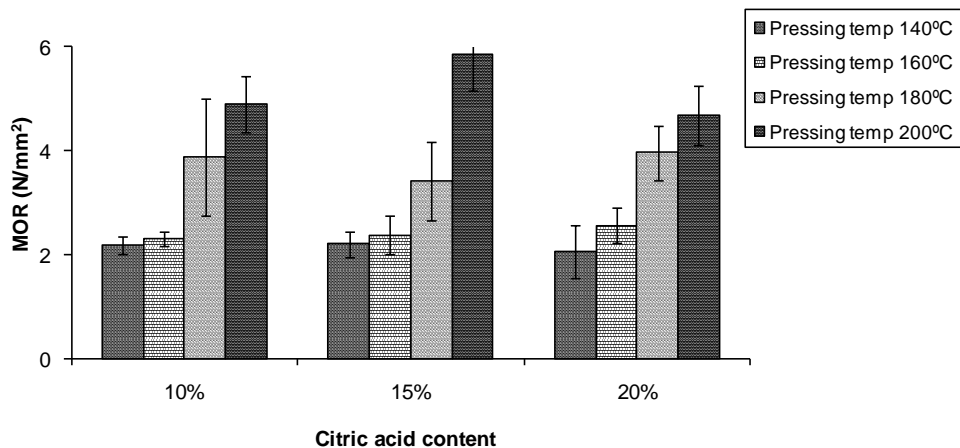


Figure 4. Oil palm fronds boards' modulus of rupture

Oil palm fronds board modulus of elasticity (MOE) also showed a similar trend (Figure 5). The maximum MOE value of oil palm fronds board in this study was 1067.03 N/mm², which produced from 15 wt% citric acid and 200°C pressing temperature. The MOE of vetiver board was higher than sisal fiber board or vetiver root boards at the same citric acid content. According to Syamani *et al.* (2010), MOE of sisal fiber board with 15 wt% and 20 wt% citric acid were 220.74 N/mm² and 308.96 N/mm², respectively. While the MOE of vetiver board with 15 wt% and 20 wt% citric acid were 221.6 N/mm² and 260.7 N/mm² (Syamani *et al.* 2012).

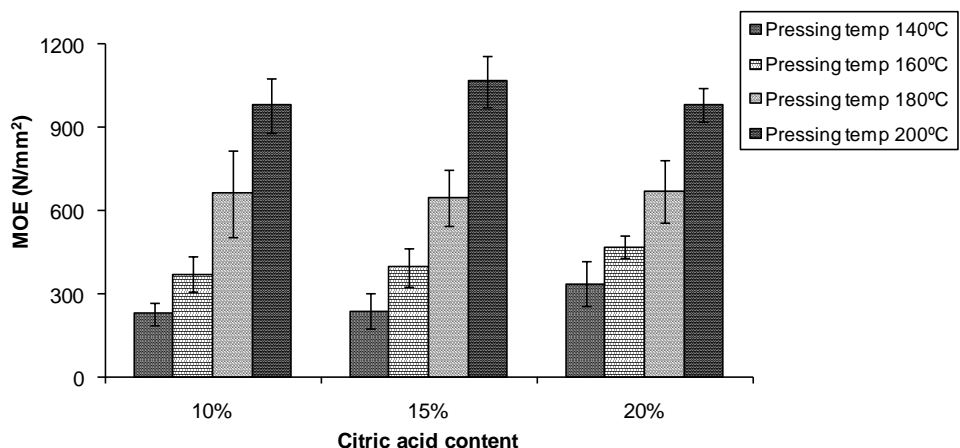


Figure 5. Oil palm frond's modulus of elasticity

The increasing of pressing temperature lead to the improvement of bending properties of oil palm frond boards. Citric acid melts at 153°C and dehydrates to give aconitic acid on heating at 175°C. Further heating results in the formation of methyl maleic anhydride (Barbooti and Al Sammerrai, 1986). The citric acid began to melt from 157°C temperature and turns into gas form at a temperature of 175°C (Munawar *et al.* 2009). In this phase the carboxyl group of citric acid will begin to bind the hydroxyl group in acacia bark through esterification process (Umemura *et al.* 2010). Esterification process in this phase that causes the bonds between citric acid and fiber becomes stronger than at other temperatures.

Oil palm frond acid boards' internal bond properties which produced from 15 wt% citric acid and 200°C pressing temperature were 0.26 N/mm² (Figure 6). Generally, internal bond properties of oil palm frond boards were improved with the increasing of citric acid content and pressing temperature. Based on analysis of variance, board internal bond with pressing temperature at 140°C and 160°C showed no significant difference, but differ from board internal bond with pressing temperature at 180°C and 200°C.

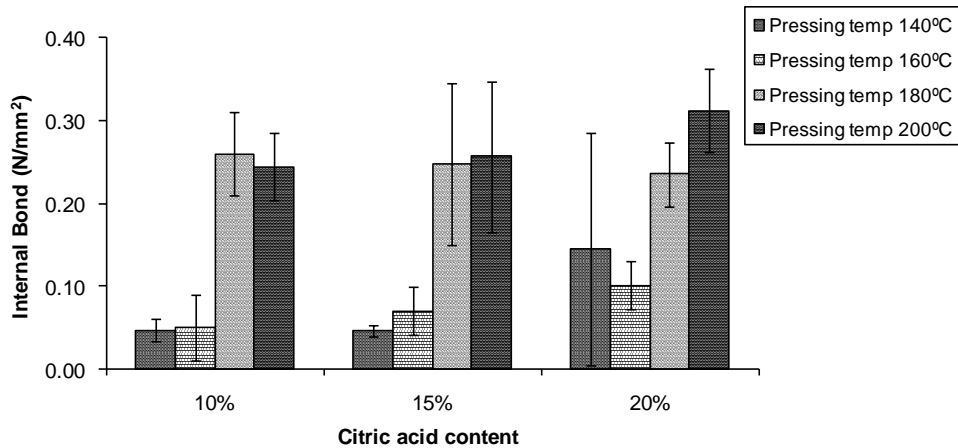


Figure 6. Oil palm fronds' internal bond

The bonding mechanism between the carboxyl groups from citric acid and hydroxyl group from oil palm frond particles occur in hemicellulose components of oil palm particles. Only the amorphous region of cellulose and low molecular weight hemicellulose fraction is expected to be accessible to chemicals and more accessible to aqueous reagents. As reported by Umemura *et al.* (2010), Optimization of bonding occurred through ester linkage between carboxyl group from citric acid and hydroxyl group from wood hemicellulose.

Efforts to improve the internal bond of the board from high cellulose content material using citric acid as a bonding agent has done by Sugihara *et al.* (2010). The research results showed that with the addition of sucrose into the citric acid from 25% -50 wt% have increased the internal bond of the wood particle boards by 150% -300%.

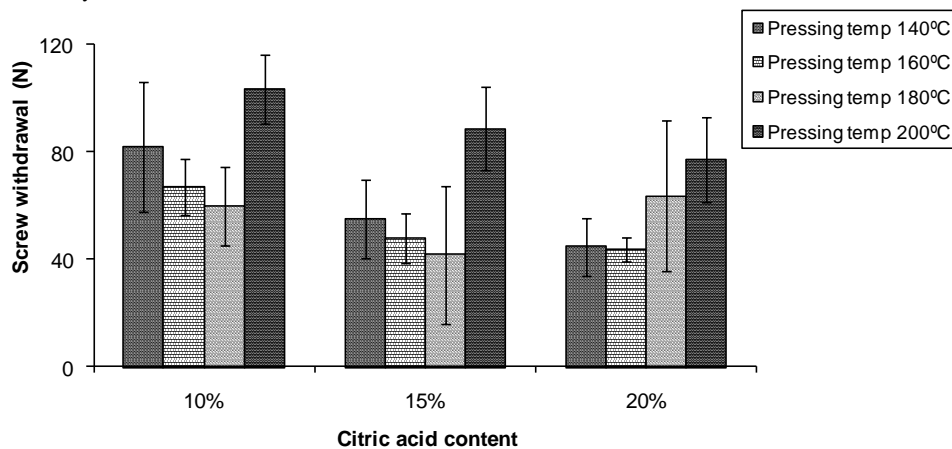


Figure 7. Oil palm fronds' screw withdrawal

Oil palm frond acid boards' screw withdrawal properties which produced from 15 wt% citric acid and 200°C pressing temperature were 88.80 N (Figure 7). Based on analysis of variance, boards screw withdrawal showed no significant difference at varied citric acid content and pressing temperature.

According to Umamera (2012), when the plant-derived material is mixed with a powdery polycarboxylic acid and is pressured, is preferred that a maximum length is controlled to 10 mm or less, although is possible to sufficiently cure a plant-derived materials which is in form of small pieces having a maximum length 50 mm. The dimension of oil palm frond particles used in this study were varied between 1 ~ 5 cm length and randomly composed inside the board, resulted a similar screw withdrawal properties.

CONCLUSION

Citric acid was used as a natural adhesive to produce oil palm frond boards. The boards obtained had good bending properties. The MOR, MOE, IB and SW values of boards with 15 wt% citric acid content and pressed at 200°C were 5.85 N/mm², 1067.03 N/mm², 0.26 N/mm² and 88.80 N respectively. The optimum of condition for board production should be analysed upon citric acid content and pressing temperature in a range of 15% ~ 20% and 180°C ~ 200°C, respectively.

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Eccentricity Effect on Bamboo's Flexural Properties

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ABSTRACT

Bamboo stem's cross sectional area is never a perfect circle, but almost ellipse. Each ellipse shape has a unique value of eccentricity as parameter to denote its circularity. A perfect circle has a zero value of eccentricity. Conventional calculation for bamboo flexural properties as designated by ISO 22157-1:2004 resulted an overestimate or underestimate value compared to the actual value because of the perfect circle cross sectional assumption. We harvested 36 bamboo stems from 4 species namely Ampel (*Bambusa vulgaris* Schrad.), Tali (*Gigantochloa apus* (Bl.Ex. Schult.f) Kurz), Gombong (*Gigantochloa verticillata* (Willd.) Munro), and Mayan (*Gigantochloa robusta* Kurz.), and found that the eccentricity value of bamboo stem could vary from 0.000 to 0.508. This paper studied the effect of eccentricity to the flexural properties of bamboo and aimed to create the strength ratio (C_e) between actual elliptical shape and assumed perfect circle shape. It was reported that the conventional calculation arise an under estimate result if the major axis (a) arranged horizontally, while overestimate result will be get if the major axis (a) arranged vertically. So the modulus of rupture (S_R) which is calculated by conventional calculation should be adjusted by the strength ratio of eccentricity (C_e) in order to define more precise value. This study result the exact relationship between C_e value and eccentricity for both conditions. For simplicity, the graphical sketches were made too.

Keyword: bamboo, eccentricity, flexural properties, strength ratio

INTRODUCTION

Bamboo is natural product which traditionally has become the rural community's main choice for many purposes in Indonesian villages because it is cheap and easy to find in their neighbourhood. Some bamboo species are used for construction material, e.g. Betung (*Dendrocalamus asper*), Tali (*Gigantochloa apus*), Andong (*Gigantochloa psedorundinaceae*), and Ampel (*Bambusa vulgaris* Schrad.). People commonly build their bamboo houses based on the traditional experiences without any engineering calculations. Since the demand for green and sustainable construction arises and spreads globally, recently bamboo construction attracts the engineer's attention because of its artistic, high performance, natural resources sustainability, and environmentally friendly. Many researcher reported the advantages of bamboo for environment [1] – [3], its properties compared to another materials [4] – [10], and its sustainability [11], [12].

As natural product, bamboo stem properties are influenced by many factors during its growth period, e.g. genetic and habitat condition. These factors create the variability in size and physical shape, then every stem could have vary diameter size, taper, and eccentricity. Nugroho and Bahtiar [13] and Bahtiar et al. [14] conducted some researches of bamboo taper effect on its flexural properties. It was reported that the taper value didn't affect to flexural properties on center point bending test, but significantly affected on third point loading bending test. So the bamboo modulus of rupture (S_R) should be adjusted by its taper strength ratio (C_t) when it was defined by third point loading bending test. Conventional method to measure the S_R of bamboo stem as designated in ISO 22157-1:2004 based on third point loading bending test resulted under estimate values than the actual ones because of no-taper assumption. Adjusting the resulted testing value with the corresponding strength ratio will result more precise value. Beside taper effect, the eccentricity on bamboo stem will affected to its flexural properties which will be studied in this paper.

Bamboo stem commonly assumed as hollow cylinder shape. Its cross sectional area is naturally never a perfect circle shape but almost ellipse. There are always maximum and minimum diameters on every pieces of cross sectional area. Some standards (e.g. ISO 22157-1:2004) designated the average value of diameter as standard value to calculate the bamboo mechanical properties. This assumption arise a new problem because it created an over or under estimate value compared to the actual properties. An overestimate mechanical properties of material could become dangerous in structural planning because the building could collapse since the overload condition, while the under estimate value created non-efficient building. It is important to study the effect of eccentricity on bamboo mechanical properties in order to plan the bamboo construction more reliable.

Eccentricity term commonly used in physical and planetary science. Eccentricity is the parameter to measure the circularity of ellipse shape. The eccentricity value for a perfect circle is 0 (zero), while the value become higher for the thinner ellipse shape

THEORITICAL BASIS

Bamboo stem's cross sectional area is commonly assumed as a perfect circle, while its actual shape is almost ellipse (Figure 1). The circle diameter (d) which calculated as average of maximum and minimum diameter of ellipse shape is commonly chosen as the standard value. Maximum and minimum diameter in ellipse shape are called major axis (a) and minor axis (b). So the mathematical relationship between d , a , dan b usually be defined as Equation 1.

$$d = \frac{a + b}{2} \quad (1)$$

The strength ratio of eccentricity (C_e) denoted as the ratio of maximum stress in actual ellipse shape (σ_e) and the assumed cylindrical shape (σ_c) (Equation 2):

$$C_e = \frac{\sigma_e}{\sigma_c} \quad (2)$$

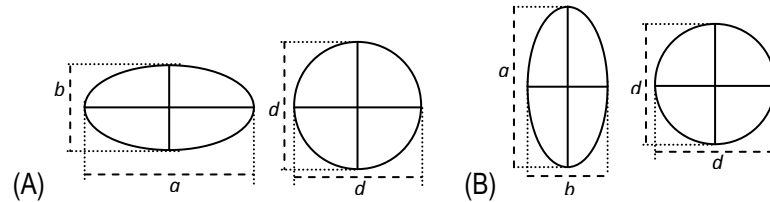


Fig. 1. The sketch of assumed cylindrical shape compared to the actual ellipse shape which the major axis coincides with absis (A) and ordinat (B).

Since the bending stress is known as Equation 3, so the eccentricity strength ratio could be define as Equation 4 because the maximum length from centroid (c) for circle is a half diameter ($d/2$) while for the ellipse is a half minor axis ($b/2$).

$$\sigma = \frac{Mc}{I} \quad (3)$$

$$C_e = \frac{bI_c}{dI_e} \quad (4)$$

Substituting Equation 1 into Equation 4 it becomes:

$$C_e = \frac{2bI_c}{(a + b)I_e} \quad (5)$$

Since the moment of inertia for circle (I_c) and ellipse (I_e) shape are denoted by Equation 6 and 7 respectively, Equation 5 could be solved become Equation 8:

$$I_c = \frac{\pi}{64} d^4 \quad (6)$$

$$I_e = \frac{\pi}{64} ab^3 \quad (7)$$

$$C_e = \frac{(a+b)^3}{8ab^2} \quad (8)$$

Eccentricity is the ratio of the distance of any point on a conic section (ellipse, parabola, hyperbola, or circle) from a focus to its distance from the corresponding directrix. This ratio is describing the shape of a conic section and the value is constant for any particular conic section. By this definition, eccentricity (e) is defined as Equation 9, so ratio of minor axis (b) to major axis (a) of ellipse could be defined as Equation 10.

$$e = \sqrt{1 - \left(\frac{b}{a}\right)^2} \quad (9)$$

$$\frac{b}{a} = \sqrt{1 - e^2} \quad (10)$$

Substituting Equation 10 into Equation 8, we get the exact relationship between eccentricity with its strength ratio as seen in Equation 11, and the graphical sketch is shown in Figure 2(A).

$$C_e = \frac{\left(1 + \sqrt{1 - e^2}\right)^3}{8(1 - e^2)} \quad (11)$$

As seen on Figure 2(A), strength ratio value for a perfect circle shape is 1 (one), while for ellipse shape is always higher than 1 (one). It is proved that the perfect circle assumption on conventional bending test resulted an under estimate flexural properties value when the major axis (a) configured horizontally during testing. The under estimate flexural properties value will made the oversize structural component. The building will be stronger but more expensive. Equation 11 and Figure 2(A) are suitable for major axis (a) arranged coincided with horizontal axis (absis) (Figure 1(A)). Different result will arise when the testing conducted with major axis (a) configurated vertically as shown in Figure 1(B). If the major axis (a) aranged coincided with vertical axis (ordinat), the C_e value could be derived by similar way become Equation 12, and the graphical sketch is shown in Figure 2(B). Figure 2(B) showed that the strength ratio commonly lower than 1 (one). This condition proved that the conventional flexural properties are over estimate compared to the actual value. This condition could be dangerous because it leads the engineer to design smaller size structural component than the demand. In extream condition, the building could be collapse before estimated maximum load applied.

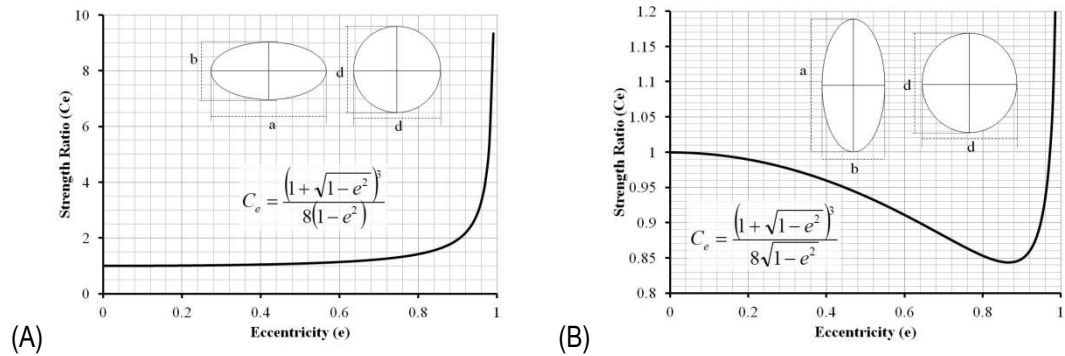


Fig. 2. Strength ratio of ellipse bamboo when major axis arranged horizontally (A) and vertically (B) during bending test.

SURVEY OF BAMBOO ECCENTRICTY

We made a survey on a bamboo shop in Bogor, and measure the basal and top diameter of 162 bamboo tali (*Gigantochloa apus* (Bl.Ex Schult.f) Kurz) stems which have 50 – 110 cm length. The maximum diameter was defined as major axis, and minimum diameter was the minor axis. The result was shown in Table 1. Then we harvested 36 bamboo stems from 4 species namely Ampel (*Bambusa vulgaris* Schrad.), Tali (*Gigantochloa apus* (Bl.Ex Schult.f) Kurz), Gombong (*Gigantochloa verticillata* (Willd.) Munro), and Mayan (*Gigantochloa robusta* Kurz.), 9 stems from each species. Our measurement found that the bamboo cross sectional shape could vary from perfect circle into ellipse. Zero eccentricity which means a perfect circle shape found in Tali and Ampel, but it was not found in Gombong and Mayan. As seen on Table 2, the overall eccentricity for 36 measured bamboo stems was 0.000 – 0.508. It is similar with the survey result on the shop. This condition proved that most of bamboo cross sectional plane was almost ellipse than circle. So the conventional bamboo's flexural properties value which assumed circle shape of bamboo stem could make 0 – 8.7% under estimate value or 0 – 6.5% over estimated value compared to the actual modulus of rupture (S_R) which calculated by ellipse shape assumption.

CONCLUSION

Bamboo stem's cross sectional shape could vary from perfect circle into ellipse. The eccentricity which denoted the circularity of the shape affected to the measurement of bamboo stem's flexural properties. The relationship between eccentricity and its strength ratio was determined by mathematical equation, and it was proved that circle assumption on bending test lead under estimate value if the major axis arranged horizontally on test configuration, and lead over estimate value if the major axis arranged vertically. The measured Modulus of Rupture (SR) could be 0 – 8.7% lower or 0 – 6.5% higher than the actual value.

Tabel 1. Summary of the dimensional properties of 162 tali stems from bamboo shop in Bogor.

	Basal				Top				Taper
	d	a	b	e	d	a	b	e	
MIN	3.33	3.38	3.28	0.00	3.21	3.28	3.14	0.00	0.0000
MAX	7.40	7.50	7.30	0.47	7.17	7.23	7.10	0.51	0.0136
Average	5.12	5.19	5.05	0.21	4.84	4.90	4.78	0.1926	0.00439
St. dev	0.96	0.97	0.95	0.10	0.96	0.97	0.95	0.10	0.0033
Covariance	18.69	18.74	18.73	49.51	19.75	19.76	19.82	52.35	75.11

Note: d: average diameter, a: major axis (maximum diameter), b: minor axis (minimum diameter)

Tabel 2. The eccentricity of bamboo stem and its strength ratio.

Species	Sample size (n)	Major axis (a)	Minor axis (b)	Eccentricity (e)	Strength Ratio (C_e) for:	
					Horizontal Major axis	Vertical Major axis
Tali	9	7.32 – 9.94	7.26 – 9.81	0.000 – 0.338	1.000 - 1.032	1.000 – 0.971
Ampel	9	5.73 – 8.60	4.94 – 8.12	0.000 – 0.508	1.000 – 1.087	1.000 – 0.936
Gombong	9	6.30 – 11.24	5.85 – 11.24	0.021 – 0.438	1.000 – 1.059	1.000 – 0.952
Mayan	9	7.05 – 9.89	6.32 – 9.78	0.126 – 0.498	1.004 – 1.082	0.996 – 0.938
Overall				0.000 – 0.508	1.000 – 1.087	1.000 – 0.935

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The flexural strength and rigidity of composite plywood-renghas double stress skin panel floor

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ABSTRACT

Composite action between plywood and wood-stringer connected with nails was analyzed and tested under destructive test. Eight double stress skin panel floor specimens were tested under third point loading. The stringer was made from *renghas* (*Gluta L – Anacardiaceae*) species and the plywood was *albasia* (*Albizia falcata*). The variation of the specimen was the thickness of the plywood and the number of stringer. The destructive test using two points loading was done to observe the rigidity and ultimate strength of the composite floor. The composite action between plywood and stringer, failure mode and ductility was observed. The load that can be carried at service load and rigidity for deflection calculation was suggested. The ultimate load was extremely higher than the load at allowable displacement, which is provided an adequate safety factor.

Keyword: flexural strength, rigidity factor, service load, failure mode, ductility

INTRODUCTION

Indonesia is located in the active seismic area and many buildings collapsed during the strong earthquake, it was necessary to have an adequate seismic resistance of the building. One of the principles of seismic design is using a light weight material such as wood to reduce the floor mass of the building which is also reduce the earthquake inertial force. The fabricated floor such as stress skin panel is light and can be used to reduce the site work and speed of the construction because easy to be erected manually. The floor can be made from plywood and stringers fastened by nail, screw or glue.

Some experimental study on the composite stress skin panel was done by Tjondro et.al (Tjondro, 2011a, Tjondro 2011b), see Figure 1 and Figure 2. It was shown that the composite stress skin panel consist of a 1220 mm x 2440 mm single panel and four of 34 mm x 72 mm 'african wood' stringers can carry 2.0 kPa of uniform water load at allowable displacement and failed at more than 15 kN of line loading. The plywood sheet was glued to the stringers, Tjondro 2011a.

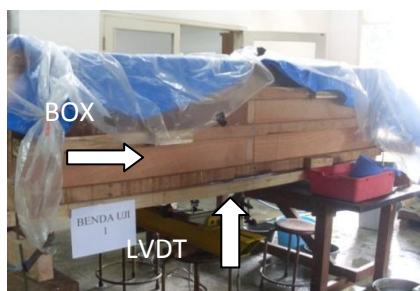


Figure 1a. Equipment and setting of the experiment with uniform water loading



Figure 1b. 500 mm height of water as a uniform loading, without failed.

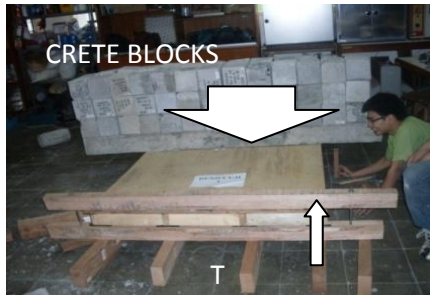


Figure 2a. Stress Skin Panel under 'line' loading test using concrete block.



Figure 2b. Specimen at failure at 15 kN line loading

The other study, Tjondro 2011b was a composite stress skin panel consist of 500 mm x 2440 mmdouble panel and six of bamboo stringers with 100 mm diameter can carried 5 kN of two point load at allowable displacement and more than 20 kN at ultimate loading. The floor was made by joining two sheets of 12 mm thickness of plywood to the bamboo stringers by mechanical connection using flat-head screws at 250 mm spacing. The average weight of the floor specimen was 35 kg. Which is about one fourth of concrete floor weight. It was shown that wood or bamboo stringers combined with plywood panel as a fabricated floor was light and strong enough to carry the live load. The test was shown as in Figure 3.



Figure 3. The Composite plywood-bamboo floor specimen under loading test

The failure in the first experimental study, Tjondro 2011a, was a brittle mode because the glue was used between plywood and stringers, see Figure 4a. In the second experimental study, Tjondro 2011b, the failure mode was ductile because ductility was built by yielding of the screw, the behaviour can be seen as in Figure 4b.

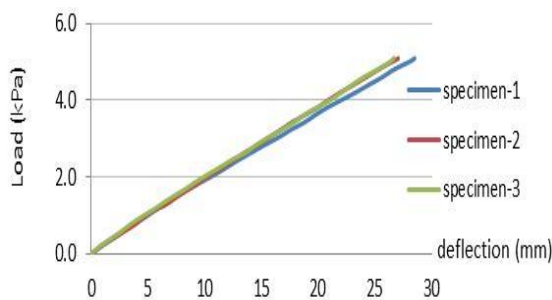


Figure 4a. Brittle failure at composite plywood- 'african wood' stringers using glue, Tjondro 2011a.

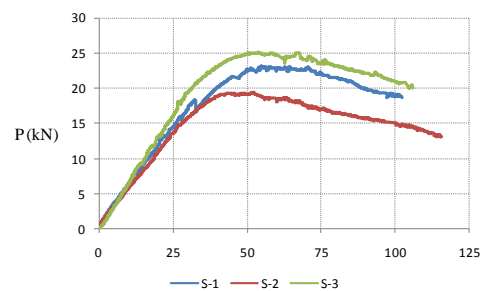


Figure 4b. Ductile failure at plywood-bamboo stringers using screws, Tjondro 2011b.

In this experimental study, The fabricated floor made from a composite double stress skin panel was tested. Eight specimens of composite stress skin panel consist of a 550 mm x 1200 mm double plywood panel with 50 mm x 50 mm stringers was introduced in this experimental study.

The aim of this study is to investigate the rigidity and strength of these composite floor. The composite action between plywood and stringer, failure mode and ductility was also observed. The load that can be carried at service load and rigidity for deflection calculation was suggested.

MATERIALS AND METHOD

Materials

The stringer of the specimen was design using *renghas* (*Gluta L – Anacardiaceae*) species and the plywood was *albasia* (*Albizia falcata*). The variation of the specimen was the thickness of the plywood and the number of stringer. The specific gravity of *renghas* wood species and plywood was 0.60 and 0.25 – 0.30 respectively. The stringers dimension was 50 mm x 50 mm and the plywood thickness variation was 12 mm and 18 mm. The floor was made from double panel plywood and stringers. The plywood and stringers was fastened by nails at 25 mm spacing. The average moisture content, specific gravity, modulus of rupture and elastic modulus of the stringer and plywood were tested through some small clear specimen based on the ASTM D143, and the result was shown in Table 1.

Table 1. Properties of element

Element	Moisture content (%)	Specific gravity (G)	Modulus of rupture (MPa)	Elastic modulus (MPa)
Stringer/ renghas	14	0.60	70	6000
Plywood t=12 mm	11	0.30	35	4500
Plywood t=18 mm	13	0.25	25	3500
Nail	Diameter = 2 mm, length = 40 mm		Fyb = 240 MPa	

Eight specimens of composite stress skin panel made of 500 mm x 1200 mm double plywood panel with variation in plywood thickness and number of stringers as in Table 2 was introduced in this experimental study. Number of specimen was 2 for each variation.

Table 2. Specimens

Specimen no.	Dimension L x B x t (mm ³)	Number of stringers	Plywood thickness (mm)	Number of specimen	Weight (kg)
S12-3	1200 x 500 x 74	3	12	2	10.15
S12-4		4	12	2	13.30
S18-3	1200 x 500 x 86	3	18	2	13.68
S18-4		4	18	2	15.90

The cross section of the specimen was illustrated as in Figure 5 and 6.

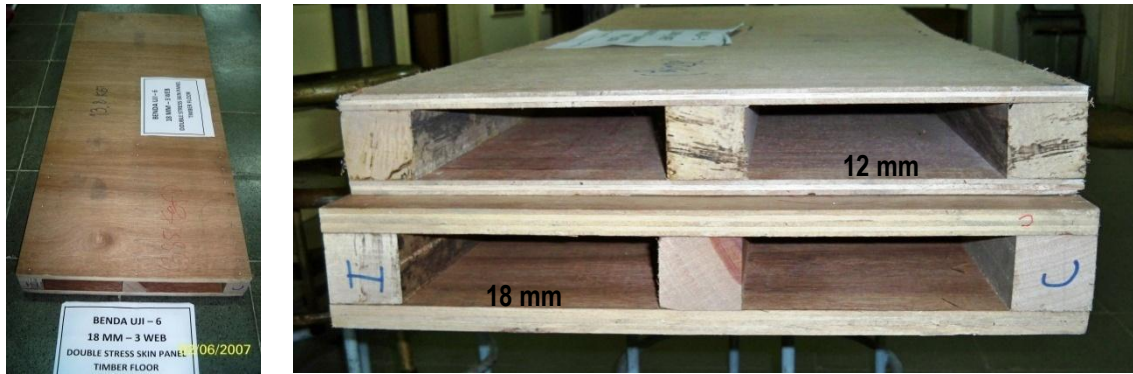


Figure 5. The composite of double plywood and three wood stringers stress skin panel (plywood thickness variation of 12 mm and 18 mm)

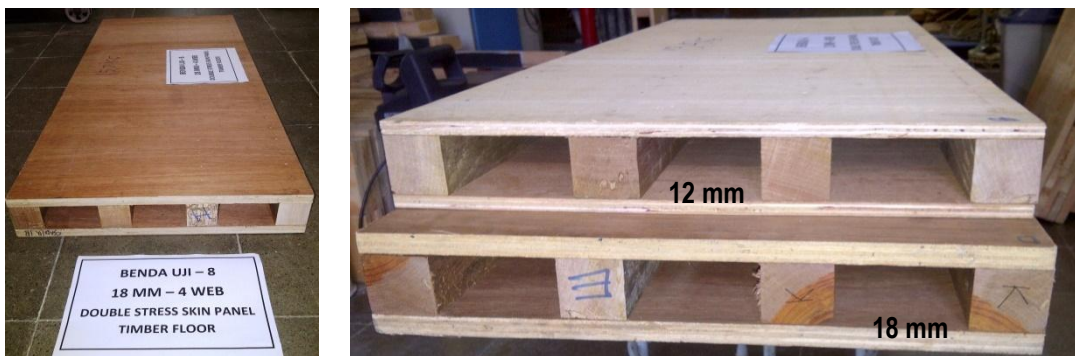


Figure 6. The composite of double plywood and four wood stringers stress skin panel (plywood thickness variation of 12 mm and 18 mm)

Testing Methods

This research based on the experimental study. The specimen was tested under third point loading test regarding to ASTM D198-05a as illustrated in Figure 7 and Figure 8. The central span displacement was measured using LVDT.

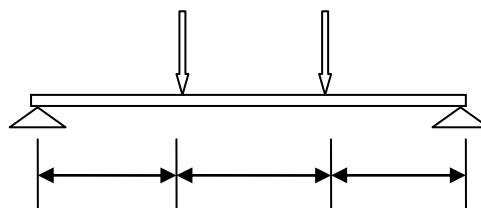


Figure 7. The schematic of floor on the third point loading test, ASTM D198-05a

The calculation of central point displacement, Δ , due to the two point loading and by neglected the shear deformation was:

$$\Delta = \frac{23 PL^3}{1296 (EI)e} \quad (1)$$

where: $(EI)e$ = effective floor rigidity (N/mm²)
 P = total point load (N)
 L = total span length (mm)



Figure 8. Setting of the specimen on the third point loading test

The effective rigidity $(EI)_e$ of floor from static uniform load test can be calculated by equations (2).

$$(2) \quad (EI)_e = \frac{23 P L^3}{1296 \Delta}$$

Where: $(EI)_e$ = effective floor rigidity (N.mm²)
 P = total load (N/mm²)
 L = span (mm)
 Δ = displacement (mm)

RESULTS

The result was plotted as load vs. displacement curves as in Figure 9 to Figure 12, and the load at allowable displacement (P_a), proportional load (P_p), ultimate load (P_u), and displacement related to each load was observed.

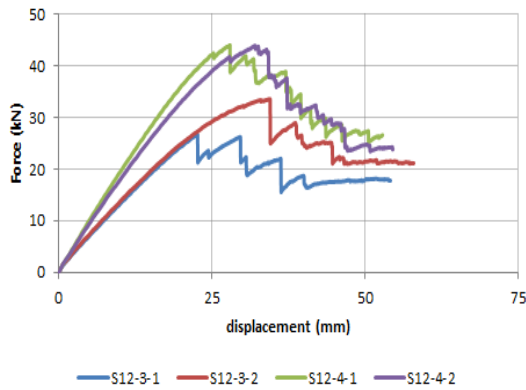


Figure 9. Load vs. displacement curve of double stress skin panel floor, plywood thickness 12 mm, 3 and 4 stringers

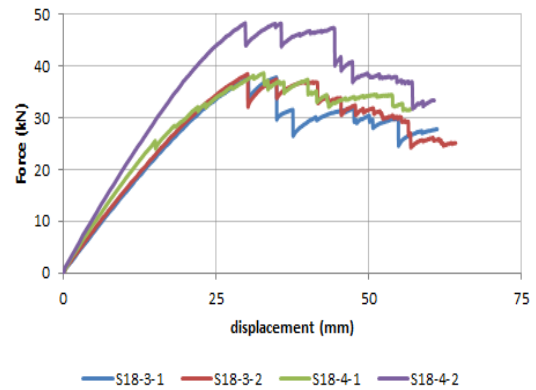


Figure 10. Load vs. displacement curve of double stress skin panel floor, plywood thickness 18 mm, 3 and 4 stringers

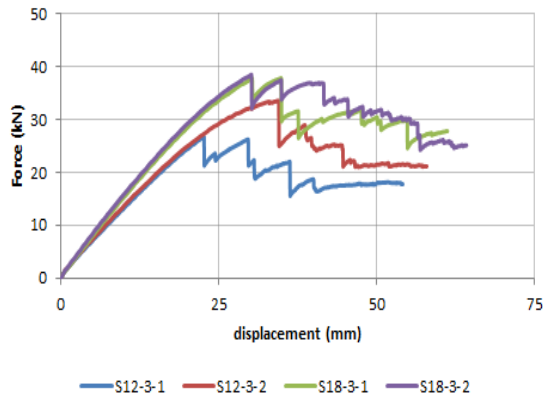


Figure 11. Load vs. displacement curve of double stress skin panel floor, 3 stringers, plywood thickness 12 and 18 mm

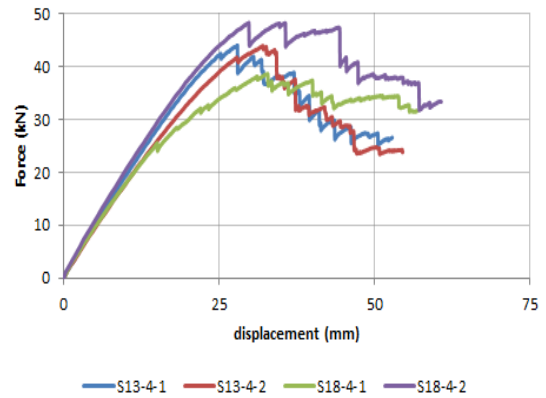


Figure 12. Load vs. displacement curve of double stress skin panel floor, 3 stringers, plywood thickness 12 and 18 mm

Failure Modes

The failure mode of all the floor occurred at ultimate load mainly in tension due to bending of the stringers as in Figure 13a, following the yielding of the nails between stringers and plywood. Some plywood was failed in tension because of the defect in plywood such as discontinues layer, Figure 13b. Some nails was also was pull out as in Figure 13c.

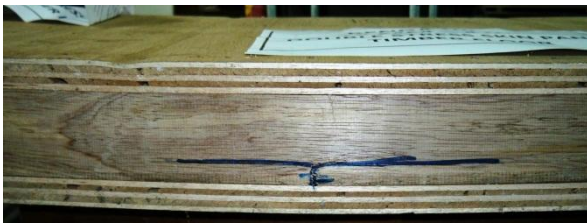


Figure 13a. Tension failure at stringer



Figure 13b. Tension failure at plywood

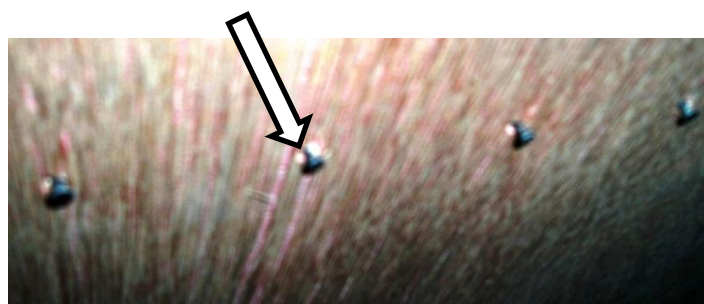


Figure 13c. Nails pull-out

ANALYSIS AND DISCUSSIONS

Table 3 presented the load at service (P_a), proportional load (P_p), ultimate load (P_u), and displacement related to each load that was observed from the curve and the ratio of loads and ductility was calculated.

The number of stringer seems significantly increased the rigidity and the strength of the floor (Figure 9, Figure 10 and Table 4) but the plywood thickness did not significantly increased the elastic

rigidity and strength (Figure 11, Figure 12 and Table 4). The ratio of ultimate to allowable load (P_u/P_a) was more than 5.0, it was extremely higher and that means giving sufficient safety factor due to failure.

Table 3. Ratio of load and displacement

specimen	P_a (kN)	Δa (mm)	P_p (kN)	Δp (mm)	P_u (kN)	Δu (mm)	P_p/P_a	P_u/P_a	P_u/P_p	$\Delta p/\Delta a$	$\Delta u/\Delta a$	$\Delta u/\Delta p$
S12-3-1	5.2 2	3.50	19.4 8	15.30	26.72	22.64	3.7	5.1	1.4	4.4	6.5	1.5
S12-3-2	5.4 7	3.50	19.7 7	15.00	33.58	34.48	3.6	6.1	1.7	4.3	9.9	2.3
S13-4-1	7.2 2	3.50	29.2 2	15.60	44.06	27.92	4.0	6.1	1.5	4.5	8.0	1.8
S13-4-2	6.8 7	3.50	24.9 7	14.40	43.94	32.04	3.6	6.4	1.8	4.1	9.2	2.2
S18-3-1	5.6 9	3.50	23.0 4	15.60	37.86	34.88	4.0	6.7	1.6	4.5	10.0	2.2
S18-3-2	6.1 2	3.50	22.6 8	14.90	38.51	30.16	3.7	6.3	1.7	4.3	8.6	2.0
S18-4-1	7.1 0	3.50	24.4 7	14.30	38.65	32.80	3.4	5.4	1.6	4.1	9.4	2.3
S18-4-2	8.0 1	3.50	32.8 2	17.00	48.31	29.76	4.1	6.0	1.5	4.9	8.5	1.8

From the result in Table 4, the equivalent allowable uniform load ($q_a-1.05m$) was calculated based on equivalent displacement of 3.5 mm. At the allowable displacement of 3.5 mm, e.g. S12-3-1 can carry 13.6 kPa of uniform load. It seems very high and the load and displacement in the curve was still in the elastic range and the moment ratio of load $P_a-1.05m$ to $q_a-1.05m$ is 1.02.

Based on the rigidity, at 1.8 span the equivalent allowable uniform load for $q_a-1.8m$ was calculated based on allowable displacement of 6.0 mm. It was found that (e.g) S12-3-1 can carry 2.69 kPa of uniform load and 1.51 kN of point load. Check on the moment ratio because of load $P_a-1.8m$ and $q_a-1.8m$ to $P_a-1.05m$ was 0.60 and 0.75 respectively. It can be concluded that the load and displacement was still in the elastic range.

Table 4. Rigidity and allowable load

specimen	(E)I _e (Nm ²)	$\Delta a-1.05m =$ L/300	$P_a-1.05m$ (kN)	$q_a-1.05m$ (kPa)	$\Delta a-1.8m =$ L/300	$P_a-1.8m$ (kN)	$q_a-1.8m$ (kPa)
S12-3-1	30640	3.5 mm	5.22	13.6	6.0 mm	1.51	2.69
S12-3-2	32078		5.47	14.2		1.58	2.82
S13-4-1	42380		7.22	18.7		2.09	3.72
S13-4-2	40325		6.87	17.8		1.99	3.54
S18-3-1	33414		5.69	14.8		1.65	2.93
S18-3-2	35923		6.12	15.9		1.77	3.15
S18-4-1	41690		7.10	18.4		2.06	3.66
S18-4-2	47002		8.01	20.8		2.32	4.13

CONCLUSION

These composite plywood-rengas double stress skin panel floor have a very good rigidity and strength. The longer span of 1.8 m may be used to carry 2.5 kPa of uniform live load. The allowable displacement requirement generally control the design rather than the strength. Since the load and displacement still in the elastic range and far away from the ultimate or inelastic range, allowable stress design is more suitable for designing this composite floor.

Some further research on the connection between these floor and to other structural elements such as beam or floor joist needs to be done.

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The flexural strength and rigidity of wood beam strengthening by wood plate connected by nails

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ABSTRACT

The flexural strengthening of wood beam using wood plate connected with nails was tested under destructive test. Seventeen mahoni (*Swietenia Jack – Meliaceae*) beam specimens were tested under third point loading. The variation of the specimens was the nail distance and wood plate species. The wood plate was made from either mahoni or keruing (*Dipterocarpaceae*). The destructive test using third point loading was done to observe the rigidity and the ultimate strength of the strengthened beam. The effect of different nail spacing and wood plate species on the increased of flexural strength and rigidity, failure mode and ductility was observed. The result of ultimate load and ductility of strengthened beams showed that the beam has an enough safety factor.

Keyword: strengthening, flexural strength, rigidity, failure mode.

INTRODUCTION

Retrofitting is become important at this time, many building with their structural element such as beam, column, floor and others has a degradation in strength, stiffness or either received more loads than their design load. Since this retrofitting has been done to many steel and concrete building, timber building also has the same matter. Gentile, 2001 did some flexural strengthening of timber bridge beam using FRP, Handoko, 2011 did some experimental study on the flexural strength of wood beam strengthening using steel reinforcement and Ali, 2012 did experimental study on the flexural strength of wood beam strengthening using FRP. All the results showed a significant increase in strength, rigidity and also ductility.

In this experimental study, seventeen beam made from mahoni species was tested, three beams as a reference and fourteen beam was strengthened using wood plate. The variation of the specimen was mahoni and keruing wood plate species and 10d, 25d and 40d nail spacing, Figure 1.

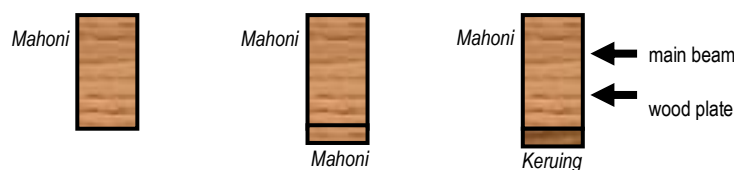


Figure 1. Specimen cross section variations

The aim of this study is to investigate the rigidity and strength of these strengthened beams. The action between main beam, wood plate and nail, failure mode and ductility was also observed. The percentage of additional load that can be carried and rigidity for deflection calculation was suggested.

MATERIALS AND METHODS

Materials

The entire main beam specimen was made from *mahoni* (*Swietenia Jack – Meliaceae*) species and the wood plate was made from either *mahoni* or *keruing* (*Dipterocarpaceae*). The main beam and wood plate cross section dimension was 50 mm x 100 mm and 50 mm x 20 mm. The specific gravity of *mahoni* and *keruing* was 0.48 and 0.70 respectively. The wood plate was fastened by two rows of nail at 20 mm, 50 mm and 80 mm spacing variations. The average moisture content, specific gravity, modulus of rupture and elastic modulus of the wood were tested through some small clear specimen based on the ASTM D143, and the result was shown in Table 1.

Table 1. Properties of wood and nail

Wood species	Moisture content (%)	Specific gravity (G)	Modulus of rupture (MPa)	Elastic modulus (MPa)
<i>mahoni</i>	14.6	0.48	54	8000
<i>keruing</i>	14.5	0.70	90	19000
Nail	diameter = 2 mm, length = 40 mm		Fyb = 240 MPa	

The arrangement of the specimen was shown as in Table 2.

Table 2. Specimen data

Specimen ^{*)}	Dimension L x B x H (mm ³)	Nail spacing (mm)	Wood plate species	Wood plate dimension (mm)	Number of specimen
M0	1800 x 50 x 100	-	-	-	3
MM-10D	1800 x 50 x 100	20	<i>mahoni</i>	50 x 20	3
MM-25D	1800 x 50 x 100	50	<i>mahoni</i>	50 x 20	2
MM-40D	1800 x 50 x 100	80	<i>mahoni</i>	50 x 20	2
MK-10D	1800 x 50 x 100	20	<i>keruing</i>	50 x 20	3
MK-25D	1800 x 50 x 100	50	<i>keruing</i>	50 x 20	2
MK-40D	1800 x 50 x 100	80	<i>keruing</i>	50 x 20	2

^{*)}M = *mahoni*, K = *keruing*, 0 = reference, 10D, 25D, 40D refer to nail spacing

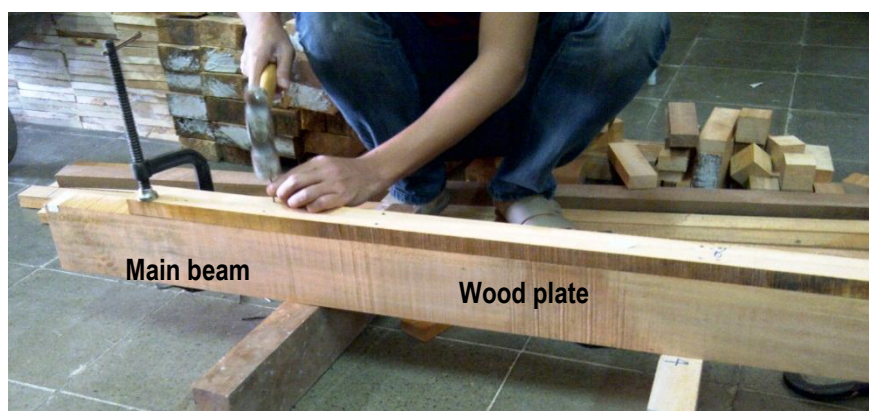


Figure 2. The wood plate fastened to the main beam by nails.



Figure 3. Two rows with 10d (20 mm) spacing of nails at MK-10D-2 specimens.

Testing Methods

This research based on the experimental study. The specimen was tested under third point loading test regarding to ASTM D198-05a as illustrated in Figure 4 and Figure 5. The central span displacement was measured using LVDT. The clear span was 1600 mm.

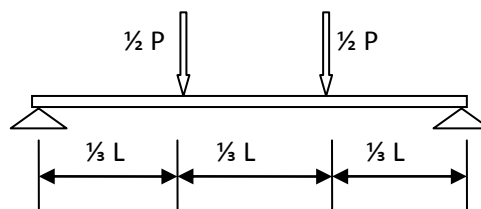


Figure 4. The schematic of beam on the third point loading test, ASTM D198-05a

The calculation of central point displacement, Δ , due to the two point loading and by neglected the shear deformation, (Gere, 2001) was:

$$\Delta = \frac{23 PL^3}{1296 (EI)_e} \quad (1)$$

where: $(EI)_e$ = effective beam rigidity (N/mm²)
 P = total point load (N)
 L = total span length (mm)

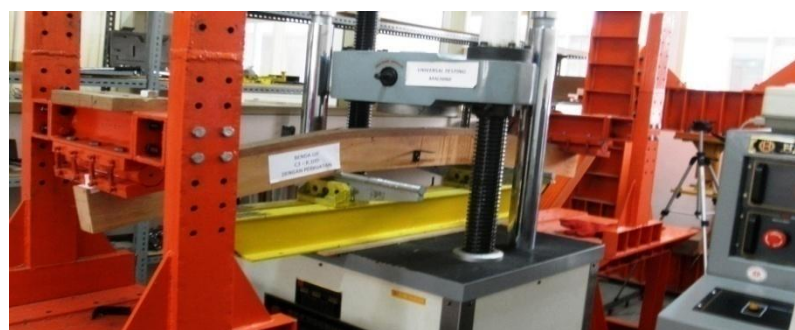


Figure 5. Setting of the specimen on the third point loading test

The effective rigidity $(EI)_e$ of beam from static uniform load test can be calculated by equations (2).

$$(EI)_e = \frac{23 P L^3}{1296 \Delta} \quad (2)$$

Where: $(EI)_e$ = effective beam rigidity (N.mm²)
 P = total load (N/mm²)
 L = span (mm)
 Δ = displacement (mm)

RESULTS

The result was plotted as load vs. displacement curves as in Figure 6 to Figure 11, and the load at allowable displacement (P_a) and ultimate load (P_u) was observed.

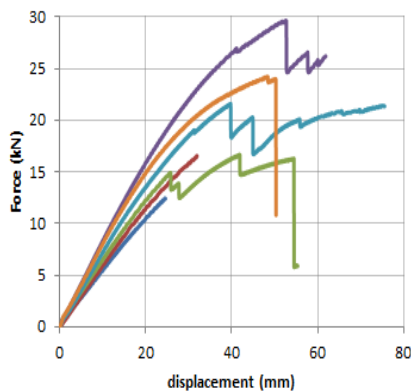


Figure 6. Load vs. displacement curve of *mahoni* beam strengthened by *mahoni* plate with 10 d nail spacing

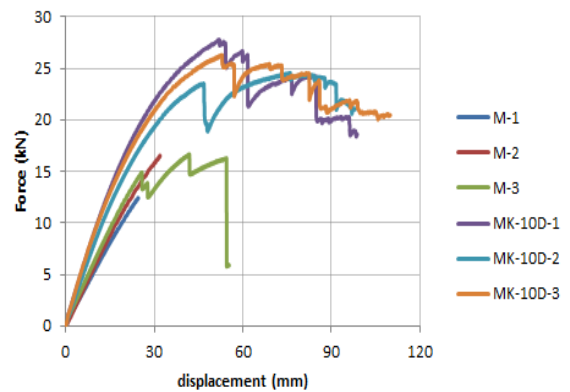


Figure 7. Load vs. displacement curve of *mahoni* beam strengthened by *keruing* plate with 10 d nail spacing

In Figure 6 and Figure 7, for the beam fastened with 10d nail spacing, it seems very clear that significantly increase in strength and stiffness was happened. The ductility for beam strengthened by *keruing* wood plate was also significantly increased. But for beam strengthened with nail spacing of 25d and 40d only increased a small value of rigidity.

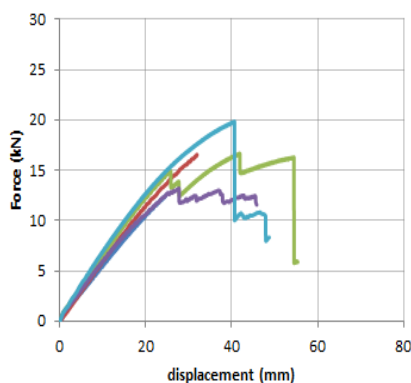


Figure 8. Load vs. displacement curve of *mahoni* beam strengthened by *mahoni* plate with 25 d nail spacing

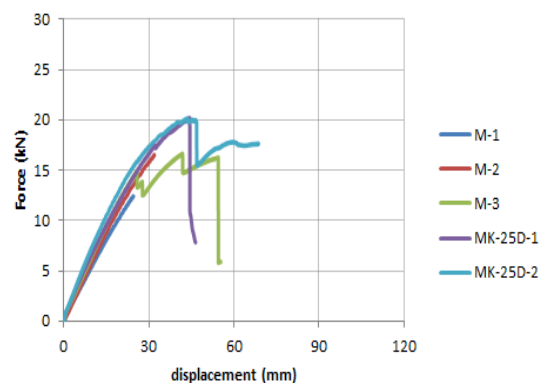


Figure 9. Load vs. displacement curve of *mahoni* beam strengthened by *keruing* plate with 25 d nail spacing

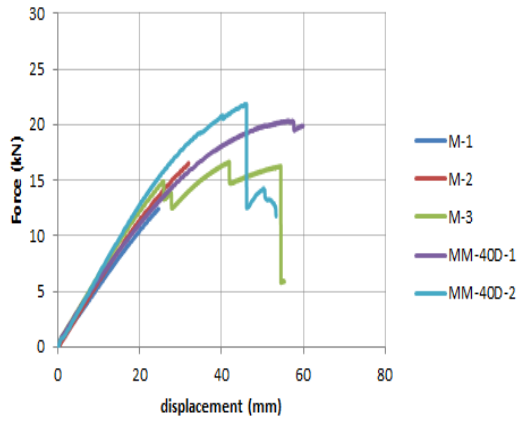


Figure 10. Load vs. displacement curve of *mahoni* beam strengthened by *mahoni* plate with 40 d nail spacing

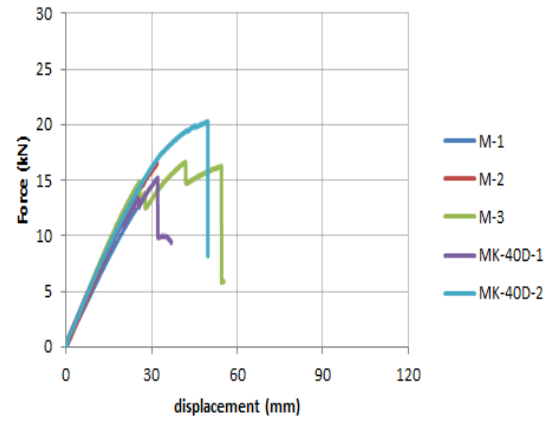


Figure 11. Load vs. displacement curve of *mahoni* beam strengthened by *keruing* plate with 40 d nail spacing

Failure Modes

The failure mode of all the beam occurred at ultimate load mainly in tension due to bending, either in main beam or wood plate as in Figure 12, 13 and 14. When the same wood species was used for beam and plate, and the nail spacing was 10d, the failure mode was tension in both elements, Figure 12. But when *keruing* was used as wood plate, and the nail spacing was 10d, the failure mode was tension failure in the main beam as in Figure 13. In the end of testing some nails also was pull out as seen in Figure 14.



Figure 12. Tension failure at wood plate following by tension failure on the main beam MM-10D-2



Figure 13. Tension failure on the main beam MK-10D-2

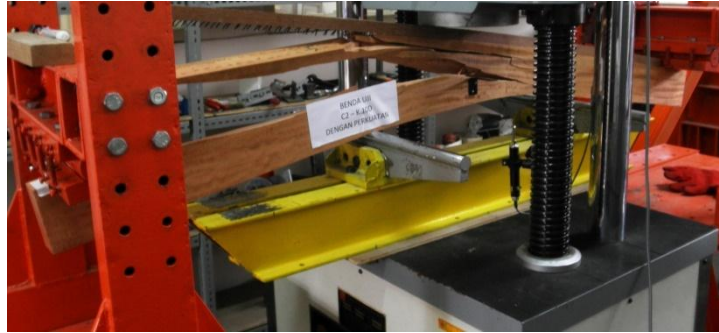


Figure 14. Tension failure on the main beam and nails pull-out MK-10D-2

ANALYSIS AND DISCUSSIONS

Table 3 presented the load at allowable displacement (P_a) and ultimate load (P_u) which was observed from the curve in Figure 6 to Figure 11, and then the ratio of loads, rigidity, percentage increase in strength and rigidity was calculated. Specimen no 1, 10 and 16 resulted in low ultimate strength because of cross grain. Reference beam specimen (no.2 and no.3) was used to make a comparison with strengthened beam.

At allowable displacement (5.5mm), specimen MM-10D increased their flexural strength from 19% to 36 %, rigidity 16% to 27% and at ultimate strength 30% to 79%. The higher value was happened when higher specific gravity 'keruing' was used as wood plate for MK-10D, see Table 3. The nail spacing of 40d have a small effect in increasing either the flexural strength or rigidity of MM-40D specimen.

Table 3. Percentage increased after retrofitting

No	specimen	P_a (kN)	Δa (mm)	P_u (kN)	$(EI)_e$ (Nm ²)	P_u/P_a	ΔP_a (%)	ΔP_u (%)	$\Delta(EI)_e$ (%)
1	M0-1*	3.125	5.5	12.430	45296	4.0			
2	M0-2	3.285	5.5	16.540	47615	5.0			
3	M0-3	3.730	5.5	16.650	54066	4.5			
4	MM-10D-1	4.600	5.5	29.640	66676	6.4	36.1	78.6	26.5
5	MM-10D-2	4.010	5.5	21.600	58124	5.4	18.6	30.1	15.7
6	MM-10D-3	4.475	5.5	24.200	64864	5.4	32.4	45.8	24.5
7	MK-10D-1	5.445	5.5	27.790	78924	5.1	61.1	67.4	37.9
8	MK-10D-2	4.675	5.5	24.550	67763	5.3	38.3	47.9	27.7
9	MK-10D-3	5.585	5.5	26.290	80953	4.7	65.2	58.4	39.5
10	MM-25D-1*	3.700	5.5	13.190	53631	3.6	9.5	-	8.6
11	MM-25D-2	3.585	5.5	19.840	51964	5.5	6.1	19.5	5.7
12	MK-25D-1	4.065	5.5	20.170	58921	5.0	20.3	21.5	16.9
13	MK-25D-2	4.410	5.5	20.220	63922	4.6	30.5	21.8	23.4
14	MM-40D-1	3.700	5.5	21.850	53631	5.9	9.5	31.6	8.6
15	MM-40D-2	3.585	5.5	20.370	51964	5.7	6.1	22.7	5.7
16	MK-40D-1*	3.660	5.5	15.250	53051	4.2	8.3	-	7.7
17	MK-40D-2	3.640	5.5	20.310	52761	5.6	7.7	22.3	7.1

CONCLUSION

The higher specific gravity of *keruing* (0.70) rather than *mahoni* (0.48) and the closer nail spacing of 10d increased significantly the flexural strength, rigidity and ductility of the strengthened beam compare to the reference beam. Since the ratio of ultimate load higher than load at allowable displacement this retrofit beam has an adequate safety factor. The used of nails is cheaper and more practical rather than using glue or embedded steel reinforcement.

Some further analysis and research on the correlation between specific gravity of main beam, wood plate and nail spacing may be develop to predict the flexural strength and rigidity of the strengthened beam.

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Effect of wood species and waiting time on bond strength of plywood

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INTRODUCTION

There are 4000 wood species in Indonesia (Memed, *et al.* 1981; and Kliwon, *et al.* 1984), but only 400 wood species have an important role in the future. From those sp, about 259 sp have been known in trade and they are classified into 120 wood trade name (Martawijaya, *at al.* 1981). This is based on the fact that those wood species are utilized, especially for veneer and plywood making. Plywood is by far the most important, in term of volume of all wood-based panel (FAO, 1963).

Prentice Hall (1990) states that plywood is a glued wood panel made up of relatively thin layers with the grain of adjacent layers at an angle, usually 90°. Each layer consist of a single thin sheet, or ply, or of two or more plies laminated together with grain direction parallel. The usual constructions have an odd number of layers. The outside plies are call faces or face and back plies, the inner plies are called cores or centers, and the plies with grain perpendicular to that of the face and the back are called cross-band. The core may be veneer, lumber, or particleboard, with the total panel thickness typically not less than 1/6 inch or more than 3 inches. The plies may vary as to number, thickness, species and grade of wood.

Hardwood Plywood Manufacturing Assosiation (1983) states that species for the face shall be hardwood species and if used for decorative face, any soft wood species may be used. Hermiati *et al.* (2006) stated that in plywood making, species of wood is an others factor that might affect bond strength. Wood species is one of so many factors that affect gluing. This might be because each species of wood has different properties, such as density, pH, moisture content and extractive.

Panis, (1963) stated that the properties of plywood are dependent upon three factors: (i) quality of the veneer; (ii) construction (number, thickness and orientation of plies); and (iii) the quality of the bond. Basic strength properties of the final product depend on the strength properties of the veneer making up the plywood and the quality of the bond between the plies.

Maloney (1977) stated that a number of parameters or factors affect the final bord properties, among the major factors are wood spacies, the binder type, and moisture content levels. Parameters in wood species include: density, acidity, moisture content and extractives, allmost all of those parameters interact with each other in one way or another.

1. **Species:** Of all the variables present in plywood, species is one of the most significant. It interacts with virtually every other variable that can be imagined in the process. It is reflect the type of raw material available. The formulating of the urea resin is determined by the species. Some species must has the moisture content more precisely controled; other wise the final board will blow or delaminate. Species is the most significant variable that the master blender has to content with particularly if there are the number of species entering the process line. If a single species or two simillar ones to use, then the importance of species as far as that plant is concerned diminisher as long as the final board are of the quality desired. Much of the problem of species variation can be handled by constantly subdividing the various type of raw materials reseived from various sources back together. Prentice Hall (1990) stated that the classifications for imported woods are based on descriptions found in the literature related to bond-ability, species properties, extarctives content and on industrial experience.

(1) **Density:** The most important species variable governing board properties is the density of wood raw material itself. The density or specific gravity has been the important factor in determining wich species are used for manufacture of plywood product. FAO (1966) and Kewilaa (2009) stated that wood species with density range from 0.40 – 0.70 g cm⁻³ are good for veneer and plywood making but the range from 0.50 to 0.55 is the best. Haygreen and Bowyer (1982) stated that the lower density species are often used for core and back of plywood faced with more expensive hardwood. Martawijaya et al (1981) stated that specific gravity of shorea leprosula is about 0.52 (0.30 – 0.86), and its pore size between 200 – 300 μ and the number of pores are 2 to

8 pores/mm². Then, Mandang and Pandit (1997) stated that specific gravity of terminalia catappa is about 0.41 – 0.78, and the number of pores per mm² are 2 to 4 pores.

- 2) **Acidity:** Another important species variable that require attention is the acidity, as measure by pH and buffering capacity. To utilize adhesive that are both economy and suitable to the type of operation used in the many plants, appropriate chemical condition must be established in the board plant using urea-formaldehyde resin binders. This is particularly important in plant using urea-formaldehyde resins. These conditions are dependent in part on maintaining a certain range of acidity in the cure. For a given species, the resin companies have developed binders that react properly within the normal range of acidity for that species. In some cases this can be achieved within the resin itself, whereas in others, it is necessary to add a separate catalyst to the resin before or after its application to the furnish. This separate addition of catalyst is required in urea resin for use with nonacid wood to avoid the very short storage life of highly catalyst resin. A number of species with wide ranging chemical characteristics can make it extremely difficult to provide the proper resin within a board plant. Species such as Douglas fir that have pH levels of approximately 4.00 to 5.00 provide a chemical situation where urea resin cure properly; however, small amounts of catalyst can be used to speed the cure. Species with higher pH levels need a catalyst added to the resin in order that the resin will cure during hot pressing. Most phenolic resin, however, do not require acid conditions for curing to take place.
- (3) **Moisture content:** Moisture content of the raw material is important in planning any plant since it will determine the required dryer capacity. If high moisture content material is anticipated at some in the future, this will have to be considered in the original design. Wide ranges in the moisture content of material entering a plant also causes productivity problem. Kollmann, *et al.* (1975) stated that in generally hardwood offer more difficulties than softwood. The higher the moisture content of wood is the lower becomes the strength of the glue joint and delaminating is possible. The specimen may be tested dry, in which case they shall have a moisture content of 8 to 12% at the time test, or they may be tested after soaking or boil test, depending on the type of information desired.
- (4) **Extractive:** Extractives are not part of the wood structure. They include tannins and other polyphenolics, coloring mater, essentil oil, fats, resins, waxes, gums, starch, etc. Extractive in wood may range between 5% and 30% in quantity. Some extractives in species cause problems such as the aforementioned blows. Western red cedar, for example, contains volatile material that turns to vapor during the hot-pressing operation, and this vapor can cause blowing and delamination problem at the end of the pressing period. Prentice Hall (1990) stated that extractive have three main effect on adhesive joint performance. First, in some species and under certain drying condition, extractives migrate to the surface. There they may concentrate and block adhesive from contact with the wood. Surfacing before bonding usually alleviates this problem. Second, certain resinous or oily extractives are naturally resistant to adhesion. Third, pH or chemical reactivity of and extractive may inhibit the normal hardening process of the adhesive so that its full cohesive strength does not develop.
2. **Binders:** Maloney (1977) stated that the predominant resins used in panel industry are urea-formaldehyde and phenol- formaldehyde. Urea resins make up by far the major portion of the binders used in the industry, not only in the United States but worldwide. Ureas are favored because of low price, ease of handling and fast curing in the press. They are also colorless and do not lend any unfavorable color to the final board product.

Prentice Hall (1990) stated that adhesive bonding is a key factor for efficient utilization of wood and is essential to the modern forest product industry. The ability of an adhesive to transfer stress from one member to another through a thin layer. Kollmann *et al* (1975) stated that the glue line dependent not only on the amount of spread per unit area of surface but also on the structure of the wood is important.

Prentice Hall (1990) stated that adhesives transfer load from one member (adherend) to another by surface attachment (adhesive bonding). The strength of adhesive bonded joint depends on the strength of each link in the joint. The performance of adhesive bonded joint then depends upon how well we understand and control the factors determining the strength of each link. The factors are: the

type of wood product, the surface quality of wood product, the adhesive, the bonding process, and the service environmental.

- 1) **The type of wood product:** Adhesives are used to bond wood solid form (lumber) and as veneer. Wood density is a crude but useful indicator of the ease of bonding. In general the strength of wood increases with its density. The strength of rigid-adhesive joint also increases with wood density up to about 0.70 to 0.80 g cm⁻³. Above 0.70 to 0.80, joint strength decreases again with our present adhesive system but different reasons. The wood failure on the surface of test joint decrease gradually up to density 0.70 to 0.80 then decreases more rapidly with further density increase. High-quality joint are more difficult to achieve consistently as wood density increases because: (1). Extractives that interfere with the development of adhesion and cohesion are more likely to be present, (2). Mechanical interlocking of the wood and adhesive is reduced, (3). Adequate surface mating is harder to attain, even with extra pressure, and (4). Shrinkage and springback stresses in the joint are higher.
- 2) **Surface quality:** Because adhesive work by surface attachment, the adherend's surface qualities are extremely important to satisfactory joint performance. Wood surface to be bonded should be smooth, true, and free of machine mark or other surface irregularities such as torn or chipped grain or planer skip. The surface should be free of extractives, dirt and other debris.
- 3) **Adhesives:** The adhesive pH is another important factor in wood bonding. The adhesive may be acidic, neutral, or alkaline. Alkaline adhesive (such as hot-pressed phenolic formaldehyde resin) or an alkaline pretreatment of the wood surface are sometimes favored for difficult-to-bond woods containing adhesive resistant extractives and also certain preservative treatments. Some wood (like oak) are quite acidic and may interfere with the cure of alkaline or neutral-curing adhesives.
- 4) **Bonding process:** The moisture content of wood at the time of bonding has much to do with the final strength and durability of joint, the development of checks in the wood, and dimensional of the bonded assembly. Large changes in the moisture content of wood after bonding cause shrinking or swelling stresses that may seriously weaken both the wood and the joint. Because different wood species vary in their absorptivity, a given adhesive mixture may penetrate more into one wood than into another under the same bonding condition. A moderate amount of such penetration is desirable, especially if the wood surface tend to be somewhat torn and damaged. Excessive penetration, however, wastes adhesive and may result in starved (totally absorbed) bondlines.

Bodig and Jayne (1982) stated that for some uses of plywood such data are inadequate and special test have been devised for direct application to this composite. Both quality control test and property evaluation test are in use. The plywood shear test used for evaluation of glue-bond quality is the most widely used of the quality control test. Specimen dimensions and configuration the depth of the notches in the central plies for the 3-ply are as shown in Fig. 1. The specimen is gripped at both ends and the entire unit loaded in tension (Fig. 2). The load at failure recorded upon completion of the test is converted to a shear stress using the area bounded with so-called exterior adhesives may be tested after boiling in water for a specified period of time.

Kollmann *et al* (1975) stated that the test specimen shall be normally 1 in (2.5 cm) in width, $3\frac{1}{4}$ in (8.25 cm) in length, and of a thickness equal to that of three-ply plywood selected.

Prentice Hall, (1990) states that In structural design of plywood, the strength of plywood can be computed by formulas relating the plywood properties to the construction of the plywood and to the properties of particular wood species of component plies. Testing all of the many possible combinations of layer thickness, species, number of layers, and variety of structural components is imperitcal. The various formula developed mathematically and presented here were checked by test to verify their applicability. For example; shear strength about 250 – 300 psi (20 – 24 kg cm⁻²). The mechanical and physical properties of LVL are affected by many factors such as wood species, veneer thickness, quality and processing variables (Hing *et al.*, 2001 in Naserian *et al.*, 2011). The treatment is one of the processes used to modify the properties of wood include shearing strength (Mazela *et al.*, 2004 in Naserian *et al.*, 2011).

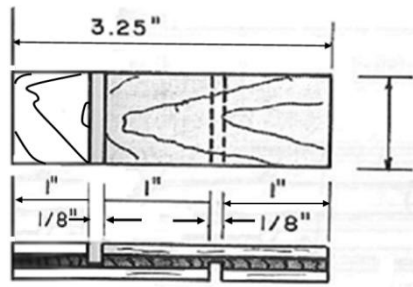


Fig. 1. Plywood Shear test Specimen used for Evaluating glue-bond quality for 3-ply plywood (Bodig and Jaine, 1982)

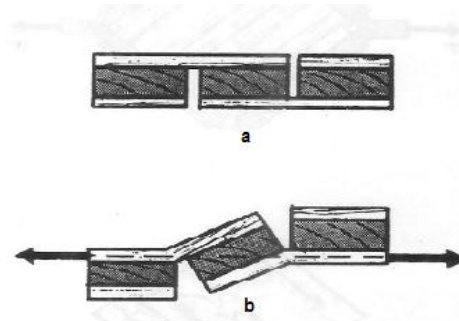


Fig. 2. Deformation of a plywood shear specimen: (a) original geometry, (b) specimen under load (Bodig and Jaine, 1982).

Previous studies showed that strength of wood decreased with any treatment (Yildiz, 2002 in Naserian *et al.*, 2011). It is well known that the wood species composition can have an impact on mechanical properties. Low wood density, numerous knots appear to be major factors contributing to low veneer stress grading, resulting in a production of low-quality veneer (Zhang *et al.*, 2004 in Naserian *et al.*, 2011). Efficient usage of LVL in the construction industry requires an understanding of the structural behavior of numerous species and knowledge about the effects of the wood species composition and waiting time on mechanical properties of LVL.

The properties of wood adherent always have a distinct affect on the properties of glue joints (Kollmann, *et al.* (1975). The pretreatment of the wood to be glued should be taken into consideration as well as species and moisture content. Impurities can reduce the strength of glue joints if they appear in the glue line or on the surface of wood. The thickness of glue line dependent not only on the amount of spread per unit area of surface but also on the structure of the wood is important.

Kollmann, *et al.* (1975) stated that in generally hardwood offer more difficulties than softwood. The higher the moisture content of wood is the lower becomes the strength of the glue joint and delaminating is possible.

Kollmann, *et al.* (1975) stated that close waiting time of glue assembled material prior to pressing is important. Some general principles for good join design:

1. The bond area should be as large as possible
2. The maximum proportion of the bonding area should contribute to the joint strength.
3. The adhesive should be stressed in the direction of its maximum strength.
4. Stresses in the weakest direction of the adhesive line should be minimized

Sutigno, (1988) stated that the range of plywood shear strength for Indonesia Standard are below 17.6 kg cm^{-2} , between $17.6 - 24.6 \text{ kg cm}^{-2}$ and more than 24.6 kg cm^{-2} .

Prana, *et al.* (2002) suggested that the future task was to complete the information provided by the various among species by research. The variation among species was among: specific gravity (density), moisture content, acidity and extractive.

From the above literature review that shearing strength is affected by various factors, ie: wood species composition and waiting time. Therefore, the aims of this study were put forward to the effects of wood species veneer composition and waiting time treatment, on the bond strength.

MATERIALS AND METHODS

Materials and equipment

The materials used in this research are urea formaldehyde glue and 2 wood species, Terminalia catappa and Shore leprosula. at PT. Artika Optima Inti.

The equipments required in this study are rotary lathe, circular saw, pressing machine, curtain, oven, desicator and universal testing machine.

Research Procedure

We used shorea leprosula and terminalia catappa, two hardwood species growing in Molucas Seram. Veneers are found from rotary lathe, drying until its moisture content among 13 %. The veneers needed are 18 pcs (122 cm x 244 cm) including 3 pcs of terminalia catappa, and 3 pcs of shorea leprosula for faces veneer; 3 pcs of terminalia catappa and 3 pcs of shorea leprosula for back veneer; and then 3 pcs of terminalia catappa and 3 pcs of shorea leprosula for core veneer. The veneers are cutting to find 30 cm x 30 cm measurement. To spread the glue to core veneer about 30 g/900 cm² of single glue line (0.03 g cm⁻²), after that the face and back veneer are assembling. After assembling the sample is pressed (cold press) with 8 kg cm⁻² during 20 minutes. Waiting time 15, 25, 35 minutes are given before hot press. Time press is about 2 minutes and 40 second, by pressure pressing 12.8 kg cm⁻² at the temperature 110⁰ C. After hot pressing, panels were allowed to cool for 24 hour then trimmed. About 36 specimens, 8.26 cm long by 2.54 cm wide by 4.4 mm thick, were used to determine the bond strength for type II (interior). Three replicates were taken for each type of wood species composition plywood and waiting time treatment. The samples are prepared and stated shear area 12.7 mm x 25.4 mm. and then make the notch 2/3 depth of inner ply.

The specimens were submerged in the water at temperature 60⁰C plus min 3⁰C. After 3 h, the specimens were cooled in cold water 15 minutes and removed them; extra water at the surface was wiped off with tissue paper and test were taken of shearing strength. The Shearing strength can be measured by shearing testing machine at the plywood industry. Bond strength was calculated as a kg cm⁻².

Test procedure by Anrew De Wolfe (2012):

1. Measure the amount of shear area in square centimeters.
2. Load each end of the specimen in the tensile grips.
3. Apply a force at a controlled rate to the specimen until it breaks and record the maximum force.

Method for collecting data by Andrew De Wolfe (2010): Test Report: 1). Maximum force, 2).

Maximum shear stress; Divide the maximum force by the shear area and report in units of kilogram/square centimeter, or bond strength can be stated by formula:

$$\text{Shearing Strength} = B/L \text{ (kg cm}^{-2}\text{)}$$

Where: B = shearing load

L = wide of shearing area

The experimental results were statistically analyzed using completely randomized design analysis, and significant or high significant effect of wood species composition, waiting time and their interaction on bond strength were determined by using F test (Steel and Torrie, 1981).

Data analysis

The statistical analysis used in this research was completely random design, with 2 factor and 3 replication: A factor (wood species composition) with 4 levels, ie:

- a1 = Shorea, terminalia, shorea (STS)
- a2 = Terminalia, Shorea, Terminalia (TST)
- a3 = Shorea, shorea, shorea (SSS)
- a4 = Terminalia, terminalia, terminalia (TTT)

B factor (waiting time) with 3 levels, ie:

- b1 = 15 minute after cold press
- b2 = 25 minutes after cod press

b3 = 35 minutes after cold press

The mathematical model by Steel and Torrie, (1981), is:

$$Y = \mu + \alpha_i + \beta_j + \alpha_i\beta_j + \epsilon_{ij},$$

where: Y = experiment value/shear strength
 μ = expected value
 α_i = effect of wood species composition
 β_j = effect of waiting time
 $\alpha_i\beta_j$ = effect of interaction between wood sp and waiting time
 ϵ_{ij} = experiment error

RESULT AND DISCUSSION

Result

Observation data (Appendix 1) show that the average bond strength of sample is 21.11 kg cm⁻², a₂ (TST) treatment has highest value bond strength (24.31 kg cm⁻²) and a₄ (TTT) treatment has lowest value (18.60 kg cm⁻²). Data on Appendix 2 show that b₁ (waiting time 15 minute) treatment gives highest value (21.57 kg cm⁻²) but b₂ (waiting time 25 minute) treatment gives the lowest value (20.55 kg cm⁻²).

The analysis result of variance in Table 1 show that wood species gives high significant effect on bond strength, but waiting time and their interaction not give significant effect on bond strength with the coefficient of variability is 16.45%.

Table 1. Analysis of variance the effect of wood species and waiting time on shearing strength

SV	Df	SS	MS	F _{cal}	F _{Table}	
					5%	1%
A	3	163.78	54.59	4.49**	2.17	2.92
B	2	6.38	3.19	0.26 ns	2.01	2.77
AB	6	61.73	10.28	0.85 ns	2.43	3.17
Error	24	291.27	12.14			
Sum	35	523.16				

Remarks: ns = non significant

** = high significant

$$\text{The coefficient of variability} = \frac{\sqrt{MSE}}{\text{Average}} \times 100\% = \frac{\sqrt{12.14}}{21.11} \times 100\% = 16.45\%$$

The test criterion for looking at differences between means directly is given by:

$$\text{Lsd (0.05)} = 2.064 \sqrt{\frac{2(12.14)}{3}} = 5.91$$

$$\text{Lsd (0.01)} = 2.797 \sqrt{\frac{2(12.14)}{3}} = 7.94$$

Table 2 shows the least significant difference between shear strength means in wood species composition (A) treatments. The test criterion for looking at differences between means directly is called the least significant difference or Lsd.

Table 2. Differences between shear strength means in wood species composition treatment experiment.

Treatment	Differences			
a ₂ (TST)	24.31			
a ₁ (STS)	21.60	2.71ns		
a ₃ (SSS)	20.38	3.93 ns	1.22ns	
a ₄ (TTT)	18.60	5.71 **	3.00 ns	2.78ns
Lsd 0.05 = 5.96				
Lsd 0.01 = 7.84				

Discussion

a. Effect of wood species composition on shearing strength

Martawijaya *et al.* (1981) stated that specific gravity of shorea leprosula is about 0.30 – 0.86 (average is 0.52), and Mandang and Pandit, (1997) stated that specific gravity of terminalia catapa is about 0.41 – 0.78 (average is 0.58).

Wood species composition TST **treatment** (Appendix 1) has highest bond strength because the specific density of shorea leprosula is lower than the specific density of terminalia catapa, so that shorea leprosula correct as inner ply because its structure is coarse and terminalia catapa correct as outer ply because its structure is fine (Martawijaya *et al.* 1981 and Mandang and Pandit, 1997).

In the other hand, the arrange of pores of shorea leprosula is ring porous and terminalia catapa is diffuse porous (Martawijaya *et al.* 1981 and Mandang and Pandit, 1997). It mean that both have different size of pore, so that it cause the differentiation in glue bond area and it can affect the differentiation on bond strength. The statement was agreed with Kollmann *et al.* (1975), that one principle for good joint design is the bond area should be as large as possible.

Statistical analysis (Table 1) showed that wood species composition treatment give high significant effect on bond strength. It means that all species composition treatments give the different response on bond strength. The statement agreed with Maloney (1977), that wood sp affected the final board properties,

The data (Appendix 1) showed that the bond strength of wood species composition treatments was among 18.60 kg cm⁻² until 24.31 kg cm⁻², and the data is in intervals 17.6 – 24.6 kg cm⁻² for Indonesia Standard of shear strength.

Table 2 shows the least significant difference between shear strength means in wood species composition (A) treatments. The test showed that only a₂ (TST) treatment gives high significant different on shear strength with a₄ (TTT) treatment.

b. The effect of waiting time on shearing strength

Data in appendix 1 showed that the longer of waiting time the bigger shear strength at STS treatment, it means that the longer waiting time cause adhesive cure completely. For SSS treatment, the longer of waiting time the smaller shear strength, it means that waiting time 15 minute is enough to adhesive cure. Kollmann, *et al.* (1975) stated that close waiting time of glue assembled material prior to pressing is important, because glue can be transfer and penetrate to other veneer clearly.

Statistical analysis (Table 1) showed that waiting time treatment not give significant effect on bond strength, it mean that the different waiting time treatments give the same response on bond strength.

The data (Appendix 2) showed that the bond strength of waiting time treatments was among 20.55 kg cm⁻² until 21.57 kg cm⁻², the data in intervals 17.6 – 24.6 kg cm⁻² for Indonesia Standard of shear strength.

c. The interaction effect among wood species composition and waiting time on bond strength.

Data in appendix 1 showed that the interaction of TST treatment and 25 minute waiting time treatment (a_2b_2) gives an highest bond strength, but the interaction among TTT composition and 25 minute treatment (a_4b_2) gives a lowest bond strength. Maloney (1977) stated that wood sp affect the final board properties, and Kollmann, *et al.* (1975) stated that close waiting time of glue assembled material prior to pressing is important. But statistical analysis (Table 1) showed that the interaction among wood species composition and waiting time not give significant effect on bond strength, it mean that all interaction treatment between wood species composition and waiting time give the same response on bond strength.

For wood species composition, the bond strength decreased from TST, STS, SSS to TTT treatment, there are about 24.31; 21.60; 20.38 and 18.80 kg cm⁻². For STS composition, bond strength increases from 15 minutes to 35 minutes waiting time (20.60; 21.57 and 22.63 kg cm⁻²), but for SSS composition, bond strength decreases from 22.37; 19.80; 17.60 kg cm⁻² respectively.

According to the results obtained in this study, bond strength increase from TTT composition treatment to TST treatment but nothing by increasing waiting time.

The data showed that the bond strength treatments (interaction between wood species composition and waiting time) were among 17.6 kg cm⁻² until 24.63 kg cm⁻² for Indonesia Standard of Shear Strength, except TTT and 25 minute treatment below 17.6 kg cm⁻² (16.20 kg cm⁻²).

The sample of TTT composition has the potential to be significantly lower in bond strength than the sample from the TST composition; the magnitude of reductions varies by wood species.

Kretschmann *et al.* (1993) in Naserian *et al.* (2011) studied effect of various proportion of juvenile wood on properties of laminated veneer lumber and showed that a significant difference exists between materials manufactured with different material mature having the same nondestructive grade. In this study, both shorea leprosula and terminalia catappa showed a predictable decrease in strength from TST to TTT.

In general, the results of this study on the effect of wood species composition and waiting time treatment on shearing strength are compatible with the findings in the literature on the effect of wood species composition treatment and waiting time on different sample.

The results of research showed that shearing strength can be influenced by wood species but not by waiting time and their interaction. A reduction in wood species composition treatment was observed for TTT sample from 9.57% in SSS treated to 30.69% in the TST treated (Appendix 1).

CONCLUSIONS AND SUGGESTION

Conclusion

Based on this research and its analysis, it can be concluded that wood species composition, waiting time and their interaction give contributes to determine the shearing strength but statistical analysis showed that only wood species composition gives significant effect on shearing strength.

The shearing strength of wood species composition treatments was among 18.60 kg cm⁻² until 24.31 kg cm⁻², the data in interval 17.6 – 24.6 kg cm⁻² for Indonesia Standard.

TST and 25 minutes treatment has the highest bond strength, but TTT and 25 minutes treatment has the lowest bond strength.

Suggestion

This research that has been conducted concern to effect of wood species composition and waiting time on shearing strength. It suggests that:

1. Following research need to be conduct to determine others wood species composition and waiting time effect on shearing strength.
2. The waiting time 15 minute is enough to give the highest shearing strength.

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Appendix 1. Bond strength data (priority for wood species composition)

Wood sp composition (A)	Waiting time (B)	Replication			Total	Average
		1	2	3		
a1 (STS)	b1 (15 minute)	13.30	32.10	16.40	61.80	20.60
	b2 (25 minute)	22.50	25.00	17.20	64.70	21.57
	b3 (35 minute)	24.90	24.70	18.30	67.90	22.63
	Sub Total	60.70	81.80	51.90	194.40	21.60
a2 (TST)	b1 (15 minute)	24.00	26.10	21.10	71.20	23.73
	b2 (25 minute)	23.50	25.80	24.60	73.90	24.63
	b3 (35 minute)	24.10	23.70	25.90	73.70	24.57
	Sub Total	71.60	75.60	71.60	218.80	24.31
a3 (SSS)	b1 (15 minute)	19.10	26.50	21.50	67.10	22.37
	b2 (25 minute)	18.10	23.80	17.50	59.40	19.80
	b3 (35 minute)	9.00	24.50	19.30	52.80	17.60
	Sub Total	48.20	74.80	58.30	179.30	20.38
a4 (TTT)	b1 (15 minute)	25.90	17.90	14.90	58.70	19.57
	b2 (25 minute)	22.10	9.40	17.10	48.60	16.20
	b3 (35 minute)	20.90	20.90	18.30	60.10	20.03
	Sub Total	68.90	48.20	50.30	167.40	18.60
T o t a l		247.40	280.40	232.10	759.90	21.11

Appendix 2. Bond strength data (Priority for waiting time)

Wood sp composition (A)	Waiting time (B)	Replication			Total	Average
		1	2	3		
a1 (STS)	b1 (15 mnt)	13.30	32.10	16.40	61.80	20.60
a2(TST)		24.00	26.10	21.10	71.20	23.73
a3(SSS)		19.10	26.50	21.50	67.10	22.37
a4(TTT)		25.90	17.90	14.90	58.70	19.57
Sub Total (b1)					258.80	21.57
a1(STS)	b2 (25 mnt)	22.50	25.00	17.20	64.70	21.57
a2(TST)		23.50	25.80	24.60	73.90	24.63
a3 (SSS)		18.10	23.80	17.50	59.40	19.80
a4 (TTT)		22.10	9.40	17.10	48.60	16.20
Sub Total (b2)					246.60	20.55
a1 (STS)	b3 (35 mnt)	24.90	24.70	18.30	67.90	22.63
a2 (TST)		24.10	23.70	25.90	73.70	24.57
a3 (SSS)		9.00	24.50	19.30	52.80	17.60
a4 (TTT)		20.90	20.90	18.30	60.10	20.03
Sub Total (b3)					254.50	21.21
Average						21.11

Effects of Shelling Ratio and Particle Characteristic on Physical Properties of Three-Layered Particleboard Made From Different Wood Species

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ABSTRACT

Wood waste materials such as flakes, particles, sawdust, planer shaving, which are residue from furniture industry can be utilized to manufacture many composites such as particleboard. The most commonly used particleboard has three layers: two face layers and one core layer. The face layers consist of fine particles, and the core layer is made of coarse particles. This study is aimed to show the effect of shelling ratio and particle characteristic on physical properties of three-layered particleboard with high density core layer (matoa hammermilled particles) and different particle on surface layer. The materials used in this study were hinoki (*Chamaecyparis obtusa*) strand and knife-milled douglas-fir (*Pseudotsuga manziesii*) as surface layer and hammer-milled matoa (*Pometia* sp.) as core layer. Those wood particles were collected from wood company. Adhesive used was MDI resin (methylene diphenyl diisocyanate) 6 % content in mat. Pressing condition were: temperature of 180 °C, pressure of 3 MPa, pressing time of 5 minutes. The target density was 0.72 g/cm³ with board size of 340 mm x 320 mm x 10 mm. Factors used in this study were layer structure according to boards shelling ratio and particle characteristic. The parameters of this study were: density, moisture content, thickness swelling, water absorption, linear expansion and vertical density profile. This study indicates that all boards meet the requirements of JIS A 5908-2003. Higher shelling ratio of surface layer resulted higher performance of three-layered particleboard. In terms of particle type, hinoki strand showed the best performance in board density and linear expansion while douglas fir particle showed the best performance in moisture content, thickness swelling and water absorption. Improvement the physical properties of particleboard with high density wood particle in core layer can be conducted by adding surface layer with higher quality wood particle such as hinoki strand or douglas fir particle. Hinoki strands as surface layer contribute on higher enhancement of three-layered particleboard with matoa as core layer than douglas-fir particle.

Keywords: shelling ratio, particle characteristic, three-layered particleboard, physical properties

INTRODUCTION

Wood supply is decreasing fast around the world, while wood products demand is increasing parallel to the number of world population. Thus the wood products become scarcity and their prices climbing up fast. Biocomposites technology is developed in order to supply alternatives of wood products. This technology converts some waste of the conventional wood processing to useful products by using wood adhesion technology. Wood composites can utilise lowgrade logs such as thinnings and bowed and twisted logs. They can also use wood waste material. There are much waste wood from furniture industry. It can be flakes, particles, sawdust, planer shaving, etc. These residues can be utilized to manufacture many composites such as particleboard. We can use knife-milled douglas-fir or hammer-milled hinoki. Both of them are softwood. Hinoki are the second famous wood in Japan and we can find easily its wood waste from furniture industry in Japan. Matoa, one of hardwood has possibility to use for particleboard production although its particles are originally low quality.

Particleboard is mainly composed of wood particles and an adhesive. Wood particles are mixed or coated with an adhesive, and then formed into a mat that is further hot-pressed to form a panel products (Youngquist, 1999). The most commonly used particleboard has three layers: two face layers and one core layer. Structures of these layers differ markedly. The face layers consist of fine particles, and the core layer is made of coarse particles. The face layers, made of smaller chips with a higher resin content, have a greater compaction ratio and density, and in consequence better mechanical properties (Wilczynski and Kociszewski, 2010).

It is well known that wood species and particle size used influence the bending strength of three-layer particleboard. Important indicators of particleboard quality are their mechanical and physical

properties. Moslemi (1974) and Maloney (1993) determined that with decreasing density of raw materials and increasing compaction ratio the bending strength increases as well. According to Moslemi (1974), there are several options in order to obtain high quality particleboards according to layering such as : (a) a higher adhesive content in the face layer, (b) different particles in the face layer (smaller, thinner), (c) lower density wood species in the face layer, (d) processing techniques which reduce compression strength of the face particles, and (e) surface particle orientation kept constant. In this study, second and third options are used.

There are two different elastic bodies (surface and core layer) in the three-layered particleboard using matoa as core layer and hinoki/douglas-fir as surface layer. The question is how layer structure and particles mixture affect the quality of particleboard made from different wood species. This study is aimed to show how layer structure enhance the physical properties of 3-lay bond with high density core layer (matoa hammermilled particles). Therefore, the objectives of this study was to determine the effect of layer structure and particles mixture on the physical properties of particleboard produced from different sources of wood particles.

MATERIALS AND METHODS

Boards Manufacturing

The particles used in this study were hinoki (*Chamaecyparis obtusa*) strand and knife-milled douglas-fir (*Pseudotsuga manziesii*) as surface layer and hammer-milled matoa (*Pometia* sp.) as core layer. Those wood particles was collected from wood company. Adhesive used was MDI resin (methylene diphenyl diisocyanate) 6 % content in mat. A blending box was used to mix the particles and resin adhesive. The adhesive mixed wood particles were placed in a forming box by hand to form a one and three layer of wood particles mat. The resulting three-layered wood particle mat was hand-pressed with a flat plywood panel and then hot-pressed. Pressing condition were: temperature of 180 °C, pressure of 3 MPa, pressing time of 5 minutes. The target density was 0.72 g/cm³ with board size of 340 mm x 320 mm x 10 mm. Three particleboard panels were prepared for each experimental variable, therefore 27 pieces particleboards were produced. After manufactured, the boards keep into conditioning room during approximately two weeks.

Boards Evaluation

The parameters of this study were : Density (ρ), Moisture Content (MC), Thickness Swelling (TS), Water Absorption (WA), Linear Expansion (LE) and Vertical Density Profile (VDP). Prior the evaluation, the boards were cut into 280 x 280 mm in size, and then measured the density (ρ) by measuring its weight (w) and volume (v). Boards density were calculated as follow:

$$\rho = \frac{w}{v} \text{ (g/cm}^3\text{)} \quad (1)$$

Moisture content (MC) of particleboards manufactured was measured by specimens measuring 50 x 50 mm. Six specimens were used for each treatment. The specimens were measured the weight (W_1) then put into oven at temperature of 103±2 °C for 24-h. After treatment, the weight of specimens were measured again to obtain oven-dry weight (W_0). MC was calculated as follow:

$$MC (\%) = \frac{W_1 - W_0}{W_0} \times 100 \% \quad (2)$$

Thickness swelling (TS) and and water absorption (WA) test were conducted according to JIS A 5908 (2003). The testing consisted of immersion in water at 20°C during 24 hours. Four specimens of each treatment with dimension of 50 x 50 mm were used for TS and WA measurement. Prior and after treatment, the thickness and weight were measured. The TS and WA were calculated by these formula:

$$TS (\%) = \frac{\Delta h}{h_o} \times 100 \% \quad (3)$$

$$WA (\%) = \frac{\Delta W}{W_o} \times 100 \% \quad (4)$$

where Δh is change of thickness (mm), h_o is initial thickness (mm), ΔW is change of weight (g) and W_o is initial weight (g).

Linear expansion (LE) measurement was conducted to evaluate the dimensional stability in the plane direction. The measurement was done according to Suzuki and Miyamoto (1998), Miyamoto *et al.* (2002) and ASTM D-1037 (1999). Two specimens of each treatment with dimension of 280 x 50 mm were used based on initial measurements taken after boards are dried at 60°C during 22 hours. The length and change of length of the samples were measured under humid condition of 40 °C and relative humidity (RH) of 90% for 120 hours and then under dry condition of 60°C for 120 hours using a dial gauge comparator. The LE was calculated by this formula:

$$LE (\%) = \frac{\Delta l}{l_o} \times 100 \% \quad (5)$$

where Δl is change of length (mm) and l_o is initial length (mm).

Vertical density profile (VDP) is density gradient in the thickness direction of the boards. It was determined using commercial density profiler based on gamma radiation system and conducted in Forestry and Forest Products Research Institute (FFPRI) Tsukuba. Four specimens of each board with dimension of 50 x 50 mm were used.

RESULTS AND DISCUSSION

Data of means of physical properties of particleboards as the effects of shelling ratio and particle characteristic are provided in Table 1.

Table 1. Physical properties of particleboards manufactured

Spec	Name	Layer	MC (%)	ρ (g/cm ³)	TS (%)	WA (%)	Δ LE (%)	LE/MC
S-L M	M 100	1	6.43	0.72	14.12	31.55	0.48	0.074
H/M Comp	H/M 1/7:6/7	3	6.27	0.71	9.16	25.11	0.38	0.060
	H/M 1/4:3/4	3	6.24	0.73	8.88	27.52	0.41	0.065
	H/M 1/3:2/3	3	6.19	0.71	12.08	32.64	0.39	0.062
	H/M 1/2:1/2	3	6.06	0.71	13.52	36.41	0.38	0.063
	H/M 2/3:2/3	3	5.92	0.77	14.37	36.47	0.36	0.060
S-L H	H 100	1	6.10	0.78	14.70	33.92	0.34	0.056
Df/M Comp	Df/M 1/3:2/3	3	6.05	0.72	10.69	35.45	0.43	0.071
S-L Df	Df 100	1	5.69	0.72	6.82	24.19	0.41	0.072

Note: S-L: single-layer, M: matoa, H: hinoki, Df: douglas fir, MC: moisture content, ρ : board density, LE: linear expansion, TS: thickness swelling, WA: water absorption.

Density and Moisture Content

The target density of the particleboards was 0.72 g/cm³. After the manufacturing, the real density of each board varies from 0.71 g/cm³ – 0.78 g/cm³ (Table 1). The trend of board's density increases with the increasing of hinoki strand ratio to matoa particles. Therefore, the proportion of hinoki strands in the board appeared to influence on the board density. This result is corresponding to the study by Sackey *et al.* (2011), who stated that higher amount of strands resulted higher density boards. Sackey *et al.* (2008) stated that this condition may be attributed to the fact that strands are more difficult to compact because of their limited ability to rearrange during compression. Considering that hinoki boards are denser than matoa

boards, there are two reasons can be proposed, first is according to the characteristic of wood species and second is according to the particles size and shape. Hinoki is a softwood species which its structure is uniform and the original density is low (0.39 g/cm^3) (Kojima *et al.*, 2009) whereas matoa is hardwood which its structure is more complex and the original density is high (0.8 g/cm^3) (Martawijaya *et al.*, 1981). After boards manufacturing, matoa has higher possibility to swell than hinoki. Particles shape and size may influence the possibility of boards to swell after pressing. As known that hinoki strands have a high slenderness ratio, it will minimize the possibility to swell and make the boards manufactured become denser than matoa hammermilled particles.

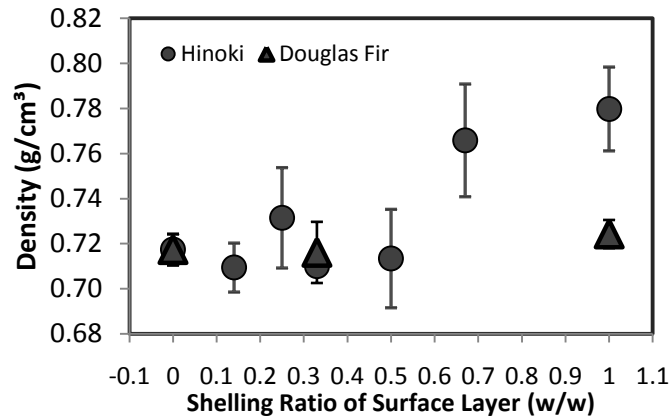


Fig. 1. The density of particleboards manufactured. Filled circle, particleboard with hinoki strand as surface layer; Filled triangle, particleboard with douglas-fir particle as surface layer; shelling ratio of 0 means matoa single-layer particleboard

Figure 1 shows that hinoki strand resulted higher particleboard density than the others. This phenomenon was due to the amount of strands used for particleboard production rather than wood species. It was similar to the study of Sackey *et al.* (2011) who found that the highest density of particleboards were measured from boards with the greatest amount of strands. That there was no difference in density between matoa and douglas-fir particleboard although douglas-fir has originally low density (0.41 g/cm^3), it appeared due to the rather similar particle shape and size of both matoa and douglas-fir particles.

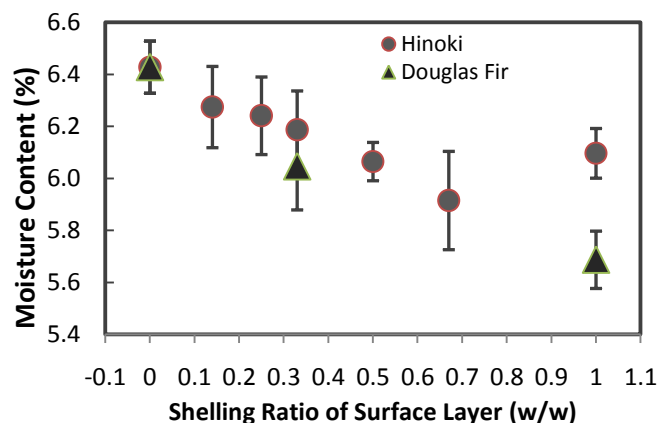


Fig. 2. The moisture content of particleboards manufactured. Filled circle, particleboard with hinoki strand as surface layer; Filled triangle, particleboard with douglas fir particle as surface layer; shelling ratio of 0 means matoa single-layer particleboard

The moisture content value of the particleboards are provided in Fig. 2. All of the boards have moisture content below 12%. It means that all boards manufactured meet the JIS A-5908 standard. Figure 2 shows that different shelling ratio and particle type affect the board moisture content. Particleboards

made from high density materials resulted in higher moisture content boards. Higher MC of matoa particleboards appeared due to the high density raw material which contains higher amount of water in the cell wall and is easy to absorb moisture. It can be said that because the rate of moisture release of high density particles during hot pressing was rather slower than that of low density particles, this can cause higher moisture content in the finish products. Lower MC of douglas-fir particleboards appeared due to the low density raw material. This is different to hinoki particleboards, which were produced from strands. Particleboards made from strands will adsorb more moisture than that from particles (Sackey *et al.*, 2011), therefore higher shelling ratio of hinoki strands resulted lower moisture content of particleboards. By adding higher quality particle on surface layer, the boards moisture decreased gradually. It implies that the quality of raw material on surface layer is important to produce high quality particleboards.

Thickness Swell and Water Absorption

Mean values of both thickness swell (TS) and water absorption (WA) of particleboards are provided in Table 1. Figure 3 and 4 show the TS and WA values of particleboards manufactured, respectively. Both of them show a rather similar trend. In this study, single layer particleboards using matoa and hinoki resulted in similar TA and WA value, but that of douglas fir is the lowest. The surface proportion of hinoki and douglas fir were not quite affect the enhancement of TS and WA, except on 1/7 and 1/4 surface proportion of hinoki. A thin hinoki surface layer improved TS and WA value.

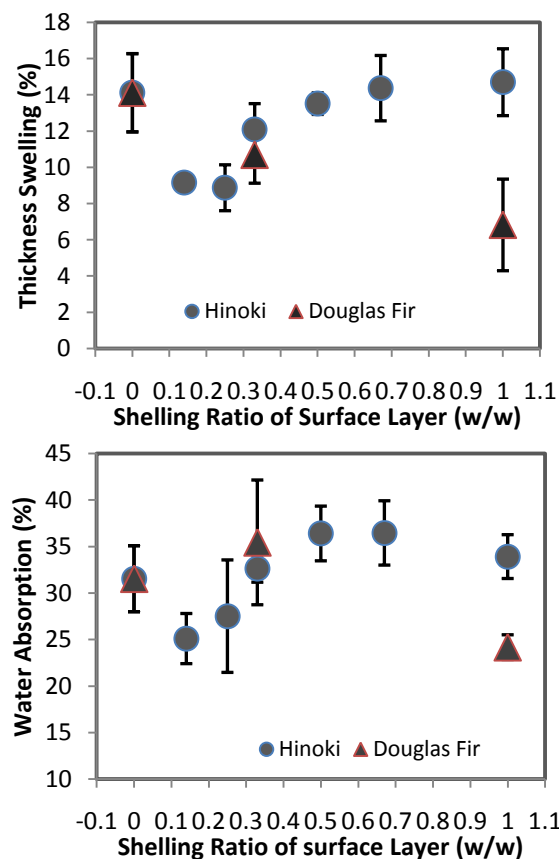


Fig. 3. Effect of layer structure and particle characteristic on TS and WA of particleboards. Filled circle, particleboard with hinoki strand as surface layer; filled triangle, particleboard with douglas-fir as surface layer; shelling ratio of 0 means matoa single-layer particleboard

In three-layered particleboard, the overall thickness change is the result of both surface and core layers. From Fig. 3, it can be seen that single-layer matoa and hinoki particleboards have a similar TS value. Therefore, the resultant of thickness swelling is same, but it shows a different behaviour in particleboard with shelling ratio 1/7 and 1/4. It should be noted in three layer particleboard with hinoki

strand as surface layer. Strands are more continuous wood elements than particles and hence had higher TS values and absorbed more moisture (Sackey *et al.*, 2011). Therefore, higher density boards containing strands can contribute to the greater TS. It seems different behavior with three-layer particleboard using douglas fir particle as surface layer, which results lower TS value.

TS was the greatest in the highest density boards (Chen *et al.*, 2010; Halligan, 1970 in Sackey *et al.*, 2011). TS is positively related to density, however, no positive correlation between the average panel density and TS. Chen *et al.* (2010) reported from several studies regarding the influence of density on TS value that some of the research are contradictory. In such case, TS was greatest in the high density boards and other case was contrarily. He also stated that the higher density boards absorb water slower, reducing the rate of TS but it will swell more caused by exposure time.

Linear Expansion

Figure 5 shows that the LE value was affected by shelling ratio of surface layer (w/w) and wood species. Higher proportion of surface layer with hinoki or douglas-fir, the LE value decreased. Hinoki has the lowest value of LE, than douglas fir and matoa, respectively. It implies that the dimensional stability of particleboard is affected by the particle source, both the wood species and the shape. Higher proportion of surface layer with hinoki strands, the LE value decreased. It is agreed to Sackey *et al.* (2011) who found that the strand elements are flatter and have higher slenderness ratio which tend to swell less in parallel direction and contributed very little to LE. The geometry, surface texture and orientation of matoa particles caused to swell in all directions, and the accumulation of this swelling led to higher LE values. Performance of particleboards made from matoa can be enhanced by adding the surface layer with higher quality particle such as hinoki strand or douglas-fir particles.

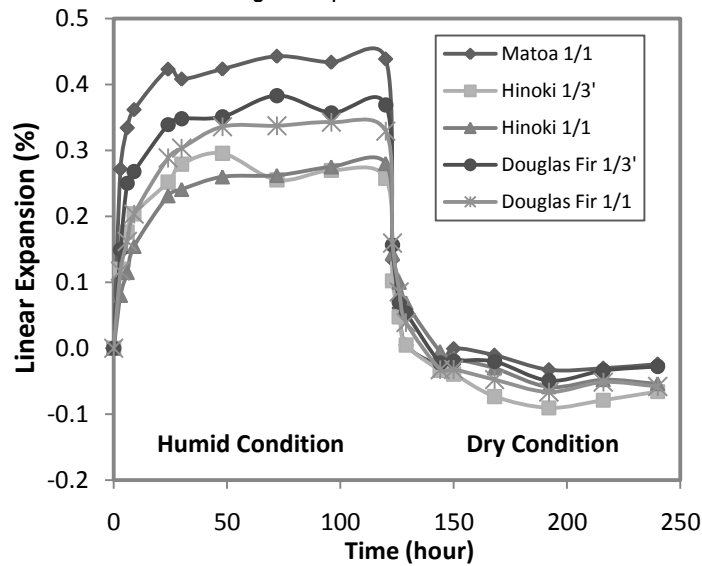


Fig. 5. Linear expansion as the effect of particle type and shelling ratio

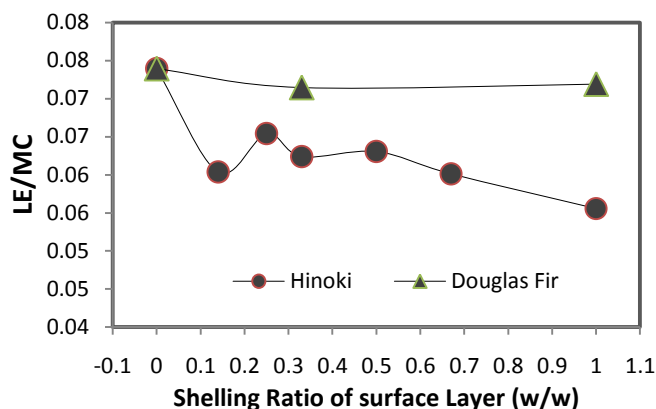


Fig. 6. Total linear expansion per unit moisture content change for humid to dry condition Filled circle, particleboard with hinoki strand as surface layer; filled triangle, particleboard with douglas-fir particle as surface layer; shelling ratio of 0 means matoa single-layer particleboard

Linear expansion of all the boards increased rapidly at the beginning of the humid condition and levelled off toward saturation values. It seemed that to reach the saturation value at approximately after 30 h. This is similar to the study of Suzuki and Miyamoto (1998) that particleboard with density of 0.7 g/cm^3 seemed to reach its saturation value at around 30 h. Values of LE per unit MC change from dry condition (RH 50%) to humid condition (RH 90%) are graphically shown in Fig. 6. A quadratic curve can be used to describe the decreasing LE/MC values with the increasing of shelling ratio. The R^2 of the curves was 0.66.

Hinoki has the lowest value of LE, then followed douglas-fir and matoa, respectively. This result is similar to that of Sackey *et al.* (2011) who reported that boards with shorter and thicker particles recorded higher LE and boards with more slender strands had lower LE. Miyamoto *et al.* (2002) also reported that boards with small particles had higher LE. It implies that the dimensional stability of particleboard affected by the particle source, both the wood species and the shape. The quality of particleboards made from matoa can be enhanced by adding the surface layer with higher quality particle such as hinoki strand or douglas-fir particles.

Vertical Density Profile

Commonly, VDP is characterized by high density surface region and low density core region. Kollmann *et al.* (1975) stated that the minimum values for density always in the center of the boards. Figure 7 is representative VDP values of particleboards manufactured as the effects of particle type and shelling ratio. It shows that single layer particleboard from matoa has the lowest difference between surface region to core region than douglas-fir and hinoki, respectively. It implies that particleboard made from higher density wood species resulted in lower difference density profile between surface and core region than that of lower density wood species. The term of higher quality material is related to the particle characteristic, where low density and high slenderness ratio of material have the important role. As the lowest density and the highest slenderness ratio of raw material, particleboards made of hinoki strand had the highest density profile in surface layer than the others.

In three-layer particleboards, the increasing of hinoki strand shelling ratio increased density of surface region, higher than that of douglas-fir. Higher density and lower slenderness ratio of douglas-fir particles caused the lower density profile in surface layer than those of hinoki surface layer. That figure also shows a typical density gradient for particleboard with high density layers just inside the board surface as noted by Suzuki and Miyamoto (2000). Three-layered particleboards with different wood species in this study gave lower difference between surface and core region. Chen *et al.*, (2010) reported several studies about VDP and it has been recognized as one of the influential factors affecting physical and mechanical properties of wood panels. The higher density in the surface layers effects correspondently higher bending strength and higher resistance to absorption and swelling (Kollmann, *et al.*, 1975).

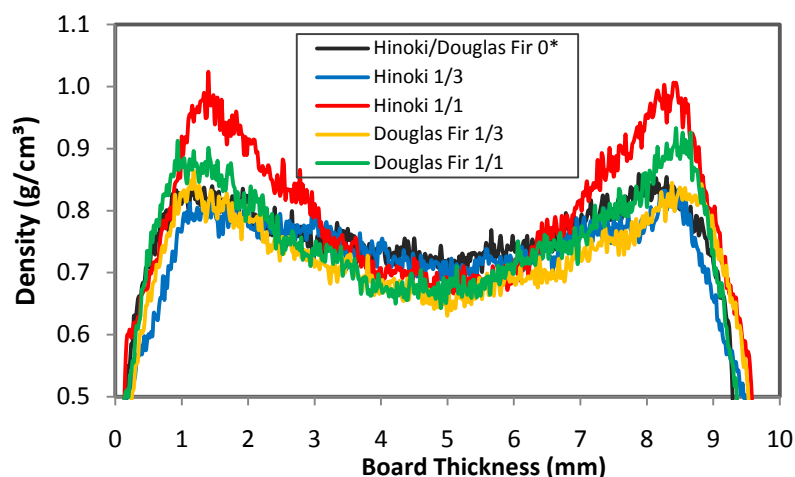


Fig. 7. Typical vertical density profile of particleboards at various shelling ratio and particle type

CONCLUSION

In this study, enhancement the quality of particleboard production using low quality matoa particle was examined. The improvement was conducted by adding surface layer with higher quality wood particle such as hinoki strand or douglas-fir particle. Higher shelling ratio based on weight of hinoki and douglas-fir as surface layer, resulted in higher performance of three-layered particleboard. Hinoki strand with shelling ratio of 1/1 showed the best performance in board density. Douglas-fir particle with shelling ratio of 1/1 showed the best performance in moisture content, thickness swelling and water absorption. In terms of particle type, hinoki strand showed the best performance in board density and linear expansion, while douglas fir particle showed the best performance in moisture content, thickness swelling and water absorption. Therefore, improvement of low quality materials for particleboard production can be conducted by adding high quality materials as surface layer.

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Utilization of Oil Palm Wastes and Recycled Polypropylene as Raw Materials for Wood-Plastic Composites

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ABSTRACT

This study examined the physical and mechanical properties of wood plastic composites made from recycled polypropylene (RPP) and oil palm biomass wastes under various particle sizes and pressing temperatures. Oil-palm biomass wastes, oil palm trunk (OPT), was used as filler. The OPT was produced in 3 groups (i.e., passed from 20, 40 and 60 meshes filtered). The RPP and OPT ratio were 7:3. The hand-mixtures of RPP and OPT with MAH and BPO were subjected to hot-press at 180°C and 190°C for 10 min at 15 kgf.cm⁻² pressure. The results indicated particle sizes, MAH and BPO and pressure of temperature were influences of physical and mechanical properties of WPC. Testing was done according to standard JIS A 5908-2003.

Keywords: particle size, oil palm trunk, recycle polypropylene

INTRODUCTION

Wood-plastic composites manufacturing by using recycled plastic and lignocelluloses material is not only increases the efficiency of wood utilization but also reduces the environmental problem of plastic waste (Setyawati, 2003). Wood-plastic composite advantage were low cost production, large availability material, flexible in manufacturing process, low density, easier decomposed (compared to plastic), having better properties than its raw material, can be applied to various purposes, and recyclable (Febrianto 2005).

The purpose of filler addition to the polymer matrix is to improve the properties of thermal and mechanical wood-plastic composite (Han, 1990). Filler play an important role in supporting composite strength through an effective load distribution between fiber and matrix. Besides, filler addition will reduce costs and can improve its products at the same time. A variety of organic materials can be used as filler, such as wood, bagase, peanut shells, bamboo, rattan, hemp, kenaf, jute, etc (Febrianto *et al.*, 1999).

The potential area of oil palm rejuvenation in Indonesia was between 20 to 50 thousand hectares per year. There are 140 acres of oil-palm trunks per hectare and trunk biomass estimation was 167 m³ per ha. A third of the trunk (outer side) is potentially as sawn timber (Boyd *et al.*, 2008, Susila, 2004, and Abraham 2004). Besides trunk, the other biomass that produced from oil palm rejuvenation were petiole, empty bunches, and shells. This biomass is potential to be used as fillers for wood-plastic composite products.

Plastic waste was also very abundant in Indonesia. In 2000, the volume of waste from big cities in Indonesia was reported around 100,000 tons per day and 2% of them are plastic waste. The volume of plastic waste will be increase continuously as increasing population growth and economic growth (Agung Wibowo 2009). Plastic waste is potential to be used as matrix in plastic-wood composite manufacturing. Plastics is hydrophobic, so the composite product is more resistant to water and humidity. Furthermore, plastic is disliked by termites so composite board made from plastic will not attacked by termites even without preservation treatment, formaldehyde emission free, and environmentally friendly (Hu *et al.*, 2005, Massijaya *et al.*, 2009)

This research is intended to test the plastic-wood composite quality from palm oil waste plantation of oil palm trunks (OPT) and recycled polypropylene plastics matrix (RPP). The influence of various pressing temperature and particle size of fillers on mechanical properties and physical properties of wood-plastic composite is reported in this paper.

METHODS

Filler material that used in this research is OPT and converted into particles by using hammer mill. Those particles filtered and divided into three groups, trough sieves p1 = 20 mesh, p2 = 40 mesh and p3 = 60 mesh. After that, particles dried with an oven until reach 10 % moisture content (MC). RPP 60 mesh in size was used as a matrix. Comparison matrix and filler material is 7: 3. Maleic anhydride (MAH) as much as 5% of matrix weight is used as a modifier and benzoyl peroxide (BPO) as much as 5% of the weight of the MAH is used as an initiator.

Particles of OPT, RPP, MAH and the BPO were manually mixed. Once it is inserted into the matt to get the sample test size of 20 cm x 10 cm x 0.33 cm. Target density of plastic composite board was 1.0 g.cm⁻³. Mixed particle was hot pressed at temperature (S) s1 = 180°C and s2 = 190 °C for 10 minutes at 15 kgf.cm⁻² pressing compression. After hot press, wood plastic composites product is left inside the mat for cooling and hardening process. Conditioning was done to uniform the moisture content and released stress inside sample test due to hot pressing.

Physical and mechanical properties plastic composites boards testing were include density, moisture content (MC), water absorption (WA), Thickness swelling (TS), modulus of elasticity (MOE) and modulus of rupture (MOR). Testing was tested in accordance with standard JIS A 5908-2003.

RESULTS AND DISCUSSION

Density

Density of plastic composite board is one of physical properties that is very affected to other mechanical properties. The density's average value of plastic composite board with OPT filler was range between 0.80-0.87 g.cm⁻³. Generally, the density of plastic composite board at pressing temperature 180°C is higher than 190°C. High temperature, according to Febrianto (1999), does not suitable with BPO initiator that commonly used at low temperature. Moreover, Iwan RS *et al* (2005) stated that density of plastic composite board from different parts of oil palm trunk with a mixture of RPP and MAPP was between 0.85-0.95 g.cm⁻³ of 1.0 g.cm⁻³ target density. There is any possibility that plastic composite board density is influenced by water content of its filler (oil palm trunks) which is still have high water content before pressing, this water will evaporate along with hot pressing process, thus the target density was not achieved (Figure 1).

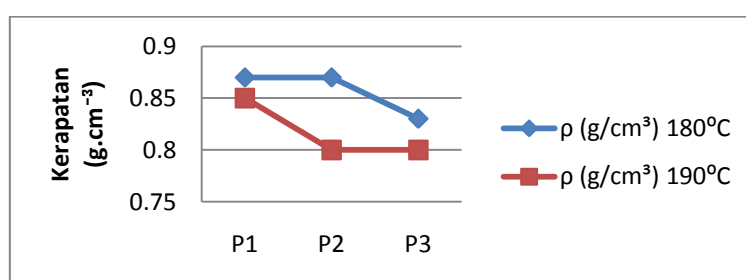


Figure 1. Density of oil palm trunk-plastic composite board on P1, P2 and P3 particle size at 180°C and 190°C pressing temperature

The analysis variants (ANOVA) showed that the interaction of particle size, pressing temperature factor is influence significantly to oil-palm trunk composite board density, so further test of DMRT was tested and showed in table 1. It was described that at 20 and 40 mesh particle sizes and at 180°C pressing temperature was not significantly different but at 60 mesh particle size was significantly different. At 190°C pressing temperature and 40 and 60 mesh particle size was not significantly different. The 60 mesh particle size at temperature of 180°C was equal to 20 mesh particle size at pressing temperature of 190°C.

Table 1. The density's average value of oil-palm plastic composite board with the interaction effect of pressing temperature to particle size

Pressing temperature (S)	Particle size (P)		
	p1	p2	p3
s1	0.87c	0.87c	0.83b
s2	0.85b	0.80a	0.80a

Note: Means with the same superscript sign indicates not significantly different by DMRT at level $\alpha=0.05$

If it compared to standard JIS A 5908–2003, the density value of all composite boards that produced in this research were met the standards JIS A 5908–2003 which requires density particle board was range between 0,40–0,9 g.cm⁻³.

Moisture Content (MC)

The ability of plastic composite board to be in equilibrium with the surrounding relative humidity (RH) is one of tested physical properties, called moisture content (MC). Moisture content composite board values with some treatment factor are presented in Figure 2. The MC's average value of plastic composite board with OPT fillers was around 2.19-2.65%. The lowest moisture content and relatively equal is obtained at 190°C pressing temperature.

RPP is a thermoplastic resin that is hydrophobic, means that it is not easy to absorb and release the water. Although the mixing process of plastic composite board raw material was manual, the presence of MAH and BPO additive is able to distribute the filler material with RPP matrix homogeneously and plastic composite boards produced is more solid (Han 1989) with relatively low moisture content. Figure 2 explained the differences of oil palm trunk-plastic composite board moisture content at pressing temperature 180°C and 190°C.

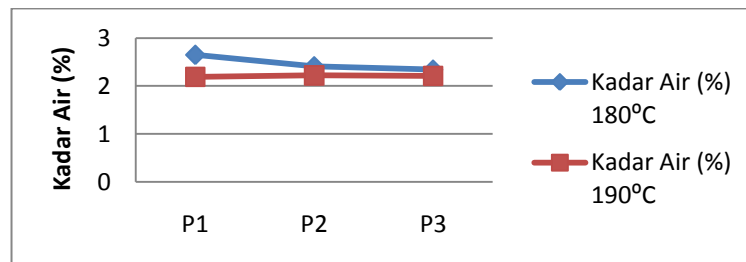


Figure 2. Moisture content of oil palm trunk-plastic composite board on P1, P2 and P3 particle size at 180°C and 190°C pressing temperature

If it compared to standard JIS A 5908-2003, the MC values of composite board were met the standards that the required value was range between 5-13%.

Water Absorption (WA)

Water absorption is a composite board properties that shows the ability of board to absorb water after being soaked in water for 24 hours. The water absorption's average value after being soaked in water for 24 hours is presented in Figure 3. WA of oil palm trunk-plastic composite board after soaked for 24 hours was range between 2.7-12.63%. High pressing temperature was affected the water absorption ability, due to the particles of oil-palm trunks was covered by stronger matrix of RPP. Analysis of variance states that interaction of particle size and pressing temperature was significant on oil-palm trunk particle filler, so further test of DMRT is done (table 3). Pressing temperature of 180°C was given different interaction in all sizes of particles, while in pressing temperature of 190°C its influence was equally on a 20 mesh and 40 mesh particle sizes.

Table 3. The water absorption's average value of oil palm trunk-plastic composite board with the interaction effect of pressing temperature to particle size

Pressing temperature (S)	Particle size (P)		
	p1	p2	p3
s1	10.79d	12.63e	10.42d
s2	9.05b	7.69b	2.7a

Note: Means with the same superscript sign indicates not significantly different by DMRT at level $\alpha=0.05$

In general, oil-palm trunks have very hygroscopic properties. However, based on the results of this study, there is a tendency of decrease in water absorption value due to the use of MAH and BPO. According to Toke et al (2003), if the MAH is mixed with PP, it will make the PP mixture is more solid to polar component. The JIS A 5908-2003 standard for water absorption of WPC is not required.

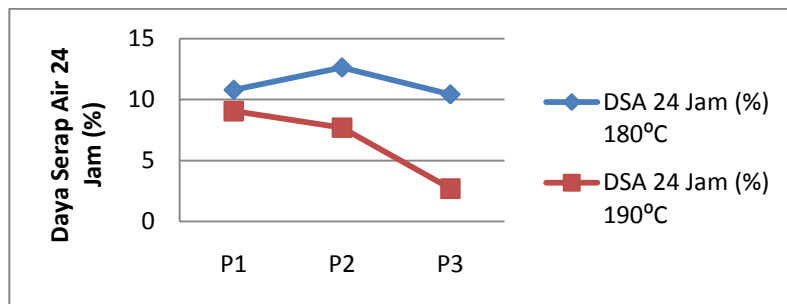


Figure 3. Water absorption oil palm trunk-plastic composite board on P1, P2 and P3 particle size at 180°C and 190°C pressing temperature

Thickness Swelling

Thickness swelling properties of particle board is one of physical properties that will determine whether a particles board can be used for the interior or exterior purposes (Massijaya *et al*, 1999).

Soaking time will increase the thickness swelling of oil-palm plastic composite board. Higher pressing temperature was also play role in these properties. In line with water absorption of plastic composite board, the thickness swelling properties was followed those ability profile. Using of RPP with MAH was decrease hygroscopic properties of oil palm truck particle filler. If compared to standard JIS A 5908-2003, thickness swelling of oil-palm plastic composite board that produced in this research was still under the maximum limit (12%) for the particle board. Thickness swelling values during the 24-hour immersion is presented in Figure 4.

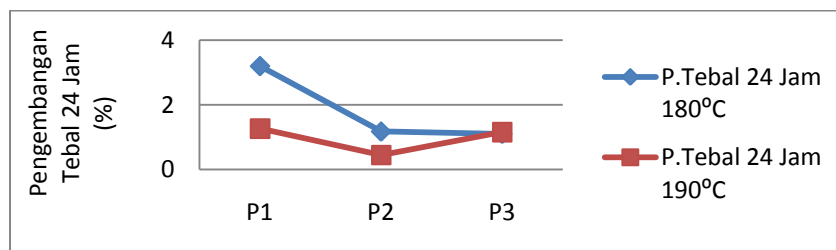


Figure 4. Thickness swelling after 24 hours immersion of oil palm trunk-plastic composite board on P1, P2 and P3 particle size at 180°C and 190°C pressing temperature

Modulus of Elasticity (MOE)

Modulus of Elasticity (MOE) is a measure of particle board resistance to hold load in proportion limit (before the break). This value is very important if the particle board was used as a construction material. The MOE value of composite board is presented in Figure 5.

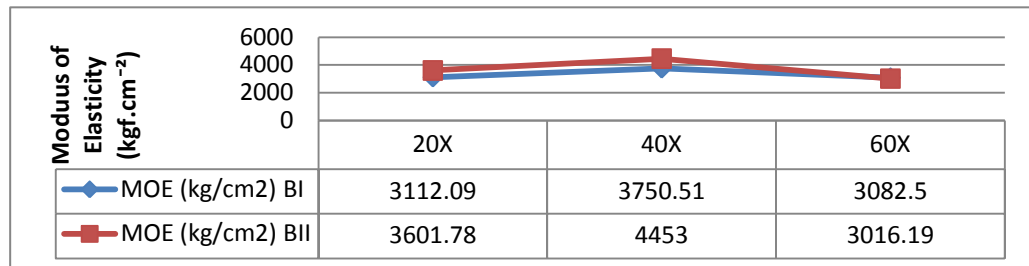


Figure 5. Modulus of Elasticity (MOE) oil palm trunk-plastic composite board on P1, P2 and P3 particle size at 180°C and 190°C pressing temperature

Figure 5 shows that the MOE's average value of oil-palm trunks particles-plastic composite boards at 180°C pressing temperature was in range of 3008.27-3750.51 kgf.cm^{-2} , and and 54.3-38.08 kgf.cm^{-2} at 190°C pressing temperature. There is increased strength due to the difference in pressing temperature. Maloney (1993) stated that MOE value is affected by the content and type of binder used, adhesive bonding, and fibers length and also type of wood particles. The type of particles (filler) of oil palm trunks is needed special treatment before it processed into plastic composite board, because it contains extractive compounds. This extractive caused the bond of filler and RPP matrix was not strong enough so that WPC is unable to hold the given loads. Risnasari et al. (2009) stated that the boiling and soaking treatment by using alkali can decrease the extractive content of oil palm trunk thus improving the nature of MOE WPC boards.

If compared to standard JIS A 5908-2003 which requires the MOE value of the composite boards was minimum 20,000 kgf.cm^{-2} , the MOE value of tested composite boards were not met the standard.

Modulus of Rupture (MOR)

Modulus of rupture (MOR) is one of the mechanical properties of wood composite boards that reflected the strength of composite board holding the load. The MOR value of composite boards can be seen in Figure 6. Figure 6 showed that the MOR's average value of oil-palm trunks particles-plastic composite boards at 180°C pressing temperature was 44.92-88.46 kgf.cm^{-2} and 54.3-38.08 kgf.cm^{-2} at 190°C pressing temperature. Modulus of rupture at 180°C pressing temperature was higher than 190°C pressing temperature. If it compared to standard JIS A 5908-2003 which requires the MOR value of composite boards was minimum 80 kgf.cm^{-2} , only the MOR value of 40 mesh oil-palm trunks particle composite boards at 180°C pressing temperature were met the standards.

Tensile Strength (TS)

Tensile strength is mechanical properties which showed the resistance of oil palm trunk-plastic composite board to forces acting across the grain that tend to split particle and adhesive.

The average tensile strength value was around 0.36 - 0.57 kgf.cm^{-2} . Febrianto (1999) stated that utilization of MAH and BPO initiator combination is not suitable to be used at more than 170°C pressing temperatures, because it can decrease the quality of matrix and filler binding. The statistical tests revealed that the particle size and interaction of pressing temperature and particle size has no significant effect, but pressing temperature has significant effect.

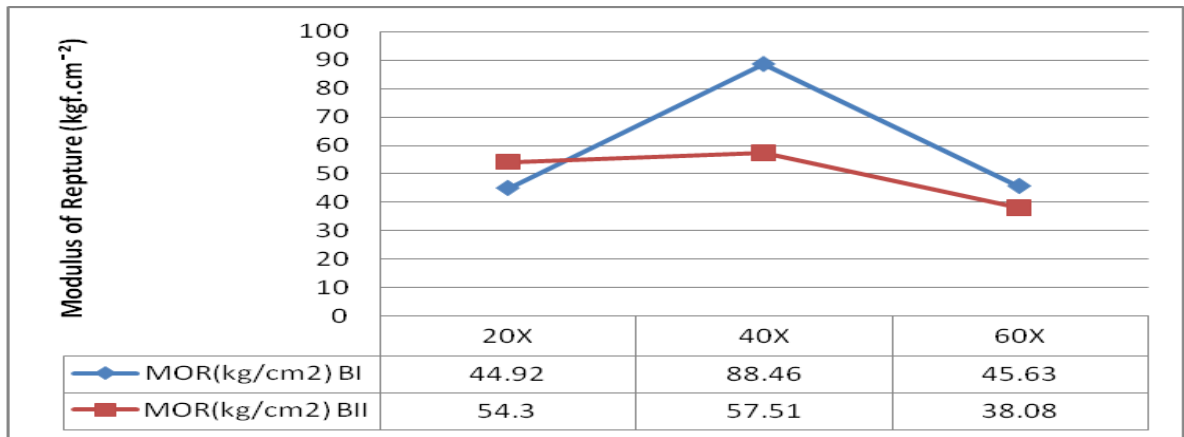


Figure 6. Modulus of rupture (MOR) oil palm trunk-plastic composite board on P1, P2 and P3 particle size at 180°C and 190°C pressing temperature

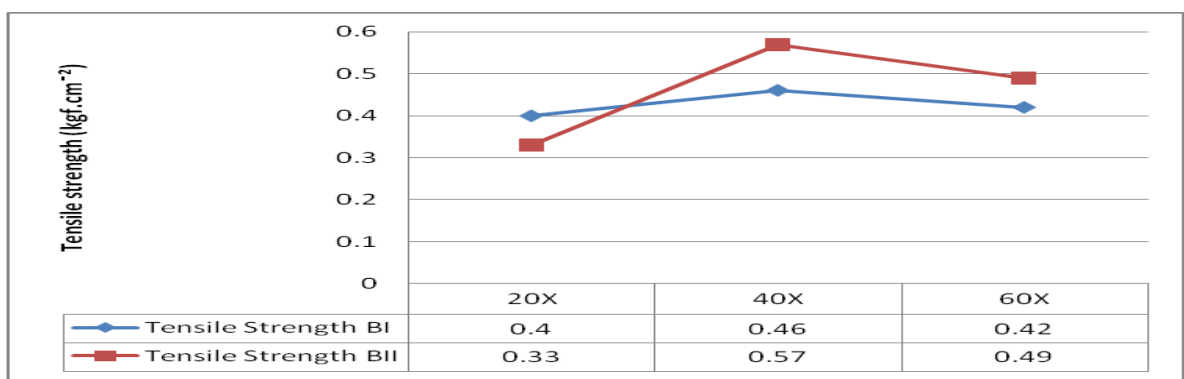


Figure 7. Tensile Strength of plastic composite boards on P1, P2 and P3 particle size at 180°C and 190°C pressing temperature

CONCLUSION

Particle size factor and pressing temperature of 180°C and 190°C factor with an additive of modifier (Maleic Anhydride) and initiator (benzoyl peroxide) was effected to mechanical and physical properties of wood-plastic composite (WPC) board made from RPP and the oil palm truck particles. Composite boards were met the standards of JIS A 5908-2003 only on physical testing, while the MOR value of 40 mesh oil palm truck particle composite board were met the standards on mechanical testing.

ACKNOWLEDGMENT

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Effects of Nodes on the Properties of Laminated Bamboo Lumber

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ABSTRACT

The objective of this study was to determine the effects of node on the properties of laminated bamboo lumber (LBL) glued with isocyanate adhesive. Bamboo strips for LBL fabrication were prepared from andong bamboo (*Gigantochloa pseudoarundinacea*) collected from private gardens in West Java. Each bamboo strip has dimension of 40 cm x 2 cm x 0.5 cm. The bamboo strips were assigned into 3 groups by the node positions: without node, the node position is 10 cm from one end of the bamboo strip, and the node position is in the centre of the bamboo strip. Prior LBL fabrication the bamboo strips were treated by cold soaking in 7% boron solution for 2 hours. The laboratory scale 3-layer laminated bamboo lumbers were manufactured with 5 different layer compositions : all layers made of bamboo strips without node, inner layer made of bamboo strips with nodes at 10 cm from one end of the strip, inner layer made of bamboo strips with nodes at the centre of the strip, all layers made of bamboo strips with nodes at 10 cm from one end of the strip, and all layers made of bamboo strips with nodes at the centre of the strip. The glue spread and cold pressing time applied were 250 g m⁻² and 1 hour respectively. The results showed that the average density, moisture content, thickness swelling, bending strength, and compression strength of laminated bamboo lumbers were 0.74 g cm⁻³, 11.3%, 2.9%, 1090 kg cm⁻², and 560 kg cm⁻² respectively. No delamination occurred in all samples indicating high bonding quality. The average bonding strength (dry test) of laminated bamboo lumbers was 70.3 kg cm⁻². Several properties of laminated bamboo lumber were not significantly affected by the present of nodes in the bamboo strips except the thickness swelling and compression strength.

Keywords : Laminated bamboo lumber, node, isocyanate, physical and mechanical properties

INTRODUCTION

The demand of wood as furniture and building materials always increase in line with the increase in the number of population. The total population of Indonesia in 2000 was 205 132 millions while in 2010 was 237 556 millions with the annual growth rate of 1.49% (BPS, 2010). According to Supriana *et al.* (2003), the need for houses in Indonesia was about 2.9 millions units per year, and every unit of house consumes about 2.97 m³ of wood on average. This means that approximately 8.613 millions m³ of sawn timber is needed annually for house construction. Since the wood supply for housing industry has been decreasing considerably, the search for substitutes is urgent concern.

Bamboo has the potential to be an alternative to housing materials due to its ability to grow fast in various soils with desirable properties. Although there is a long history to use bamboo as construction materials, furniture, household utensils and handicrafts in Indonesian villages, the shape and dimension appear to limit the usage of bamboo. Due to its circular and hollow shape, bamboo must be converted into the flat and relatively thick materials as wood substitutes. It is fortunately possible to produce timber-like-materials with the desired dimensions from bamboo strips, so-called laminated bamboo lumber (LBL) by the aid of appropriate adhesives. LBL is a lumber-like product in dimensions, consisting of several layers of bamboo sheets bonded together with the grain in parallel direction, and may be formed into planks or beams. This paper describes the results of an experiment to determine the effects of nodes on the properties of laminated bamboo lumber (LBL).

MATERIALS AND METHODS

Andong bamboo (*Gigantochloa pseudoarundinacea*) was used in the experiment because this bamboo species are widely planted in West Java. Ten mature culms of *G. pseudoarundinacea* were collected from private gardens in Bogor, West Java. The culms used in the experiment were obtained by taking out the first segment at about 60 cm in length from the bottom. The remaining culms (only the bottom and middle parts) measuring about 8 m in length were cross cut into segments. Each segment was 90 cm in length and generally had two internodes.

Preparation of bamboo strips

To produce bamboo strips, each bamboo segment (90 cm in length) was manually fed into a bamboo splitter machine. Six to seven strips were obtained from each segment, each about 2 cm wide. Only straight bamboo strips were used for this study. After scraping out the inner and outer layers, the selected strips were then planed and stacked for air drying at room temperature for one week. Then the bamboo strips were immersed in 7% boron solution for two hours and after which they were sun-dried to about 12% moisture content. The bamboo strips were then cross cut into 40 cm length and assigned into 3 groups by the position of node: without node, the node position is 10 cm from one end of bamboo strip, and the node position is in the centre of bamboo strip.

Producing bamboo sheet

Each bamboo sheet comprised eight bamboo strips. The bamboo strips were assembled side-by-side and edge-glued using isocyanate adhesive. The glue mix (main fluid 100 and cross linker 15) of 250 g m⁻² for a single glue line was then hand-spread on each side surface of bamboo strips using a metal spatula. The assemblies were cold-pressed for one hour using a wooden clamp.

Producing laminated bamboo lumbers (LBLs)

LBLs were produced by assembling three layers of bamboo sheet (each bamboo sheet consisted of 8 bamboo strips) with the grain in parallel direction. The laboratory scale 3-layer laminated bamboo lumbers were manufactured with 5 different layer compositions: all layers made of bamboo strips without node, inner layer made of bamboo strips with nodes at 10 cm from one end of the bamboo strip, inner layer made of bamboo strips with nodes at the centre of the strip, all layers made of bamboo strips with nodes at 10 cm from one end, and all layers made of bamboo strips with nodes at the centre of the strip. The LBL was manufactured using isocyanate adhesive. The assemblies were cold-pressed using a wooden clamp for one hour and the glue spread applied was 250 g/m². Three replications for each treatment of LBL were prepared. The LBLs produced were conditioned for two weeks before testing.

Testing

The laminated bamboo lumbers were cut into desired specimen dimensions and measured for density, moisture content, thickness swelling, wide expansion, modulus of rupture (MOR), modulus of elasticity (MOE), compression strength and bonding strength. The tests were performed using the American Standard ASTM D 1037-93 (ASTM 1995) with some modifications and Japanese Standard for Glued Laminated Timber (JPIC 2003) for evaluating properties of LBLs. A completely randomized design was used in the experiment with the position of nodes in the bamboo sheet as the treatment factor. Three replications were prepared for each treatment.

RESULTS AND DISCUSSION

The mean values of physical and mechanical properties of laminated bamboo lumbers (LBLs) and the results of analysis of variance (ANOVA) are presented in Table 1. The moisture content of LBLs varied from 11.1 to 11.6 % with an average of 11.3 %. The moisture content of LBL was not affected by the present of nodes in the bamboo strips.

The density of LBLs produced varied from 0.73 g cm⁻³ to 0.75 g cm⁻³ with an average of 0.74 g cm⁻³. These values are higher than the original air dry density of bamboo raw material. The average air dry density of *G. pseudoarundinacea* strips in this study was 0.72 g cm⁻³. Possible reasons that contributed to the higher value are the use of adhesive and the pressure applied during laminated bamboo lumbers manufacture, which produced a denser product. According to Dransfield and Widjaya (1995) the specific gravity of *Gigantochloa pseudoarundinacea* is 0.5 - 0.7 (internodes) and 0.6 - 0.8 (parts with nodes). ANOVA showed that the density of LBLs was not affected by the present of nodes in the bamboo strips.

Table 1 Physical and mechanical properties of LBLs and the results of ANOVA

Properties	Position of nodes					ANOVA results
	P ₁	P ₂	P ₃	P ₄	P ₅	
MC (%)	11.2 (0.08)	11.6 (0.19)	11.1 (0.68)	11.3 (0.33)	11.5 (0.40)	ns
Density (g cm ⁻³)	0.74 (0.03)	0.73 (0.03)	0.75 (0.03)	0.75 (0.03)	0.74 (0.02)	ns
TS (%)	3.1 (0.37)	3.9 (0.07)	3.1 (0.38)	2.6 (0.71)	1.5 (0.12)	**
WE (%)	2.2 (0.59)	2.7 (0.60)	2.3 (0.16)	2.4 (0.03)	1.8 (0.23)	ns
MOR (kg cm ⁻²)	1159 (151)	1039 (139)	1198 (167)	971 (184)	1085 (69)	ns
MOE (× 10 ³ kg cm ⁻²)	175.3 (20.2)	171.4 (20.1)	176.3 (6.8)	163.7 (16.7)	166.2 (9.6)	ns
CS (kg cm ⁻²)	549.8 (29)	629.4 (72)	571.2 (13)	533.1 (11)	518.6 (77)	*
BS (kg cm ⁻²)	71.1 (2.5)	64.4 (3.8)	72.3 (2.9)	72.7 (8.2)	71.2 (6.7)	ns
Delamination,%	0	0	0	0	0	

Each value was the average of three specimens except for bonding strength which had six specimens. Numbers in parentheses represent one standard deviation; MC, moisture content; TS, thickness swelling; WE, width expansion; MOR, modulus of rupture, MOE, modulus of elasticity; CS, compression strength; BS, bonding strength; ns : not significant; * : significant ; **, highly significant

Thickness swelling of LBLs varied from 1.5 to 3.9% with an average of 2.9% . A previous study by Nugroho and Ando (2001) showed that the average thickness swelling of four-layer laminated bamboo lumber made from moso bamboo (bamboo zephyr mats) glued with resorcinol-based adhesive was 12,13%. Other study was carried out by Lee & Liu (2003) on selected physical properties of commercial bamboo flooring and the results showed that the thickness swelling of laboratory made three-layer laminated bamboo lumber and natural bamboo flooring made from moso bamboo strips were 1.0 and 0.7% respectively. Thickness swelling of LBL made from andong bamboo strips glued with tannin resorcinol formaldehyde and the layer composition in combination with acacia and pine wood varied from 0.8 to 3.3% (Sulastiningsih *et al* 2005). Parallel and crossed-laminated bamboo panel made from *Dendrocalamus yunnanicus* had thickness swellings of 3.5 and 3.6% respectively (Guo 2007). From this information it was found that LBL made from bamboo strips had better dimensional stability than LBL made from bamboo zephyr mats. ANOVA showed that the thickness swelling of LBL was significantly affected by the present of nodes in the bamboo strips. The present of nodes reduced

thickness swelling of LBL. The possible reason is the structure especially vascular cells of the node section of the bamboo culm is more complicated than the internode's section (Shao *et al.* 2010) resulted in denser and harder materials and this condition will hinder water enter to LBL.

The width expansion (WE) of LBL varied from 1.8 to 2.7% with an average of 2.3%. This finding is in agreement with the previous study which reported that the width expansion of LBL made from andong bamboo strips glued with urea formaldehyde varied from 2,04 to 2,70% with an average of 2.38% (Sulastiningsih and Santoso, 2012). ANOVA showed that the width expansion of LBLs was not affected by the present of nodes in the bamboo strips.

The MOR of laminated bamboo lumbers varied from 971 to 1198 kg cm⁻² (Table 1). The data on MOR of LBLs were subjected to analysis of variance (ANOVA) and the results showed that the MOR of LBLs was not affected by the present of nodes in the bamboo strips. Compare to Indonesian wood strength class (Seng, 1964), based on MOR value, the three-layer LBLs produced had strength values similar to wood strength class II (725 – 1100 kg cm⁻²) to I (> 1100 kg cm⁻²). MOR of a four-layer laminated bamboo lumber made from moso bamboo (bamboo zephyr mats) glued with resorcinol-based adhesive varied from 639 to 707 kg cm⁻² (Nugroho & Ando 2001). The four-layer laminated bamboo lumber had strength values similar to Indonesian wood strength class III (500 – 725 kg cm⁻²). Guo (2007) reported that MOR of parallel and crossed laminated panels made from *D. yunnanicus* were 210 and 195 MPa respectively, while that panels made from *Heterocyclus pubescens* were 175 and 136 MPa respectively. Those strength values are similar to Indonesian wood strength class I (>1100 kg cm⁻²). Correal and Lopez (2008) reported that the MOR of Colombian glued laminated bamboo (*Guadua angustifolia* Kunt) which used polyvinyl acetate (PVA) as adhesive was 81.9 MPa or 835 kg cm⁻² (similar to Indonesian wood strength class II). Other study showed that three - layer and five - layer LBLs made from bamboo zephyr mats of *D. asper* glued with urea formaldehyde were 1031 and 962 kg cm⁻² respectively which were comparable to Indonesian wood strength class II (Sulastiningsih *et al.* 1996). MOR of a three-layer LBL made from bamboo strips of *G. pseudoarundinacea* glued with tannin resorcinol formaldehyde was 1241 kg cm⁻² (Sulastiningsih *et al.* 2005), whereas the MOR of that glued with urea formaldehyde was 1236 kg cm⁻² (Sulastiningsih and Santoso 2012). Those MOR values were similar to Indonesian wood strength class I (>1100 kg cm⁻²). Based on this information It was found that in general the LBL made from bamboo strips had MOR value higher than LBL made from bamboo zephyr mats.

Syafii (1984) in Suryokusumo and Nugroho (1994) reported that the MOR of andong bamboo culm (*G. pseudoarundinacea*) was 1356 kg cm⁻², while Dransfield and Widjaya (1995) reported that the MOR of andong bamboo culm varied from 1745 to 2112 kg cm⁻². Other investigator (Idris *et.al* 1994) reported that the MOR of *G. pseudoarundinacea* were 1032.6 kg cm⁻² (parts with nodes) and 1835.6 kg cm⁻² (internodes). It can be seen that the MOR of laminated bamboo lumber is lower than the MOR of the original bamboo. This was due to the fact that in bamboo sheets of LBL specimen, there are many small splits which occurred from some imperfection joints among strips and, thus, reduced the strength of LBL. Conversely, the specimen used in determining MOR of the original bamboo strip was the small clear specimen.

MOE of laminated bamboo lumbers varied from 163 667 to 176 257 kg cm⁻² with an average of 170 563 kg cm⁻². MOE values of LBL in this study had similar trend with that of the MOR values (Table 1). The result of analysis of variance showed that the present of nodes in the bamboo strips did not affect the MOE value of LBL. Sulastiningsih *et al* (1998) reported that the MOE of laminated bamboo lumber made from bamboo strips of *G. pseudoarundinacea* glued with urea formaldehyde varied from 116.07 kg cm⁻² to 202.31 kg cm⁻² with an average of 146.96 kg cm⁻², whereas the MOE of that glued with tannin resorcinol formaldehyde was 133 615 kg cm⁻² (Sulastiningsih *et al* 2005). Syafii (1984) in Suryokusumo and Nugroho (1994) reported that the MOE of *G. pseudoarundinacea* was 98,294 kg cm⁻² while Idris *et. al.* (1994) reported that the MOE values of *G. pseudoarundinacea* were 96.616 kg cm⁻² (parts with nodes) and 121.395 kg cm⁻² (internodes). It can be seen that the MOE of laminated bamboo lumber is higher than the MOE of the original bamboo.

The compression strength of LBL varied from 518.6 to 629.4 kg cm⁻² with an average of 560.4kg cm⁻². Compare to Indonesian wood strength class (Seng, 1964), based on compression strength value, the three-layer LBLs produced had strength values similar to wood strength class II (425 – 650 kg cm⁻²). The previous study (Sulastiningsih and Santoso 2012) reported that the compression strength

of LBL made from andong bamboo strips glued with urea formaldehyde varied from 522 to 580 kg cm⁻² with an average of 562 kg cm⁻². Correal and Lopez (2008) reported that the compression strength of Colombian glued laminated bamboo (*Guadua angustifolia* Kunt) which used polyvinyl acetate (PVA) as adhesive was 47.6 MPa or 485 kg cm⁻² (similar to Indonesian wood strength class II). ANOVA (Table 1) showed that the compression strength of LBLs was significantly affected by the present of nodes in the bamboo strips. The present of nodes reduced the compression strength of LBL. This was due to the structure especially vascular cells of the node section of the bamboo culm which is more complicated than the internode's section (Shao *et al.* 2010) resulted in denser and harder materials. This condition will bring some difficulties in manufacturing process of LBL especially in joining or gluing process of bamboo strips and assembling several bamboo sheets to produce LBL which is need higher pressure to be applied. Consequently, the intimate contact between bamboo strips or bamboo sheets does not achieve the maximum condition.

The delamination test and glue shear strength test were carried out to determine the bonding quality of LBLs glued with isocyanate adhesive. The result of the delamination test showed that there was no delamination in all samples and, therefore, the bonding quality of the LBLs was considered acceptable. The glue shear strength test showed that the bonding strength (dry test) of LBL produced varied from 64.4 to 72.7 kg cm⁻² with an average of 70.3 kg cm⁻². Those values surpassed the minimum requirement of Japanese Standard for Glued Laminated Timber (JPIC 2003). Previous study by Correal and Lopez (2008) showed that the bonding strength of Colombian glued laminated bamboo (*Guadua angustifolia* Kunt) which used polyvinyl acetate (PVA) as adhesive was 7.92 MPa (80.78 kg cm⁻²). Ashaari *et al.* (2004) reported that the bonding quality of *G. scortechinii* laminates had superior glue bond quality than *D. asper*. Other study (Hanim *et al.* 2010) reported that preservative treatments on bamboo strips of *G. scortechinii* significantly affect shear strength and wood failure of the laminates. Shear strength and wood failure of the laminated bamboo were significantly reduced especially in the wet condition where, the range is 0 N mm⁻² (WBP-treated) to 0.65 N mm⁻² (boiled –treated) when compared to untreated bamboo laminates (0.79 N mm⁻²). While, in dry condition test, the glue bond strength of the laminated bamboo were range from 0.64 N mm⁻² (WBP-treated) to 2.04 N mm⁻² (borax-treated).

CONCLUSIONS

Several properties of laminated bamboo lumber were not affected by the present of nodes in the bamboo strips except the thickness swelling and compression strength. Based on the Indonesian wood strength classification, the three-layer laminated bamboo lumbers glued with isocyanate adhesive had comparable strength to the wood strength class II.

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Strenght Ratio Formulation of Bamboo Taper on Center Point Bending Test

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ABSTRACT

Bamboo became the best material choice for sustainable construction because it is fully renewable materials. Indonesian people traditionally choosed bamboo for their housing since along time ago. Bamboos usually have unique shape. Its geometrical shape assumed as tapered hollow pipe. This study aims to find the effect of bambo taper to its strenght properties on center point bending test. The ratio between the Modulus of Rupture (S_R) calculated in the center point, and the maximum bending stress along the beam is called strength ratio of taper (C_t). The theoretical calculation results C_t is 1 if the taper lower than 0.023, while C_t become lower if the taper is higher than 0.023. The survey on Ampel (*Bambusa vulgaris* Schrad.), Tali (*Gigantochloa apus* (Bl.Ex Schult.f) Kurz), Gombong (*Gigantochloa verticillata* (Willd.) Munro), and Mayan (*Gigantochloa robusta* Kurz.) found that the overall taper range is -0.0047 – 0.0088 and 0 – 0.0127 for inner and outer taper respectively. On that range the C_t value is 1, so it is reasonable to neglect the taper effect on one point bending test.

Keywords: bamboo taper; strength ratio; one point bending

INTRODUCTION

Bamboos are giant perennial grasses which grow very fast, easily cultivated and processed, continuesly profitable, and its mechanical properties are good enough. In the future, bamboo will be the most important material because it is potentially well placed to address four major global challenges: shelter security, livelyhood security, ecological security, and sustainable security [1]. Bamboos have been traditionally used as main material for house construction in Indonesia since a long time ago. As fully renewable materials, bamboo became the best material choice for sustainable construction. Bahtiar et al. [2] reported that bamboo culm had superior carbon dioxide sink capability (82.35 kg/clump/year) than slow growing tree, and equal to fast growing tree species. Vogtländer, et al [3] applied Life Cycle Assessment Analysis (as defined in the ISO 14040 series) coping with all environmental effects along the bamboo production chain; they reported that bamboo stem is the most environmentally friendly material for local application than other building materials.

Bamboos usually have unique shape. Their shapes are like slim tubes which periodically connected with joint. The joints are always solid which called nodes, and the areas between nodes are called internode. Internodes are mostly hollow. The high strenght fibers are highly accumulate in the outer part of the tube, while the lower strenght are in the inner part. This unique shape makes very good mechanical property especially in bending. There exist a perfect relation between this geometrical shape with its Modulus of Elasticity (E) and Modulus of Rupture (S_R). Both E and S_R become important variables to justify the quality of material. The bamboo quality is higher if its E and S_R are higher too.

On center point bending test configuration, the S_R commonly calculated by formulae which assumed that the maximum bending stress is appeared in the center. This premise is valid if cross section along the beam has the same shape and dimension. On the contrary, bamboo diameter tapers from basal to top, with differences between species [4, 5]. Its tops have smaller diameter than the basal. Some standar (e.g. ISO 22157-1:2004) designate the average value of diameter used for E and S_R calculation, while its cross section is assumed as hollow cylinder. It is important to evaluate effect of taper to the S_R value of bamboo in order to design a better bamboo construction. The ratio between S_R which considered the taper effect with the S_R of perfect cylindrical bamboo called strenght ratio of bamboo taper. This strenght ratio should be use as adjustment factor in bamboo design and construction.

RESULTS AND DISCUSSION

Theoretical Basis

Moment inertia of plane area

Moment inertia of plane area is geometrical property which should become an important consideration for structural analysis. Moment inertia of plane area is often called second moment of area which refer to the beam's resistance to avoid deflection in bending. Beam deflection in bending is not only affected by force amount and direction, but also the geometrical shape of plane area. The deflection of beam is usually smaller if it has the higher moment inertia. In common, the momen inertia could be calculated by devide the area became much amount of very small (differential) areas, and apply the Equation 1:

$$[I_x = \sum Ay^2] \tag{1}$$

If the bamboo stem is assumed as a hollow tube (Figure 1), the moment inertia formulae could be derived by calculus and geometric analysis:

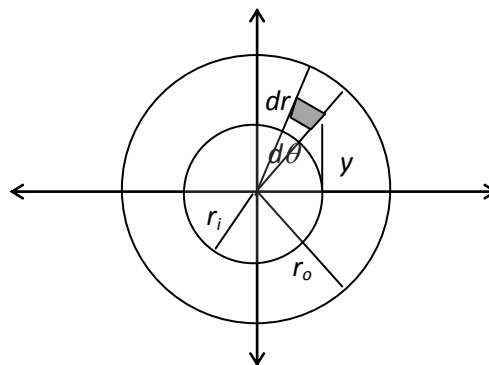


Figure 1. Skets of bamboo plane

In accordance with Figure 1, distance (y) from absis is:

$$[y = r \sin \theta] \tag{2}$$

And the cross sectional area of differential area (dA) is:

$$[dA = r d\theta dr] \tag{3}$$

Substituting Equation 2 and 3 into Equation 1, we get:

$$[I_x = \int_0^{2\pi} \int_{r_i}^{r_o} r^3 \sin^2 \theta d\theta dr] \tag{4}$$

$$[I_x = \frac{\pi(r_o^4 - r_i^4)}{4}] \tag{5}$$

We prefer use bamboo diameter (d) than radius (r) for calculation because it is easily measured, so we change Equation 5 become:

$$[I_x = \frac{\pi(d_o^4 - d_i^4)}{64}] \tag{6}$$

Bambo diameter commonly is not the same size along the stem, but the basal diameter is higher than the top. We define taper (t) as ratio between diameter difference and its length (Equation 7 and 8).

$$[t_o = \frac{d_{bo} - d_{to}}{L}] \tag{7}$$

$$[t_i = \frac{d_{bi} - d_{ti}}{L}] \tag{8}$$

By definition, the outer and inner diameter of the stem at a distance x from the top, could be defined as:

$$[d_{xo} = d_{to} + \left(\frac{d_{bo}-d_{to}}{L}\right)x = d_{to} + t_o x] \quad (9)$$

$$[d_{xi} = d_{ti} + \left(\frac{d_{bi}-d_{ti}}{L}\right)x = d_{ti} + t_i x] \quad (10)$$

So, the moment inertia of bamboo stem at a distance x from the top could be calculated by:

$$[I_x = \frac{\pi}{64} ((d_{to} + t_o x)^4 - (d_{ti} + t_i x)^4)] \quad (11)$$

Normal stress in beam

It is assumed that bamboo stem is composed from some amount of fine fibers which arranged longitudinally. On bending test with center point loading configuration (Figure 2), the fiber below neutral axis will become longer, while the fiber above neutral axis will be shorter. This condition caused the tension stress for fiber below neutral axis, and compression stress for fiber above neutral axis. Both tension and compression stresses are usually called normal stress in beam which could be calculated by Equation 12:

$$[\sigma = \frac{My}{I}] \quad (12)$$

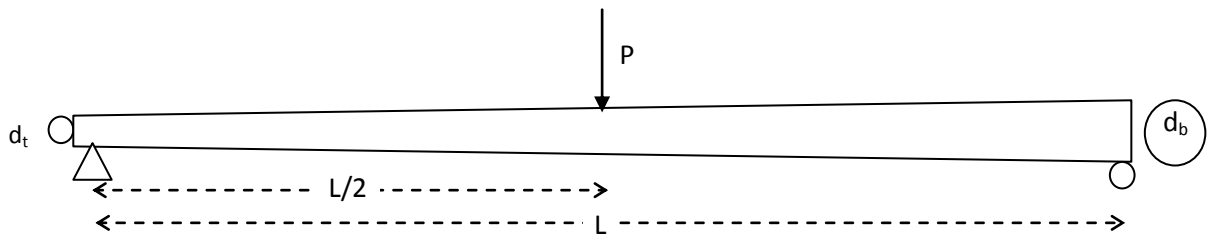


Figure 2. Bamboo stem on bending test with center point loading configuration

Momen (M) through the length of bamboo beam which is rated by center point bending, could be defined as Equation 13.

$$[M_x = \begin{cases} \frac{Px}{2}; & \text{for } 0 \leq x \leq \frac{L}{2} \\ \frac{P(L-x)}{2}; & \text{for } \frac{L}{2} \leq x \leq L \end{cases}] \quad (13)$$

While y is maximum distance from neutral axis, which could be calculated as:

$$[y_x = \frac{(d_{uo} + t_o x)}{2}] \quad (14)$$

Substituting Equation 11, 13, and 14 into Equation 12, we get formulae for normal stress in bamboo stem:

$$[\sigma_x = \begin{cases} \frac{16Px(d_{uo} + t_o x)}{\pi((d_{to} + t_o x)^4 - (d_{ti} + t_i x)^4)}; & \text{for } 0 \leq x \leq \frac{L}{2} \\ \frac{16P(L-x)(d_{uo} + t_o x)}{\pi((d_{to} + t_o x)^4 - (d_{ti} + t_i x)^4)}; & \text{for } \frac{L}{2} \leq x \leq L \end{cases}] \quad (15)$$

Equation 15 doesn't always have maximum value in the center, eventhough the load is rated in the center. Meanwhile the measurement and calculation of Modulus of Rupture (S_R) is usually in the center of the length. This condition could be dangerous for building planning because the estimation of material properties could be higher than the actual maximum normal stress in bending test, especially for bamboo with high taper value. To avoid this condition, a strenght ratio of taper (C_t) should be conducted to adjust the material properties in bending. The strenght ratio of taper (C_t) is defined as the ratio of stress in the center length and maximum stress throughout the length (Equation 16).

$$[C_t = \frac{\sigma_{(L/2)}}{\sigma_{(max)}}] \quad (16)$$

Figure 3 shows the skets of bending stress in every taper value. The Figure 3 is built within assumption that the inner and outer tapers are the same value.

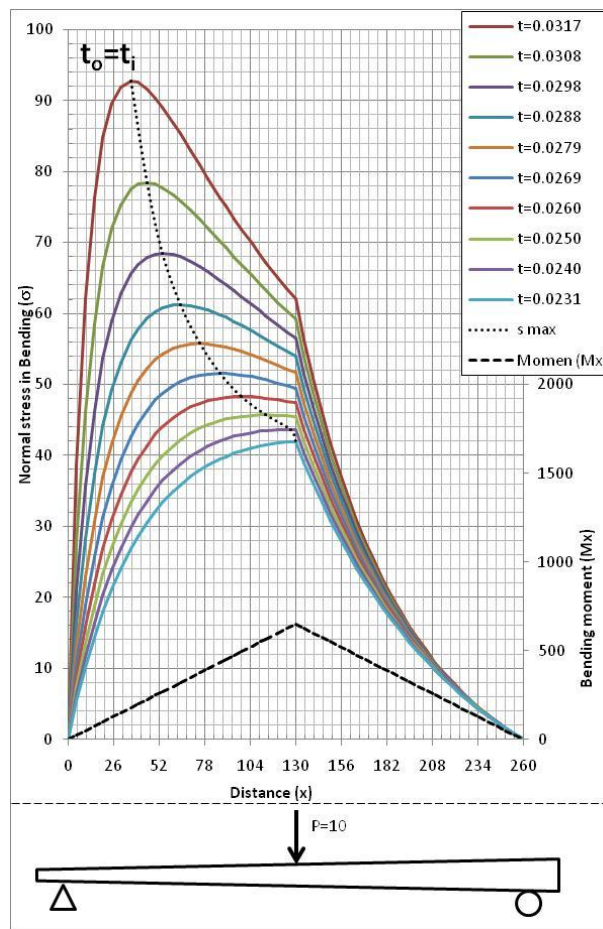


Figure 3. Effect of bamboo taper on its bending stress

As seen on Figure 3, the maximum bending stress moves to the top of stem. The peak is farther from the center length and closer to the top if the taper value is higher. If the taper value is lower than 0.0231, the maximum bending stress is still in the center length, so in this condition the maximum bending stress is the same value as conventional calculation for modulus of rupture (S_R). The dot type line in Figure 3 shows the maximum bending stress in every bamboo taper. This line could be determine as the first derivation of normal stress which has zero value, because it is a constellation of peak value of the normal stress curve (Equation 17). The maximum value of bending stress will be obtained if Equation 17 is fulfilled. Equation 17 could be solved become Equation 18:

$$\left[\frac{d}{dx} \left(\frac{16Px(d_{uo} + t_o x)}{\pi((d_{uo} + t_o x)^4 - (d_{ui} + t_i x)^4)} \right) \right] = 0; \text{ for } 0 \leq x \leq \frac{L}{2} \quad (17)$$

$$\left[\frac{16P(d_{uo} + 2t_o x)}{\pi((d_{uo} + t_o x)^4 - (d_{ui} + t_i x)^4)} - \frac{16Px(d_{uo} + t_o x)(4t_o(d_{uo} + t_o x)^3 - 4t_i(d_{ui} + t_i x)^3)}{\pi((d_{uo} + t_o x)^4 - (d_{ui} + t_i x)^4)^2} \right] = 0; \text{ for } 0 \leq x \leq \frac{L}{2} \quad (18)$$

The skets of Equation 18 is the dot type line in Figure 3 which shows the maximum bending stress along the beam length. The strenght ratio (Equation 16) is gone down into graphical skets by divide the bending stress value in the center length with the maximum value, and finally we have Figure 4. As seen on Figure 4, the C_t value is always 1 if the taper is lower than 0.023. While the C_t value less than 1 if the taper is higher than 0.023, which means the bamboo modulus of rupture (S_R) should be adjusted by C_t if

this condition found. For simplicity, the C_t value for taper higher than 0.023 could be estimated by quadratic equation (Equation 19), because it has high coefficient of determination:

$$[C_t = \begin{cases} 1; & \text{for } t \leq 0.023 \\ -5708t^2 + 276.2t - 2.338; & \text{for } t > 0.023; R^2 = 99.9\% \end{cases}] \quad (19)$$

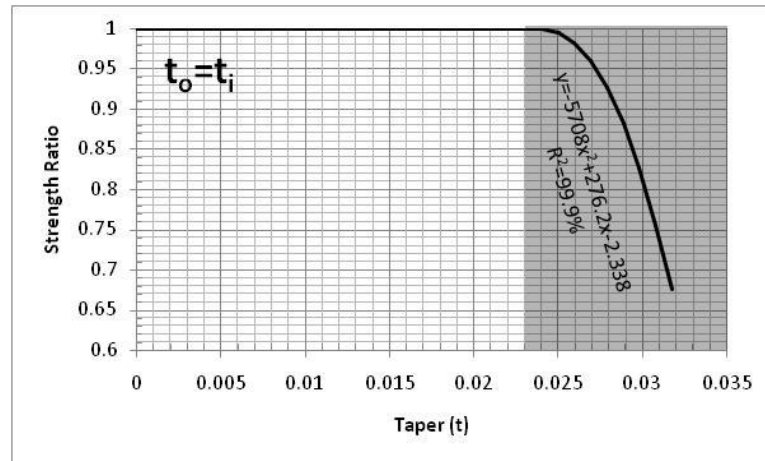


Figure 4. Strength ratio (C_t) of bamboo taper (with restriction $t_o=t_i$)

Bamboo Taper Measurement

This research conducted by measuring 36 bamboo stem from 4 species, namely Ampel (*Bambusa vulgaris* Schrad.), Tali (*Gigantochloa apus* (Bl.Ex Schult.f) Kurz), Gombong (*Gigantochloa verticillata* (Willd.) Munro), and Mayan (*Gigantochloa robusta* Kurz.). The stem was cut from Arboretum Bamboo in Bogor Agricultural University. It is found that the minimum outer taper value for Ampel and Tali are zero. It means there are some stems which have no diameter difference between top and basal of the stem. While the maximum outer taper value is 0.0127. We may find some negative value for inner taper, which means that bamboo stems sometime have higher inner diameter in the top than the basal. The range value is also wider than the outer. The detail of bamboo taper measurement is shown in the Table 1. Some researcher had reported the similar range of bamboo taper. Yu, et al [6] reported the typical dimension of two bamboo species, namely Kao Jue (*Bambusa pervariabilis*) and Mao Jue (*Phyllotachys pubescens*) for buckling test. Kao Jue had almost straight cylindrical shape with similar diameter from the basal to the top. The average outer and inner diameters were 40 and 30 mm, respectively. On the contrary Mao Jue had tapering stem. For the 6 m length, the basal outer and inner diameters were 90 and 72 mm, while the top were 60 and 48 mm respectively. It means the average outer and inner tapers of Mao Jue are 0.005 and 0.004.

Applying overall taper range of both bamboo species, Figure 5 (a, b, c) are created according to Equation 15. As seen on the Figure 5, all peaks are happened in the center length. It means the strength ratio of taper value is always 1 for that range. This condition proves that it is reasonable to neglect the effect of taper in the center point bending test as stated in some standard test methods or designations.

Table 1. Taper of Bamboo Stem.

Species	n	Taper	MIN	MAX
Ampel (<i>Bambusa vulgaris</i> Schrad.)	9	Inner (t_i)	0.00239	0.0083
		Outer (t_o)	0	0.0079
Tali (<i>Gigantochloa apus</i> (Bl.Ex Schult.f) Kurz)	9	Inner (t_i)	-0.0042	0.0085
		Outer (t_o)	0	0.0054
Gombong (<i>Gigantochloa verticillata</i> (Willd.) Munro)	9	Inner (t_i)	0.0004	0.0087
		Outer (t_o)	0.0013	0.0127
Mayan (<i>Gigantochloa robusta</i> Kurz.)	9	Inner (t_i)	-0.0047	0.0088
		Outer (t_o)	0.0008	0.0079
Overall	36	Inner (t_i)	-0.0047	0.0088
		Outer (t_o)	0	0.0127

CONCLUSIONS

Theoretically, taper plays an important role for defining the Modulus of Rupture (S_R) of bamboo stem especially for high taper value. The strength ratio of taper (C_t) is only affected to material properties if the taper value is higher than 0.023. Meanwhile, the taper range of bamboo selected is much lower than 0.023. So it is reasonable to neglect the taper effect on bamboo center point bending test.

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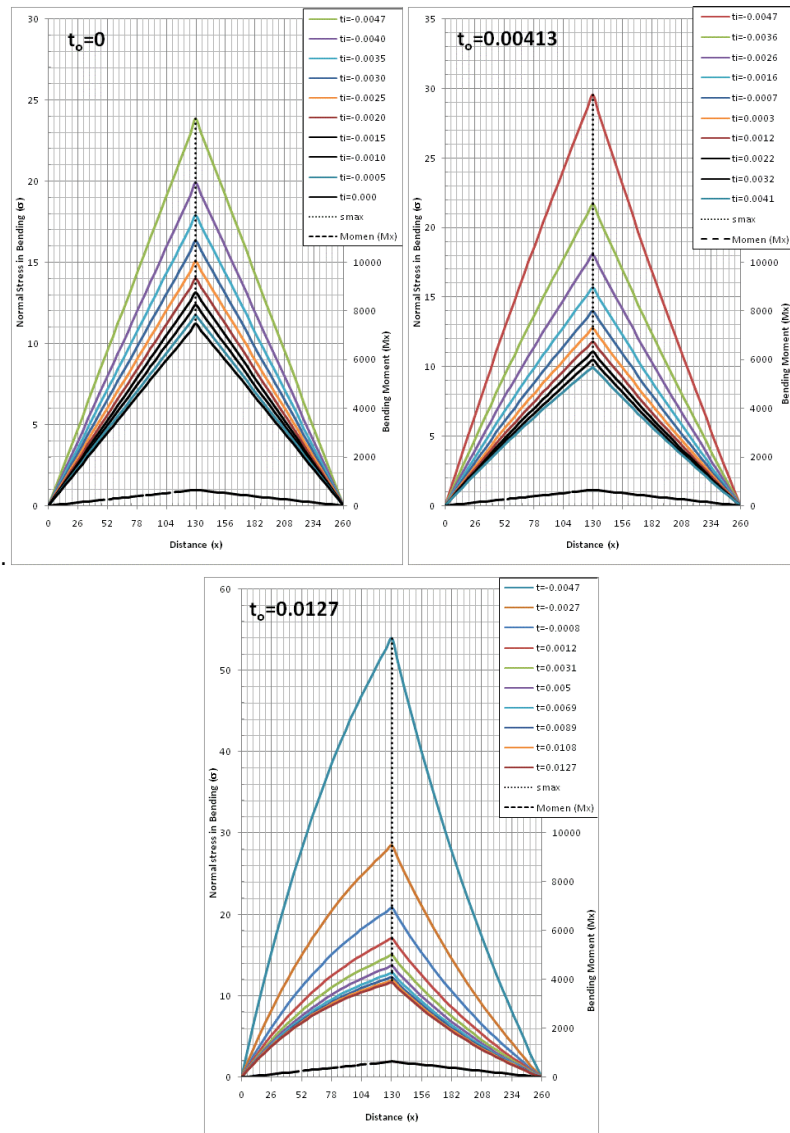


Figure 5. Normal stress in center point bending test for overall range of bamboo taper

Antitermitic Activities of Juvenile Teak Wood Grown in Community Forest

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ABSTRACT

The objectives of this study are to evaluate the bioactivity against termites of young teak wood in the form of wood extracts and wood blocks as well as to relate the extractive content to their antitermitic properties. Materials used in this study were five of 8-year-old and four of 22-year-old trees from community forests in Jogjakarta. The disc samples from the bottom part of each tree were sawn. The samples for termite resistance test and chemical properties were taken at 4 radial positions (outer sapwood, inner sapwood, outer heartwood and inner heartwood). Cold extraction using *n*-hexane, ethyl acetate (EtOAc), and methanol (MeOH) were separately conducted to the respective wood powders. The extractive contents then were determined. The termite resistance test was performed by force-feeding method using *Reticulitermes speratus* Kolbe termites. Parameter tested included mass loss of paper discs/ wood blocks and mortality percent of the termites. The results showed that by ANOVA, there were significant interactions between tree age and radial direction factors with regards to *n*-hexane and EtOAc extractive content. The mass loss levels due to termite activity were not statistically different between 22-year old and control trees (51-year-old) in the wood block samples as tree age factor did not affect the mass loss levels in the extract samples. In addition, the sapwood parts of the 8-year old trees showed the most susceptible ones. Based on the termite mortality rate, no significant differences were found among the radial parts in the 22 and control trees (51-year-old) in the wood block samples while significant differences between inner and outer heartwood were measured in the *n*-hexane and EtOAc extracts. Further, the outer heartwood in EtOAc extracts showed the most active against termites. Despite all the extracts exhibited activity against termites, no significant correlations were detected in the heartwood part between the extractive content and antitermitic properties.

Keyword : *Tectona grandis*, antitermitic activities, extractive, tectoquinone, *Reticulitermes speratus*

INTRODUCTION

The woods of teak (*Tectona grandis* L.f) have been recognized for various utilizations due to its high durability. In the last decades, that demand of teak has been increasing. To meet this demand, there is a trend by changing from older, larger trees, which contain wood with a proven durable performance, to younger trees, from community forests, whose wood properties are not as well understood. There are questions over the quality of the wood obtained from such younger trees. Logs from these community forests will have a large proportion of sapwood and immature wood, whose properties may differ from those of older trees. To achieve more rational utilization of naturally durable timber, the effects of changes in wood properties on resistance to termites and decay fungi should be studied.

From previous result, 5-year-old juvenile wood is less decay resistant than the wood of 13-year-old trees and mature teak wood of forest plantations (Bhat and Florence 2003). The lower durability of young plantation teak and inner heartwood of older trees were also observed by some researchers (Da Costa *et al.* 1958,1961; Bhat *et al.* 2005, Kokutse *et al.* 2006). As the natural durability is attributed to the extractives, however, not many works have been done to relate the extractive content to natural durability in teak, particularly in natural termite resistance. In addition, the method used for assessing the natural durability was varied of which the samples were both in natural condition and extracts (*in-vitro*). In other species, lower extractive content has been correlated with reduced termite and fungal resistance (Hillis 1987, Hashimoto *et al.* 1997). In *T. plicata*, lower extractive contents have been observed in the heartwood near the pith of a number of species (DeBell *et al.*1999). As a continuation of our parallel works (Lukmandaru and Takahashi 2008, Lukmandaru 2011), the purpose of the present study is to evaluate the natural termite resistance of 8- and 22-year-old teak woods grown in community forests based on no-choice feeding method and to relate it with the extractive contents. Another purpose was to compare the results between the methods using wood blocks and wood extracts.

MATERIALS AND METHOD

Sample Preparation

Trees of the 8-year-old (5 trees, dbh 8-13 cm, sapwood proportion 66-84 %) and 22-year-old groups (4 trees, dbh 23-30 cm, sapwood proportion 36-44 %) were felled from farm plantations or 'community forests' in Jogja Province. A 5-cm-thick disc was removed at approximately breast height from the trees. The 8-year-old discs were divided into three parts (Fig. 1) : outer sapwood (OS), inner sapwood (IS), outer heartwood (OH), while the 22-year-old discs were divided into three parts : outer sapwood (OS), inner sapwood (IS), outer heartwood (OH), middle heartwood (MH) and inner heartwood (IH). For each part, blocks were sawn on two opposite radii and were converted into wood meal (40–60 mesh size) to determine the content and chemical composition of the extractives. For the termite resistance test, blocks ca. 5.0 (L) × 0.8 (T) × 0.8 (R) cm matching samples for extractive content determination, were stripped from each part and radius. The blocks were then dried at 100 °C for 3h, after which they were cooled and weighed. The meals from two opposite radii were then combined to form a single sample in order to minimize any variation between radii. For comparative purposes, 5 of 51-year-old trees were felled from Perhutani Plantation, Randublatung, Central Java as well as susceptible pine sapwood blocks.

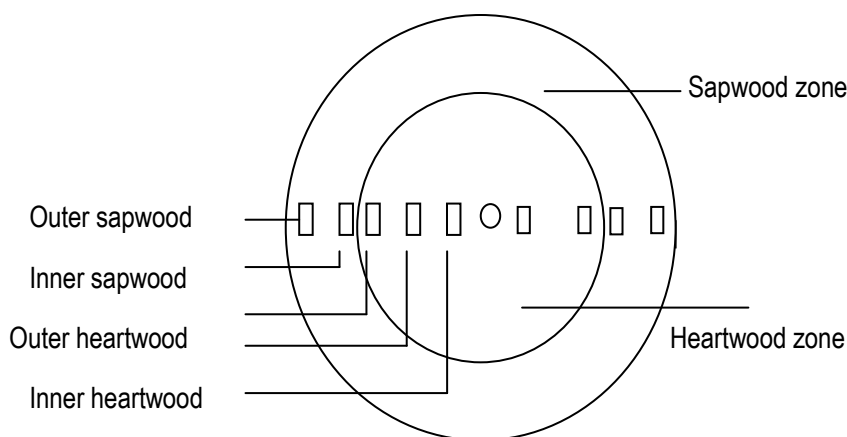


Figure 1. Sampling position on a cross-section of teak trunk

Extractive content

Extractives were obtained by cold extraction of two g of wood meal with *n*-hexane, ethyl acetate, and methanol separately for 24 hours. After evaporating the solvent, the extractives were removed, dried and weighed to determine the percentage of extractive content based on moisture-free sawdust. No extraction was conducted to the controls (51-year-old trees).

Termite resistance test

Wood extract

No choice antifeedant bioassay test was carried out in this research. A petri dish (diameter 9 cm, height 2 cm) containing 20 g moistened and sterilized sea sand was used as a container test. Paper disc diameter 8 mm; Whatmann International) were impregnated with chloroform solution containing each extract of the test fractions. No extracts from the control trees were tested. The treatment retention was 5 % (w/w) per disc and 5 duplicates were applied for each sample. After drying at 60 °C for 2 hours, followed by drying in a vacuum dessicator for 24 hours, they were put on a petri dish. The control discs were impregnated with chloroform only and dried with the same manner. Fifty worker *Reticulitermes speratus* Kolbe termites were introduced into the petri dish. The petri dishes were placed in a dark chamber at 27 °C and 80 % relative humidity. After 10 days the disc were taken out, dried in the same manner and the weight loss was determined. Dead termites were counted at the end of observation.

Wood block

For each test, an air-dried wood block (moisture content 10–12%) was inserted into a plastic cup (5.0 cm × 6.0 cm), and placed on 20 g of sterile sand. The sand was moistened with distilled water regularly to retain a constant relative humidity. Fifty worker termites were added to each cup. Included in the tests for comparative purposes were controls (51-year-old trees). Three replicates were measured for each sample. The cups were placed in the environmental chamber for 14 days. To measure the termiticidal activity, surviving termites were counted at the end of observation. The blocks were then dried at 100 °C for 3h, after which they were cooled and weighed. The mass loss was determined to quantify the extent of the termite attack on the wood.

Data analysis

The effects of tree age and radial position on extractive content, survival rate and mass loss were calculated by analysis of variance (ANOVA) GLM procedures followed by Duncan's multiple range test ($p = 0.05$). The relationships between the independent variables were studied with a Pearson's correlation analysis. The termite survival rates (percentages) were transformed by the arcsine function for analysis but were presented as untransformed values to facilitate interpretation. All statistical calculations were conducted using SPSS-Win 10.0

RESULTS AND DISCUSSION

Factorial analysis of variance results for the various property measurements are summarized in Table 1. There are significant interactions between tree age and radial direction factors in regards to *n*-hexane and EtOAc extractive content. Both factors did not significantly affect termite mortality in *n*-hexane and MeOH extracts. Tree age factor significantly affected termite mortality in EtOAc extract while the radial direction affected the rest parameters.

Extractive content

Generally, the extractive content increased with the polarity in every part of the wood (Table 2). Methanol extractive contents gave the highest amounts although the values obtained here were lower than the published data (Da Costa et al. 1958, Lukmandaru and Takahashi 2008, Lukmandaru 2011, Narayanamurthi et al. 1962) of young teak wood. Theoretically, methanol could extract not only non-polar extractives, but also the polar ones. The lower values were due to cold extraction was used in this experiment instead of reflux or soxhlet extraction in the early reports. In each solvent, the outer heartwood showed significantly higher values than sapwood. There were significant differences in the extractive content levels between inner and outer sapwood as well as between inner and outer heartwood depend on the solvents. The average of *n*-hexane extractive contents in the inner sapwood is almost twice as those in the outer sapwood. The increasing of *n*-hexane and EtOAc extractive content from the inner to outer heartwood was also found. Those trends are interpreted as the increasing of non-polar substances along with the increasing the age of the wood in radial direction.

Table 1. Factorial analysis of variance results for extractive content, mass loss, and termite mortality of three different extracts (*n*-hexane, ethyl acetate, and methanol).

Source of variation	df	ss	MS	VS	Fpr
(a) <i>n</i> -hexane extractive content					
Tree age	1	2.312	2.312	33.317	<0.01**
Radial direction	3	5.061	1.687	24.309	<0.01**
Tree age x radial direction	2	0.515	0.257	3.710	0.038*
(b) Mass loss in <i>n</i> -hexane extract					
Tree age	1	21.757	21.757	2.498	0.126 ^{ns}
Radial direction	3	138.915	46.305	5.316	0.005**
Tree age x radial direction	2	8.010	4.005	0.460	0.636 ^{ns}
(c) Termite mortality in <i>n</i> -hexane extract					
Tree age	1	0.0314	0.0314	1.047	0.316 ^{ns}
Radial direction	3	0.230	0.076	2.551	0.078 ^{ns}
Tree age x radial direction	2	0.0079	0.003	0.133	0.876 ^{ns}
(d) EtOAc extractive content					
Tree age	1	3.795	3.795	24.557	<0.01**
Radial direction	3	30.704	10.235	66.228	<0.01**
Tree age x radial direction	2	1.248	0.624	4.037	0.03*
(e) Mass loss in EtOAc extract					
Tree age	1	5.391	5.391	0.643	0.43 ^{ns}
Radial direction	3	143.451	47.817	5.704	0.004**
Tree age x radial direction	2	2.853	1.426	0.170	0.844 ^{ns}
(f) Termite mortality in EtOAc extract					
Tree age	1	2925.714	2925.714	6.359	0.019*
Radial direction	3	8746.445	2915.482	6.337	0.003**
Tree age x radial direction	2	80.647	40.323	0.088	0.916 ^{ns}
(g) MeOH extractive content					
Tree age	1	21.757	21.757	2.498	0.126 ^{ns}
Radial direction	3	138.915	46.305	5.316	0.005**
Tree age x radial direction	2	8.010	4.005	0.460	0.636 ^{ns}
(h) Mass loss in MeOH extract					
Tree age	1	1.764	1.764	0.167	0.686 ^{ns}
Radial direction	3	331.869	110.623	10.478	<0.01**
Tree age x radial direction	2	23.358	11.679	1.106	0.345 ^{ns}
(i) Termite mortality in MeOH extract					
Tree age	1	136.896	136.896	0.183	0.673 ^{ns}
Radial direction	3	3412.214	1137.405	1.522	0.237 ^{ns}
Tree age x radial direction	2	169.936	84.968	0.114	0.893 ^{ns}

ns = not significant, ** Significant at 1 % level, * significant at 5 % level

Table 2. Extractive content (% oven dried mass m/m) of cold extraction *n*-hexane, EtOAc, and MeOH in teakwood by tree age and radial position. Mean of 5 trees (8-year-old) and 4 trees (30-year-old), with the standard deviation in parentheses.

Tree age	Radial position	Extracts		
		<i>n</i> -hexane	Ethyl acetate	Methanol
8 year old	Outer sapwood	0.32 (0.16) a	0.71 (0.21) f	2.13 (0.67) j
	Inner sapwood	0.63 (0.28) b	0.93 (0.28) f	2.31 (1.10) j
	Outer heartwood	1.05 (0.34) c	2.61 (0.43) h	4.00 (0.56) k
22 year old	Outer sapwood	0.53 (0.06) b	0.96 (0.21) f	1.73 (0.62) j
	Inner sapwood	1.31 (0.27) d	1.60 (0.72) g	2.14 (0.73) j
	Outer heartwood	1.89 (0.28) e	3.90 (0.41) i	3.69 (0.55) k
	Inner heartwood	1.34 (0.32) d	2.43 (0.35) h	3.14 (0.36) k

Mass Loss

In the form of wood block, the tree age factor significantly affected the mass loss levels, in that 51 year old tree gave the lowest values in each part. The level of activity of the OS of 51-year-old trees is even comparable to that of the OH of 8-year-old trees. The striking differences were found in the sapwood part in that the 8-year old tree showed the most susceptible ones. It is noticed, except in the outer sapwood part, the mass loss levels trees were not statistically different between 22 and 51-year-old trees. The termite susceptibility in the sapwood must be taken into consideration, since the percentage of sapwood is relatively high in trees younger than 51 years.

In the form of extracts, the EtOAc extracts tend to give lower values of mass loss than other extracts. In line with our previous study (Lukmandaru 2011), by successive extraction, EtOAc the greater the ethyl-acetate-soluble extractives (EEC) then the higher the termite resistant (lower mass loss), and conversely the greater the methanol-soluble extractive (MEC) then the lower the termite resistant (greater mass loss). It seems that not all of these components are equally important in determining natural durability as heartwood extractives within a piece of wood can range from low molecular weight volatile compounds to large polymers. The ANOVA showed that tree age did not affect the mass loss on contrary to radial direction. As expected, the outer heartwood part showed significant higher activities although it did not significantly differ between outer and inner heartwood in the MeOH extracts. No significant differences were also found between outer and inner sapwood as well as between the outer heartwood of 8 and 22-year old trees in all extracts. Compared to the patterns in wood blocks, the similarity was found in 8-year-old trees in that an increase in natural termite resistance from sapwood to heartwood in all extracts is evidenced. The pronounced differences in the patterns between the wood blocks and extracts were detected between the outer and inner heartwood in the 22 year-old trees.

Mortality Rate

In the form of wood blocks, sapwood of 8-year-old trees showed the lowest activities while no systematic differences in the heartwood parts were found among the three ages (Table 4). It was also noted that the mortality rate levels in sapwood of 22-year-old trees were not statistically different than the those of the heartwoods. The patterns in the mortality rate of the 8-year-old trees is in line with those of mass loss levels in the same tree age. However, the insignificance of mortality rate levels among the parts in the 22 and 51-year-old trees was differed from those of mass loss levels.

Table 3. Mass loss (mg) against *Reticulitermes speratus* of teakwood by tree age and radial position. Mean of 5 trees (8-year-old) and 4 trees (30-year-old), with the standard deviation in parentheses. The same letters in the same column are not significantly different at $p < 5\%$ by Duncan's test.

Tree age	Radial position	Extracts ^a			Wood block ^b
		<i>n</i> -hexane	Ethyl acetate	Methanol	
8 year old	Outer sapwood	6.55 (2.68) b	5.95 (4.08) c	8.84 (2.88) e	27.68 (8.05) j
	Inner sapwood	5.90 (3.54) b	6.67 (1.72) c	8.82 (3.46) e	31.81 (14.78) j
	Outer heartwood	2.74 (1.97) a	1.37 (0.83) d	2.45 (1.08) f	7.45 (6.39) h
22 year old	Outer sapwood	8.97 (2.07) b	5.48 (3.09) c	11.67 (2.80) e	14.52 (6.78) i
	Inner sapwood	8.45 (2.81) b	4.92 (1.01) c	7.22 (4.43) e	7.84 (6.23) h
	Outer heartwood	2.99 (1.63) a	1.00 (0.83) d	2.74 (1.01) f	4.07 (3.32) gh
	Inner heartwood	6.08 (4.90) b	5.58 (3.30) c	3.80 (2.93) f	5.69 (4.36) gh
Control (untreated)		20.62			
Control (51 years)	Outer sapwood				6.30 (4.34) gh
	Outer heartwood				1.39 (1.22) g
	Inner heartwood				4.72 (3.46) gh
Control (pine sapwood)					52.41 (5.69)

Note : a = 10-day observation, b= 14-day observation

In the extracts, most outer sapwood parts gave lowest values of mortality rate. The inner sapwood parts showed significantly higher activities than outer sapwood in the EtOAc of 8 year-old trees. In the heartwood, significant differences between inner and outer heartwood were measured in the *n*-hexane and EtOAc extracts. The outer heartwood in EtOAc extracts showed the most active against termites. No

significant effects were found after treating with methanol extracts although it still showed activities compared to untreated controls. This fact indicated that most of active substances were EtOAc soluble on the other hand MeOH solubles weakened the termite resistances. The patterns were similar between the wood blocks and the extracts in the 8-year-old tree samples. On the contrary, the those trends were not found in the 22 year-old trees as no significant differences were measured in every parts in the wood block samples. The different patterns were also found between the mass loss and mortality rate levels in the EtOAc and MeOH extracts. Those facts were interpreted as the complexity in natural resistance as well as in heartwood extractives that some factors could affect the results.

Table 4. Mortality rate (%) against *Reticulitermes speratus* of teakwood by tree age and radial position. Mean of 5 trees (8-year-old) and 4 trees (30-year-old), with the standard deviation in parentheses. The same letters in the same column are not significantly different at $p < 5\%$ by Duncan's test.

Tree age	Radial position	Extracts ^a			Wood block ^b
		<i>n</i> -hexane	Ethyl acetate	Methanol	
8 year old	Outer sapwood	13.00 (7.58) a	11.00 (9.61) c	23.00 (17.58) g	44.15 (14.68) h
	Inner sapwood	10.00 (5.72) a	6.25 (4.78) c	46.80 (24.47) g	52.50 (19.33) h
	Outer heartwood	27.50 (16.41) b	45.00 (32.78) e	53.00 (11.80) g	62.44 (13.10) i
22 year old	Outer sapwood	15.00 (4.24) a	28.75 (24.95) d	25.00 (18.66) g	75.67 (18.56) i
	Inner sapwood	20.00 (5.77) a	32.50 (11.90) d	32.50 (15.24) g	75.82 (22.60) i
	Outer heartwood	36.25 (8.87) b	65.00 (29.43) f	38.50 (13.30) g	71.19 (21.09) i
	Inner heartwood	18.75 (3.76) a	20.00 (17.79) cd	39.25 (18.67) g	74.19 (13.51) i
Control (untreated)		7.00 (6.70)			
Control (51 years)	Outer sapwood				76.27 (15.15) i
	Outer heartwood				72.80 (13.81) i
	Inner heartwood				68.67 (14.57) i
Control (pine sapwood)					11.33 (2.30)

Note : a = 10-day observation, b= 14-day observation

Relationship between termite resistance and extractive contents

The correlation between antitermitic properties and extractive content was described in Table 5. If the data in the sapwood and heartwood were combined, significant moderate correlations were measured in the methanol and EtOAc extracts that means the variation in antitermitic properties between those parts could be explained partly by extractive contents. The positive correlation in the mortality rate and extractive content levels means that the higher extractive content, the higher mortality rate will be. In contrast with the negative correlation between the mass loss and extractive levels. This result is reasonable since the extractive content in the heartwood are higher than in the sapwood. If the data were divided, unexpectedly, the correlation was found in the sapwood part between the mortality rate and EtOAc extractive content levels. On the other hand, no significant correlations were detected in the heartwood part.

Quinones and their derivatives have been detected to inhibit termite and fungal attacks (Haupt et al., 2003; Rudman and Gay, 1961; Sandermann and Simatupang, 1966; Sumthong et al., 2006; Thulasidas and Bhat, 2007). The *n*-hexane would extract non-polar substances such as fats, oil, resin, and waxes as well as some quinones (Windeisen et al 2003). The moderate polar solvent EtOAc could extract non-polar substances as well as some phenolics whereas the polar solvent MeOH would extract non-polar substances, phenolics and sugars. The significant correlation was measured in the sapwood means that this part contained some toxic components. Although the *n*-hexane extractives showed antitermitic activities, no significant relationship was found. As the mass loss is moderately correlated with *n*-hexane extractive content obtained by soxhlet extraction in previous communication (Lukmandaru and Takahashi 2008), this fact indicated that toxic quinones were not thoroughly extracted by cold extraction in this experiment. By cold extraction, it is thought that EtOAc extracted most toxic quinones in mortality rate levels despite MeOH extracted toxic quinones also but some non-quinones such as other phenolics or sugars were also extracted which were conversely responsible for lowering termite resistance (lower mortality rate). The variation in the extractive content also could not explain the variation in the antitermitic properties in the heartwood. This could be assumed that there is synergistic or antagonistic among the the

extractives with regard to antitermitic properties. Furthermore, the weak correlations were due to the toxic component concentrations are independent to the pattern of extractive content. A subsequent study will describe the quantity of toxic components of each extract to explain this discrepancy.

Table 5. Pearson's correlation coefficients between natural termite resistance parameters and extractive component contents.

	Antitermitic properties					
	Mass loss			Mortality rate		
	Total	Sapwood	Heartwood	Total	Sapwood	Heartwood
a) <i>n</i> -hexane extract	-0.23	0.07	0.17	0.30	0.16	0.04
b) Ethyl acetate extract	-0.53**	-0.14	-0.38	0.64**	0.58*	0.52
c) Methanol extract	-0.50**	-0.01	-0.08	0.47*	0.48	0.29

** Significant at 1 % level, * significant at 5 % level

CONCLUSIONS

The heartwood and sapwood of all of the younger trees tested showed antitermitic activity both in the form of wood blocks and wood extracts. The mortality rate and mass loss levels in the wood block samples of sapwood and heart-wood of 8-year-old trees are significantly lower than those of 22-year-old trees. The similar patterns were also observed in the EtOAc extract samples. Different results were observed between wood blocks and extracts in force-feeding method to termites, as well as the patterns between mass loss and mortality rate levels which suggest that the relationship between heartwood extractives and heartwood durability is complex. Variations in extractive contents were moderately correlated with the antitermite properties in the ethyl acetate and methanol solubles but weakly correlated in the *n*-hexane extracts. However, no significant correlations were detected in the heartwood part alone between the extractive content by cold extraction and antitermitic properties.

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Greenship Rating of Wood Materials in Building

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ABSTRACT

The implementation of the greenship rating is a measuring instrument qualitative the occurrence of a green building that environmentally friendly since planning, development, until the operation and maintenance of daily. This assessment with the system any buildings who declare themselves as green buildings will be assessed and certified based on raw criteria that exist in the assessment system. One factor as criteria is material resources and cycle/MRC by research and innovation to produce green products. At the stage of building maintenance occurs a decrease in function that is one of the cellulose materials can be measured in detail to find out the causes, symptoms and treatment improvements that need to be given to address them. The research that has been done is aimed at analysing the condition of illness, greenship rating in quantitative (pathology building) as well as terotechnology; that is to see conditions afflicted of wood material infected by termites and economic losses as well as during their useful life due to termite attack. The result showed that the damage that occurs commonly in the Apartment and Hotels in South Jakarta is the surface of crinkles and cracking hair on cellulose materials, while in FT-UKI building in East Jakarta damage found crinkles, is the surface of cracked hair and loose/undone. Termite colony is walking through the tunnel network where termite built of flattened land mixed salivary termite, explores vertically and horizontally from floor to floor with a function room on each floor. Loss due to termite attacks on this did not damage the structure of the system but only made from cellulose as well as construction of comfort and loss factor in residence security quite significantly. Calculation of the damage caused by termites attack was on par and in line with the decline in the value of the building without maintenance.

Keywords: greenship, pathology building, terotechnology

INTRODUCTION

A system of "greenship rating" is aids for the construction/building industry, businessman, engineer, and other agents in applying best practices and reach a standard unmeasured that may be understood by the general public, especially tenant and users of the building. To be achieved in the implementation of standards greenship is the occurrence of a green building that environmentally friendly since planning, development, until the operation and maintenance of daily. One factor that judgment is material resources and cycle (MRC) that deals with the maintenance of a building.

Pathology building can be defined as of the systematic knowledge of building diseases, with the purpose to understand causes, symptoms, and treatment improvements need to be given to solve the problem. In the context of medical, someone be the subject of testing and investigation of which detailed considering time of service, time health and the manner of its treatment. Building pathology both of concept and overall need holistic approach and condition of buiding anatomy. Some element detail what is needed in its approach are building design, election materials, constructing manner, use, changes in existing and other mechanism that associated with a local environment (Watt, 1999). According to Harris (2001); knowledge pathology buildings and its diagnosa aimed at deterioration and decreasing the condition of buildings and a system of its components.

Meanwhile, termites are insects that always identified as pest crusher building, housing, filing, book, plants and so on. In fact, termites are insects which have as a cleaning trashes nature. But with the narrowness land that result against the narrowness life habitats termites, they begin to run human habitations to find food resources to keep their survival. Any of various termites crusher building namely *Coptotermes curvignathus* from Rhinotermitidae family inflict attack levels most terrible and capable of being struck up to 33 the floor at the high of building. Re-invasion of termites is capable of destructive element construction from one floor to floor subsequent; as ceiling from gypsum up to kitchen set made of wood in room in a building.

MATERIALS AND METHODS

Materials

Material used is master plan and pictures apartment buildings and hotels in the south area of Jakarta and visual data of Tower 1 (apartment), Tower 3 and Tower 4 (hotel) was attacked by termites. In addition as a basis for comparison is master plan and pictures building FT-UKI with the data visual; and lay-out of room were attacked by termites.

Methods

The method used in system of “*greenship*” assessment rating is divided 6 (six) categories, namely: (a) appropriate site development, maximal value 17 percents; (b) energy efficiency and conservation, maximal value 26 percents; (c) water conservation, maximal value 21 percents; (d) material resources and cycle, maximal value 14 percents; (e) indoor health and comfort, maximal value 10 percents and (f) building environmental management, maximal value 13 percents. An assessment system rating of “*greenship*” associated in this research is MRC-2, MRC-4, MRC-5 and MRC-6: certified wood (maximal value 10 percents) which included in (d) material resources and cycle in “*greenship*” rating system.

In this research an observation is performed directly on the buildings, as well as on the basis of records researched report from management of maintenance building, includes:

- To conduct observations on the condition of building construction floor by floor in accordance with possible termite colony lives in the building construction in the interior areas.
- Investigation of damage location of the building construction and the cause of the attack as well as identify the kind of damage termites, either due to the design, construction, maintenance system, user carelessness, and also due to the utilization of the building materials. The next step is to categorize the conditions of building construction.

In this case utilization of material (wood materials) is a component of a building anatomist. Wood materials had benefits integrated with other material in a building to know the quality standard of utilization related to the lifetime of the observed building. The observation data used in this research are data from 5 (five) years of damage in component of wood materials and occurring by 3 (three) factors, namely:

- Acceleration of the damage that occurs due to election early draft of building
- Mitigation, factors outside the building by termite attacks from the ground surface around the building
- Substitution, to change an old material damage by using the same material.

The efforts solved an incidence of damage regularly takes the concept of an integrated to produce a work of architecture by minimizing the risk of economic loss levels, security, and convenience for users. In this case, the management of building maintenance needs to have knowledge about conditions the building construction, utilities building has to do with the use of wood materials; in order to minimize damage happened.

RESULT AND DISCUSSION

Apartment and Hotels in South Jakarta

Building Pathology

Data found visually on Tower 1 (30 floors), Tower 3 (33 floors) and Tower 4 (30 floors) found the path of a roaming ability until the top floor of buildings; suspected is a roaming path of *Coptotermes curvignathus* termites. Characteristics of vertically on cruising of termites in apartment buildings and hotels in South Jakarta begin from plumbing systems of clean water coming in through the basement floor which high moisture and coated with dark conditions (less lighting). The occurrence of condensation on cold water pipes or air conditioner, clean and dirty water pipes, clogged gutters water, leakage from gutter and some plants in terrace at every floor of building are all potential vehicles for termite colonies. Termite attack that occurred until to the top floor of apartment and hotel buildings, shows that the roaming ability of *Coptotermes curvignathus* termite are not affected by the force of gravity.

Characteristic of roaming ability of *Coptotermes curvignathus* termites in horizontally happen by termites entered into the adjoining room (inter) through plinthed wood at corridor between rooms and in every unit apartment at each floor. To reach out to the whole unit apartments/rooms each floor (8 rooms), a colony of termites can directly go to the humid rooms such as bathrooms/WC, laundry room and around it. It is also supported by the activity of residents of apartments and hotels tend to be low (maximum time of residence is only 8 hours a day), resulting in a lack of vibration of the occupant as a source of brominated/power interruption activity of termites. In addition, a small gap (1 - 2 cm) on the dilatation system (separator of building structure), slit between wall and tile floor, and existence of the wooden sills is closely related to ground also is access of termites attack.

Observations of material damage occurred by 3 factors i.e. acceleration (acceleration), mitigation (by a factor of external damage) and substitution (substitution of materials with the same ingredients). A third factor such damage may occur again within 3 - 4 years, so it must be renovated. In this case the management of maintenance building need to have knowledge about the status of building structure, building utility and wood material more detail, in order to minimize happened damage. The damage rate of wood material will be happened quickly, especially in the apartment building that have become a resident's property. These things happen, because management can not directly to care of apartment units. On the hotel building, the coverage area for entire building includes the unit of hotel.

Common type of damage that occurs in Tower 1, Tower 3 and Tower 4 is the crinkles surface and cracking hairs found in wood material. The losses direct were only caused by termite colony of *Coptotermes curvignathus*, and excludes loss indirect is to renovate around the occurred defects. By weighting damage for wood material in building construction that accounting is only about 8 (eight) to 10 (ten) percent of overall cost the building apartment.

According to Harris (2003) on many modern structure, termites destructive not only material construction but also attack material in the room (interior) like wooden floor, panel dividing wall space, wallpaper, wallboard, furniture, and fibers at back of synthetic carpet. These events also occur in every observed apartment unit /room on this research, so the indirect damage will add value of previous weights percentage and become larger.

Terrotechnology

Terrotechnology is a discussion to analyze factors of technology and economic. According to Juwana (2005), the calculation of operational and maintenance at high-rise buildings is 25 percents from the total value of apartment and hotel room rates. From the results of research showed the maintenance building of apartment and hotel in South Jakarta area include: consumption of electricity and water, maintenance of equipment, security and safety of building, environmental control, maintenance of cleanliness, and also landscaping works.

To calculate the decreasing value of wood component in Tower 1, Tower 3 and Tower 4 buildings; the calculation shall be based on the condition index of building and also wood content in building at least 8 (eight) percent from the overall construction components of building. The calculation results of decreasing value of component based on condition index for Tower 1 was 3.98 percent; Tower 3 was 3.19 percent and Tower 4 was 2.14 percent respectively as seen in Figure 1 below.

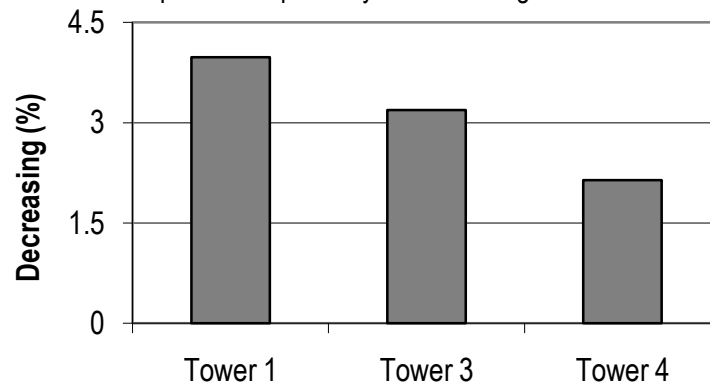


Figure 1. Histogram of Decreasing (%) in Wood Materials in Tower 1, Tower 3 and Tower 4 at Apartment dan Hotel in South Jakarta.

The research ever done before shows the condition index of building for Tower 1 is 50.22; condition index of building for Tower 3 is 60.10 and for Tower 4 is 73.19. If the rate of decreasing calculated based on condition index of each tower (assuming the condition index will keep until 25 years), and wood components of at least 8 percent from overall building components and also based on decreasing percentage of building every five years (Wordsworth, 2001), therefore the decreasing rate of Tower 1 is faster than Tower 3 and Tower 4 (Figure 2). Loss due to termite attacks on Tower 1, Tower 3 and Tower 4 did not damage the structure of the system but only the construction were made from wood material and loss of comfort and security factor of residence were significantly. The losses calculation caused by termite attacks equivalent with cost of roof cleaning and yard is 2 percent a month, so that same with a decreasing value of a building without maintenance.

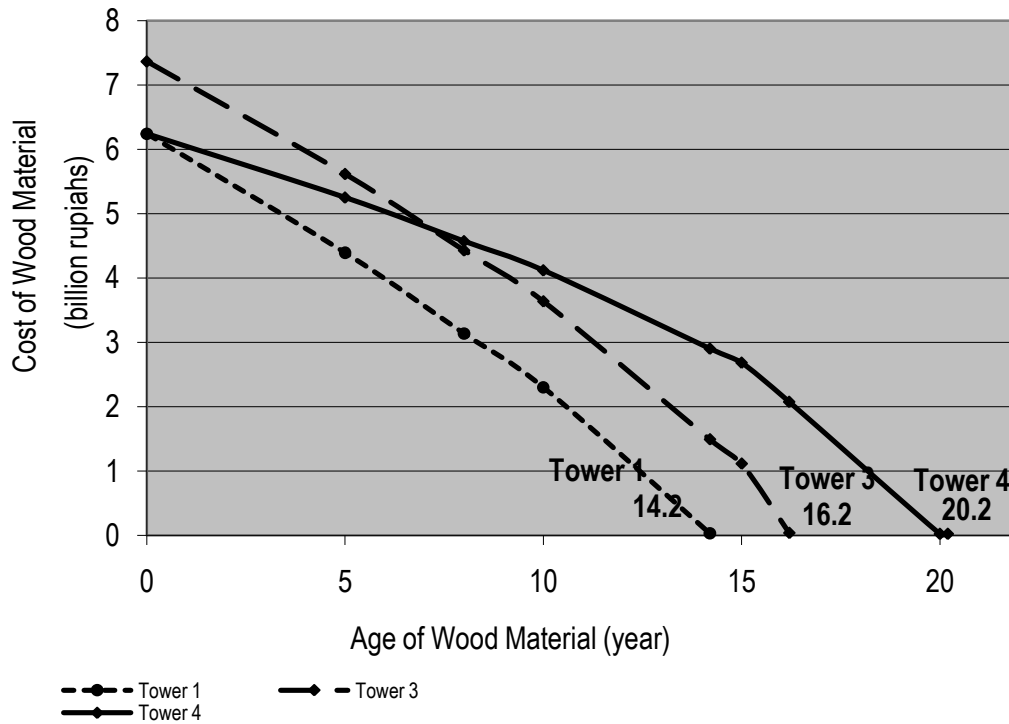


Figure 2. Decreasing Rate of Wood Materials in Tower 1, Tower 3 and Tower 4.

Greenship value

Assessment rating greenship in this research is only done on a wood material that exists in the location of the customized research with scoring of conditions index. Thus, the assessment of the maximum rating from wood certified by 2 percent indicated that the condition of wood materials in buildings is 100 percent. When the condition index less than 100 percent, then it can be said that the cellulosed material has less or do not meet the criteria of greenship.

Table 1. Greenship Score for Tower 1, Tower 3 and Tower 4.

Tower	Condition Index	Greenship	
		Score	Maximal
1	50.22	1.00	2
3	60.10	1.20	2
4	73.19	1.46	2

As has been mentioned before, the assessment of condition index in this research is an assessment of the condition of wood material only. Based on the condition index of building for each Tower, obtained that Tower 1 has a greenship value 1.00, greenship value of Tower 3 is 1.20 and Tower 4 greenship value is 1.46. Greenship value is aimed to using of cellulosed materials can be accounted for its origins to protect the sustainability of forests. The measure of indicator was to using certified wood

materials that its legal based on government regulation about the origin of wood and legitimate free from wood illegal trade. The next indicator was 30 percent use certified wood materials from Indonesia Ecolabel. Other purposes of greenship scoring is to material not wood materials, that is considering environmental factors that includes building material reuse, environmental friendly process product, zero-ozone depleting potential, modular design and regional material.

Building of FT-UKI in East Jakarta

Building Pathology

Building of FT-UKI has 3 (three) floors. The observations of *Coptotermes curvignathus* termite colony attacks the FT-UKI building this relate to some factor such as: structure system in the wall construction, floor construction and beam construction. All three of these factors have being access to be entrance media for termite colonies. The termite colonies are then expanded their habitat in the area of FT-UKI building from one floor to the next floor. This happens due to the ceiling, walls and floor (parquet) contains wood materials and can be a source of food for the termite colonies. In addition, the use of wood material in construction of wood composite panels (furniture) is also to be a medium life for termite colonies.

Termite colonies through of flattened tunnels network of land material that mixed with their saliva, roams vertically and horizontal from floor to next floor and from room to another room in each floor. The network conditions of the tunnel flattened always allegedly relate to the nest is on the ground (the main reproduction), especially around The FT-UKI building. On the conditions of the high building construction both vertical and horizontal directions, termite colonies only experienced relatively small obstacles when seeking food (attack), for allegedly reduced the natural enemy of termites in the building. This was confirmed with an explanation of Nandika *et al.* (1994) that the termite's nest predators or natural enemy is ant where located in the ground, termite colonies so easily get food inside a building.

Common type of damage that occurs at wood materials in FT-UKI building is crinkles surface and unsteady/loose for 1st floor; crinkles surface, cracking hairs and unsteady/loose in 2nd floor; and unsteady/loose in 3rd floor were found in components wood materials. Direct losses were only caused by termite colonies of *Coptotermes curvignatus* and excludes indirect losses to renovate around the damage occurred. Replacement of wood materials in this building is usually done on a periodic basis; i.e. every 4 (four) years, and the last replacement made in October 2010. This can be taken to mean that decreasing value can occurred in components of a wood material in FT-UKI building due to termite attack.

As long as the research progresses, seen that the 2nd floor level is used more, because there are also a lot more on the 2nd floor; so the level of usage is also higher. The higher use rates, then operational buildings using clean water through plumbing and due to air conditioner piping also getting high. Meanwhile the plumbing of clean water, dirty water, rainwater pipes and air conditioning pipe is a source of moisture are all potential for habitat of termites; so use more often than these building utilities also serves as the entrance of termites into the building and damaging components of wood materials. It also explains that it is on the 2nd floor damage conditions of wood material higher than the 1st floor and 3rd floor.

Terrotechnology

Juwana (2005) explains that value decreasing of the building is calculation of age structure and calculation of value of buildings (in rupiahs) that influenced by factors treatment and depreciation. The management of buildings maintenance need to take into account as a result of termites attack on components of wood material (4 percent of the total building component) in every the floor at this building with the lapse of time 3 - 4 years. So far the building maintenance includes:

- consumption of electricity and water
- treatment equipment,
- building and work safety
- environment control
- janitorial maintenance and
- landscaping

Results of value decreasing calculation of the wood component based on the value of condition index for first floor is 0.68 percents, second floor is 1.27 percents and third floor is 0.88 percent as seen from Figure 3 below.

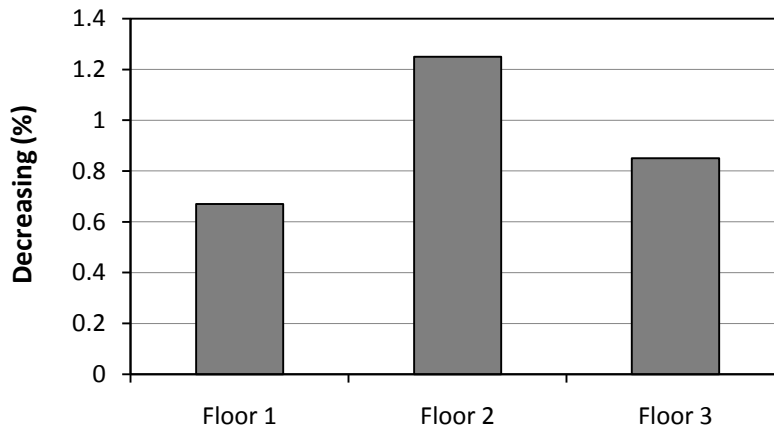


Figure 3. Histogram of Decreasing Value in Wood Materials in Floor 1, Floor 2 and Floor 4 at FT-UKI Building in Easth Jakarta.

Meanwhile, the result of previous study obtained an index condition for building FT-UKI is 77.36, consisting of: index conditions on the first floor with a value of 83.18; the second floor at a value of 68.82 and the 3rd floor with a value of 78.67. To calculate the value of the decreasing of wood material components at FT-UKI building, then these calculations based on an condition index of floor as well as the content of wood material is 4 percent of the overall construction component of this building (based on construction cost). The results showed a calculation of rate decrease in wood materials components are calculated based on condition index each floor (assuming the condition index will keep until 20years) and based on the decreasing percentage of building every five years (Wordsworth, 2001); the decreasing rate of wood material components on the 2nd floor on The FT-UKI is faster compared to the 1st floor and 3rd floor (Figure 4).

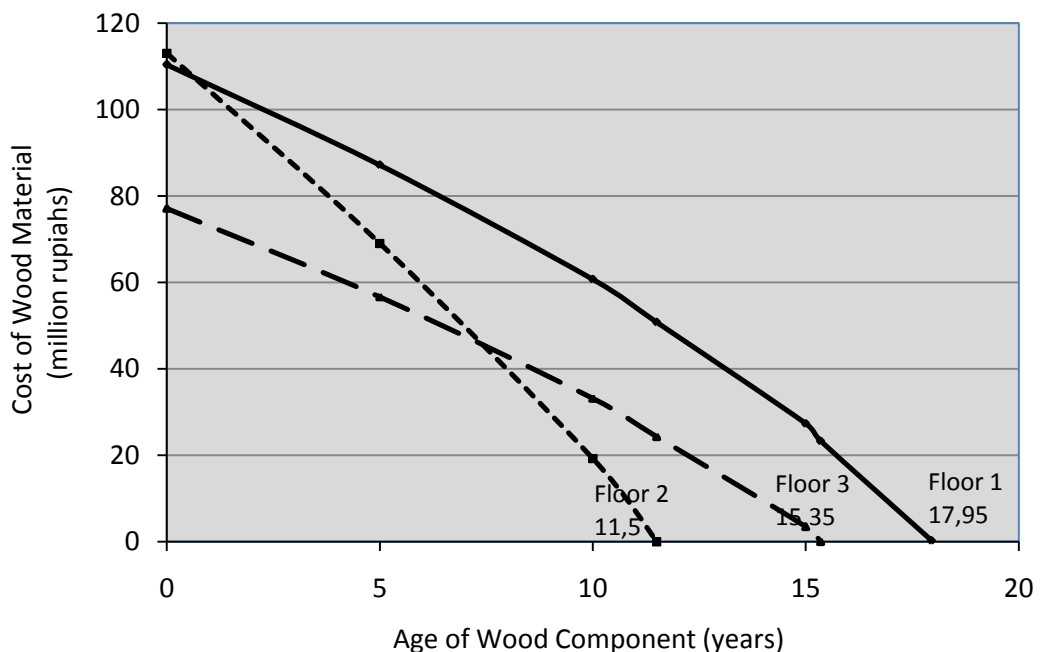


Figure 4. Decreasing Rate of Wood Components in FT-UKI Building.

Greenship value

Just as in the discussion for the apartments and hotels that located in South Jakarta, then an assessment of greenship rating on The FT-UKI is also only done for wood material. The research results obtained based on the conditions index of building pathology shows a greenship value for first floor is 1.66, second floor is 1.38 and greenship value for third floor is 1.57. Based on the assessment of the maximum rating from certified wood is 2 percent, shows the first floor nearly meet the greenship criteria (Table 2).

Table 2. Greenship Score for Tower 1, Tower 3 and Tower 4.

Floor	Condition	Greenship	
	Index	Score	Maximal
1	83.18	1.66	2
2	68.82	1.38	2
3	78.67	1.57	2

Greenship scoring is aimed to make use of the wood is in line with wood certification which guarantees that wood is not from wild logging. The existing of green building from green architecture concept identical with sustainable architecture. Sustainable architecture is conception offered by architecture science to minimize negative impact of building design to nature, environment and people. In an element of green building is building material those materials product can be reused or may be made recycled, just like wood and bamboo. To support this, wood materials need required greenship criteria; to use of certified wood.

CONCLUSIONS

From this research to assessment of building pathology; obtained condition index of Tower 1 is 50.22, Tower 3 is 60.10 and condition index of Tower 4 is 73.19; as well as the terrotechnology obtained a decrease in the condition of wood material for Tower 1, Tower 3 and Tower 4 respectively are 3.98 percent, 3.19 percent and 2,14 percent. Based on two factors (building pathology and terrotechnology), then obtained greenship value of Tower 1, Tower 3 and Tower 4 respectively are 1.00, 1.20 dan 1.46. Greenship value of three buildings (Tower 1, 3 and 4) was less than 2.00 (two) which showed a tendency of wood material used for these buildings not certified.

Research results are obtained upon the condition index from building pathology assessment of FT-UKI for floor 1, floor 2 and floor 3 respectively are 83.18, 66.82 and 78.67; as well as terrotechnology factor obtained wood material reduced for floor 1, floor 2 and floor 3 respectively are 0.68 percent, 1.27 percent and 0.88 percent. Based on the results of this research, obtained a greenship value for floor 1 is 1.66, floor 2 is 1.38 and floor 3 is 1.57.

The greenship assessment shows conditions in floor of FT-UKI building is better than three tower buildings which located in south Jakarta. It is allegedly because FT-UKI building has already been built since 30 years ago using wood quality of a 1st class, although at that time system of greenship rating in Indonesia not been applied yet. The application of greenship rating in another country of wood is certified began in the last 20 years, this caused by chopping down of wood harvesting in a forest is not controlled. Thus, FT-UKI building from 30 years ago was using wood that relatively high quality so that wood quality which is nearly equivalent to a wood with greenship certified.

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Challenges for Forest Management Unit Establishment: a Case Study in South Sulawesi

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ABSTRACT

Forest degradation rate tends to increase over time although various programs for land and forest rehabilitation involving large funds have been carried out. Thus, it can be said that in general the programs were not successful, and the funds disbursed largely were evaporated without a trace. Hence, up to present, the sustainable forests management is still in the scope of concept. Forest Management Unit (FMU) establishment is one of possible alternatives which is expected to increase the effectiveness of forest management efforts. The existence of FMU means that the forest management could be undertaken by professional foresters who will really concentrate on forest management activities in the field. However, FMU establishment is not free from challenges. Various challenges, related to technical aspects and institutional aspects, were identified and presented in this paper.

INTRODUCTION

Forest resources needs to be managed sustainably for the benefit of humankind. In reality, degradation rate of the resources tends to increase over time. Meanwhile, various programs for land and forest rehabilitation that have involved large fund were generally not successful and it means most of the fund disbursed were largely evaporated without a trace. Thus it can be said that, up present, the sustainable forests management is still in the scope of concept.

Forest Management Unit (FMU) establishment is one of possible alternatives which is expected to increase the effectiveness of forest management efforts. It is based on the understanding that the existence of FMU, as a forest management at the site level, will make a significant separation between forest administration and forest management, which currently still converges on the forest service. Additionally, the existence of FMU means the forest management needs to be undertaken by professional foresters who could focus on forest management activities on the field.

However, FMU establishment is not free from challenges. Various challenges, either technical or institutional aspects, were caused by those who already feel comfortable with the pattern of existing forest administration or forest management, and tend to have no concern on forest degradation. This presentation describes various challenges for the FMU establishment particularly in South Sulawesi. This is expected to be later on taken into consideration in the formulation of policies related to the FMU establishment and forest management in the future.

METHODS

This study was begun by preparing forest organization design. The design was made in 2008 in which forest area in South Sulawesi was classified into several Forest Management Units (FMUs) on the basis of medium-sized watershed ecosystem. This is also based on the consideration that South Sulawesi has experienced related to the forest organization (Macro-sized of watershed ecosystem) in which the forest area in South Sulawesi was divided into 3 management units. In contrast, forest organization with micro-sized watershed will result in at least 22 FMU which in general covers two or more administration area of regions.

Socialization on the above FMU organization was disseminated to all stake-holders of forest resources, either when it was still in the design step or when it has been legally determined by Minister of Forestry after considering a recommendation from the Governor of South Sulawesi. Through the socialization, several responds or challenges were identified as well as those which were potentially become inhibiting factors to FMU establishment. The identification results were then analysed

descriptively and used for the basis in the formulation of alternative efforts. This could be later utilize to support the FMU institution establishment and the optimalization of FMU management in the future.

RESULTS AND DISCUSSION

Forest Management Unit Establishment

FMU organization classified on the basis of medium-sized of watershed as mentioned above, resulted 10 FMUs (Table 1). Based on the interpretation results of Land-satellite image, it was found that land covering by forest area in South Sulawesi is being dominated by secondary forest (58.5%) and underbrush (15.1% or almost 400,000 ha.). Primary forest that still remains in this area is only 8.3%, where in general most of the area is located on non-accessible sites. The specification of land cover of FMU area is presented in Table 1.

Based on forest function, forest area in South Sulawesi is dominated by Protected Forest (59.7%). Production forest area in this region is only 30.7% of the total forest area including some areas that have to be managed for protection purposes. That means that effective area that can be managed for production purpose is less than that is mentioned above. This condition indicates that the FMU manager will face two main tasks. i.e. forest rehabilitation and forest land protection. So, up to a certain period, almost all of the forest area in this region can not produce any thing that can be used in supporting FMU establishment and or its management activities. Accordingly, all FMU managers in this region have to do various efforts to gain larger donation to support their activities until forest land in FMU could produce something and support their management activities independently.

At present only two of FMUs that have started their activities by FMU Institution establishment, namely Larona-Malili FMU and Jeneberang FMU. Larona-Malili FMU is one of the **SKPD** (Working Unit of Regional Government Instrument) in Luwu' Timur Regency, while Jeneberang FMU is one of the **UPTD** (Technical Implementor Unit of Regional Government) under the Governor of South Sulawesi Province. Others 8 FMUs are seemed in a waiting position for guidance and assistance from the government, either central government or regional government. So, it can be said that FMU establishment and forest management autonomy in South Sulawesi still need a long journey for realization. This is followed by a hope that the process could be initiated immediately as a respond of serious threat of forest degradation and before the recovery efforts become more complicated.

The challenges for FMU establishment

The main challenge for FMU establishment is unreadiness of forestry apparatus in the region conduct more professional forest management. A number of socialization participants asked about the seriousness of central government in implementing of decentralization, especially in forestry sectors. They commented that the concept of FMU establishment is leading to re-centralization. However, a more fundamental aspect behind this statement is the existence of understanding that decentralization means distribution of donation by central government to the regional governments. The donation can be used on the basis of regional desire and interest which are in many cases the orientation are mainly to fulfill short-term requirement, and not in accordance with forest development and preservation.

It was identified that some participants in the socialization stage have worried about reallocation of donation from the central government that they have been obtained up to the present time. They thought that the existence of FMU will potentially become a competitor for them in getting the allocated donation. Accordingly, they want the border of FMU to be in accordance with the administration border of regency area, and in fact some of them has planned to organize forest area in their region into several FMUs.

It is noteworthy that a small area of FMU, in general, can not guarantee the continuity of forest products, especially if FMU is managed for the purpose of timber production, and moreover if managed for the purpose of watershed ecosystem protection. Some factors can be pointed out as the reasons for the organizing of forest area in ---to a number of small FMU. However, in connection with the donation allocated from the central government, it can be said that one of the most possible reason is the presence of desire in obtaining a more allocate donation by preparing more channels and recipients namely FMU. The more upcoming of this mentioned desire, the more complicated of challenges for FMU establishment.

In relation to allocated donation from the central government, and probably also from the provincial government, it is necessary to make a proportional allocation both to regional Forest Service (for administration and supervision affairs) and to FMU Institution (for management and implementation of FMU establishment activities). By this way, appearance and development of an unfair competition between Forest Service and FMU Institution, can be avoided. Both institutions should put forward cooperation between each other, since they have the same problems and challenges, that need to be overcome together, through a series of systematic, planned and long-term efforts

It is also noteworthy that forest development, particularly in South Sulawesi, from the past to present, still mainly relies on donation from the central government. The regional government, in general, allocates a very limited donation for forest development, as they pay a more attention to development sector(s) that can provide Original Income of Region (*Pendapatan Asli Daerah*) in short-term or medium-period. Accordingly, it is still difficult to expect the regional government to allocate enough amount of donation for the establishment of FMU. In contrary, delays of FMU establishment will potentially accelerate the rate of forest degradation.

In accordance with the above mentioned, assistance and facilitation efforts from the central government in supporting the acceleration of FMU establishment is extremely needed. It is desirable that these assistance and facilitation efforts not only at the initial step, but have to be continued up to stage where FMU can produce something and be able to support their management activities by themselves. Again, the assistance and facilitation efforts must be for a long-term or at least for a medium term, and not annually oriented. Accordingly, every FMU manager has to construct a long-term utilization planning of all biophysical potencies existed in each FMU managed by themselves. The utilization planning must consist of systematic, objective and rational steps toward a target of a period in which the related FMUs will be able to support all of its management activities by its own donation. Furthermore, the above mentioned plan should be able to motivate and invite all of stakeholders to play their roles in accordance respectively with their own capacities and competencies.

It is necessary to emphasize that FMU establishment is a long-term program, and it is not an annual project. For the FMU establishment in South Sulawesi, in particular, where the forest area is mostly dominated by damaged Protection Forest, it needs a large financial support for a long period. In accordance with the dominant part of forest area, i.e. Protection Forest, the capital that has spent in FMU establishment will be in general, paid back from intangible benefit. Accordingly, the FMU managers, have to make serious efforts for gaining donation or grant from non profit institutions. At the same time, they have to try to develop forest environmental merits by involving the members of society as well as simultaneously have to pay attention to the ecosystem health and the long-term interest of the forest area in FMU.

CONCLUSION

The main challenge of FMU establishment in South Sulawesi is the presence of understanding among development agents not in accordance with regional autonomy. But, in fact, the autonomy, particularly related to forest development, in general, is not clearly understood from the right perspectives, i.e. the presence of responsibility in every development stakeholder. Each stakeholder has to find and develop all of its regional potency based on funding resources, and allocate them proportionally to all of development sectors, including forestry sector. Conversely, the above mentioned development agents tend to interpret autonomy is a freedom in of the use of donation given by the central government which are based on regional desire and interests.

All of FMUs in South Sulawesi need a large amount of financial support, before it can produce something and be able to financially support their management activities by themselves. In relation to this condition, all stake-holders have to play their roles in accordance respectively with their own capacities and competencies. The question that must be put forward by all stake-holders is "who donate what", not, "who obtain what".

FMU establishment needs support from many parties or stake-holders. Accordingly, FMU managers have to construct an objective and rational utilization plan. The plan must present clear expected role or contribution of every stake-holder, until FMUs can fulfill their own needs.

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Table 1. The Proportion of FMU area to the total area of watershed

No.	The Name FMU	FMU Areas		Percentage (%) to the Watershed Area
		ha	% to Forest Area	
1.	Bila FMU	84,427.6	4.08	5.31
2.	Jeneberang FMU	195,039.7	9.43	17.74
3.	Kalaena FMU	153,134.3	7.40	4.68
4.	Noling-Gilereng FMU	144,183.1	6.97	8.95
5.	Larona-Malili FMU	344,648.7	16.66	9.31
6.	Maros-Sawitto FMU	140,103.5	6.77	8.47
7.	Rongkong FMU	547,312.3	26.46	18.72
8.	Saddang FMU	277,496.8	13.42	12.95
9.	Selayar FMU	19,713.9	0.95	1.43
10.	Walanae FMU	162,130.3	7.84	12.45
Total Forest Area		2,068,190.2	100.00	48.69

Tabel 2. The specification of FMU area in South Sulawesi based on land cover

Name of FMU	Bush & Bare land		Secondary Forest		Primary Forest		Others		Total
	ha	%	ha	%	ha	%	ha	%	ha
1. Bila	10,028.0	11.9	51,469.9	61.0	2,876.8	3.4	20,052.9	23.8	84,427.6
2. Jeneberang	48,747.3	25.0	76,986.0	39.5	-	-	69,306.4	35.5	195,039.7
3. Kalaena	9,399.1	6.1	112,385.1	73.4	11,256.9	7.4	20,093.2	13.1	153,134.3
4. Noling-Gilireng	24,364.5	16.9	96,785.4	67.1	-	-	23,033.2	16.0	144,183.1
5. Larona-Malili	11,319.8	3.3	198,039.6	57.5	24,157.0	7.0	111,132.3	32.2	344,648.7
6. Maros-Sawitto	54,071.9	38.6	61,615.4	44.0	-	-	24,416.1	17.4	140,103.4
7. Rongkong	18,618.2	3.4	142,328.9	69.8	116,711.1	21.3	29,982.8	5.5	547,312.4
8. Saddang	93,236.5	33.6	382,000.3	51.3	10,402.8	3.7	31,528.6	11.4	277,496.8
9. Selayar Ds	1,448.2	7.3	8,130.9	41.2	5,575.3	28.3	4,559.5	23.1	19,713.9
10. Walanae	40,753.0	25.1	79,911.0	49.3	-	-	41,466.3	25.6	162,130.3
Total Forest Area	311,986.5	15.1	1,209,652.5	58.5	170,979.9	8.3	375,571.3	18.2	2,068,190.2

Tabel 3. The specification of FMU areas in South Sulawesi based on its Forest Function

Name of FMU	Production Forest		Protection Forest		Conservation Forests		Water-body		Total	Type of FMU ^{*)}
	ha	%	ha	%	ha	%	ha	%	ha	
1. Bila	13,253.4	15.7	53,626.1	63.5	-	-	17,548.1	20.8	84,427.6	Protect
2. Jeneberang	100,126.3	51.3	70,239.2	36.0	12,840.2	6.6	11,834.0	6.1	195,039.7	Product
3. Kalaena	61,233.8	40.0	89,826.4	58.7	425.4	0.3	1,648.6	1.1	153,134.2	Protect
4. Noling-Gilireng	44,849.8	31.1	95,955.2	66.6	-	-	3,378.1	2.3	144,183.1	Protect
5. Larona-Malili	85,173.2	24.7	168,045.6	48.8	8,144.0	2.4	83,286.0	24.2	344,648.8	Protect
6. Maros-Sawitto	49,138.2	35.1	79,252.1	56.6	240.9	0.2	11,472.2	8.2	140,103.4	Protect
7. Rongkong	144,993.8	26.5	395,535.7	72.3	551.2	0.1	6,231.7	1.1	547,312.4	Protect
8. Saddang	50,679.6	18.3	218,103.0	78.6	-	-	8,713.7	3.1	277,496.3	Protect
9. Selayar	8,506.3	43.2	7,735.2	39.2	3,387.4	17.2	84.1	0.4	19,713.0	Product
10. Walanae	77,553.6	47.8	55,615.4	34.3	2,499.0	1.5	26,462.3	16.3	162,130.3	Product
Total Forest Area	635,508.0	30.7	1,233,933.9	59.7	28,088.1	1.4	170,658.8	8.3	2,068,190.2	

^{*)} Product = Production Forest Management Unit (3 FMU); Protect = Protection Forest Management Unit (7 FMU)

Planting of Mangrove Species to Sustain Coastal Stability: Malaysia Experience

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ABSTRACT

Coastal line is an important feature to ones country. The very long coastal line of Malaysia is subjected to open sea and waves hitting the coastline. Some portion of the coastline is affected and damage except for those having Mangrove forests along it. Some of the coastline in the states of Kedah and Johor have been destroyed and retreat inland. Steps have been taken by the Forestry Department Peninsular Malaysia to plant species of Mangrove together with other coastal species like *Casuarina equisetifolia* in order to reduce the impact of the damage. This paper tends to highlight the long term program undertaken by the Department in order to reduce the damage to the coastline.

INTRODUCTION

Mangrove forests are very important tropical coastal tidal ecosystems and grow on nutrient-rich muddy substrates that are low in oxygen and that undergo variations in salinity. The important functional role of mangrove forest communities and their transitional position between marine and terrestrial environments have led to these ecosystems being the object of study within a variety of scientific disciplines such as biology, ecology, geology, oceanography and pedology. However, scientists, including pedologists, often refer to the substrate on which mangrove vegetation develops as soil (Corredor *et al.*, 1999, Clark *et al.*, 1998 and Tam and Wong, 1998). The soil is always an important component in the system comprising the lithosphere, the atmosphere and the biosphere. Soil properties reflect the varying nature of the interactions within this system. Soil is essential for many human activities if we understand how soil has been developed and how it is affected by changes in the system, particularly those in the biosphere caused by our manipulation of vegetation and soil. Soils are vital resources in every country of the world. Increasing population pressures and demands for food, fibre and timber emphasize the need for careful management. In order for sustainable system of land management to be adopted, the effects in soil properties must be measured and the data obtained correctly interpreted (Rowell, 1996).

Towards the end of December 2004, there was an occurrence of Tsunami off the coast of Sumatera, Indonesia and devastated the many life forms including humans and trees. Lives have been lost. The areas included coastline of Malaysia, South Thailand, Sri Lanka and other surrounding areas. From then on, many countries including Malaysia have started the massive planting along the coastline coastal species such as Mangrove species, Nyireh (*Xylocarpus granatum*) and Rhu (*Casuarina equisetifolia*). This activity is also to safeguard the possible erosion of coastline by the high waves from the sea. This paper will highlight the activities conducted by the Forestry Department Malaysia in planting millions of mangrove plants over the years since 2005.

MALAYSIA'S EXPERIENCE – ACTIVITIES

Planting activities

At the beginning of 2005, Government of Malaysia through various Ministries and Agencies started the initiatives of planting Mangrove species and other coastal species in the country. Started with a total of only 169 ha distributed all over the country planting a total of 476 602 seedlings in 2005 and by 2011 it had risen to a total of 2342.95 ha and a total of 6,060,366 seedlings planted (Table 1). The largest areas planted are in the state of Sabah, followed by Perak, Sarawak, Kedah with the least being in Malacca (Photo 1). A total of 1,117,175 seedlings planted in Sarawak and 1,095,946 seedlings planted in Perak.

From the areas planted, 94.3% were planted with Mangrove (Bakau) species, followed by *Casuarina equisetifolia* (Rhu Pantai) 3.3% and other species. 2.4%. Other species to include palms like Nyireh (*Xylocarpus granatum*) and Nipah (*Nypa fruticans*), Gelam (*Melaleuca cajuputi*), Kelat Jambu Laut (*Eugenia macrophylla*) Bintangor Laut (*Calophyllum innophyllum*) and Tembusu (*Fragrea fragrans*).



Photo 1. Planting activities (Photo courtesy of Forest Department, 2011)

Table 1. Cumulative Physical achievement since 2005 till 2011 on the no of seedlings planted and area covered

State	2005		2006		2007		2008		2009		2010		2011		Cumulative 2005-2011	
	area	No of seedlings	area	No of seedlings	area	No of seedlings	area	No of seedlings	area	No of seedling	area	No of seedlings	area	No of seedlings	area	No of seedlings
Johore	64	189150	12	37094	31	80800	42	131250	18	1250	13.2	23100	17	45275	198	517919
Kedah	3	18000	11	53000	41	220000	90	530862	77.9	465200	42.90	222201	0	0	265.8	1509263
Kelantan	11.3	14300	10.49	33833	14.4	50283	22.06	62221	23	45664	8	7430	1	625	90.25	214356
Melaka	0	0	0	0	0	0	8.50	10500	2	1000	2.5	5750	0	0	13	17250
N.Sembilan	0	0	0	0	6.5	30151	34.5	58365	15.3	67127	14.15	61	0	0	70.45	216643
Pahang	4	1600	11.3	7627	30.6	15888	25.55	14109	16.6	10373	17.55	10406	2	1250	107.6	61253
Perak	31	167100	16	90000	18	72800	69	147300	65	238671	55	255076	50	125000	304	1095946
Perlis	2	10000	2.3	12104	5	18200	8.79	44336	4.66	9649	4.55	3600	3	11111	30.3	109000
Penang	9.2	25000	10	53388	4.5	18450	10.6	38670	14.30	32916	14.20	40299	3.5	6702	68.20	215425
Selangor	40	48000	10	60000	12.5	37000	25	81000	33	101588	37.5	90900	8	7750	166	426238
Terengganu	4.8	3452	5.36	3059	14.4	9216	18.35	11704	13.08	8176	12.71	14056	0.78	490	69.48	50153
Sabah	0	0	15	166665	186.0	420465	200.84	223165	157.43	189087	115.90	117793	0	0	675.17	1117175
Sarawak	0	0	10	22220	35	77770	64.4	153638	88.6	176732	90.70	79385	0	0	286.7	509745
TOTAL	169.3	475602	113.45	538990	398.9	1051023	620.29	1507120	526.87	1357433	428.86	930995	85.28	198203	2342.95	6060366

Source: Annual Report Forestry Department Peninsular Malaysia 2011

Extension work

Extension work (Photo 2) has been carried to involve the local communities by encouraging them to plant the seedlings. This is carried out through various NGO's and sponsoring agencies like Bank Islam Malaysia. School children are also organised to make trips on weekends to plant the trees.



Photo 2. Extension work conducted (Photo courtesy of Forest Department, 2011)

Monitoring and Evaluation

Routine checks on areas planted (Photo 3) were conducted by state forestry department and also by Forest Research Institute Malaysia and the research committee involving various agencies and bodies. The committee will have to report to the main committee and in turn will report to the Minister of the agency concerned for the progress made thus far. This has become the Key Performance Index of the Minister since the start of the planting. Pictures as shown showed that the growth performance of the species planted over the years taken from the same spot.



Photo 3. Routine checks on areas planted by the Forest Department and staff from the Research Committees (Photo courtesy of Forest Department, 2011)

Issues and Problems

Some of the issues faced in undertaking such big projects were coastal deterioration (Photo 4). The coastline tends to be eroded away by the strong waves hitting the area. Some of the seedling got carried away as shown in the following pictures.



Photo 4. Coastal deterioration (Photo courtesy of Forest Department, 2011)

Other issues faced are strong winds (Photo 5) that can break the branches or stem of the planted species.



Photo 5. Strong winds along the coast can break the trees (Photo courtesy of Forest Department, 2011)

Vandalism (Photo 6) is another factor that can fail the project as in some areas the locals are not aware of the activities undertaken by the forestry department. Steps were taken to reduce such problems through talks to the chieftain and other local committees.



Photo 6. Vandalism cause by the public (Photo courtesy of Forest Department, 2011)

Another issue is the mismatching of the areas planted. There are occurrences of *Caladium* species (Photo 7) at the areas planted. Some areas are inundated with acidic soil and therefore cannot plant the wanted species.



Photo 7. Occurrence of *Caladium* species can affect the growth of mangrove (Photo courtesy of Forest Department, 2011)

Grazing of cows and goats (Photo 8) along the coast can be another big issue as some of the planted Rhu Pantai (*Casuarina equisetifolia*) species are eaten and grazed by these animals.



Photo 8. Grazing of cows in the area (Photo courtesy of Forest Department, 2011)

OUTCOME

The immediate outcomes by undertaking such projects can provide extra jobs to the locals through the establishment of more nurseries and contracting jobs in the planting of the species.

The Intermediate outcomes though will increase the areas of for eco-tourism, increase the awareness of the public on the importance of planting the species. By doing this therefore can increase the biodiversity.

The end outcome after the project hopefully will stabilize the coastal areas and increase the protected coastal line by having more buffer zones. This in the long run will increase the carbon stock and provides corridor for flora and fauna to the areas.

CONCLUSION

The physical planting achievement of the projects showed that such projects can be achieved with the help of all those concerns through the planting of more than 6 million seedlings. In most areas, more than 80% of the planted seedlings survived and replanting has been carried out especially those affected by grazing animals.

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Wood Traits and Tropical Forest Trees Species Life Strategies

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ABSTRACT

Wood anatomical traits are potentially meaningful indicators of growth and survival strategies of co-existing tree species in dry tropical forest. In this study, wood anatomical traits of 31 tree species growing in a dry tropical forest in Bolivia are examined, Associations between traits were calculated and a comparison was made with data of growth, mortality and juvenile crown exposure.. It was found that wood traits varied substantially across the 31 tree species, with vessels density and potential hydraulic conductivity showing the highest variation. A strong trade-off was found between vessel diameter and vessel density. Unexpectedly, I found that the potential hydraulic conductivity (Kp) to be negatively related to vessel density which could point to the overruling influence of the vessel diameter on Kp in the investigated tree species. No significant relation between cross-sectional tissue fractions and wood density was found. However, wood density turned out to be the only wood trait related to mortality and juvenile crown exposure – in both cases significantly negatively. This indicates that both survival and shadow tolerance are determined by wood density. The only wood anatomical trait that shows a significant relation to one of the tree performance variables was vessel density which showing a negative relation with growth rate. The lack of strong relation between wood traits and life performance indicates that across the species they have different reaction to the niche and the limitation of the resources availability

Keywords: Wood Trait, Vessel, Wood Density, Life strategy.

INTRODUCTION

It has been known that, wood-anatomical characteristic are related to growth strategy and survival of the tree species in tropical forests (Poorter et al. 2010). In dry tropical forests, tree species tend to have either small vessels or a combination of vessels of different sizes with large vessels providing a higher conductance during the beginning of the wet seasons and small vessels providing safety margins against cavitation at the end of the growing season with increasing chance of drought (Markesteyn et al., 2011). Yet, a large variation of the amount of water-conducting tissue (vessels) as well as assimilate-conducting and storage tissue (parenchyma) and tissue for mechanical support (fibres) can occur in species growing in moist and the dry forest, but also in species growing in the same forest type possibly as a consequence of adaptation strategies to mitigate drought and/or facilitate survival (Poorter et al. 2010)..

Among wood variables, wood density is the most studied features and has found to be positively related to shade tolerance of a species and negatively related to growth, and mortality of tropical tree species (Castro-Diez et al., 1998). Relationships between wood density and other wood properties are often complicated because wood density as a measure of the amount of cell-wall area in relation to lumen area does not contain information on the amount and organization of wood-tissue types in a certain species (Poorter et al. 2010).

Wood traits largely define the physiological status (water-transport capacity) of the living tree, but also the quality of wood and have implications for the management of forest for timber or carbon sequestration. Wood density is widely used as an estimator of wood quality because of its positive relationships with various wood properties. For example, wood density plays a prominent role in wood strength, workability, decay resistance and in carbon-sequestration ability (Gilmore et al., 1959; Guiley et al., 2004; Panshin & De Zeeuw, 1980; Polge, 1966).

In this study I study variation in different wood-anatomical variables including wood density, vessel variables and tissue percentages, in relation to their ecological correlates, growth and survival, among tree species growing in a dry tropical forest in Bolivia. The study aims to evaluate the relation among the measured wood-anatomical characteristics and between wood traits and other functional traits related to

life-history and mortality for the species. I decompose variation in wood density into variation in its component vessel traits (in average vessel, vessel diameter, and vessel density) parenchyma and fibers.

MATERIALS AND METHODS

Study Site and species

The samples are taken from dry tropical forest (INPA), situated in Bolivia. The forest is described as follows by Markesteijn (2011): The INPA forest is located 50 km south east of the town of Concepcion (16806 S, 61843 W) (fig. 1). The annual precipitation of the area is ranging from 1269- 871 mm, and 1160 mm in the average with a 4-month dry season from June to September. In terms of vegetation, this forest is classified as deciduous tropical dry forest. The area is part of the Pre Cambrian Chiquitano Shield, characterized by rolling hills the silt type mostly is superficial thin oxisols derived from gneiss or other Graniti corks. The mean temperature of this region is 23.9 °C. The tree with diameter at 1.3 m above ground (DBH) larger than 10 cm. the forest density is approximately 437 trees ha, with 21 m² ha⁻¹ for basal area, and 134 species ha⁻¹. At least 98 canopy tree species have been identified in INPA. We used 31 Species and most of the species are deciduous species occurring in high density.

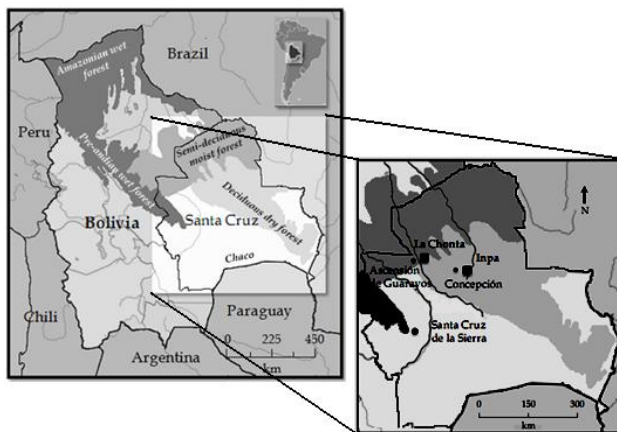


Fig. 1. Location of the study site within Bolivia ; from Markensteijn 2011

Data Collection and Sampling methods

The most common species were selected to include a wide range of shade tolerance and adult stature. Samples were chiseled from the main trunks of selected species at a depth of 3 to 5 cm. 1-3 samples were collected per species with sample sizes on average being 3cm x 3cm x 1 cm. The samples were taken approximately 0.5-1.5m from the ground. One sample was selected for each species to measure wood-anatomical features. Transversal micro-thin sections (10-30 µm) were made from all of 31 sample blocks by using a sliding microtome (G.S.L.1 lightweight microtome, WSL). The sample images are taken by using the LEICADFC 320 digital camera connected to a LEICAMZ125 microscope and computer. Magnification ranged from 2.5 to 10x. To determine vessels, parenchyma and fibers and conduct the measurements, the images were colored manually.

For Image analysis, the Image J software was used in determining the percentage of vessels, fibers and parenchyma. In addition the vessel diameter and vessel density were measured. Image analysis was conducted on each sample which has a whole annual ring. The data generated measured in mm unit and stored in the excel file.

To calculate the potential hydraulic conductivity, (K_p), the law of Hagen-Poiseuille law will be used. The following equation will be used:

$$K_p = \pi \rho w / 128 \eta \times VD \times Dh^4 \quad (\text{eqn. 1})$$

Where:

- Kp = potential specific stem conductivity (in Kg m MPa⁻¹s⁻¹),
 η = water at 20°C (1.002 x 10⁻³Pa),
 ρ_w = water density at 20°C (998.2 kg m⁻³)

The average Dh was calculated by using a formula suggested by Sterck et. al, (2008) to account for non-circularity of the vessels. The diameter of vessel will be calculated as the mean of the minimum and maximum diameter.:

$$D_h = \left[(1/n) \sum_{i=1}^n d^4 \right]^{1/4} \quad (\text{eqn. 2})$$

Analysis

For each species an area of 2.3 x 1.7 was analysed containing exclusively complete tree rings to account for intra-annual variation in cell size and density. Statistical Analysis: to explore the relation between wood traits regression analysis was used with statistical coefficient in Pearson matrix. Principal Component Analysis was used to analyze the association between wood traits. A stepwise multiple regressions was done to see how wood traits influenced the performance of species.

RESULTS

Variation in wood traits and association amongst wood traits

The wood traits varied substantially across the 31 tree species Wood density varied 2-fold (0.39-0.81 g/cm³), vessel cross-sectional area varied 7-fold (4-29%), fiber sectional cross-area varied 6-fold (15-87%), parenchyma cross-sectional area varied 16-fold (5-77%), vessel density varied 28-fold (11.2-317.2.1 mm⁻²), the average, maximum and the hydraulic potential vessel diameter have the same 5-folds variation and Kp varied 515-fold (0.4-201.2 kg m⁻¹s⁻¹MPa⁻¹) (Table 2).

Table 1. Descriptive statistics for 9 wood anatomical traits for the 31 tree species. Max/Min (the ratio of wood anatomical traits in the dataset), Mean, and Standard deviation (SD) are given

Wood Traits	Unit	Min	Max	Max/Min	Mean	SD
Vessel area (Varea)	%	4.2	29.1	6.9	14.5	6.6
Fiber area (Farea)	%	15.4	86.8	5.6	59.3	16.9
Parenchyma area (Parea)	%	4.9	76.7	15.8	26.2	18.4
Wood density (WD)	gr/cm ³	.4	.8	2.1	.7	.1
Vessel density (VD)	mm ⁻²	11.2	317.2	28.3	90.5	77.7
Average vessel diameter (Dav)	µm	19.0	88.7	4.7	49.5	17.5
Maximum vessel diameter (Dmax)	µm	33.8	169.6	5.0	87.8	32.0
Potential hydraulic vessel diameter (Dh)	µm	19.3	105.2	5.5	54.4	54.5
Potential hydraulic conductance (Kp)	Kg.m ⁻¹ s ⁻¹ .MPa ⁻¹	.4	201.2	515.8	26.3	37.1

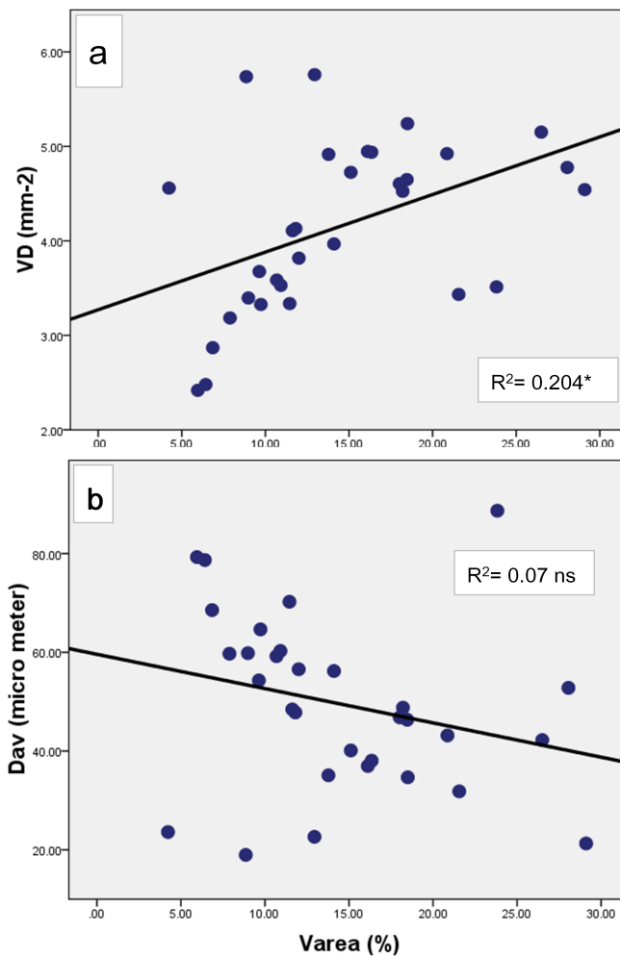


Fig. 2. Relationships between the cross-section vessel area (Varea) and (a) the vessel density (VD) and (b) average Vessel diameter (Dav). Regression lines, coefficients of determination (r^2) and significance levels are shown. Ns $p > 0.05$, * $P < 0.05$. Vessel density has been In-transformed prior to statistical analysis

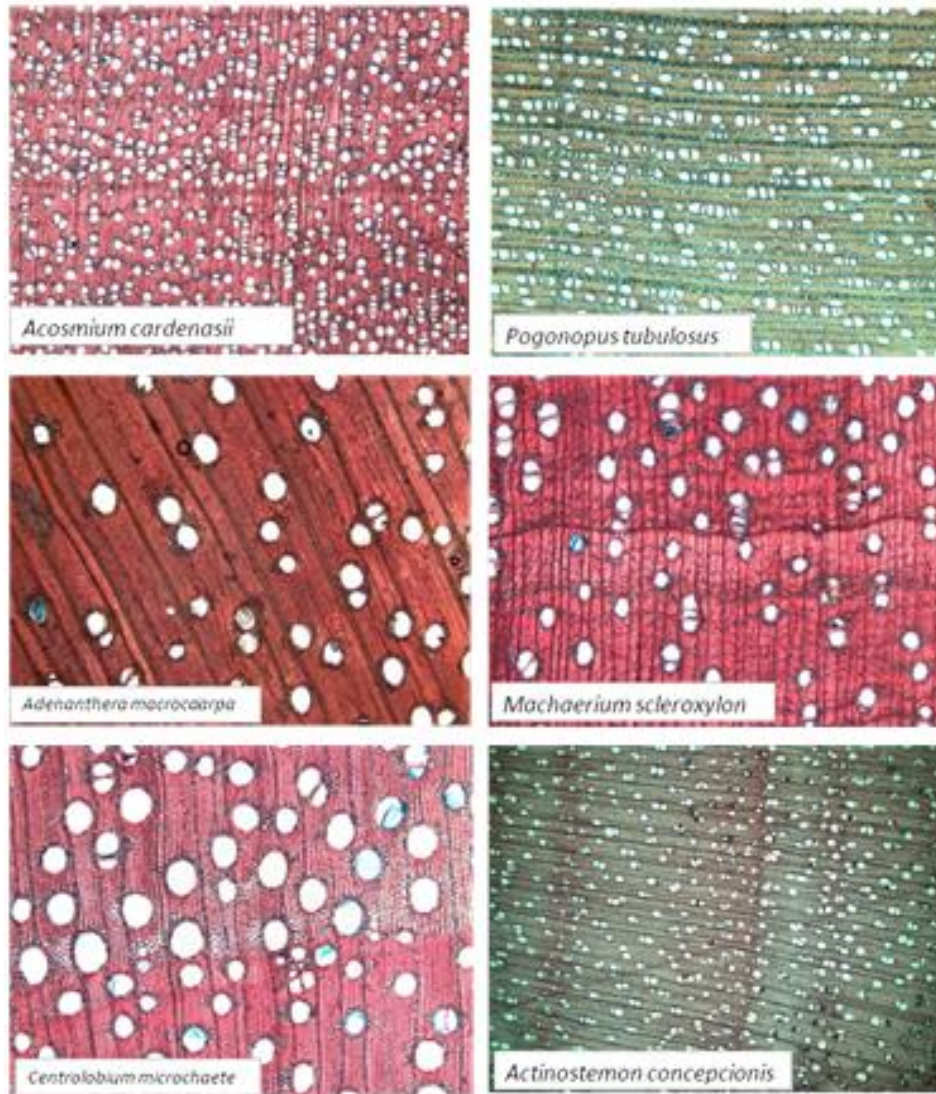


Fig . 3. Example of six wood anatomy of tropical forest tree species

Basically, wood density is a function of the vessel area, fiber area, and parenchyma area and the densities of these three different tissues. Across the 31 studied species there are no significant relations between wood tissue fractions and the wood density (fig. 4). Nevertheless, there is a tendency for a decline of vessel area with wood density. This is in line with the expectations, because more vessel area means more open conduit spaces which will lead to a lower material density. The wood density tends to increase with the fiber area since the fibers construct most of the solid wood mass.

To evaluate the association amongst nine wood traits, a principle component analysis (fig. 5) was done. The first axis explains 74% of the variation and shows a positive association with a group of traits consisting of maximum vessel diameter, average vessel diameter, hydraulic vessel diameter and the potential hydraulic conductance, and the axis shows a negative association with vessel density. The second ordination axis explains 16.8% of the variation; it shows a strong negative association between parenchyma area and fiber area.

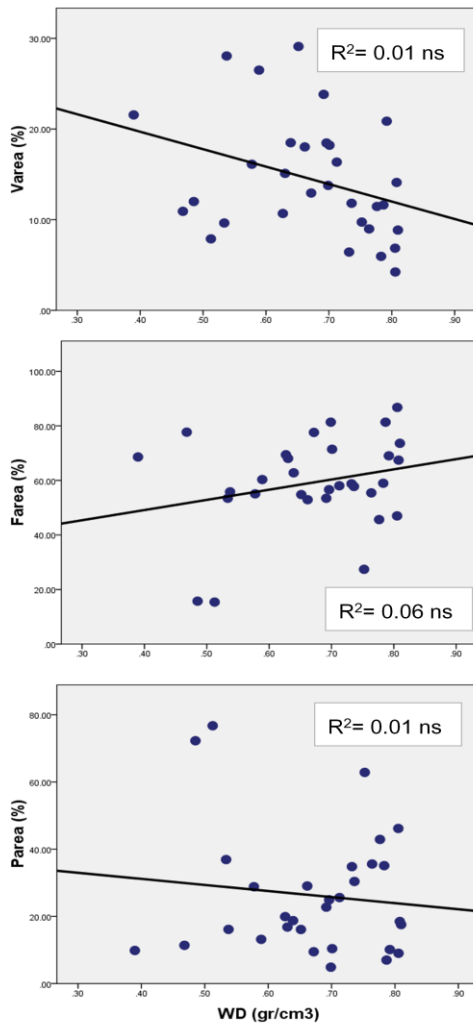


Fig. 4. Relationships between wood density (WD) and the cross sectional wood fractions; vessel area (Varea %), fiber area (Farea %), and parenchyma area (Parea %) for 31 dry forest tree species. Regression lines, coefficients of determinant (r^2) and significance levels are shown. Ns: not significant ($P>0.05$), * $P<0.05$, ** $P, <0.01$,

Table 2. Pearsons correlation table of nine wood anatomical traits across 31 dry forest tree species.

	Varea%	Farea%	Parea%	WD	VD	Dav	Dmax	Dh	Kp
Varea%	1								
Farea%	.05	1							
Parea%	-.40*	-.93**	1						
WD	-.34	.25	-.11	1					
VD	.45*	.41*	-.54**	.01	1				
Dav	-.26	-.44*	.49**	.09	-.82**	1			
Dmax	-.12	-.45*	.46**	.06	-.74**	.94**	1		
Dh	-.19	-.47**	.49**	-.02	-.79**	.97**	.93**	1	
Kp	.12	-.25	.19	.01	-.17	.64**	.61**	.72**	1

Remarks:

Trait abbreviations are Parea : parenchyma area (%), Farea : fibre area (%), Varea : vessel area (%), WD : wood density (gr/cm^3), VD : vessel density (mm^{-2}) Dmax : maximum vessel diameter (μm), Dav : average vessel diameter (μm), Dh : hydraulic potential vessel diameter (μm), Kp : potential hydraulic conductance ($\text{kg}\cdot\text{m}^{-1}\cdot\text{s}^{-1}\cdot\text{MPa}^{-1}$). Vessel density, hydraulic potential vessel diameter and specific hydraulic conductance have been Ln – transformed prior to analysis. Correlations in bold are significant at $P<0.05$. * $P<0.05$, ** $P, <0.01$, *** $P <0.001$.

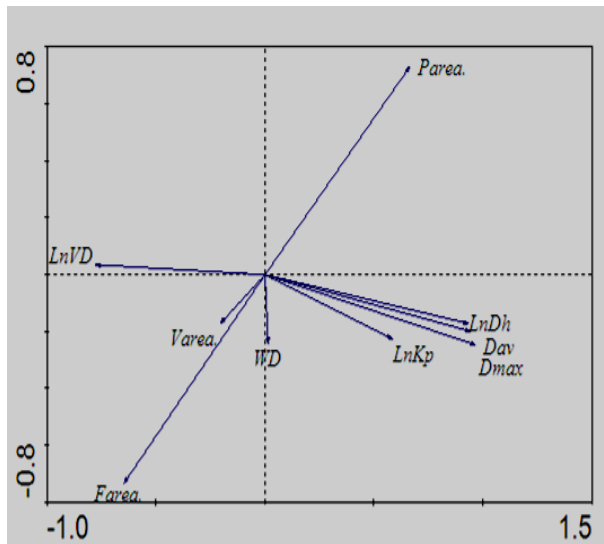


Fig. 5. Principal component analysis of 9 wood traits of 31 dry forest tree species. Farea; Fiber area, Varea; Vessel area, Parea; Parenchyma area WD: wood density, Kp: potential hydraulic conductivity, Dh: potential hydraulic vessel diameter, VD: vessel density, Dmax: maximum vessel diameter and Dav: average vessel diameter. The first axis and the second axis explain respectively 74% and 20 % of the variation.

Kp is a function of vessel density and the hydraulic vessel diameter. Kp was found not to be significantly related to vessel cross-sectional area. As expected it was strongly and positively related to Dh and tends to decrease with vessel density (fig. 6, table 1.). The negative relationship between Kp and vessel density was not as expected. This is probably because of the trade off between the vessel density and vessel diameter (fig. 5). The potential hydraulic vessel diameter has a stronger influence on Kp than the vessel density, as indicated by its higher r^2 (respectively 0.51 and 0.01).

The cross-sectional vessel area should be the product of vessel density and vessel diameter. The vessel area increases with the vessel density, which is in line with the expectations, but tends to decrease with the vessel diameter, which is opposite to the expectations (fig. 2).

Relation of wood traits to growth rate, mortality rate and juvenile crown exposure?

In general, the wood traits are not strongly related to annual growth, mortality rate and juvenile crown exposure. It is found that only wood density has a significant and negative relation with mortality and juvenile exposure but not to the growth rate. It is also found that vessel density is the only trait which has a significant relationship with the growth rate; a higher growth rate results in wood with less dense spaced vessels associated with larger vessels (not significant). It is expected that the stem diameter growth rate would increase with the water transportation capacity and decrease with the volumetric stem construction cost. It is found that growth rate tends to increase with the vessel diameters and decrease significantly with vessel density. The mortality rate decreases significantly with an increase in Kp and wood density (table. 3). The wood density is significantly and negatively related to crown exposure (fig. 6),

combination of wood anatomical traits

To find out what wood traits determine performance and juvenile crown exposure, a stepwise multiple regression analysis was done. The growth variations are negatively influenced by vessel density, and not significantly to other traits. Surprisingly the wood density is not significantly determining the variation of the growth rate (table. 3). However, wood density determines the variation in mortality and Crown exposure significantly and negatively. The same holds true for the potential hydraulic conductivity (K_p).

Tabel 3. Pearsons correlation between wood anatomical traits, annual growth rate (GrRate; mm/year), mortality rate, and juvenile crown exposure (CE) across 31 dry forest tree species.

	Growth rate	Mortality rate	CE
Varea%	.01	.34	.08
Farea%	-.26	.00	-.08
Parea%	.23	-.11	.05
WD	-.24	-.43*	-.62**
VD	-.43*	.15	-.28
Dav	.29	-.40	.10
Dmax	.27	-.33	.17
Dh	.30	-.40	.15
Kp	-.03	-.59**	-.13
CE	.15	.49*	1
Mortality rate	.25	1	
Growth_rate	1		

Remarks:

Trait abbreviations are Parea : parenchyma area (%), Farea : fibre area (%), Varea : vessel area (%), WD : wood density (gr/cm³), VD : vessel density (mm⁻²) Dmax : maximum vessel diameter (µm), Dav : average vessel diameter (µm), Dh : potential hydraulic vessel diameter (m), Kp : potential hydraulic conductivity (Kg.m⁻¹s⁻¹.MPa⁻¹), Mortality, crown exposure and annual growth, vessel density, diameter hydraulic potential hydraulic conductivity have been Ln – transformed prior to analysis. * P<0.05, ** P, <0.01, ***P <0.001

DISCUSSIONS

Trait variations

In general there is large variation in wood traits across the co-existing species in the INPA dry forest (Table 1). The fiber, parenchyma and vessel areas have relatively low variation because there is a clear upper limit (100%) and lower limit (0%) between which these cross sectional tissue area can occur. In additions, fiber, vessels and parenchyma together form the cross sectional wood area, which means that the maximum percentage of the area each occupies will always be lower than 100%. Among the three tissue types the amount of parenchyma is most variable but there is a strong negative association between the amount of fibres and the amount of parenchyma. There was little variation among species in wood density (2-folds) while a substantial amount of variation was evident in vessel density and the potential hydraulic conductance (respectively 28-folds and 515-fold). The potential hydraulic conductance (K_p) shows the most variation since it is the function of vessel density (which shows high variation), and the variation in potential hydraulic diameter, scaled to the power of four. The similar variations were found in the moist forest (Poorter et al. 2010), where amongst the wood traits, the large variation is also resulted in vessel density (509-folds) and potential hydraulic conductivity (1050-folds). These large trait variations may resulted a different resource gradients respond for each species, and may help the species to uniquely adapt the different niches and coexist in this dry tropical forest (Pearman et al. 2008).

Trait associations

In this section I look at trait associations, because it is the combination of *wood anatomical features that determine how trees react to the environment.*

I hypothesized that there will be a large variations in vessel size, percentage of fibers and parenchyma and wood density amid dry tropical species. There was a little variation in wood density, vessel, fiber and parenchyma areas (variation range between 2-15 folds). Basically, wood density should be a function of the vessel area, fiber area, and parenchyma area and the densities of these three different tissues. However, across the 31 studied species there are no significant relations between these different wood fractions and the wood density (fig. 5). There is a tendency for a decline of percentage vessel area with wood density because when the vessel area is larger it increases open conduit space which leads to less dense material (cf. Preston et al. 2006). The wood density tends to increase with the fiber area, since the fibers in many species make up most of the solid wood mass. Probably the lack of significant

relationships is caused by the fact that species vary in their fiber lumen area and fiber cell wall thickness. Species with a large proportion of fibers do not necessarily also have dense fibers. Jacobsen et al. (2007) found that there is a positive relation between fiber cell wall thickness and wood density, and negative relation between fiber lumen area and wood density.

It is expected that K_p will have a positive relationship with vessel density and vessels diameter since K_p is a function of vessel density and the hydraulic vessel diameter. K_p was indeed positively related to the potential hydraulic diameter but negatively but not significantly related to vessel density (Fig 2). The potential hydraulic diameter has the strongest influence on K_p as indicated by its high r^2 (0.51). Reason is that the conductivity scales to the fourth power of vessel diameter, and only to the first power of vessel diameter (eqn 1.). The negative correlation between K_p and vessel density possibly occurred because of the strong trade off between vessel density and hydraulic vessel diameter (fig. 2) The occurrence of trade-off as also found by others indicates that there is a coordinated mixture shifting in vessel area and vessel number across the species (Zanne & Falster, 2010). This resulted small space available in adjusting the stem percentage to vessels. In addition, since the potential conductivity is increase with the square of vessel diameter, the potential conductivity will have change when if the size of the mixture is changed (Zanne & Falster, 2010).

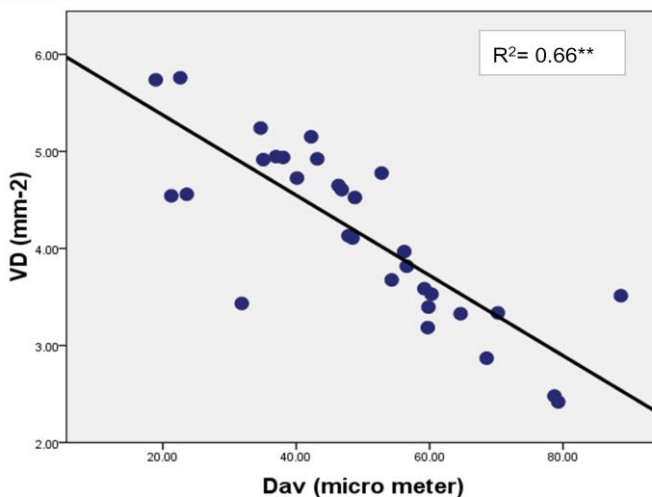


Fig.5. Trade off between \ln (vessel density) (VD) and average vessel diameter (D_{av}) for 31 dry tropical forest species. The regression line, coefficient of determination (r^2) and significance level are shown. ** $P, <0.01$.

To evaluate the associations amongst wood traits a principal component analyses (PCA) was done. The PCA shows that there is a negative association between vessel density with a group of traits consisting of maximum vessel diameter, average vessel diameter, hydraulic vessel diameter and the potential hydraulic conductance (Fig. 5). Since potential hydraulic conductivity is the product of vessel density and hydraulic vessel diameter, the positive association between K_p and hydraulic vessel diameter is logic. It is also logic that all three indicators of vessel diameter (D_{av} , D_{max} , and D_h) scale closely with each other.

The second axis illustrates the strong negative relationship between the fiber area and parenchyma area. It is probably that the strongest trade-off is between fiber area and parenchyma area, because they make up the bulk of wood tissue whereas the vessel area, occupies only a small part of the cross-sectional wood area (on average 15% range, 4-29%, Table 2).

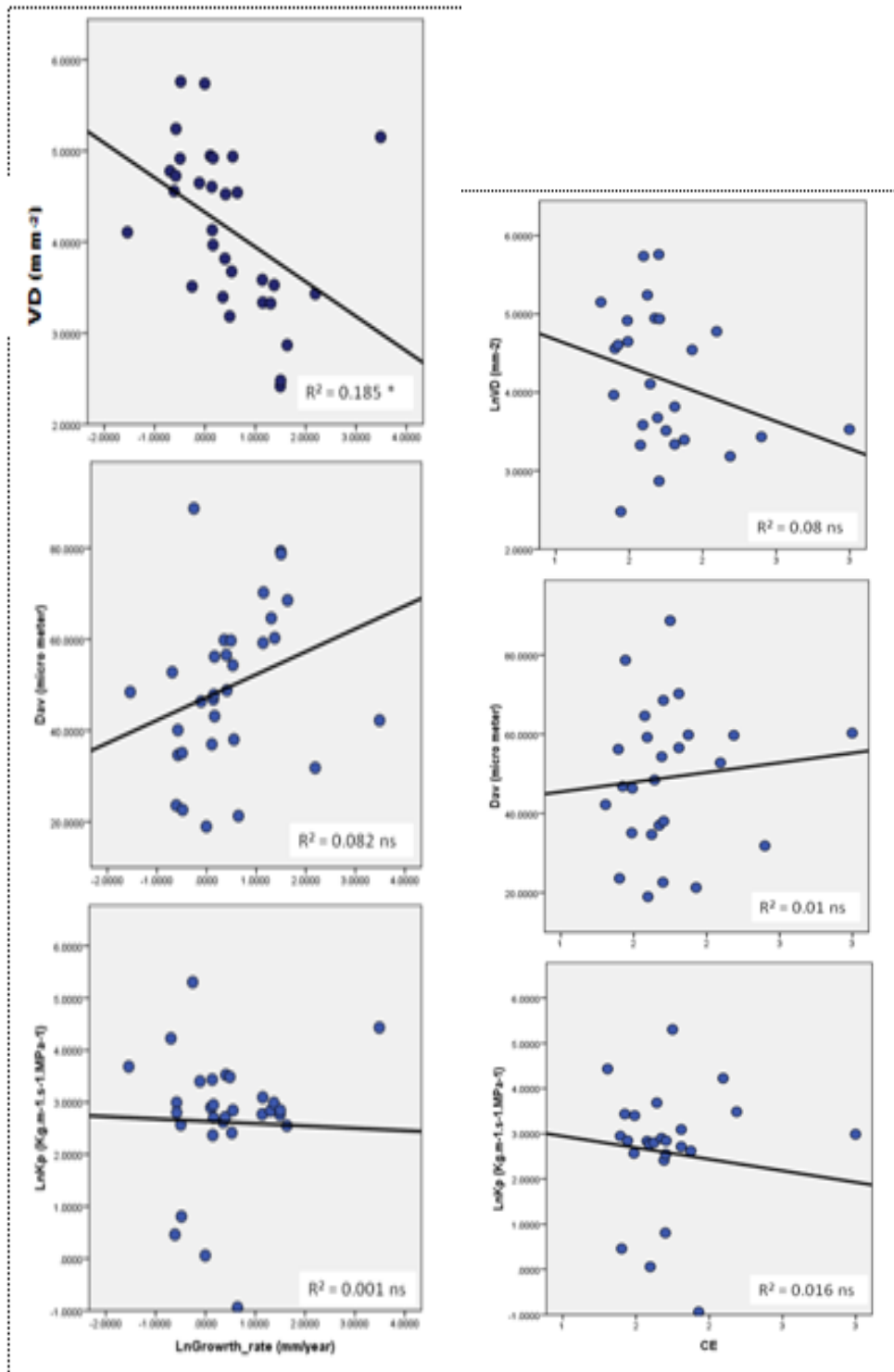


Fig. 6. Relation between annual growth rate (GrRate), juvenile crown exposure (CE) and underlying wood traits; vessel density (VD) average vessel diameter (Dav) and potential hydraulic conductivity (Kp) for 31 dry forest tree species. Regression lines, coefficients of determination and significance levels are shown. $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. The Growth rate, vessel density and potential hydraulic conductivity were Ln-transformed prior to analysis.

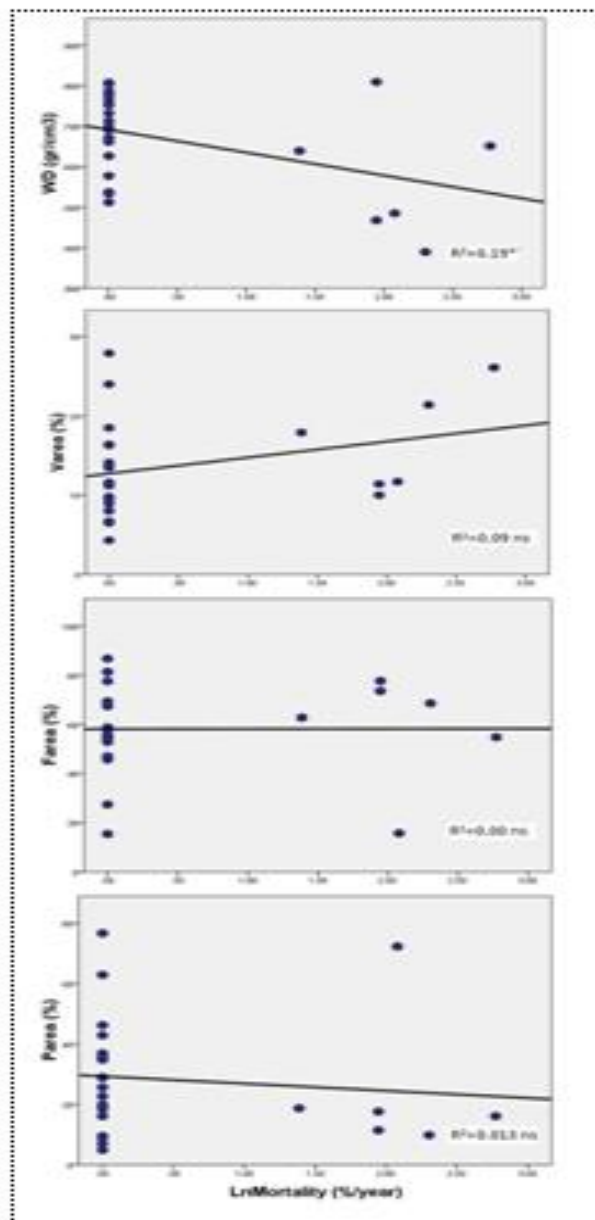


Fig. 7. Relation between mortality rate and wood characteristics; wood density (WD), vessel area (Varea), parenchyma area (Parea), and fiber area (Farea) for 31 dry forest tree species. Regression lines, coefficients of determination and significance levels are shown. $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. The mortality (%/year) has been Ln-transformed prior to analysis.

Wood traits versus growth rates

I hypothesized that vessel size and wood density are the best predictors of plant growth, since low density wood is cheaper to construct and allows for rapid growth of tree diameter and height. Wood density is negatively related to growth (table 2), but not significant, as predicted. It was predicted that vessel size (average vessel diameter, maximum vessel diameter, and potential hydraulic diameter) and the potential hydraulic conductivity (K_p) would be positively related to growth, because trees with more and larger vessels will have higher potential hydraulic conductivity (K_p). It will raise the water flow through the stem which will produce higher stomatal conductance and more rapidly transpiration rates. A higher stomatal conductance leads to the higher availability of carbon dioxide which is important for photosynthesis. The higher photosynthesis will increase the growth rate of the trees. This is evidenced by the findings of Zang&chao (2009) and Poorters et al. (2010) that hydraulic conductance is positively related to annual growth rate of plantation grown tree species. However, we did not find a relationship between these traits and growth rate (table 2), because, probably, we used the growth data for small sapling. It is expected that vessel density should be negatively related to growth rate because vessel density is negatively associated with the potential hydraulic conductivity (K_p), which is the main driver of

productivity and hence growth. Surprisingly the vessel density showed a negative relation with growth rate (Fig. 11) for which I do not have a clear explanation.

Wood traits versus mortality rates

As expected, the mortality rates decrease with the wood density (Fig. 6) since wood density provides mechanical strength which leads to high resistance to wind and falling debris and pathogen attack. Fiber area is not related to the mortality rate, probably because species which has higher fiber area may have large fiber lumen area and a low wood density. Parenchyma area showed a non-significant negative correlation with mortality rates which means the higher the parenchyma area the mortality rates is lower. A larger parenchyma area may allow the tree to store more carbohydrate which can be used to overcome the stress and damage (cf. Kobe, 1997, Myers & Kitajima 2007)

Wood traits versus juvenile crown exposure

We hypothesized and found a strong negative correlation between juvenile crown exposure and wood density (Table 3). The light-demanding species regenerate in gaps will have a low wood density to grow fast in terms of height to gain more light. On the other hand, the shade tolerant species will have higher wood density which leads to a lower mortality rate. Juvenile crown exposure was indeed significantly and positively ($r = 49^*$, table. 3) related to mortality rate, indicating that shade-tolerant species (with low juvenile crown exposure) have a low mortality rate.

Growth rate, Mortality rate and Crown Exposure

It is found that growth rate was only significantly and negatively related to vessel density, and that potential hydraulic conductance does not play a role. As mentioned above, I do not have a clear explanation why the relationship with VD should be negative. In the other hand, mortality rate was significantly and negatively related to K_p and to wood density. Tree species with low density will easily damage due to wind force, vulnerable from falling branch and susceptible to pathogen attacks. The negative relationships between K_p and mortality is counterintuitive, it is probably the result is might be an artifact, since I used the sapling mortality. Furthermore, the mortality in this dry forest is very low, it makes only a few species showed mortality during the evaluation periode.

Species survival depends on the growth rates of the species. It is expected that the light demanding species will have low wood density. The multiple regression analysis depicted that wood density is the best predictor for the crown exposure, since wood density is also the best predictor of survival, and it is also (non-significantly) and positively correlated with growth rate, (which should be high for light demanding species).

CONCLUSION

Wood anatomical traits are explaining the strategies and life history of tree species in dry tropical forest in terms of growth; a high vessel density is associated with a slow growth of the dry forest tree species. Wood density is the best predictor of the survival rates and regeneration light requirement of the dry forest tree species. In this study, it is found that wood density increased the survival rate and negatively related to light requirement of the species.

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Biodiversity of Insect in Darupono Natural Forest, centre of Java, Indonesia

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ABSTRACT

The insects play a very important role in forest ecosystem and as an crucial element of biodiversity. Unfortunately, the insects are now threatened by illegal hunting and habitat destruction. The objectives of the research were to study biodiversity of insect in Darupono Natural Forestry, Centre of Java, Indonesia. Research was conducted June 2012 in Darupono Natural Forestry, Centre of Java, Indonesia. The collection of insects from litter, leaf, log, and tree with altitude 150-175 asl. Vegetation analyses were conducted using systematic plot method. The result of study identified 24 families of insects of Darupono Natural Forestry. Mean of species richness, abundance, and species diversity of insects were recorded to be lower in disturbed forest. We conclude that factors insects in Darupono Natural Forestry, Centre of Java is due to the contribution of climatic, edaphic, and biotic condition.

Keywords: Biodiversity, insects, natural forest, Darupono

INTRODUCTION

Tropical countries are attractive to the study seasonal fluctuation of insect population as well as community studies. Climatic condition of those countries some time difference from place to another places. In a place, wet and dry seasons exchange clearly, but another center of attention to ecologist to conduct research in thin country.

Insects are the most diverse group of organisms on the planet with over one million described species. However, these numbers represent less than the actual species richness of insects (Gullan and Cranston 2005). There are many species left for taxonomists to describe. Assessing the biodiversity of insects is of vast importance. Insects are crucial for such ecosystem functions as nutrient recycling, pollination, seed dispersal, maintenance of plant community composition and structure, food for vertebrates, and maintenance of animal communities via transmission of diseases of large animals and predation and parasitizing of smaller animals. There are insects that are considered keystone species because if they became extinct, the wider ecosystem might collapse (Gullan and Cranston 2005).

Insects are abundant soil animals and play an important role in the process of litter decomposition in tropical terrestrial ecosystems. The energetic basis of their abundance lies in the symbiosis with microorganisms which allows them to utilize cellulose, the most abundant organic matter on the earth (Noirot & Darlington 2000).

Given all the support for the importance of insects to our ecosystems and our lives, it is critical that all people have access to, awareness, and knowledge of insects. However, this is not possible without accessible means of study.

MATERIALS AND METHODS

We study site was located in Darupono sanctuary, central of Java, Indonesia. Arid lands represent approximately 64% of the total area of forest in centre of Java. Darupono sanctuary is located between Semarang 6° 51' 22" LU - 70° 7' 17" LS dan Kendal 109° 43' 28" BT - 110° 24' 35" BT. Field insect on the tropical forest of Indonesia, was selected for the object of this study. Insect distribution survey at least 33,2 Ha was conducted in strip transect, 50 m width interval, and supported by *Global Positioning System* (Turner 2000). These zonations were digitized data from the survey transects were overlaid using GIS procedures. The physical analyses included water content and temperature. In addition, a vegetation was also analysis with a transect method of 20 x 20 m for trees, 10 x 10 m for small trees, and 5 x 5 m for seedling. Data processing and analysis were conducted using ANOVA. In order to normalize the data, counts were transformed using the natural logarithm (Steel & Torrie 1980).

RESULT AND DISCUSS

Darupono Sanctuary is located in central of Java not very far from Semarang city. The sanctuary has areas around 32,2 Ha, high altitude 138-142 asl, and rainfall 2000 mm/year (Macquire and Goodchild, 1991). The invertebrates are by far the most numerous of all the creatures in the sanctuary and also the less known. In fact, many thousands are unnoticed while walking among the vegetation in the forest due to their small size or their perfect camouflage. They are not only interesting to see and explore but of great importance in the forest and for the local communities. Insect collection with transect design in Darupono natural forest (Picture 1).



Picture 1. Landscape transect design in Darupono Sanctuary, centre of Java, Indonesia

The most frequently collected individuals and the individuals collected in the greatest quantities were found in the families 27, In total were identified including 27 families we can see in (Table 1). Result study a total of 918 trees were encountered in 5 transect. These natural forest which prefer warm temperature (29-30 °C) with high humidity (80%).

Table 1. The species trees diversity area in Darupono Sanctuary, centre of Java, Indonesia

No	Tree	Value indeks
1	Verbenaceae	82,22 %
2	Lycopodiaceae	38,14%
3	Myrtaceae	37,43%
4	Guttiferae	17,46%

A total of 226 species and 169 families were identified in the study subplot. These families, Verbenaceae 82,22%, Lycopodiaceae 38,14%, Myrtaceae 37,43%, and Guttiferae 17,46% were the most represented families. To compare the species diversity between the different areas, the specific density was calculated as species richness at the unit of 100 m² of area.

The most frequently collected individuals and the individuals collected in the greatest quantities were found in the ordo Coleoptera, Lepidoptera, Blattodea, Diptera, Hemiptera, and Orthoptera. This Darupono Sanctuary is natural forest with a heterogeneous composition provides a greater variety of food for insects. We found insect type on the habitat natural forestry type as much 24 family, 10 ordo by biodiversity indexes 2.04. The high biodiversity show that a community have high complexity. The community arranged by a lot of diversity the same with , therefore species interaction happening that involve energy transfer (Odum, 1971).

Table 2. Number of species in Darupono Sanctuary, Centre of Java, Indonesia

Ordo	Family	Transect Number				
		1	2	3	4	5
Lepidoptera	Famili: Papilionidae, Pieridae, Lycaenidae, Nymphalidae: (<i>Doleschallia sp</i> , <i>Hypolimnas sp</i>), Geometridae, Adelidae, Pieridae: (<i>Eurema sp</i>)	4	5	6	4	2
Odonata	Libellulidae (Orthetrum sp)	-	2	-	-	-
Hemiptera	Alydidae (Leptocorisa), Pentatomidae,	-	2	1	3	-
Orthoptera	Tetrigidae, acrididae (<i>Caryanda sp</i> , <i>Phlaeoba sp</i> , <i>Valanga sp</i>), tettigoniidae, Phasmidae (<i>Lomachus sp</i>)	4	-	-	-	-
Blattodea	<i>Coptotermes sp</i> , <i>Macrotermes sp</i>	2	3	5	4	2
Coleoptera	Coccinellidae (<i>Ephilachna sp</i>), Cuculidae, Cerambycidae,	6	5	7	4	2
Hymenoptera	Formicidae: sub family: Dorylinae, formicinae, Vespidae (<i>Parischnogaster sp</i>)	2	1	3	1	-
Araneae	Araneidae/sub family: Argiopinae, Araneinae, family: Lycosidae, ordo Opiliones: subordo: Palpatores,	-	1	2	-	-
Diptera	Cecidomyiidae, Calliphoridae, Culicidae, Sarcophagidae (<i>Sarcophaga sp</i>)	5	2	4	2	3
Mantodea	Mantidae (<i>Hierodula sp</i>)					

Living plants are intensively exploited by insects, particularly by means of herbivory. Nearly all plant species have a few species of insects associated with them as consumers of their leaves, roots, stems, flowers or seeds (Rieske and Buss, 2001). The style of feeding includes juices, mining certain tissues, chewing small pits into the plant or eating entire plant parts. The herbivores may be considered as a guild within which interspecific competition contributes to the composition of the ecosystem. In some cases the guild of insect herbivores may consist of 50-100 species or more. The plant may be pollinated by insects and the plant may provide a place of refuge, pollen and nectar for many insect species (Basset *et al.* 2004).

CONCLUSION

From the research on biodiversity of insect in Darupono Natural Forestry, Centre of Java, Indonesia: The result of study identified 24 families of insects of Darupono Natural Forestry. Mean of species richness, abundance, and species diversity of insects were recorded to be lower in disturbed forest

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Ironwood Products: The Chain of Production to Consumption

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ABSTRACT

Despite the fact that Indonesian law forbids the export of ironwood timber, and the Ministry of Agriculture has enacted a ministerial decree (*Surat Keputusan*) Nr. 54/Kpts/Um/2/1972 creating a ban on the cutting of ironwood trees with a diameter at breast height (DBH) of less than 60 cm, modern processed products continue to be heavily traded and illegally exported to many consuming countries and provinces in Indonesia. Indeed, ironwood has been included on the IUCN's Global Red List of vulnerable and threatened species since 1994. However, it has not yet been included in the CITES Appendix. As a result of deforestation and forest conversion, ironwood has now been logged in most of its home range. This high value tree species is threatened by international trade and is also a target species for selective illegal logging in many production, protection and conservation forests in Kalimantan.

Keywords: Ironwood, *Eusideroxylon zwageri*, timber trade, East Kalimantan

INTRODUCTION

Information about ironwood production can be obtained from the Provincial Forest Service (*Dinas Kehutanan Tingkat I*), however this does not reflect all cases of ironwood cutting and ironwood timber production is often not reported. Therefore, the information available on the cutting volume of ironwood is far from complete. Because of this, the identification of a proper policy intervention to support the sustainable management of ironwood is not easy. Although the study presented in this paper is about East Kalimantan, ironwood trade information is also available for other regions, such as South Kalimantan and South Sulawesi. The implications of this paper may be two fold. First, from a methodological perspective, where government data are poor and inconsistent, these data can still be useful for assessing the severity of the illegal exploitation of ironwood. Second, a study such as this can generate useful information for local policy initiatives, because good qualitative information is absolutely essential to back up the use of unreliable government statistics. This result of research is designed to fill existing information gaps with regard to ironwood logging, production, distribution and consumption. It also describes ironwood business and trade as a side-effect of illegal cutting in the province of East Kalimantan

METHODS, RESEARCH AREA AND OBJECTIVES

Methods and research area

This research used a multidisciplinary approach comprising socio-economics and politics to analyse the linkages between local, regional and international scales of intervention. I have made field observations, and held semi-structured meetings with various stakeholders (government and administrative representatives; local and customary authorities; companies associated with timber extraction, processing and commercialisation; and members of civil society), as well as collected and analysed data on forests and taxes. This research was largely conducted between 2005 and 2007 in the cities of Balikpapan and Samarinda, and the districts of Kutai Kertanegara, East Kutai, Penajam North Paser, and Paser, where sawmills and industries were visited during this period. The flow of ironwood raw material, which comes from diverse areas, districts and municipalities, is complex.

Research objectives and questions

The main objective of this paper is to provide information about the chain of production to consumption for ironwood. It also provides a trade analysis and an assessment of the extent of ironwood business, including those external factors that contribute to the degradation of ironwood stands. The study also addresses the following questions:

1. Where are the sources of ironwood raw material from different status forests?
2. What is the extent of ironwood business and trade in East Kalimantan province?
3. What are the specific factors that drive ironwood trade and which actors are involved?
4. To what extent is ironwood business, trade and the market chain a side-effect of illegal cutting and what we can learn about current ironwood markets by analysing available ironwood trade documentation
5. Are the current Forest Law Enforcement (FLE) policies appropriate for curbing the illegal cutting and trading of ironwood?

IDENTIFICATION OF RAW MATERIAL SOURCES

Clear-cutting of conversion forest¹ areas

Sources of ironwood timber originate from forest areas that have been converted to transmigration areas, oil palm and tree crop plantations or timber estates and mining areas. Within the conversion forest, clear-cutting or felling is allowed, and activities such as transmigration settlements are supposed to be located in contiguous blocks, after the area has been logged. Over the last two decades, much ironwood habitat in Kalimantan has been cleared to make way for transmigration settlements and timber and oil palm plantations. The timber estate plantation transmigration scheme (*Hutan Tanaman Industri Transmigrasi* – HTI-Trans), introduced in 1992, allows for clear-cutting in forest concessions (*Hak Pengusahaan Hutan* – HPH), provided that 10 per cent of the area is reserved for transmigration purposes. The rest of the arrangements are similar to other HTI contracts. In 1992, the Ministry of Forestry (MoF) took other measures to benefit the pulp and paper industry by introducing regulations. For example, it is now required that all production forests within a 100 km radius of a pulp mill must be used for pulpwood plantations. Ministerial Decision 442/1992 circumvents the original HTI regulations on converting productive natural forests and permits clear cutting of significant stands of commercially valuable timber (Triwibowo & Haryanto 2001).

Ideally, the land allocation of tree crops and oil palm plantation areas is expected and designated to rehabilitate the unproductive (or degraded) forest. These types of land use are also expected to rehabilitate young secondary forest with a residual standing forest inventory of less than 20 m³ per hectare of commercial species with a minimum diameter of 30 cm DBH. In reality, most of the land allocations for plantation areas are natural forests with a high density of trees. The conversion process is implemented through the forest release permit (*Izin Pelepasan Kawasan Hutan*). Among the economic considerations of the companies that seek a permit to develop tree crop and oil palm plantations is an assumption that natural forests with highly valuable timber will give an early profit.

In Kalimantan, the development of tree crop and oil palm plantations have been developed using land preparation techniques such as clear cutting or felling system. These techniques are employed because timber or tree crop plantations comprise fast growing species such as *Acacia mangium* and oil palm *Elaeis guineensis*, which needs full light. These techniques involve cutting down all of the natural trees and ironwood trees are no exception. The clearing of the land in this way resulted in a considerable increase in the production and trade of timber, particularly ironwood (Obidzinski 2003).

For reasons that are not clear, during fieldwork I observed ironwood logs, which had not yet been removed, piled up at certain sites or left inside the forest. Ironwood has excellent physical characteristics; it is such highly durable and very strong and, even though the logs may be left for years, they are will not decay. When the demand for ironwood raw material increases, local people who live around timber

¹ Forest that is designated (under an IPK licence) for clearance and permanent conversion to another form of land use; typically a timber or estate crop plantation. IPK (*ijin pemanfaatan kayu*) or legal conversions via timber use permit, specifically allowing clearing for plantations or transmigration settlements.

plantations and transmigration areas dig up, pull up and sell the timber to small-scale sawmill industries. A survey of field locations of ironwood stems in conversion forest areas reveals stockpiles of logs in, among others the timber estate plantation area of PT. Surya Hutani Jaya, in the Sebulu sub-district, Kutai Kertanegara District, East Kalimantan. The majority of the ironwood sourced from forest conversion comes from districts in East Kalimantan such as Kutai Kertanegara, East Kutai, Penajam North Paser and Paser.

In terms of the process of land clearing, the fastest and cheapest method of clearing new land for plantation is burning. Fire has always been a useful instrument to get rid of all the leftovers in the forest after the valuable timber has been harvested. While ironwood stems cannot escape these events, it is one of the tree species that is resistant to fire. Indeed, fire cannot burn the ironwood stems at all; even hot fires rarely penetrate the dense wood and only scorch the surface of stems.

Most of the ironwood raw material destined for small sawmills, large-scale industries, and domestic uses is sawn in the form of square blocks. The square blocks, beams, posts and poles are sawn in the forest or on converted forest land, because the timber's density and weight make it difficult to transport round log. Typically, the extremely heavy logs are first split and cut into square blocks and beams in order to facilitate transportation. The woodcutters or chainsaw men and loaders (*tukang pikul*) call the square blocks *segitiga* (triangular), although they do not really look like triangles. Other forms of square blocks, which have a longer shape, are commonly called *blambangan*. During field work, I observed that the forms and surface conditions of the square blocks could be distinguished and, consequently, the sources of ironwood raw material could be identified. Typically, the surface conditions of the square blocks (*segitigas*) are black after burning, which indicates that its sources are transmigration areas and timber estates or tree crop plantation areas. By contrast, *blambangan* raw material has better surface conditions and it originates from fresh cutting, frequently from timber poaching in conservation areas. These areas, including Muara Kaman Sedulang Forest Reserve, Kutai National Park and other concession areas such as Menamang and Bengalon in Muara Bengkal sub-district, are close to the research villages (personal observation 2005; Anonymous 2000a). Square blocks of both *segitiga* and *blambangan* are supplied to many small sawmills located close to sources of raw materials.

Procurement and origins of ironwood timber

Sawmills in Sebulu sub-district rely on three methods of procuring the necessary raw material of ironwood for processing: (1) they obtain ironwood square blocks as a result of land-clearing of timber plantation areas and of 'village forests', under the guise of establishing community plantations for village cooperatives or *Koperasi Unit Desa* (KUD) and village work groups or *Kelompok Tani* (KT); (2) they establish a network of cutting crews, who are charged with the task of seeking, cutting and loading ironwood square blocks and delivering it to sawmills; and (3) they buy ironwood square blocks from cutting crews working independently.

Gathering ironwood timber waste from transmigration areas in Sebulu is largely undertaken by migrants from Java who have been in the area since 1981. Gatherers are either part-time or full-time collectors. Some work under a head cutter, who takes care of the transactions with the owners of sawmills or his agents. Most ironwood raw material traders are unlicensed middlemen (illegal traders).

Sebulu sub-district is a centre for the timber processing industries and most of the transmigrants who work in ironwood sawmills come from a limited number of villages: Sumber Sari, Sebulu Modern, Manunggal Jaya, Giri Agung and Sebulu Ulu. The timber entrepreneurs provide the capital and equipment, such as timber cutting machines, there is an incentive for migrants to gather and process ironwood waste. In Sumber Sari village, for example, there are 70 sawmills actively processing ironwood timber. Each sawmill has five ironwood seekers and loaders, four circle machine operators, a driver and a co-driver (*kernel*).

Interviews with migrants revealed that they are forced to become seekers and gatherers of ironwood waste because their farming activities in the transmigration settlements did not develop as planned. Cropping intensities and yields of annual crops were much lower than expected. Settlers have not been able to develop their land fully. Income from ironwood gathering is substantially higher than from agricultural yields. However, it is not a sustainable source of income. Unsustainable logging will ultimately affect the communities' livelihoods. They cut the remaining ironwood stumpages to produce raw material with a length of only 1-2 meters. This is why such raw material is called *waste* (*limbah*). These operational mini-sawmills are powered by diesel and manually operated by at least two people during the slicing

process. The mill is operated by a team of migrants who are paid according to the volume of lumber produced by the mill.

Using these mini-sawmills, they can carry out basic cutting for flooring. During the production of semi-finished flooring in primary processing sawmills, the remaining raw materials are processed as side- or secondary products, such as *siring* (thin planks), *siring modern or millennium²* (millennium planks), *sirap* (shingles), and *papan* (plank boards). The forms, size and price range of ironwood products obtained from primary processing in Sebulu are presented in the table below.

The ironwood secondary products from sawmills in Sebulu are transported by trucks or pick-up cars to buyers for reselling in timber kiosks in Samarinda or Balikpapan. These secondary products are sold for local uses. Meanwhile semi-finished flooring produced at these sawmills tend to be special orders for export, which go on to be processed further into finished products. These semi-finished floorings are processed at sawmills in Samarinda, at a distance of about 64 km from the location where the final processing takes place. In this way, all sawmills, whether small or large, can participate and have a role to play in ironwood production for export.

Table 1. Forms, size and price range of ironwood obtained from primary processing

Forms	Size	Price Range (Rp ³ /m ³ /packet)	Uses
<i>Siring</i> (Thin plank)	1 x 10 x 200 cm	15,000/packet (10 pieces)	For wall and floor
	1 x 10 x 100 cm	8,000/packet (10 pieces)	For fence
<i>Siring</i> (Plank) Millennium	1 x 12 x 200 cm	20,000/packet (10 pieces)	For wall and floor
	1 x 12 x 100 cm	10,000/packet (10 pieces)	For fence
<i>Sirap</i> (Roof Shingles)	0.2 x 11 x 30 cm	25,000/packet	For roof
<i>Papan</i> (Plank board)	1.3 x 14 x 200 cm	3,000/piece	For wall and floor
Flooring			Export order
a. Jumbo	2.5 x 14 x 100 cm	5,000/piece	(include NTFP)
	2.5 x 14 x 200 cm	10,500/piece	
b. Standard	2.5 x 10.7 x 100 cm	2,500 /piece	
	2.5 x 10.7 x 200 cm	5,000/piece	

Source: Interviews, August 2006

Because the ironwood products are very heavy, the transport to the secondary processing location is complicated. Each truck or pick-up car can load 1.5 m³ of semi-finished flooring. To facilitate the transportation of ironwood products, the timber owner regularly provides small payments (*pungutan liar-pungli*) through the driver to security and administration officials posted along the road. If they meet in at coffee shop, he treats them to a drink. During my field investigations, I observed that there were twelve stopping points along the route of transmigration settlements where small payments were made. These small payments were between Rp. 5,000 to Rp. 20,000 per truck. At one stopping point, the organised gangs (*oknum*) or a local term '*polisi cuk*' asked the wood owner for more, between Rp. 50,000 to Rp.150,000 (US\$ 1 = Rp.10,000). The *oknums* commonly base of their operations at *ojek* (motorcycle hire) posts or guard posts. Along the route from Sebulu to Samarinda, the cumulative small payments can reach Rp. 45 million/per day (based on 300 pick-up trucks per day). These small payments are not the only source of such informal income, however. The police and the military also ask for additional small monetary contributions (*uang rokok*), or for donations in kind (i.e. timbers). All the sawmills in Sebulu were specialised in ironwood processing and the surrounding forest was also exploited without much state control. According to the head of the Provincial Forest Service in Samarinda, most of the ironwood raw material that is processed by sawmills in Sebulu is illegal timber locally called '*Spanyol*' (abbreviation of *separo nyolong* means a part of raw material from timber poaching).

² Another plank of ironwood processed product or modern plank call locally millennium plank.

³ Rp. is the abbreviation for Indonesian Rupiahs, the national currency. 1US\$ = Rp. 9,300 (2008).

Legality

The physical form of timber and the island's zone (explained below) are used to determine the tropical wood group as a base of forest contribution at the Forestry Department in Indonesia (the ministerial decree of the Ministry of Forestry Nr.163/Kpts-II/2003) and the standard prices for the calculation of Forest Resource Rent Provision (PSDH = *Provisi Sumber Daya Hutan*) (the ministerial decree of the Ministry of Industry and Trade Nr.444/MPP/Kep/6/2003). These physical forms of timber include: round wood; small round wood (< 30 cm); logging waste; wood chips; other forms of wood; timber from plantation forest; and timber from the Perhutani Company in Yogyakarta Province. Indonesia's islands are divided into zones: Zone I covers Sumatra, Kalimantan, Sulawesi and Maluku; zone II covers Papua, Nusa Tenggara and Bali. Round wood groups are categorised as follows: (1) meranti (*Shorea spp.*) group and mixed woods (*rimba campuran* or multi-species timber) group; (2) fancy wood and *torem* wood (*Manilkara kanosiensis* Lam.) and (3) another wood group.

Although ironwood is considered to be a protected tree species, a contribution to its reforestation is included in its trade prices. Ironwood timber is included, along with 32 other kinds of timber in the fancy wood category (see Appendix 3) with a standard price for calculating the Forest Resource Rent Provision (PSDH) at about Rp. 905,000 per cubic metre. The ironwood Reforestation Fund (DR = *Dana Reboisasi*) takes about 18 dollars per cubic metre of timber, but the ironwood business remains profitable. Informally obtained ironwood timber is easier to trade than other kinds of timber. In order to understand this, table 6.2 compares the types of timber in relation to the Reforestation Fund and the Forest Resource Rent Provision.

Table 2. Comparison between Reforestation Fund and Forest Resource Rent Provision by timber group in Indonesia

No.	Island Zone	Species Group	Forest Contribution	
			Reforestation Fund (US\$)	Forest Resource Royalty (Rp)
1.	Kalimantan and Maluku	1. Meranti ⁴	US\$ 16/m ³	500,000
		2. Mixed woods (Rimba) ⁵	US\$ 13/m ³	300,000
2.	Sumatera and Sulawesi	1. Meranti	US\$ 14/m ³	500,000
		2. Mixed woods (Rimba)	US\$ 12/m ³	300,000
3.	Papua, Nusa Tenggara and Bali	1. Meranti	US\$ 13/m ³	414,000
		2. Mixed woods (Rimba)	US\$ 10.5/m ³	221,000
4.	All Indonesia	1. Ebony ⁶	US\$ 20/m ³	6,000,000
		2. Natural teak	US\$ 16/m ³	192,000 s.d 764,000
		3. Fancy wood (Sonokeling, Ramin ⁷ and ironwood)	US\$ 18/m³	905,000
		4. Cendana ⁸ wood	US\$ 18/m ³	700,000 up to 7,000,000
		5. Chip or particle wood	US\$ 2/m ³	204,000
		6. Logging waste and other special sortimen	US\$ 2/m ³	204,000

Source: Ministerial decree of the Ministry of Industry and Trade Nr. 444/MPP/Kep/6/2003 and Indonesian Government Regulation Nr. 92/1999.

As a result of clear-cutting conversion forests, local people and foresters generally categorise ironwood stems as waste (*limbah*). The term *limbah* is confusing because according to the regulation issued by the Ministry of Forestry, it means of a small log (*kayu bulat kecil*), with a length of less than 1.20 metre. Initially, no rules or licences were implemented for the gathering of ironwood waste. However, once waste began to become valuable and the demand for ironwood timber increased, the Provincial Forest

⁴ Meranti from Dipterocarpaceae such as (*Shorea spp.*), *kapur* (*Dryobalanops sp.*), *keruing* (*Dipterocarpus sp.*) and *bangkirai* (*Shorea laevis*).

⁵ Mixed woods (*Rimba campuran*) comprise many different tree species.

⁶ Ebony or *kayu hitam* (*Diospyros spp.*): the best quality wood in Sulawesi.

⁷ Sonokeling (*Dalbergia latifolia*) and Ramin (*Gonystylus spp.*).

⁸ Cendana (*Santalum album*).

Service had to step in and manage and regulate this forest product. According to the Provincial Forest Service staff in Samarinda, in order to avoid misinterpretation, the term *limbah* has been changed to mean 'rejected timber' (*kayu rejek*). This was done following an increase in the number of timber clearance permit (*Izin Pemanfaatan Kayu - IPK*) and timber extraction and utilisation permit (IPPK⁹ or *Izin Pemungutan dan Pemanfaatan Kayu*) (see box 6.1) applied for by local people in the form of a cooperative (*Koperasi Unit Desa, KUD*) proposing to utilise the timber waste. A number of local organisations are also involved in ironwood gathering and trade cooperatives (see table 6.3) and *HIPKABA (Himpunan Pengusaha Kayu Bangunan)* building material entrepreneur associations. Each co-op has a permit to establish itself, and some of those currently engaged in logging may have permits from the local government that allow for cutting.

Ironwood collection is classified as a small-scale, forest-based enterprise. Recently, local people established cooperatives such as the *Koperasi Unit Desa* or village cooperative (KUD), cooperative with enterprise or *Koperasi Serba Usaha (KSU)*, and the villagers' work group (*Kelompok Tani*). They requested timber utilisation permits (*Izin Pemanfaatan Kayu* or IPK) from the Provincial Forest Service for ironwood and other timbers species. In fact, there are two types of utilisation permits for ironwood: (1) timber utilisation permits for ironwood in waste form and dead tree, and (2) permits for cutting new ironwood trees. This last permit relates to the cutting of ironwood trees in forests that are designated for conversion.

Illegal cutting or timber poaching of ironwood

Concession forest areas

As continuous exploitation of ironwood trees results in a decrease in conversion forests, loggers are forced to go deeper into the forest. Loggers and gatherers are not concerned with the status of forests and this attitude has resulted in overexploitation. To keep the sawmills supplied with ironwood raw materials, woodcutters and loggers move further and further into accessible, remote areas but also re-enter previously logged forests to look for or cut and salvage small-diameter ironwood logs. The result has been a wave of destructive logging. A further source of pressure on the forests comes from new export processing industries established to produce semi-finished or ready-to-use products. The investments in these wood processing industries necessitate the permanent flow of ironwood to these centres. These were meant to be supplied with raw materials from illegal cutting but often these raw materials were short in supply and unable to meet the needs of sawmills and industries. As the demand for ironwood raw material increases, particularly in terms of inter-island and export trading, intensive cutting of ironwood trees occurs in many accessible concession areas. The result is that these sawmill and industries have to use ironwood raw material from other sources, or even obtain it from protected areas or indigenous reserve forests (*hutan adat*). The extensive areas where the forest was opened up by re-entry logging were subject to fires. Timber poachers of ironwood are a 'significant source' of fires in the areas in which they were operating, especially in the Sangatta, Sangkulirang, Menamang and Bengalon regions in the East Kutai District of East Kalimantan (Vayda 1999; Anonymous 2000a; Salam 2007). Fires were either started deliberately to facilitate removal of trees, or accidentally by cigarettes or campfires.

Almost all logging in tropical forests involves the short-term extraction of valuable timber species with little concern for the future of the forest. The logging activities are an inefficient extraction of timber and cause unnecessary damage to remaining trees, excessive waste wood left in the forest, soil erosion and river pollution. The ironwood raw materials come from excessive waste wood and fresh cutting of ironwood stands as a result of the Indonesian Selective Cutting and Planting System (TPTI = *Tebang Pilih Tanam Indonesia*) activities in concession areas such as the opening up of the working areas for base-camps, log yards, forest road infrastructure, and logging operations. To facilitate the transport of timber products, the logging concessionaires opened up roads to reach logging areas using heavy equipment (see box 6.2). The increased accessibility of forest areas opened by concessionaires is leading to greater problems of uncontrollable exploitation in large parts of the forests of Kalimantan. The opening up of access routes to and within forests further facilitates the entry of illegal loggers into the area. Currently the

⁹ IPPK (*Izin Pemungutan dan Pemanfaatan Kayu*) is a timber extraction and utilisation permit, which allows timber harvesting associated with forest conversion in areas designated as Social Forest or privately owned forest. Granted by district-local government since 1998.

road network attracts outsiders looking for ironwood waste and who cut down the residual stands of ironwood in accessible concession areas that are the target of selective illegal logging. These activities then result in illegal logging inside cutting blocks that have been exploited, or inside logged-over areas (LOA), which leave residual stands including ironwood. As the residual stands suffer from severe damage during the logging operation, extraction of the biggest trees of the most valuable species leads to destruction of vast areas. Migrants from Java, Sulawesi and other areas in Indonesia, who initially arrived as transmigrants, are interested in working in the ironwood business in order to boost their incomes.

Ironwood cutting in logged-over areas of concessions occurs in many areas in Kalimantan, such as in the cutting blocks and conversion forests of the P.T. ITCIKU (Timber Company) areas, Sepaku sub-district, Penajam North Paser District. Indeed, such activities were observed during visits to the area and field research. Gangs involved in illegal cutting are operating freely along logging roads. Numerous piles of ironwood sawn timbers indicate extensive portable saw mill operations within the forest. Within concessions, basic security measures are lacking, and road barriers are unmanned. I observed that a skid trail used by the illegal gangs to drag out rough-sawn timber even crossed one concessionaire's yard. Local entrepreneurs (known as '*cukong*') pre-finance these gangs; loans are paid back with timber delivered to sawmills and warehouse gates.

During my observations, I noticed that there were two different groups involved in ironwood cutting and the ironwood products that originate from these areas are shingles, beams and square blocks. The first group consists of four people in an unlicensed woodcutting team who cut ironwood trees into beams of four metres in length. The work pattern of the team is called *sistem koboi* (cowboy system). This 'cut and run' system is simple and effective. The second group cuts ironwood trees for shingles. Most of these ironwood products are cut from fresh beams. The ironwood felled either by professional wood fellers or by chainsaw operators or peasant villagers is collected by affluent middlemen who in turn sell it to timber dealers in port towns such as Samarinda, Balikpapan, and Sangata. In some cases, dealers collect the timber directly by employing teams of wood fellers or they buy it from independent fellers. During my interviews, loggers admitted that ironwood, the highest priced timber species, has become scarce because of uncontrolled logging. As none of them has a logging permit, no single person can stop the others from cutting down ironwood trees in the forest. In the eyes of the law, their activities are considered illegal.

The other sources of ironwood products in East Kalimantan are districts such as East Kutai (sub-districts of Sangata, Sangkulirang, Muara Bengkal, Bengalon), Kutai Kertanegara, Berau, Bulungan and Penajam North Paser. According to Peluso (1992), where a HPH was valid, the holder had the right to organise local villagers to collect and trade ironwood. However, all the wood that was to be cut by villagers within the concession area had to be reported to and approved by the Forest Service as part of the timber company's annual logging plan. Few if any companies are willing to go to such trouble. These legal and logistical snares have made virtually all village ironwood cutting for commercial disposal illegal. Ironwood stands in concession areas are not easy for the Forest Service to control. The timber company that the Forest Service placed in charge of managing the forest and the trees, including the ironwood, within its concession, is not willing to manage what the local people perceive to be their forest resources. Although ironwood trees are found in concession areas, the timber companies can not cut or log and harvest ironwood for commercial purposes. Fig.3 (D) pictures a sign that informs people that it is forbidden to cut and take away commercial tree species from the area, including those trees of the *Dipterocarpaceae* family with white colour wood. However, they can cut ironwood, because ironwood has a black colour wood and perceived as the 'people's tree species'.



Figure 1. (A) Ironwood beams from fresh cutting in the P.T.ITCIKU concession in Sotek, Penajam North Paser; (B) Loading beams onto a truck; (C) Basecamp of loggers or woodcutters; (D) Portal-post of the timber company – ‘Do not cut and take away the white timber or wood’

Exploitation in protection¹⁰ and conservation¹¹ forest areas

My field observations also yielded information about the exploitation of ironwood in protected and conservation forest areas. Many accessible protected and conservation forest areas have become the target of timber poaching and illegal logging. In fact, the poaching of ironwood timber occurs in many accessible protected areas. Natural parks are attractive because of their commercially valuable stands. In addition, transmigration and so-called ‘spontaneous’ immigration into East Kalimantan from other provinces has continued. Some resettlement communities in the lowlands were badly disrupted by the droughts and fires of 1982-83, and consequently, a number of people from these communities have moved to other locations within the lowlands. Population growth has been especially rapid around the coastal town of Bontang, where industrial and mining projects have attracted immigrants. This has contributed to accelerated encroachment into the nearby Kutai National Park (KNP), East Kutai District. At the same time, in recent years, increasing attention has been paid to Kutai National Park in the far interior of the province, where the human population is sparse and threats to natural forest are less than in the heavily exploited lowlands.

Although ironwood cutting is illegal, the practice continues. It is speculated that woodcutters sneak across borders to cut ironwood trees in Kutai National Park. These protected areas are home to some of Asia’s most threatened animal species, such as the grizzled leaf monkey (*Presbytis comata*), silvery gibbon (*Hylobates moloch*), Sumatran rhinoceros (*Dicerorhinus sumatrensis*), Asian elephant (*Elephas Maximus*), Asian rhinoceros (*Rhinoceros unicornis*), proboscis monkey (*Nasalis larvatus*) and orangutan (*Pongo pygmaeus*) (Schweithelm 1999). Clearly, the issue will remain a matter of controversy between environmentalists and ironwood producers.

¹⁰ This is forest that is intended to serve environmental functions, to maintain vegetation cover and soil stability on steep slopes and to protect watersheds.

¹¹ Forest that is designated for wildlife or habitat protection, usually found within national parks and other protected areas.

In indigenous reserve forest

The penetration of roads has facilitated outsiders' access to formerly remote areas. Chainsaws and logging roads have facilitated villagers' commercial harvest of ironwood and generated changes in the villagers' management of the wood. Outsiders look for opportunities to cooperate with indigenous people for the exploitation of ironwood trees. Ironwood is a forest product in Kalimantan that is traditionally has been managed according to local ethics of access, but this is frequently ignored. According to Peluso (1992), private control has taken precedence over common (village) controls, and the ethics of access have been transformed.

Outsiders attempting to cash in on this forest product, which they perceive to be 'free goods', have caused unnecessary damage to ironwood stands; for example, in Lusan village, close to Muluy village, in Muara Komam sub-district, Paser District. In my interview with Lusan villagers, it was stated that there is evidence of timber company guards illegally cutting ironwood. Such acts sometimes led to violent confrontations between local inhabitants and company guards or loggers (Ardiansyah, PEMA personal communication, August 2005). This is a threat to the continued existence of ironwood stands. This also happens in other areas in Kalimantan. Although local groups such as the Muluy people have tenure rights over the resource, which could play a role in preventing damage, the enforcement of such laws is a perilous and persistent problem.

As a result, the tribal people in remote areas are increasingly and actively protesting against any cutting and harvesting of ironwood in their forests. For example, in 2001, Loir Botor Dingit, a notable and famous leader of the Dayak in East Kalimantan and the holder of The 1997 Goldmann Environmental Award, wrote an open letter and took action against an official timber company that was impinging on customary law. Dingit imposed *adat* fines on the company, namely P.T. Rimba Karya Rayatama, for cutting down community-owned ironwood trees in Bentian and Muara Pahu Districts equal to 50,000 cubic metres (Letter by L.B. Dingit, June 17, 2001; Kompas, May 25, 2003). Many cases of ironwood logging in indigenous reserve forest or *hutan adat* occur in East Kalimantan. This results in conflicts between indigenous people and outsiders and internal conflicts.

IRONWOOD PROCESSING AND INDUSTRIES

Ironwood products are differentiated into three types: (1) sawn timber as construction materials, i.e. posts, beams and planks, (2) roof shingles, and (3) modern processing products, i.e. moulding. Each type of product is processed at a different location and due to its high durability ironwood is the most important commercial timber species used for heavy construction, such as building materials (pillars for houses, column, pile foundation, floor), bridges and footpaths, posts, industrial flooring, furniture, printing blocks, quay, ship industries and roof shingles. This rare tree is extremely hard and classed as high quality wood. This makes it useful for many products in industrial and local enterprises. In fact, there are many ironwood industries, ranging from small local industries to large private companies. The industry size depends on the type of ironwood products that are processed.

Indispensable construction material in Kalimantan

Faced with growing populations and rising housing needs, the provinces of Kalimantan are devoting increasing amounts of their forest resources to meet the domestic demand. Climate is one of the factors influencing housing design, along with culture and tradition, which vary widely in character, and the idea of the house as an animate entity, as a kinship unit, as a forum for the expression of social relationships and as an image of power and wealth. Cultural influences are shown in the distinctive styles of the traditional housing that is unique to each ethnic group in Kalimantan. Despite the diversity of styles, the traditional homes of Kalimantan share a number of common characteristics, such as timber construction, a varied and elaborate roof structure, and a pole and beam construction that takes the load of the house straight to the ground.

During my fieldwork, I observed that, as a hardwood, ironwood is used as foundation for most houses. It is generally used for poles and a combination of soft and hardwoods is used for the upper house's non-load bearing walls. These are often made of lighter wood or thatch. Although indigenous construction materials such as cement, bricks and tiles abound in many districts of East Kalimantan, and

significant amounts of iron and steel bars are also imported, ironwood remains the most important construction material that is available in the region in substantial quantities. There is an escalating demand for ironwood as a timber species, but the quantity of ironwood available to local people is only a fraction of its former amount. In the coming years, ironwood will almost certainly be both a major construction material and recognised as incredibly vulnerable.

Most of the traditional, local houses and submerged buildings such as bridges, wharves and boat building locations in Indonesia, particularly in Kalimantan and neighbouring islands, are constructed on top of huge logs and beams of ironwood. Ironwood remains an important component of these structures, even today. Because ironwood does not easily decay, it is ideal for submerged constructions, quays, bridges, dugouts, and boat structures. Local people believe that ironwood timber is better than bricks or iron because the boards and posts made from ironwood can last for three to five generations.



Figure 2. (A) House in coastal area of Balikpapan above water with ironwood pillars and posts; (B) Footpath or bridge made from ironwood timber

During my fieldwork I found that, typically ironwood beams have a length of four metres and that the price of the beam per cubic metre is higher than for other local products made from ironwood. Local people use ironwood timber in the form of large planks (*papan*), small planks (*siring*) and beams and bars (*balok*). These products can be found in timber construction shops in Samarinda, Balikpapan, Bontang, Tarakan, Tanah Grogot and many other small towns. Because of the limited supply of ironwood, the price continues to increase. In the local and regional market, the demand for ironwood is very high, which causes the price to become high when compared with the prices of other timber species such as *meranti* (*Shorea spp.*), *kapur* (*Dryobalanops sp.*), *keruing* (*Dipterocarpus sp.*) and *bangkirai* (*Shorea laevis*). The forms, size and price range of local ironwood products in Samarinda are presented in the table below.

Table 4. Prices and forms of local ironwood products in Samarinda

Forms	Size	Price Range (Rp/m ³ /unit)	Uses
Beam and bar (<i>Balok</i>)	5 cm x 5 ^{up} x 4 m	1,500,000 - 1,750,000/m ³	For post and pole
	8 cm x 8 cm x 4 m		
	10 cm x 10 cm x 4 m		
Plank (<i>Papan</i>)	2 ^{up} x 20 x 4 m	1,000,000 – 1,250,000 /m ³	For fence, floor.
	2.5 x 10 x 4 m	1,450,000 – 1,600,000 /m ³	Profile (plafond)
Small plank (<i>Siring</i>)	1 cm x 11 cm x 2 m	20,000/packet (10 pieces)	For fence

Source: Primary data, interviews carried out during July 2006.

The prices of many forms of ironwood timber vary depending on the selling location in Indonesia, and because the costs of transportation differ per location. Ironwood beams command the highest prices in the local market. In 2007, the price of ironwood material for building construction reached between Rp.1.5 - 2 million (US\$ 150) per m³ in the local markets of East Kalimantan, while the prices were as high as Rp. 3.5 million (US\$ 350) per m³ in South Sulawesi (Salam 2007).

Distribution channels

The flow of square blocks of ironwood within Indonesia

Ironwood construction materials are in great demand through-out Indonesia; the market is seemingly insatiable and the highly prized wood must be imported from Kalimantan. Sawn log blocks or square blocks (*balok*) and long planks (*lejang* in the Bugis language) of ironwood from East and South Kalimantan are exported to a large number of destinations within Indonesia itself, including South Sulawesi and the provinces of Java. According to Salam (2007), a considerable volume of ironwood - a major material for house construction and boat building in South Sulawesi comes from Kalimantan, via a number of islands in the Spermonde Archipelago which is located off the west coast of South Sulawesi in the Makassar Strait. The ironwood trade from East and South Kalimantan across the Makassar Strait is closely related to the development of trading enterprises of people in the Spermonde Archipelago. The main actors in this trade are those who live on the islands and in the Bugis frontiers on the west coast of their homeland. They pioneered the felling of wood for the inter-island trade and they have been operating its transportation and distribution on both sides of the strait. Salam (2007) estimates that the volume of ironwood trade from Kalimantan may reach 2,400 - 4,800 m³ per year, with a monthly average in the range of 150 - 400 m³.

The distribution channel for ironwood construction material involves chainsawmen or woodcutters, collectors, processors, traders, retailers and local or inter-island consumers. Figure 3 shows the market chain of ironwood construction material.

Legality and regulation of domestic inter-island wood trading

The ministers of transportation (Nr. KM 3/2003), forestry (Nr.22/Kpts-II/2003) and trade and industry (Nr.33/MPP/Kep/I/2003) jointly issued a decree that regulates inter-island wood trading in Indonesia. This decree is designed to control and tackle illegal logging, the distribution of illegal wood and the preservation of raw material resources for the wood industry. The legislation deals with both log wood and primarily processed timber being transported through ports for domestic inter-island trading. The monitoring and checking of timber transportation through ports includes the flow of timber, i.e. the flow of timber entering the port until it is loaded on to a ship, as well as the flow of timber being unloaded from a ship until it is trucked out of the port.

Only ships sailing under the Indonesian flag can transport timber for domestic inter-island trade. These ships are operated by a licenced national shipping company or so-called 'peoples' shipping enterprise' (*usaha pelayaran rakyat*). According to these regulations, the checks include examination of the SKSHH document (*Surat Keterangan Sahnya Hasil Hutan* or Legal Forest Product Transportation Permit) and the physical appearance of the timber, i.e. the type of wood, its dimensions, volume and amount. The SKSHH is an official document that is regulated by a decree of the Ministry of Forestry (Nr.

132/Kpts-II/2000). A SKSHH contains the name and registration number of the PKAPT¹² (*Pedagang Kayu Antar Pulau Terdaftar* or Registered Inter-Island Timber Trader) that owns the products, as well as the physical data (type, dimension, volume and amount) relating to the products. Based on an official assessment, the SKSHH is issued by the Department of Forestry of the district or town where the forest products are sourced. It is proof of legality and is to be used in the transport, holding and ownership of forest products. Copies of SKSHH must also be sent to the offices of trade affairs in the districts or towns of origin and destination.

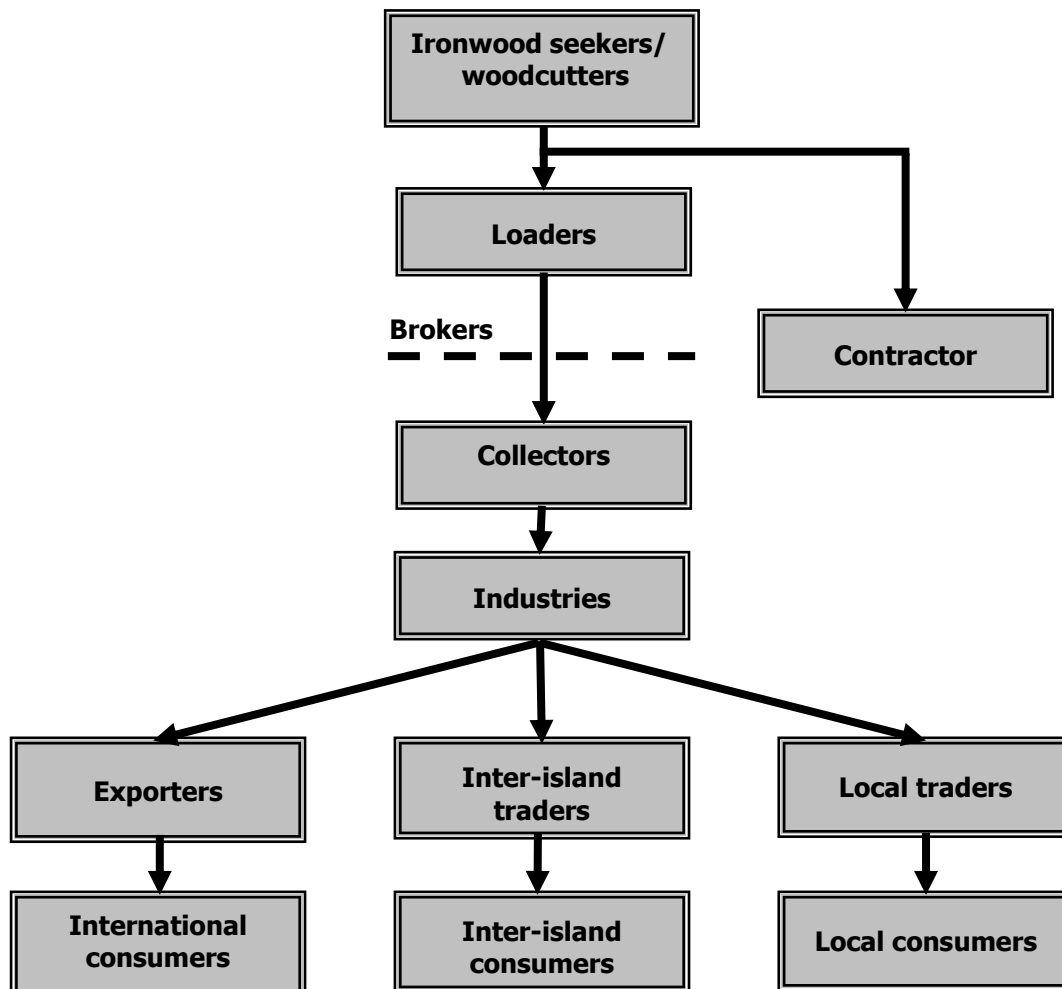


Figure 3. Flow chart of ironwood construction material market chain in East Kalimantan

The regulations do not provide specific rules for any particular wood species. They cover all forest products, timber or non-timber. Therefore, the inter-island ironwood trade is considered legal as long as the shipment is accompanied by a SKSHH. In South Kalimantan, the inter-island shipping of ironwood had been forbidden by provincial regulation, but in 2002, as an acknowledgement of the demand for timber for boatbuilding, it was permitted again. In July of this year, a governor's decree (No. 522.21/3820/Proda 2.1/EK) was issued, which gave special permission to a firm to cut 50,000 m³ of ironwood within a one year period by land clearing for an industrial tree plantation. This measure had a significant impact on ironwood timber flows. Such restrictions on the trade and logging or cutting of ironwood have never been applied in East Kalimantan (*Kaltim Post* 21 November 2003).

¹² A PKAPT is a person or a firm authorised for the inter-island trading of timber or forest products. The authorisation is acquired from the General Directorate of Domestic Trade under the Ministry of Trade and Industry. The PKAPT requires companies or individuals to submit monthly reports to the Directorate General of Domestic Trade, through the Market and Distribution Section, on its trade records.

The progressively increasing volume of ironwood timber trade results directly in the over-exploitation of the species and, ultimately, will cause its local extinction. The Minister and Director General of the Department of Forestry (S.147/MENHUT-VI/2006, 9 March 2006 and S.669/VI-BPHA/2006, 15 August 2006) issued a letter to four governors in the provinces of Kalimantan, suggesting that ironwood timber collection should not be allowed to be commercialised or exported and marketed outside Kalimantan.

Occasional news reports of 'illegal' logging and smuggling of cut timber have appeared in the national and regional press (see e.g. Anonymous 2003b), but efforts to stop it have been meagre. Locals are of the opinion that nothing will be done about it because of local-level corruption, with government officials, military and police being paid off by the timber bosses or their representatives. In addition, there has been a challenge to local communities' territorial boundaries. Since the logging boom began there have been a number of instances of community disputes over forest. In at least one case, the dispute was over forest land that had never been part of any traditional community territory. Locals have felt it necessary to make hasty claims on timber resources in order that they may profit from logging rather than outsiders.

Roof shingles

During my fieldwork, I investigated the flow of shingles from production to the market. Borneo ironwood (*Eusideroxylon zwageri*) shingles, locally called *sirap ulin* are torn pieces of wood and are a traditional roofing material in Kalimantan. The word *sirap* means 'shingles' and is used to describe the *Eusideroxylon zwageri* variety, which has straight fibres and is easy to crack or split, making it the usual choice for shingles. The size of shingle is between 50 to 60 cm in length, 7.5 to 8 cm in width and the thickness is between 1 to 3 mm. One corner of the shingle has a triangular shape. They are highly valued in local markets for their ability to resist termites. Moreover, they do not rot. They have been used for hundreds of years by local people for traditional housing. In colonial times, the Dutch introduced shingles to the rest of the archipelago and they are now found on many large government buildings as well as on luxury houses (www.tropicalbuilding.com).

Sirap trees

Ironwood varieties have been recognised by Paser and Dayak indigenous people in East Kalimantan. Field observations at the research sites revealed a number of varieties of ironwood, namely *telien baning*, *telien sirap* or *jambu* (by Rantau Layung people) and *telien jupe*. According to Muluy people, the variety of *telien baning* is the most suitable *ulin* for construction. The Muluy and Rantau Layung people use the name *telien sirap* or *jambu* for *ulin sirap*. The Dayak Agabag people in Nunukan District call it *tagas agintanga*. This variety is scarce in forests around some villages, including Muluy and Rantau Layung in Paser District, and even in villages along the Sembakung River in Nunukan District. Therefore, these villagers do not make roof shingles for their house from this species.

The *sirap* makers also cut *sirap* trees. The makers are local people who have been living in the forest for several decades. When looking for ironwood trees suitable for *sirap*, they check and identify the tree using a machete. According to *sirap* makers, of every ten *ulin* trees checked, they might find only two *sirap* trees. The morphological characteristics of a *sirap* tree are, according to *sirap* makers: (1) the position of the first bough of the tree always faces up, whereas for beam ironwood trees, the first bough is horizontal, (2) the *sirap* tree has small boughs and bright bark, and (3) when the bark is cut, the fibres are revealed. The tools for making *sirap* are the *kapak* (traditional axe), *mandau* (traditional knife) and a short machete. These tools are used to make torn pieces of the wood and to crack the fibres. The timber's straight fibres make slicing sections into shingles with an axe or a bush knife (*parang*) relatively easy and quick. These makers work in groups of eight to ten people.

Evidence that *ulin sirap* trees are declining was obtained from the personal experiences of *sirap* producers, and from official statistics relating to the declining number of *sirap* maker groups in operation. The quantity of trade has declined as the *ulin sirap* tree species has become increasingly scarce or underreported. In areas where *sirap* trees have been depleted or became rare, other varieties of ironwood can still be used for making beams (*balok ulin*). Ironwood beams require a length of about four metres. The stumpage is the waste of the stem and is about one metre in length. It should be noted that fibre structure is not a problem when these species are cut with a circular saw. The makers use a Damping

circular saw for making *sirap*. The machine produces *sirap* with a thickness of 3-5 mm, while those produced manually 1-3 mm thick. Both versions of this products can be recognised by their fibre direction.

Price, profit margin and distribution channel

The *sirap* is bundled in packets of one hundred pieces. One bundle of shingles consists about one metre square of roof. The income of *sirap* makers depends on the number of packets that they can produce per day. If *sirap* raw materials are available, a *sirap* maker can produce between 1000-1500 pieces (10-15 packets) of *sirap* per day. In 2006, the price of one packet was approximately Rp.10,000 (US\$ 1) at the makers level.

In Samarinda, most *sirap* products come from upstream Mahakam, and from many sub-districts between Muara Pahu and Melak in West Kutai District, as well as from the regional border area between East and South Kalimantan. Every month a trader exports *sirap* to Java (Jakarta, Bandung) and Bali. *Sirap* are transported by container, which can hold about 1500 packets. Traders have to pay a Forest Product Royalty (*Iuran Hasil Hutan* or IHH) of about Rp. 2,000 per packet to transport the products. *Sirap* buyers have to pay for renting a container. The costs of the rent of the container to Jakarta reached Rp. 4 million, but transportation to Bali was between Rp. 8 to 9 million, because of the fees for transiting in the port of Surabaya. These *sirap* are also used for tourist accommodation on the beaches in places such as Bali because *sirap* roofs are more resistant to salt water compared to metal roofs. They also make a more authentic impression. Although, the price of *sirap* is increasing according to local people in Kalimantan, the market continues to grow.

Sirap in packets are mostly exported within Indonesia to Jakarta (approximately 70 per cent). The remainder (30 per cent) is transported and sold in East Java, West Java, North Sulawesi and Bali. Until 2004, official documentation categorises ironwood products such as shingles as a non-timber forest product, even though it is clearly timber. However, the fact that the gathering and processing of ironwood is classified as a small-scale, forest-based enterprise means that its products are considered as non-timber forest product. Those provinces in Indonesia importing *sirap* from East Kalimantan (Samarinda and Balikpapan) between 2003 and 2006 are indicated in figure 4.

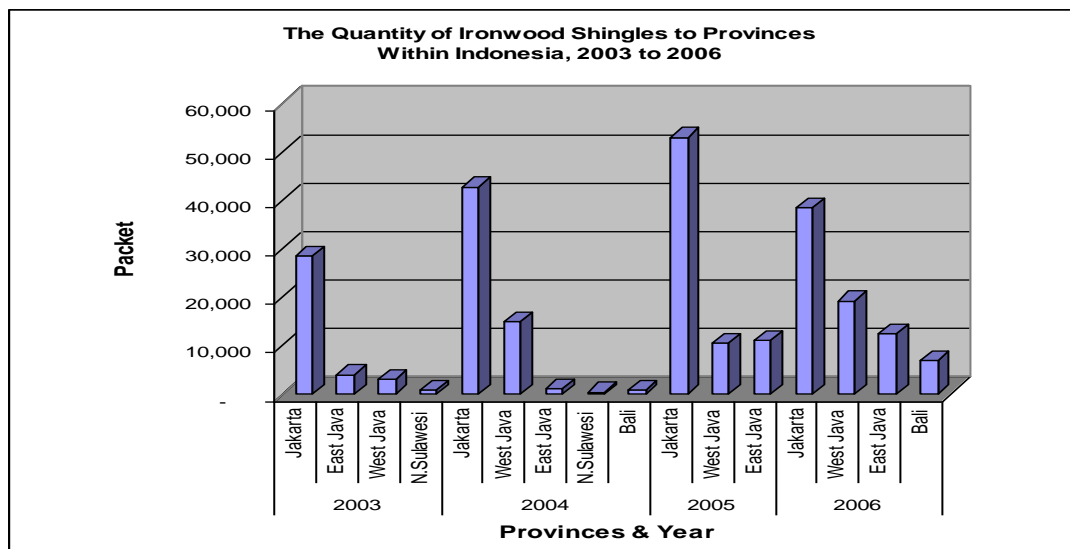


Figure 4. Data export of ironwood shingles to provinces within Indonesia from East Kalimantan, 2003 to 2006 (Source: Data obtained and processed from Provincial Forest Service, 2007)

The distribution channel for ironwood shingle roofs in East Kalimantan involves shingle makers, collectors, traders, retailers and local/foreign consumers. Figure 8 describes the ironwood shingles or *sirap* market chain. There are three quality grades used in trading of shingles. The shingles are selected by private sellers and then classified into grades by the Forest Service. These grades are based on the mean thickness of each 100 pieces (because the product is sold in packets). However, ironwood shingles have become too expensive for local communities and they are being replaced by corrugated metal, zinc roof or thatch made of palm leaves in particular sago palm leaves (*Metroxylon warburgii*), known locally as *atap*

rumbia. Roofs of thatched fronds are much cooler than the metal version, but must be replaced every two or three years.

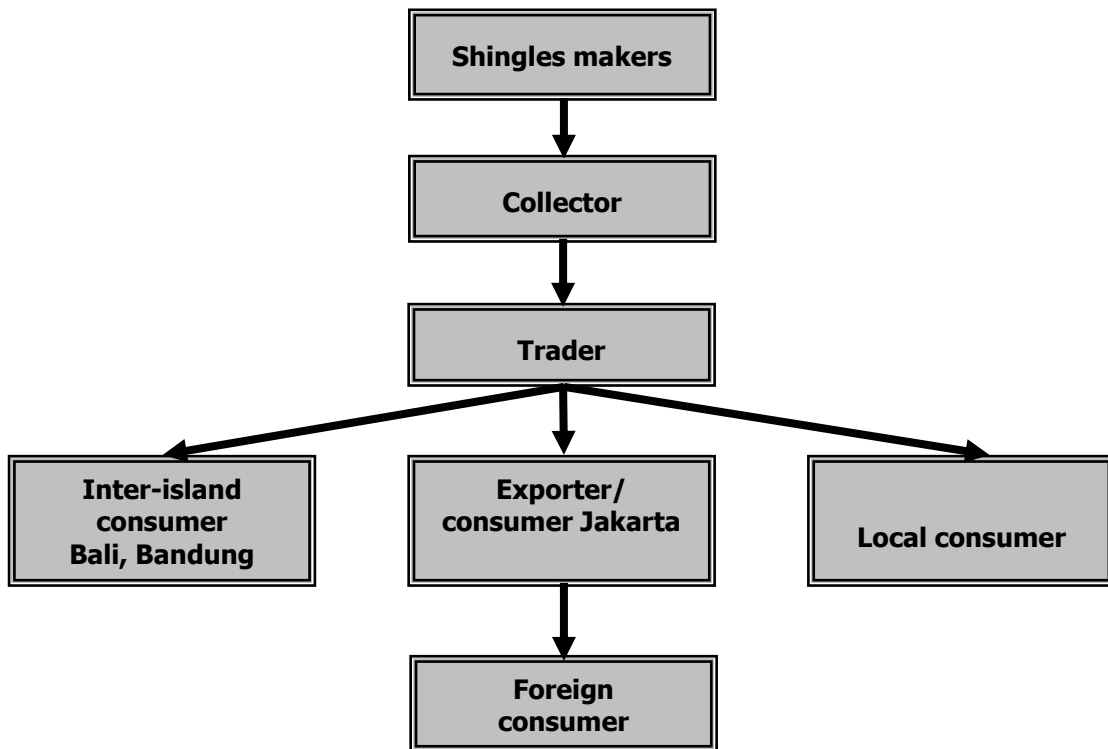


Figure 5. Actors in the ironwood shingles market chain

The use of these modern products affects the use of ironwood shingles. The number of houses using ironwood shingles has declined. Compared to modern shingles, traditional *sirap* shingles have certain disadvantages: They only come in one colour and need more support materials for making the frame of the roof. Roof shingles structuring requires special skills. However, the advantage of *sirap* is that it is light weight and extremely durable, with a life span of between 15 and 20 years. That said, *sirap* trees are becoming scarce and the result is that other raw timber materials are being used. Recently, *sirap ulin* has been substituted by other timber species such as teak (*Tectona grandis*) and *sepang* (*Caesalpinia sappan* Linn). According to the *sirap* makers, roofs from Simpur (*Dillenia spp.*) timber may look more decorative, but their strength and endurance are inferior to those of *sirap ulin*.

Ironwood processed export products

New uses for ironwood have been found within the fluid context of modernisation in Asia. Ironwood utilisation has shifted in accordance with changes in social and economic conditions, for example, after the introduction of sawmills. The fact that transportation of ironwood products has become easier has also added value to the wood. Ironwood square blocks are now manufactured into sawn timber or semi-finished and furniture parts such as flooring, dowels, decking, trimming board, fence material, decorative mouldings and broom handles. This exotic hardwood is rich in colour, durable and becoming increasingly popular. From interviews carried out for this research, it became clear that the boom modern ironwood products reached a peak in 2003. These products are marketed locally, regionally and also exported to some countries abroad. For example, decking made from ironwood is incredibly water resistant and as a processed product, in 2006, it commanded a price of between US\$ 780-970/m³.

Throughout the years, the majority of sawmills have been concentrated close to harbour towns like Samarinda and Balikpapan. These towns have become the central processing industry of ironwood products before the finished products are exported. Balikpapan is the largest central point of ironwood square block flows in East Kalimantan. Large-scale industries for processing export products in

Balikpapan are supplied by ironwood raw material from South and Central Kalimantan, East and West Kutai and North Penajam Paser.

Ironwood processed products flows within Indonesia

Official data on the production of ironwood products which flow within Indonesia and to international markets are recorded and obtained from the Forest Service in two large cities in East Kalimantan, Samarinda and Balikpapan. Ironwood moulding is a common trade name for all forms of ironwood product and regularly features in reports from the forestry and trade service office. Interviews with provincial staff of the Forestry, and Trade and Industry Service in Samarinda, revealed that ironwood processed products, such as flooring are classified as 'fancy products' (*produk or kayu mewah*). Based on information about sale destinations within the provinces of Indonesia, the products are exported for finishing products to provinces of Java (East, Central, West Java, Banten, and Jakarta), South Sulawesi, Bali and East Kalimantan. Most ironwood semi-processed products are still being processed in industries in Balikpapan for export orders. From 2003 to 2006, East Java accepted the majority of ironwood processed products from Samarinda. Figure 6 shows the trade volume and details the Indonesian provinces that imported processed ironwood products from Balikpapan and Samarinda between 2003 and 2006.

The international export market

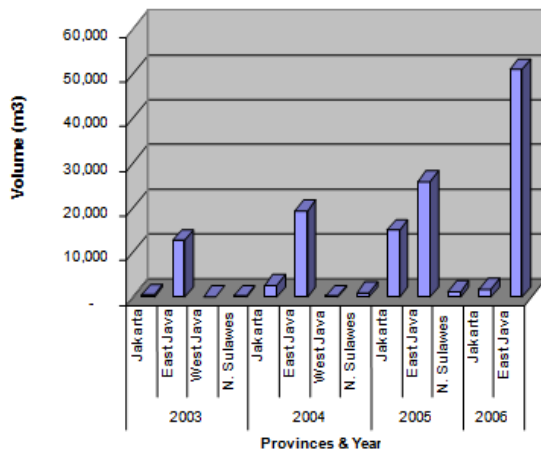
There are many kinds of ironwood products. Semi-finished parts are commonly called 'cutting size': S2S (surfaced two sides sawnwood is smooth) and E2E (two corners are bent), while finished parts are called 'invoice size': S4S and E4E. The largest portion of the international trade of ironwood products is in semi-finished parts and in the form of ready-to-use shapes or finished products such as *flooring, decking, trimming board, and letis*. These products are exported to countries such as China, Japan, Korea, Taiwan, Hong Kong, England and Germany. They are sold to the public by home improvement stores. These products will eventually find their way into homes and buildings in the lucrative markets of those countries. As previously mentioned, the main attributes of ironwood include its weather resistance, strength, durability and dimensional stability, making it particularly suitable for outdoor applications such as garden furniture. In Japan most garden furniture, modern flooring, facade and terrace applications use ironwood (see www.ecowood.jp).

From 2003 to 2006, the three countries which imported the largest volumes of ironwood processed products were Japan, China and Korea. During that period, Japan imported the highest volume from industries in Balikpapan, while China imported the highest volume from industries in Samarinda. In terms of volume, Japan is the biggest importer country of ironwood processed products from East Kalimantan. The criteria grades of Chinese importers are relatively easy to fulfill, when compared to other countries such as Japan. Indeed, Chinese importers accept all grades and it is not difficult for a grader or quality controller to check the condition of ironwood products. For example, grade A has as criteria of: *one face clear, no crack*. By comparison to Japan's grade A criteria is: *two faces clear, no crack, and no pinhole*. Although Japan's criteria are difficult to fulfill, the prices are higher than in China. For example, in 2005, the price of all grades of flooring forms to China was US\$ 570/m³ CNF¹³ Shanghai, compared to Japan US\$ 750/m³ CNF Tokyo. In China, the products will be further processed and exported to the United States and European countries. China and the US are both importers and exporters in this case.

The trade volume and the countries that imported ironwood products from Balikpapan and Samarinda between 2003 and 2006 can be seen in detail in figure 7.

¹³ CNF means cost and freight. The seller is responsible for shipment and ocean freight.

The Volume of Ironwood Processed Products in Inter-Island Trade to Provinces within Indonesia from Samarinda, 2003 to 2006



The Volume of Ironwood Processed Products in Inter-Island Trade to Provinces within Indonesia from Balikpapan, 2003 to 2006

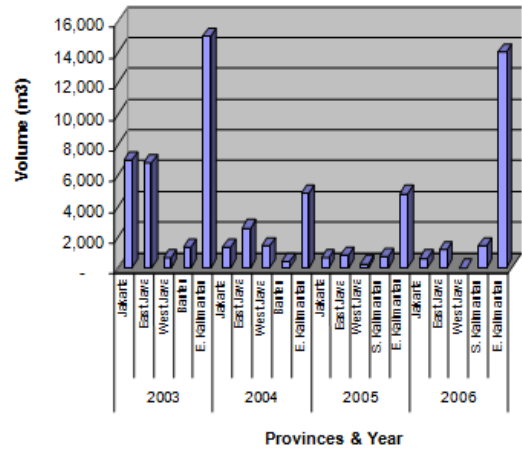
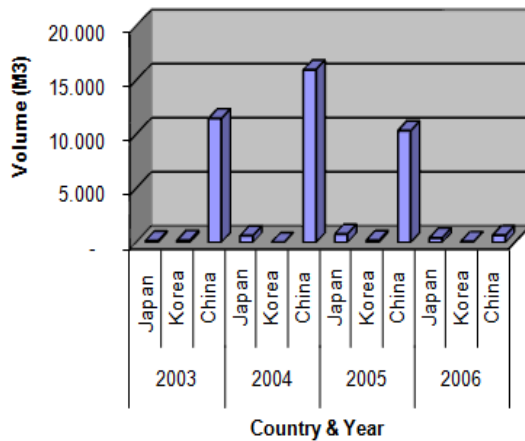


Figure 6. The volume of ironwood semi-finished products in inter-island trade from Samarinda and Balikpapan to provinces within Indonesia, 2003 to 2006.

Source: Data obtained and processed from Provincial Forest Service, 2007.

The Volume Of Ironwood Processed Product to Importer Countries From Samarinda, 2003 to 2006



The Volume of Ironwood Processed Product to Importer Countries From Balikpapan, 2003 to 2006

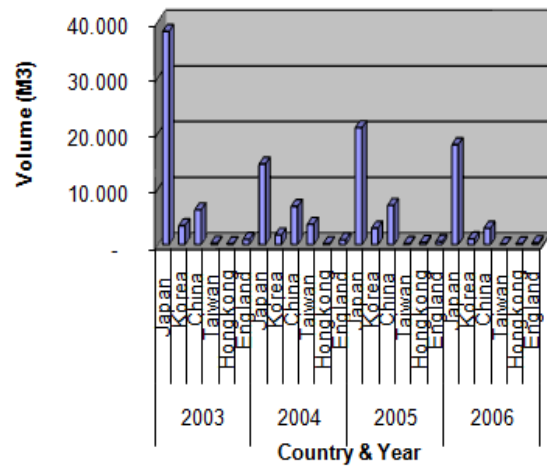


Figure 7. The volume of ironwood products to three importer countries from Samarinda and Balikpapan, 2003 to 2006.

Source: Data obtained and processed from Provincial Forest Service, 2007.



Figure 8. (A) Ready-to-use shapes of ironwood export products; (B) Packing export products

In 2006, the price of ironwood products for export orders reached between US\$ 750-970 per cubic metre and increased to US\$ 1,100 in 2007 (www.kompas.com, accessed on 18 May 2007). In 2006, the export volume of ironwood products reached 3.48 million cubic metres, with a value of US\$ 1.6 billion. However, in 2007 this volume decreased to about 1.31 million cubic metres and a value of US\$ 659.9 million (Majalahtrust.com, accessed on 11 March 2011). These processed products for export (FOB¹⁴: 'free on board' condition) reached prices that were five to six times higher than the prices obtained in the domestic market. The disparity price is attractive and the strong demand from buyers willing to pay the price for ironwood products creates a powerful incentive for ironwood trees to be cut illegally and poached. Export of ironwood flooring, moulding, decking and FJLB (Finger Joint Laminating Board) to these countries still takes place, particularly from industries in Balikpapan and Samarinda. In 2005, the total export value of ironwood products in East Kalimantan reached a value of US\$ 50 million.

To reduce ironwood timber waste, the remaining raw material is also processed into finger joint laminating board. This product is created by a process that joint together small pieces of waste timber and off-cuts, which might otherwise have been discarded, to form longer pieces of wood. Finger-jointed floorboards are a better alternative to long, single-length floorboards because long boards usually have come from very large, very old, majestic trees, which are few in number these days. Interviews with staff of a company called CV. Diana Bhakti in Balikpapan which processes ironwood products for export, revealed that most of their ironwood raw materials came from timber clearance permits (IPK or *Izin Pemanfaatan Kayu*) and timber extraction and utilization permits (IPPK or *Izin Pemungutan dan Pemanfaatan Kayu*). About half of the raw materials came from Central Kalimantan and the rest came from East Kalimantan. This company has processed ironwood export products since 2002.

Legality and regulation of international forest industry product trade

Since October 2003, Indonesian timber exporters have been required to apply for a new licence: the ETPIK (*Eksportir Terdaftar Produk Industri Kehutanan* or Registered Forest Industry Product Exporter). To obtain an ETPIK certificate, a company must join BRIK¹⁵ (*Badan Revitalisasi Industri Kehutanan* or The Forest-based Industry Revitalization Body). Companies or mill owners must supply three documents to obtain the ETPIK: a report containing the volume of timber consumed by their mill from 1 January 2003 until the application date (*Laporan Mutasi Kayu*); a copy of each transportation document or SKSHH (*Surat Keterangan Sahnya Hasil Hutan* or Legal Forest Product Transportation Permit) that has accompanied each load of logs received; and the total volume of plywood, sawn timber or mouldings

¹⁴ The term 'free on board' or FOB (often seen as f.o.b.) is commonly used in the shipping of goods to indicate who pays loading and transportation costs, and/or the point at which the responsibility of the goods transfers from shipper to buyer. FOB shipping is the term used when the ownership/liability of goods passes from the seller to the buyer at the time the goods cross the shipping point to be delivered.

¹⁵ BRIK was jointly established by the ministers of Trade and Industry and Forestry in December 2002. It is an independent organization or a non-profit organization managed and funded by business representatives and non-government officials, such as forestry industries (mills and factories), which serve as members. Its broad brief encompasses 'realising sustainable forest management, supporting forest industry revitalisation and improving the development and utilisation of technology in the forestry sector'.

manufactured at the end of each year. All data are entered into the BRIK computer system and the amount of timber each factory is consuming is calculated and compared with its output. Furthermore, a licenced company must inform BRIK each time it wants to export wood products.

The BRIK system relies heavily on SKSHH documents as proof of the legality of timber. However, SKSHH documents are the weakest link in the chain of verification. They are the responsibility of the Department of Forestry, not BRIK and they are produced centrally, and then issued in batches to provincial and district forestry offices. Local authorities appear unable or unwilling to stamp out the thriving illegal trade in real and forged SKSHH documents. Since the introduction of regional autonomy, forestry officials in Jakarta certainly have no authority to control them. If a company with a SKSHH and sufficient quota asks BRIK to endorse a shipment for export, BRIK must grant this. It can only refer documents to the Forestry Department at a later date if these are found to be counterfeit.

Like the regulations for domestic inter-island wood trading, the ETPIK licence also covers all forest industry products such as plywood, sawn timber, pulp and paper and mouldings. However, it does not provide specific rule for any certain wood species. According to the head of BRIK, there are no clear regulations for ironwood processed products for export. There is disharmony between the two ministries about the regulations. The General Directorate of Forest Production under the Ministry of Forestry issued a letter Nr.S.266/VI-BPHA/2006 on 15 August 2006, which forbids the trade of ironwood timber for export from Kalimantan. However, another regulation from the Ministry of Trade Nr.09/M-DAG/PER/2/2007, issued on 14 February 2007 and regarding the determination of export forest industry products states that ironwood processed products are not excluded from trade as long as the technical requirements are fulfilled.

Trade, market chain and channel of distribution of ironwood

In general, actors in the trade and market chain of ironwood products comprise producers, collectors, traders and local and foreign consumers. Ironwood product traders and producers (small industries and manufacturers) are linked together, forming the market chain. The various trade patterns depend on the sources of raw material. Actors involved in the trade and market chain of ironwood products can vary, depending on short- or long-term distribution channel patterns and the location of sources of raw material.

Moreover, prices of ironwood vary considerably and there are strong fluctuations due to international demand and exchange rates. Furthermore, traders offer higher prices when products become scarcer. In addition, prices can vary with the place of transaction, from remote upriver settlements to coastal market towns, due to high transportation costs and with the perceived grade or quality of the products. Profits for traders are generally high, but also depend on the number of middleman along the trade and market chain, with major traders in Samarinda and Balikpapan dealing directly with Surabaya, China and Japan. In general, actors involved in activities within the ironwood market channel can be identified as follows:

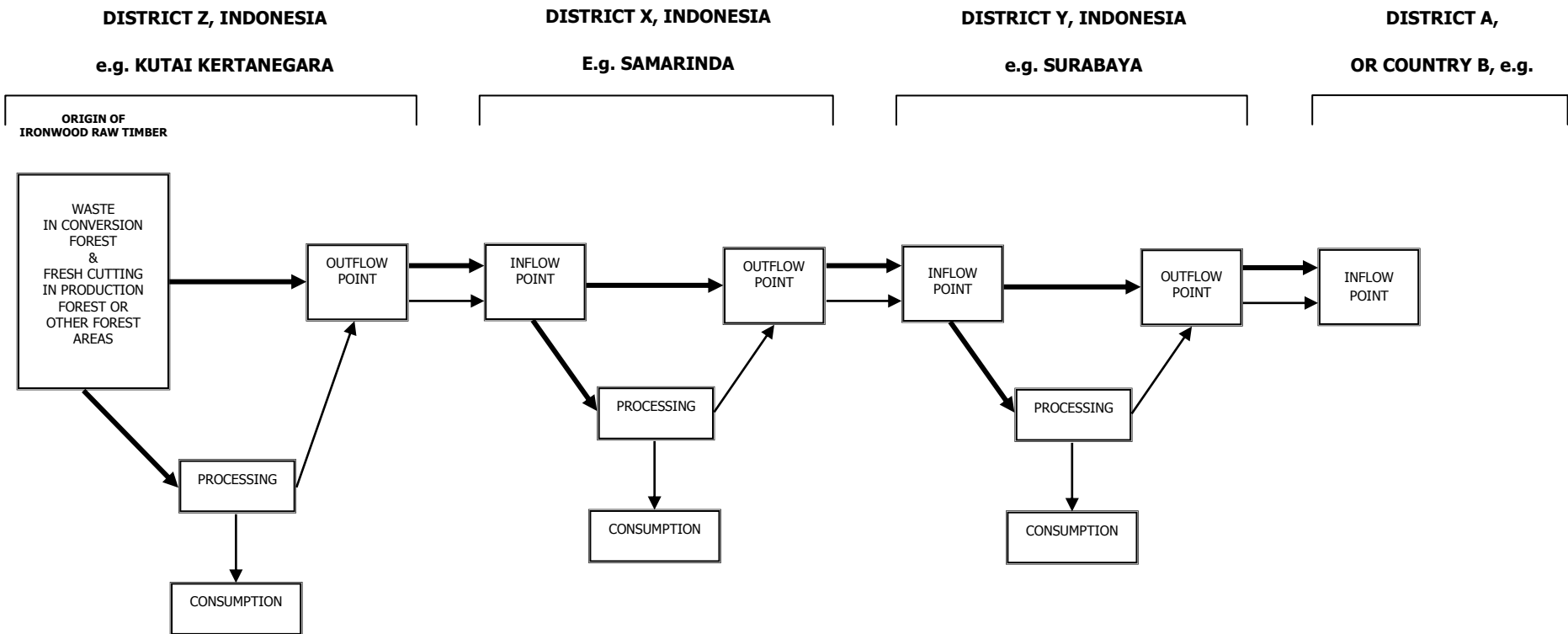
1. **Ironwood seeker** (*pencari*) also acts as a chainsaw man. Activities are to seek and cut waste and squared blocks of ironwood from the source areas.
2. **Loader** (*tukang pikul*), is somebody who loads ironwood squared blocks from cutting areas or hauls timber to the roadside or to the collection field at a point along the road.
3. **Contractor** (locally call *animer* that adapted from Dutch language *aannemer*) is a person who provides logistics and capital to ironwood seekers and loaders. Typically, they own or have access to transportation cars to facilitate the loading of timber and transporting of sawing machines for processing. They also load the semi-finished processed products themselves and transport to the manufacturer.
4. **Collectors, brokers or upstream trader middlemen** (*tengkulak* or *pengumpul*). These people have a direct link to the ironwood seekers. A broker sells ironwood raw material, such as square blocks, to the sawmill. Their main bases in East Kalimantan are in Berau, East Kutai and Bulungan Districts.
5. **Middle man** (*pedagang perantara*) is an agent between the *animer* and industry.
6. **Sale retailer** (*pedagang pengecer*) sells ironwood products directly to consumers (commonly for domestic or local need). The products are bought from a broker or wholesaler (*tengkulak*) in the form of semi-finished construction material shapes, i.e. planks, thin planks, roof shingles and beams.

7. **Ironwood industry producer**, also acts as a wood processor. There are three kinds of industries: primary, secondary and finished manufacturer, which process ironwood raw material obtained from *animers*, commission agents and wholesalers in order to process export products such as flooring, decking, trimming and moulding. Most industries directly process raw material into ironwood products without the intervention of exporters.
8. **Exporter agency or broker** is an organisation that exports processing products from industry. This exporter is located in Java (Surabaya and Jakarta).
9. **Consumers: Local and foreign consumers.**

There are two forms of ironwood (sawnwood and moulding) distribution channels: (1) marketing channels (through which information flows and sales of products are made); and (2) delivery channels (through which products flow). Many companies are members of both distribution channels (as defined above), such as importers and timber and builders merchants. Others, for example some agents, are only members of the marketing channel as they never take ownership of the product. In this case, the ironwood product passes directly from the overseas producer to ironwood timber importers and merchants or sometimes directly to end users. However, from interviews carried out for this survey and other research, it is clear that the traditional collectors and traders are still the main actors dealing with ironwood producers and exporters. Finished product traders are engaged in the commercialisation of the Indonesian market, the international market, or both. They may be retailers, wholesalers or both. Those agents and importers contacted for this research emphasised the changing nature of the distribution channels and the need to adapt to these changes.

There are many outside participants, who are not primary actors, involved in these channels and the wider system. These include state institutions such as the Provincial and District Forest Services, which come under the Department of Forestry (*Dephut*), Department of Industry and Trade (*Depperindag*), BRIK (*Badan Revitalisasi Industri Kehutanan* or The Forestry Industry Revitalisation Agency) and local and international associations such as *HIPKABA* (*Himpunan Pengusaha Kayu Bangunan* or building material entrepreneur association) and *ISA* (International Sawn Timber Association). These actors are involved in policy formulation and the trade chain. Ironwood timber flows from supply to final demand can be seen in the figure below.

Figure 9: IRONWOOD TIMBER FLOWS THROUGH CUTTING CHAIN FROM SUPPLY TO FINAL DEMAND



Note: The thick arrows correspond to flows of ironwood raw material and the thinner arrows correspond to flows of ironwood processed products

IRONWOOD PRODUCTION IN EAST KALIMANTAN

Based on the volume of log species during the seven years in East Kalimantan from 1999 until 2005, ironwood occupied the seventh level of twelve timber species with a percentage of 0.6 per cent (see fig.10).

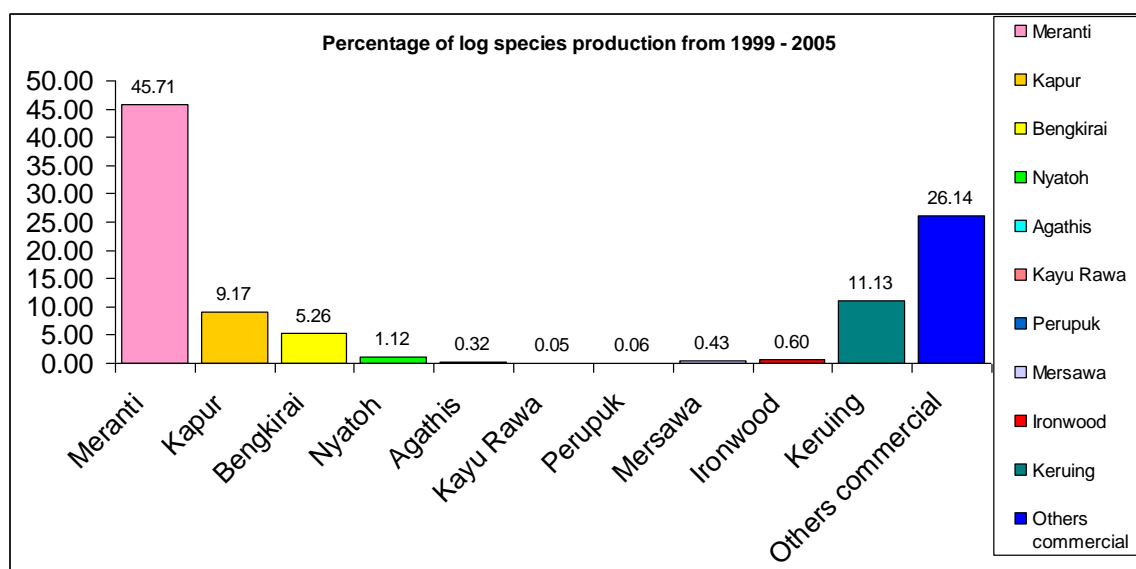


Figure 10. Percentage of log species production from 1999-2005

Source: Data obtained and processed from Provincial Forest Service, 2006

This research shows that there is very little quantifiable information on the amount of ironwood rough sawn wood (in the form of square block) flowing from various sources in remote upriver areas in some districts of East Kalimantan. Information on ironwood production data collected from the Provincial Forest Service (*Dinas Kehutanan Tingkat I*) of East Kalimantan in Samarinda does not reflect entirely the ironwood cutting. Information available on the cutting volume of ironwood is often not reported and that's why it is also far from complete.

The volume of ironwood cutting by concession holders is reported by timber companies to the Provincial Forest Service, but not all holders of timber clearance permits (IPK) and timber extraction and utilisation permits (IPPK) provide this data about the volume ironwood cutting. Consequently, information about the volume of ironwood log production from the Provincial Forest Report in 1999 reports a peak of 91,735 m³; this declined to around 747 m³ in 2004. This situation corresponds with the decreased log production from forests in East Kalimantan in general. In 2004, ironwood log production increased slightly due to land clearing activities for plantations and mining operations. As the table below shows, ironwood log production has decreased drastically since 2002. Since June 2005, there have been no reports sent to the Provincial Forest Service about ironwood log production, although in reality there was a large volume of timber movement in East Kalimantan during that year. It is important to note that the ironwood processing industries are still receiving raw ironwood material that has been transported from various sources. For example, from 2003 to 2004, the total volume of ironwood trade (flow within Indonesia 5,005.02 m³ and to international market 9,701.20 m³) far exceeded the official production of ironwood, which was reported to be only 747.40 m³ (see figure 11).

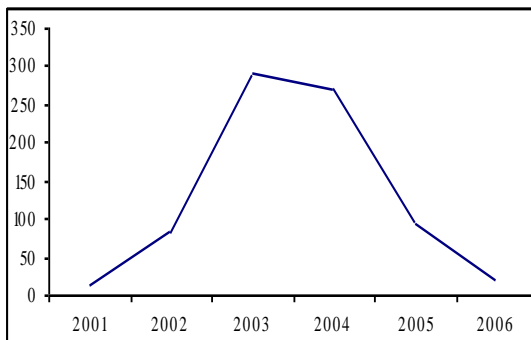
A comparison of data on the volume of ironwood log production (all legal log supply) at provincial level with the volume of ironwood processing products flow within Indonesia (domestic shipping) and the flow to international markets (according to estimates from reporting companies), show that ironwood trade far exceeded logs production, as officially recorded in 2003 and 2004.



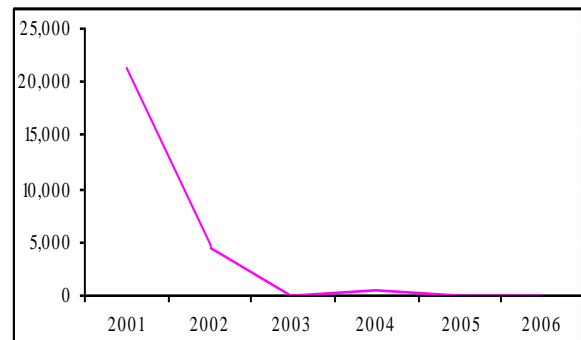
Figure 11. A comparison of ironwood log production with domestic shipping and international market, 2003-2004.

Source: Data obtained and processed from Provincial Forest Service, 2006.

The volume of officially processed ironwood products far exceeds the volume of ironwood logs or round wood. This can be explained by the fact that ironwood square blocks (raw material) come from the logs left over from clear-cutting in timber estate plantations, transmigration sites, mining areas, concession areas, many timber clearance permits (IPK), timber extraction and utilisation permits (IPPK), as well as from illegal ironwood logging and poaching from accessible protected and conservation forest areas. From 2003 to 2006, there were no reports of ironwood production from IPK. The forest land needed for oil palm and timber plantation affected the volumes of ironwood logging. As figure 12 below shows, the volume of ironwood from IPK is higher than that from TPTI.



A. Volume (m³) of ironwood from TPTI (Indonesian Selective Cutting and Planting System)



B. Volume (m³) of ironwood from IPK (Timber Clearance Permit)

Figure 12. The volume of ironwood production from TPTI and IPK.

Source: Data obtained and processed from Provincial Forest Service 2006 (see Appendix 8).

EMPLOYMENT AND INCOME FROM IRONWOOD BUSINESS

Employment and income from ironwood activities are of increasing importance, not only in the rural economy of developing villages in some accessible districts in East Kalimantan but also in the economy of developing cities. Small forest-based enterprise activities constitute one of the largest sources of such income. They also account for a large part of the total harvest from forests in many areas. Ironwood business may generate employment in the short run, but in the longer run it can contribute to the depletion of ironwood timber resources and the subsequent collapse of forest industries. Many agriculturalists supplement their income by gathering and trading products such as forest foods, medicinal plants and fuel wood. Income from these activities tends to be particularly important during seasonal shortfalls in food and cash crop income and in periods of drought or other emergencies.

In developing policies in support of sustainable activities, it is important to be able to distinguish between those that have the potential to grow and those that do not. Policy issues include regulations that discriminate against the informal sector, policies that result in the shift from managed to uncontrolled open access use of forest resources, and restrictions on private production and sale of forest products that impede the development of farm-based sources of these products.

Ironwood gathering and trading activities within the local economy

The commercialisation of gathered ironwood timber is affected principally by the growth in urban markets. Ironwood timber that is not sold in rural areas can acquire commercial value as urban demand emerges, and ironwood commercial products are traded in rapidly growing quantities. As previously noted, this creates growing part-time income earning opportunities for rural collectors and seekers, and the emergence of employment, often on a considerable scale, in trade and vending.

Changes in the value of particular products such as ironwood have altered the way they are used. Commercialisation of some products is accompanied by a decline in rural subsistence use of forest products, and the diversion of supplies of saleable products from use by the collecting household to the market. Rising urban and international demand and prices for ironwood in Indonesia have led to overexploitation. Growth in forest-based product trade also alters relationships and rights. As pressures on a resource rise, traditional rights of use tend to become circumscribed or removed. Some of the longer established trade relations that were earlier based on barter and credit-based personal ties of mutual obligation are increasingly based on short-term competitive established relationships of expediency (Beer and McDermott 1989). As quantities and values grow, urban traders and wholesalers tend to exercise closer control over their supplies by hiring people to collect on their behalf rather than buying from local gatherers.

Thus, though the growing intrusion of organised trading systems into the rural areas as the value of forest products rises may create additional rural employment and income, it can also divert control and access from those who earlier benefitted from the production and trade of these products. Nevertheless, the system has recently come under severe pressure. As demand for other gathered forest products declined in face of competition from synthetics, collectors became increasingly dependent on the sale of ironwood. With growing demand for ironwood, and the opening up of the forests in order to exploit timber, short-term traders entered the market, raising prices for producers stimulated increased harvesting. The construction of industrial processing plants in Kalimantan has raised output to levels that observers consider are unlikely to be sustainable.

ANALYSIS OF RISK OF IRONWOOD DEPLETION

The conversion or transformation of natural forests into agricultural and tree crop plantations is an important cause of forest clearing in Kalimantan. This timber extraction in Kalimantan is an example of how state tenure policies can accelerate destruction of a common-property resource (Peluso 1992). In tropical countries with rapid deforestation, it is widely expected that wood supplies should increasingly come from plantation forest rather than from natural forests. In 1985, the Indonesian government targeted 6.2 million hectares for plantation development (Handadhari 2001). In addition, Indonesia is the country that has the largest areas of oil palm plantations in the world. The total area of oil palm plantation in

Indonesia is 6.2 million hectares. In East Kalimantan, the oil palm plantation estate area has reached 158,786 hectares. Palm plantation estate area in East Kalimantan is bigger than other types of plantations (Kehati et al. 2006)

The concessionaires show little interest in reducing timber waste, mitigating environmental impact and manage their concessions sustainably (see figure below). Indeed, all concessions have some activities that lead to depletion of ironwood. This depletion is set to continue. However, there is a coherent tendency to exploit ironwood from conversion forests and logged-over forest areas belonging to timber companies, as well as conservation and protected forests and even from indigenous reserve forests.

Table 5. Number of establishment and HPH-HTI areas by districts and municipality in East Kalimantan between 2004-2009

District/ municipality	HPH		HTI	
	Number of establishments	Areas (ha)	Number of establishment	Areas (ha)
Paser	4	276,959	2	30,600
West Kutai	32	1,306,423	2	47,910
Kutai Kartanegara	11	889,717	5	433,848
East Kutai	16	1,346,146	5	89,235
Berau	10	559,556	4	230,416
Malinau	8	931,900	-	-
Bulungan	7	2,296,475	-	-
Nunukan	5	40,000	-	-
Balikpapan	3	505,903	3	48,853
Samarinda	-	-	1	9,945
Tarakan	-	-	3	799,651
Total	96	8,153,079	25	1,690,458

Source: Data obtained from Statistics for Forest Area Establishment Centre Region IV Samarinda 2009.

As with other tropical wood species, only a few individual ironwood trees occur per hectare. Although the number of cutting areas vary from source to source, this analysis will assume that depletion of ironwood will continue without much state control and law enforcement. Indeed, forest policy itself has had little influence on the current patterns of ironwood cutting.

In Indonesia, forest and land management is based on an agreed forest landuse classification (*Tata Guna Hutan Kesepakatan* or TGHK) which distinguishes protected forest, limited and general production forest and conversion forest, in addition to smaller areas for parks and reserves. The boundary between the production and conversion forest is a controversial one, based on rates of tree stocking. Within the conversion forest, clear felling is allowed, and such activities as transmigration are supposed to be located on contiguous blocks, after the area has been logged. This does not always happen, as the lack of suitable sites sometimes necessitates the 'swapping' of parcels of land from within the designated production area (Potter 2005).

After thirty years of forest utilisation in East Kalimantan, most of the leased-out area has already experienced an initial round of selective felling. In those areas where concessionaires adhere to regulations that limit them to only a few of the largest diameter trees in each hectare, forest ecosystems have suffered less damage. Nonetheless, depending on the extraction practices utilised, up to 40 percent of the standing stock may be damaged during timber operations. Many concessionaires have had inadequate capital to carry out logging operations according to guidelines. Instead, they have subcontracted small operators who fail to follow the regulations. Other contractors, who have the resources to harvest less destructively, have no incentives to follow regulations. In some cases, the Ministry of Forestry has begun to withdraw logging rights (*Hak Pengusahaan Hutan*, HPH) from concessionaires who have violated felling and extraction procedures. Furthermore, concessionaires have difficulties protecting their thirty-year lease areas from subsequent illegal cutting, which often takes place once a road is built for the initial felling.

Production forest is logged by concessionaires on a 'selection felling' basis, later revised to 'selection felling and planting', as some replanting is now compulsory. It has been suggested that proper land-use planning needs this information base, in order to reduce settler incursions into protected forests, production forests and also national parks. Such areas should be clearly demarcated, and some of the

production forests should be more intensively logged to secure the same levels of production from a smaller coupe, thus making it possible to release other lands, preferably that can be used for tree crops, or for settlement. At the same time, some forest areas may be returned to community control, with community-operated forest 'buffer zones' surrounding important protected areas. Collection activities, especially for ironwood, fuel wood, fruit and rattans would be permitted in such zones (GOI & IIED, 1985). Furthermore, there appear to be no criteria on how to regulate ironwood harvest in a concession (unless this is stipulated by national law). Again, clear guidance is necessary, in part because ironwood dead wood is a very important component of healthy forests, and the best way to ensure a constant supply of dead wood, at least in the medium term, is to retain ironwood large and fecund or productive trees.

DISCUSSION AND CONCLUSIONS

The study reveals that, the global demand for ironwood products is met with timber originating from the old-growth forests of Kalimantan through the clear-cutting of conversion forest in combination with illegal cutting from different status forests. The majority of ironwood entering into international trade is from unmanaged natural forest. Most significantly, a large amount of ironwood timber raw material has been illegally exported within Indonesia's provinces and supplied illegally to ironwood processing industries in East Kalimantan, primarily in Balikpapan and Samarinda.

The main issue for this type of analysis is that, in using official data at a time when all government institutions in Indonesia were in state of rapid change and uncertainty, there is a high risk of error and uncertainty within the data itself. That said, a methodology has been developed that attempts to compare and cross-check a relatively simple and limited data-set at every possible level. However, in spite of these checks, the sheer number of gaps and missing figures imply that I should err on the side of caution with respect to the situation in East Kalimantan, although a large amount of qualitative research allows us to paint a relatively detailed picture about ironwood illegal logging for this province. Although it has long been known that the official production figures for timber output from Indonesia's forests have been far from accurate (Casson & Obidzinski 2002), the record of ironwood processed products shows that ironwood is traded worldwide in significant volumes.

The main reason why this trade exists is because prices for ironwood semi-finished products in East Kalimantan are almost six times higher than domestic and local prices both in Samarinda and Balikpapan in particular, and in East Kalimantan in general. Customs and other government officials can be easily bribed and persuaded to turn a blind eye to this trade, both in East Kalimantan and Surabaya. Local government, through the issuance of timber clearance permits (IPK) and timber extraction and utilisation permits (IPPK) permits, has allowed this trade to continue and expand, although very little taxation is paid and many IPK and IPPK companies underreport log production. All ironwood log production data in Samarinda tends to account for only larger, centrally regulated concessions and not the IPK and IPPK or small concessions that are regulated by district government. The most important observation to be made from the analysis of these flows is that there appear to be significantly large gaps between different types and sources of reporting. This at least indicates the severity and depth of illegal activities in the ironwood problem.

The timber companies or concession holders' responsibilities should control illegal cutting of ironwood and take action to conserve ironwood stands and the planting of ironwood seedlings. They should also avoid outright destruction of ironwood stands in the course of their logging activities. Unfortunately, with many companies not even re-planting trees - and those that are using fast growing exotic species - the potential success of ironwood re-growth is uncertain. Many timber companies blatantly misuse their concession rights. Technically, companies are not allowed to cut and log ironwood, but enforcement is lacking. There is much evidence of timber companies' guards illegally cutting and logging ironwood for commercial purposes, well in excess of the total cut permitted in the first three years of the thirty-year lease (Rudy Suryadi, personal communication, August 2007) and leaving the province without any pretence of reforestation. Improved enforcement of the logging ban by the responsible Department of Forestry staff is also vital. The government and NGOs should support options for the development of alternative sources of income to reduce dependence on forest resources.

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Improving Added Value and Small Medium Enterprises Capacity in the Utilization of Plantation Timber for Furniture Production in Jepara Region

ACIAR Project No. FST 2006 / 117

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ABSTRACT

An international collaborative project funded by the Australian Centre for International Agricultural Research (ACIAR) with a significant contribution by the partner organizations. Duration of project is July 2009 until July 2014. The aim of the project is to support the Indonesian furniture industry by enhancing value-adding from plantation timber production. To achieve project purposes, series of wood processing and manufacturing training have been conducted for furniture SMEs in Jepara: Sawing course, training of wood drying, training related to manufacturing, finishing training and preservative treatment training. Project has been resulting findings and conclusion of studies undertaken which presented in reports, journal publications and conference proceeding and disseminated at the project workshop, training courses and in data sheets tailored for the industry. Project milestone and budget boundaries constraint to an expansion and development of project activities for further improvements on SMEs capability on wood processing and manufacturing to encounter changing industry and market challenges. Further project has to develop programs of obvious practice on applying new methods, adopting technology and improving work habits by SMEs. A collaboration to stakeholders institutions would serve better in implementing activities for SMEs's readiness to encounter timber supply challenges, industry advancement and market requirements and competition.

Keyword: ACIAR, Furniture, Jepara, SMEs, Wood

INTRODUCTION

ACIAR Project No. FST 2006/117 theme ***“Improving added value and Small Medium Enterprises capacity in the utilization of plantation timber for furniture production in Jepara region”***. This project is an bilateral collaborative project between Australian and Indonesian governments. Funded by the Australian Centre for International Agricultural Research (ACIAR), The project is led by the University of Melbourne (UoM), Australia, in collaboration with Department of Agriculture, Fisheries and Forestry (DAFF), Australia; Forestry Research and Development Agency (FORDA), Indonesia; Bogor Agricultural University (IPB), Indonesia ; Gadjah Mada University (GMU), Indonesia ; Pendidikan Industri Kayu (PIKA), Indonesia ; Forum Rembug Klaster (FRK), Jepara, Indonesia. The project was officially commenced in the workshop held on July 2009 in Bogor and will run until July 2014.

Background

Furniture industry is one of the ‘big four’ Indonesian pillars for export along with rubber, palm oil, and footwear. Wooden furniture dominates the furniture sector, accounting for two-thirds of the total furniture exports. In 2006, the volume of Indonesian furniture export was 835,612 ton with a total value of US \$ 1,810 million (ASMINDO, 2007). The industry relies heavily on timber as its raw material with an annual requirement of 7.0–7.5 million m³. Wood species used as raw material for furniture come from natural forest and plantation/community forest (mainly teak and mahogany). The furniture industry is mainly concentrated in Java (notably Jepara, Semarang, Solo, Yogyakarta and Surabaya), where furniture accounts for about 40% of Java's total exports. Jepara is particularly known for its crafted wooden furniture. The business in this region is comprised of about 15,271 companies (Roda, *et al.*, 2007), mostly dominated by small-medium sized enterprises (SMEs). Based on analysis undertaken by Jean Marc Roda

(2007) written in "Atlas Industri Mebel Kayu di Jepara, Indonesia", Annual consumption of log in Jepara region is 1.5-2.2 million m³. There is a great potential for the industry to increase its production efficiency and product quality in order to allow the companies to meet international standards and compete on international markets. A technical assistance is required to support the industry's effort to improve its competitiveness in a "smart" manner by matching the use of sustainable plantation timber resources with appropriate processing and manufacturing methods. The ACIAR project was developed to assist the industry in achieving this goal.

Objectives

The aim of the project is to support the Indonesian furniture industry by enhancing value-adding from plantation timber production.

1. To increase timber recoveries and furniture quality through the improvement of processing and manufacturing methods for teak and mahogany timbers.
2. To explore new manufacturing technologies for new products and new designs, which would be competitive on international markets.
3. To increase Indonesian timber processing research and training capacity.
4. To monitor and analyse economic impact of improvements and innovations introduced to SMEs during the project duration.

Mechanisms employed to enhance dissemination of research outputs:

1. Project meetings, seminars, conferences and workshops;
2. Development of newsletters, publications and simple leaflets;
3. Industry/company-based training at PIKA and at selected companies;
4. A continually updated website to be hosted through FORDA;
5. Distribution of written materials such as products specifications ;
6. Formation of focus groups during various stages of the project to discuss the findings, recommendations and implementation ;
7. International organizations, such as SENADA, TFT, IFC PENSA will be invited to be involved in monitoring and advising on the project progress.

METHOD AND ACTIVITIES

In order to attain project objectives, various research and field activities related to processing and manufacturing aspects; sawing, preservation, drying, manufacturing, and finishing have been undertaken. Research and activities are summarized below :

1. Industry sampling

Project selected 15 companies as project site partner representing small, medium and large furniture industries in Jepara region. Project named "Champion industry" for a network consists of those 15 companies selected. Companies were grouped by the type of production aspects: Sawing, Treatment, Drying, Manufacturing and Finishing with some companies being involved in more than one production aspect. Champion industry's selection was based on several criterias of which the most critical was the willingness for self-development and company improvement through knowledge and technology transfer. 15 companies were appointed as champion industries are : Mandiri Mebel, Cipta Mandiri Mebel, Lima Saudara Mebel, Erik Finishing, Hartoyo Mebel, Prasetya Indra Brata, Proliman, Elok Sejati Mebel, Sugiman Mebel, Raisa House of Excellence Furniture, Els-Artsindo Furniture, Bakti Usaha, Kecik Mirror and Art, Sugiyanto Mebel, and Solichin Furniture.

2. Assesment on industry capabilities in processing aspect

Real time assessment activity was conducted to collect actual data on the current companies' capabilities and to find common problems faced by the companies related to technology, infrastructure and products. Team of Experts from the project partner organizations visited each company site to conduct a survey to obtain reliable and feasible data and information. Five production aspects were assessed: sawing, drying, treatment, manufacturing and finishing. The assessment included such issues as raw material used, production methods undertaken, quality of materials, machinery, wood

waste, production organization and manpower skill and training.

3. Developing recommendations for industries

The outcome of the assessment was a detailed data to analyze and identify areas where improvements can be made. The results were summarized to develop recommendations related to processing aspects for the participating companies. Distinguished recommendations developed for each company and directly distributed and discussed to the owner and/or manager of the company .

4. Development of Database on Alternative Species for High Value Wood Products.

Utilizing the available research studies and data on properties and processing characteristics of selected species provided by all research partners, has been developed a database of alternative wood species (from community forest, plantation forest or agroforestry) suitable for high value furniture production. The database can be used as guidance for industries to switch into alternative species as raw material, displacing teak and mahogany which eventually solve cost escalation driven by scarcity of raw material. The database was disseminated to industries in a workshop.

A book 'Alternative wood species for furniture and creative industry' presents the basic data and information on 21 plantation/community forest wood species that are suitable for creative industry such as handicraft and furniture. Data includes: botanical name, trade/commercial name, geographic distribution, general features/characteristics of wood (with pictures of wood structure and wood macroscopic features for wood identification), physical, mechanical and drying properties, as well as machining and gluing properties. Potential utilization of each species is also discussed based on the wood properties and characteristics. The book will be published in November 2012

5. Annual Workshop

The aim of Project Annual workshop is to provide an update on the project progress against its objectives and milestones. The First Annual Workshop was held on 6th August 2010 in Jepara. The 2nd Annual workshop was held in Jepara on 29 October 2011. And, The 3rd Project Annual Workshop will be held in 7th and 8th of December 2012 in Jepara as well. In the workshop also discovered from an open discussion, some major problems faced by industries related to wood processing such as quality timber, machining, new finishing, utilization of young timber etc. and the unrelated supporting ones such as product marketing, government policy on timber price, etc. Launched during the 2nd annual workshop, an official website of the project provides information and update on project activity and progress. The website address is: www.aciar-valueadded-furniturejepara.com.

6. Consolidation Meeting with Champion Industries

The purpose of the meeting was to ensure that the ACIAR project will provide benefits to the Champion companies by a strong consolidation and coordination of the project activities as well as an improved communication based on trust and open discussion. The main problems in the furniture industries in Jepara relate to raw material, processing and manufacturing; and design/construction aspects. As SMEs use mainly low quality wood material. These are discovered during consolidation meeting with champion industries. ACIAR project would provide technical advice on how to improve the quality of products made from low quality wood and to undertake research on the wood waste utilization as well as improving the efficiency of production. Another proposition related to wood processing is an urgent need to improve wood drying methods. Traditionally, most SMEs in Jepara use a simple stove to dry wood by placing the boards directly on the top of the burner. This is totally improper drying method which causes serious drying defects and timber distortion. Companies need prototype of a simple small capacity of drying facility to adopt. Issue of wood dryness is very important due to market requirement on moisture content. In the meeting also discovered the industries need for a wood bending technology which result material saving and eventually cost saving. Quality product at low price surely will enhance product competitiveness in international market.

7. Focus Team Activities

Due to project time boundaries, 5 focus teams have been formed in order to cope all aspects of wood processing and manufacturing, Sawing, preservation, drying, manufacturing and finishing.

a. Sawing Team activities

- A review on available metal detector technologies and their suitability for Jepara sawmills. The equipment regarded as most suitable based on cost, easy to use, portability and accuracy, was purchased by DAFF (Department of Agriculture, Fisheries and Forestry, Australia) and used for training in Industry Champions. The principle of lean management and waste

minimization as relevant to sawmilling practice were reviewed and summarized into a report for translating into *Bahasa* for the benefit of the Industry Champion and other SMEs in Jepara.

- A review of the availability and cost of personal protective equipment was undertaken by PIKA and provided to the Industry Champions in an effort to implement a culture of safety awareness in the industry.
- A sawing recovery study was completed in five Industry Champion facilities in Jepara and a report completed. The recovery values were obtained for 4 sawmilling companies and 1 carving company in which sawing is done by chainsaw. The study revealed that the sawing recovery in Jepara is higher than that in the regulation on sawn timber recovery issued by Ministry of Forestry due to the sawing pattern used by Jepara companies. The mill recovery studies resulting a benchmark data report and an article in Indonesian Journal.
- Study on sawing of the four wood species i.e. teak, mahogany, mindi, and trembesi at FORDA sawing workshop to complete the basic data of those species.

b. Preservation Team activities

- Prepared a "Treatment Options 1" report that outlines decision processes on the preservative treatment of wood products manufactured in Jepara.
- Prepared a "Treatment Options 2" report that describes various treatment processes that might be used by the Jepara wood processing industry.
- Program of research into steaming followed by soaking in preservative of teak, mahogany, trembesi and mindi. Treated material will then be exposed to beetle and termite attack.
- Carried out vacuum pressure treatment of
 - Teak using copper, chrome arsenic wood preservative
 - Teak using copper naphthenate dissolved in kerosene
 - Teak using copper naphthenate dissolved in methanol
 - Teak and mahogany using copper, chrome boron preservative
 - Trembesi and Mindi using copper, chrome boron preservative
- Non-pressure treatment of teak using boron based preservative. Techniques include, dip diffusion, cold soak and hot & cold processes.
- Research program into brush & dip treatment using a pyrethroid insecticide.
- Constructed demonstration treatment plants (cold soak, hot & cold, vacuum pressure). It is planned to use these plants for demonstration and training.
- Carried out heat treatment of teak to reduce the colour difference between sapwood and heartwood.
- Research into the susceptibility of heat treated teak to attack by beetles.
- Research into the wood properties of heat treated teak.
- Carried out laboratory research into the decay durability of heat treated teak.
- Field research into the decay durability of heat treated teak is planned
- Carried out preliminary research into the impact of ammonia fumigation on the colour of teak.
- Prepared a draft plan for establishing a quality monitoring system for preservative treated wood. Work on refining the program is continuing.
- A journal article on the impact of heat treatment on the colour and durability of teak sapwood is in preparation
- Industry Champion consultancy related to preservation method. Discuss the range of options for equipment and chemical requirements for effective treatment of lyctus-susceptible furniture timber.

c. Drying Team activities

- Identifying problems faced by industries related to wood drying
The main drying problems identified by team were cracking, splitting and twist, mainly in joints. A number of companies reported that small defects were repaired by using wood fillers after finishing, however there were still a number of small defects visible (i.e. hairline cracks) in the finished products. It was considered that these defects were as a result of drying semi-finished, already assembled components. This was the main problem identified with the overall drying process; with the majority of companies reporting that they dried the products

twice, once to dry the sawn timber and second, when they re-drying the unfinished or assembled components, as the material had not been dried to the required MC, initially. This was considered to be a very inefficient process and is not recommended by the Drying Team.

- Identify areas of training related to wood drying. (i.e stacking, drying schedule determination, temperature control, storage and end point MC determination).
 - Drying trials have been conducted in the facilities at FORDA on four primary wood species used in Jepara- teak, mahogany, mindi, and trembesi. The results from this work is provided in technical brochures to interested kiln operators throughout Jepara and presented at training sessions.
 - Procurement of drying facility in accordance to the needs of SMEs in Jepara Drying chamber with the capacity of 12 m³ was constructed. It is located in Bpk. Latif industry area, one of SMEs in Jepara. The decision of drying chamber location was made based on the consultation of PUSTEKOLAH team and APKJ's representative.
 - Performed distinguished assistance for champion industries that are in the process of building drying chambers for their use related to implementation of recommended improvements in the current drying methods. Assistance and mentoring carried out by UGM and FORDA
 - Recommend improvements in drying schedules and local kiln design for champion industries.
 - Drying trials have been conducted by Efrida Basri at FORDA on four primary wood species from young plantation forests used in Jepara: teak (*Tectona grandis*), mahogany (*Swietenia* sp.) and trembesi (*Samanea saman*). The occurrence of warping defects in trembesi wood has been observed and further study will be carried out to investigate causes of this problem. The results of drying properties, kiln drying schedules and drying process of these species using the combination of solar energy and heating stove system have been presented in a research report.
 - Drying trials on preservative treated wood in solar drying chamber
 - Investigating of kiln drying schedules of three wood species i.e. lamtoro (*Leucaena leucocephala*), bayur (*Pterospermum javanicum*) and angšana (*Pterocarpus indicus*).
 - A study on the use of solar kilns in Indonesia was undertaken by Gerry Harris (The University of Melbourne). This study indicated that drying of timber using solar energy is feasible in the majority of the locations studied around the island of Java, in particular if the kilns are fitted with a form of night-time insulation. This may not always be possible due to difficulties in retro-fitting or initial kiln design, however in Jepara, where the furniture industry urgently requires drying facilities, it is considered that a simple uninsulated solar kiln could still adequately dry timber during six months of the year (i.e. between April and October inclusive), without the need for supplementary heating. For developing countries in tropical latitudes such as Indonesia, the capital cost of conventional kilns may be prohibitive for SME's. Therefore given the low cost of solar kilns (compared to conventional kilns) and the abundance of solar energy in the region, a moderately sized solar kiln (i.e. 22 m³) may be obtainable for most SME furniture companies, in particular in the Jepara region.
- d. Manufacturing Team activities
- Implementation visits to the Industry Champions manufacturing companies.
The purpose of the implementation visits is to work with each individual company on implementation of recommended improvements and changes to the current production methods. The recommendations for each Industry Cluster company were provided in the project Report: *Assessment of the Current Capabilities of the Industry Champions representing furniture industry in Jepara. Part 4: Manufacturing Process*". During each visit, the company manufacturing process was assessed in detail to determine which changes or improvements are most important for the company. A discussion with the manager/owner of the company was held to decide which changes and improvements are possible taking into account financial or other constraints.
 - Developed a detailed plan for improvements and changes for each individual company according to the observations made and taking into account the financial restrictions identified during the discussion with the company's manager/owner. Team members will be working

closely with each company on continual basis, until the project completion, suggesting improved factory layouts, machinery set ups, OH&S issues, production methods, quality improvements etc.

- Collection and review of standards and specifications for furniture at SMEs has been carried out by FORDA and the University of Melbourne teams. A comprehensive list of Indonesian, Australian, European and International standards and specifications has been collated.
- Collection and review of basic properties of the alternative species for furniture: Jabon (*Anthocephalus cadamba*) and Sungkai (*Peronema canescens*) has been carried out by Jamaludin Malik (FORDA).
- The literature review on alternative species of mangium (*Acacia mangium*) and trembesi (*Samanea saman*) is in progress.
- Literature review on various options for products made from low quality, small dimension timber by IPB team.
- Study on current recovery of furniture components and a report prepared (FORDA and IPB team)
- Implementation of improvements and changes in production efficiency and product quality at the Industry Champion companies has commenced, led by Bpk. Among Subandi with a valuable input of the members of the manufacturing team. The companies' owners/managers are open for suggestions on how to improve factory layouts, machinery set ups, OHS practices, production methods, quality of products etc.
- Discussions with the industry were held to identify new value-adding manufacturing methods which should be investigated by the Manufacturing team for future implementation by the Industry Champions. Wood bending and wood gluing/laminating were selected as the priority technologies which are particularly suitable to the utilization of small dimensions plantation timbers and which will allow the introduction of new products and designs.
- Sets of books on wood bending have been purchased by the Project Leader and distributed to researchers involved in this work: Among Subandi (PIKA), Abdurachman (FORDA) and Heru Purnomo (UGM) to study wood bending principles in detail. Methodology for wood bending research has been developed and the equipment will be constructed at the end of 2012.
- Research on gluing/laminating has commenced at FORDA. Research methodology on the assessment of gluing characteristics of selected species has been developed by Bpk. Abdurachman and the timber for experimental studies is being prepared.
- Review of design skills in Jepara has commenced. A survey is being developed with the aim to identify design skills, design education and training available to furniture manufacturers in Jepara.

e. Finishing Team activities

- The finishing team are investigating improved methods for the application of coatings and other finishing techniques.
- Research study on the development of ammonia fuming as finishing and preservation method was completed by Dr. Wayan Darmawan (IPB). The purpose of the research work was to investigate the effect of ammonia fuming and wood characteristics on the surface appearance of five species: teak (*Tectona grandis*), mahogany (*Swietenia* sp.), nangka (*Artocarpus heterophyllus*), waru (*Hibiscus tiliaceus*) and akasia mangium (*Acacia mangium*). The experimental results showed that ammonia in the volume of 2 liters could significantly change the natural colour of the timbers after 24 hours of fuming. Increasing the fuming time to 48 hours did not provide any difference in colour compared to the 24 hours of fuming, however the 48 hours fuming generated deeper changes in colour on the surfaces of the wood. Heartwood was observed to generate more significant changes in colour compared to the sapwood. Green wood produced a darker colour than air-dried wood. The wood treated by ammonia fuming showed an increase in resistance against termite and fungi attacks. A paper on this research was published.
- Trials on the application of oil based and water-based wood finish has been compared with the oil based wood finish using teak and mahogany timbers. The experimental results showed

that teak and mahogany wood could be finished by using both the oil and water based wood finishes which obtained good performance results, in particular high resistance against household chemicals. Wood samples finished with water-based suffered mechanical damage and weight loss of 1.55% and 0.52% respectively, while no damage was observed on the samples finished with oil-based finish.

- The investigation of the effect of heat treatment on wood properties and finishing quality has been carried out by UGM team. The aim of this research is to increase colour homogeneity and wood quality of teak and mahogany timbers from community forest. Two types of heat treatment methods were used in this research, i.e. oven and steaming methods. Treatments were set on 90, 120 and 150°C for 2, 4 and 6 hours. Physical and mechanical properties were then evaluated. To understand the effect of heat treatment on finishing quality, water-based finishes were applied on heat-treated wood after 2 hours treatment. The tests performed were cross cut test, coin test, gloss test and delamination test. The experiment are in progress.

8. Training activities

Training is one of dissemination method of project findings. Targeted furniture industries in Jepara, particularly champion industries network, training were conducted in Jepara and Semarang at PIKA facility.

Extensive training programs for Jepara furniture industry has been developed by the project team, aiming to increase skills and knowledge in various aspects of wood processing and manufacturing.

No.	Training Subjects	Dates
1	Sawing: · Use of metal detectors in sawmills · Sawing pattern, target size · Standard efficiency, productivity, and safety	19 April 2011
2	Drying: · Wood water relationship, · Lumber stacking, · High speed kiln design, · Lumber kiln drying · Solar drying system · Drying schedule, defects, storage and shipping, · Demonstration of wood drying/stacking wood/temperature setting etc.	22–23 May 2011
3	Manufacturing: · Workplace design, factory environmental and labour fatigue issues, · Standard machines and machining, · Safety tools, · Production layouts, · Furniture factory—practical observation, · Timber Legality Assurance System (TLAS)	24– 25 July 2011
4	Finishing (stage 1): · Wood finishes, equipments, and finishing techniques · Quality control in finishing wood products · Finished Product – Drying Practice :Water-based and Solvent-based Finishing for teak, mahogany, MDF and plywood.	8–9 October 2011
	Finishing (stage 2): · in collaboration with PT. PROPAN RAYA, one of the largest wood finishes company in Indonesia (Practice)	26-27 May 2012

No.	Training Subjects	Dates	
5	Preservative Treatment:		
	· Wood - its origin and properties		
	· Causes of timber degrade		
	· Treatment chemicals		
	· Preparing timber for treatment	28–29	March
	· Timber treatment processes	2012	
	· Treatment levels		
	· Control over treatments records		
· After treatment			
· Safety and the environments			

Data sheets for many aspects of wooden furniture

According to MacMillan dictionary, definition of 'data sheet' is a document that gives description of something in detail especially a product. A **data sheet** or known also as **specification sheet** is a document summarizing the performance and other technical characteristics of a products, machine, component, material, a subsystem and methodology in sufficient detail to be used by a design engineer and operator or business owner to integrate the component into a system.

During the Project Steering Committee Meeting in Jepara, November 2011, Associate Professor Barbara Ozarska, the Project Leader, suggested that a series of data sheets should be developed to transfer important technical information to the Jepara furniture industry. Till now, seventeen data sheets have been developed in both languages, English and Bahasa Indonesia, on various aspects of wood processing and manufacturing. All data sheets will be made available on the project website and the hardcopies of all datasheets will be printed, bundled and distributed to Small and Medium Enterprises in Jepara by the end of this year.

The following data sheets are currently available:

1. Ozarska, B. Gluing of furniture components.
2. Ozarska, B. Requirements for timber used in high quality furniture. Part 1 – Appearance characteristics of timber.
3. Ozarska, B. Requirements for timber used in high quality furniture. Part 2 – Timber stability and drying quality.
4. Ozarska, B. Requirements for timber used in high quality furniture. Part 3 & 4 – Engineering properties if timber and Processing characteristics.
5. Krisdianto and Abdurachman. Finger jointing.
6. Krisdianto. Types of woodworking joints.
7. Norton, J. How does a tree grow.
8. Norton, J. Water and wood.
9. Norton, J. Softwood and hardwood.
10. Norton, J. Causes of wood breakdown.
11. Norton, J. Decay.
12. Norton, J. Insects.
13. Norton, J. Treatment chemicals.
14. Norton, J. Cold soak with boron.
15. Norton, J. Hot and cold soak with boron.
16. Hopewell, G. Band saw roughness.
17. Hopewell, G. Metal detector.

Limitations and Improvements Need

Project milestone and budget boundaries constraint to an expansion and development of project activities for further improvements on SMEs capability on wood processing and manufacturing to encounter changing industry and market challenges.

Further project has to develop programs of obvious practice on applying new methods, adopting technology and improving work habits by SMEs. A close collaboration to stakeholders

institutions would serve better in implementing activities for SMEs's readiness to encounter timber supply challenges, industry advancement and market requirements and competition. Programs comprise possibility for SMEs to get personal assistance by expertise on improving their workplans, Leading effort to construction of second prototype drying facilities in different cluster area, studies to develop proper drying facilities for non-lumber material, such as furniture components and half-made products which are high size-varied. Studies on methods of preservative treatment on non-lumber raw material are also needed by SMEs in Jepara. Collaborating with motivator and psychology expertise to conduct workshop to be addressed to create and improve good habits in workplace.

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- Drying Team ACIAR Project No. FST 2006/117 : Drying activity report, 2011.
- Manufacturing Team ACIAR Project No. FST 2006/117 : Manufacturing activity report, 2011.
- Finishing Team ACIAR Project No. FST 2006/117 : Finishing activity report, 2011.

Influence of Ethanol Extract from Sappan (*Caesalpinia sappan* L.) Wood on Blood Glucose Level of White Rats

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ABSTRACT

Sappan wood or kayu secang (*Caesalpinia sappan* L.) plant was reported of having medicinal uses, such as for natural antioxidant, relieve vomiting of blood, and mix ingredients for malaria drugs. The research was conducted to study the influence of ethanol extract from sappan wood on blood glucose level of white rats. The blood glucose level in rats was carried out by using glucose tolerance method. It was measured by Reflolux S (Accutrend GC) and Chlorpropamide 50 mg/200 g BW (Body weight) as positive control. The ethanol extracts were used in various concentration 10, 20, 30, 40 and 50 mg/200 g BW per-oral and observed every an hour and beginning one hour before to 7 hours after the extract being administered. The results showed that the administered dose 30 mg/200 g BW of the ethanol extracts equal the positive control. Statistical analysis gave significant differential ($P < 0,05$) in 2 and 3 hour after treatment.

Keywords: sappan plant, wood, ethanol extract, blood glucose level

INTRODUCTION

Since 50 years ago, Indonesia started and developed research on efficacy of plants as medicine materials. Three criteria that must be fulfilled when extracting plants to medicine materials, namely quality, safety and efficacy. Advanced research is done until the effective and simple drugs discovery (Chairul, 2003).

Sappan wood or kayu secang (*Caesalpinia sappan* L.) is a species of flowering tree in the legume family Caesalpinaceae or Fabaceae, that is native to Southeast Asia and the Malay archipelago. Common names of sappan are patanga-chekke sappanga (Kannada name) and suou (Japanese). Sappan belongs to the same genus as Brazilwood (*C. echinata*), and was originally called "brezel wood" in Europe (Anonymous, 1998). Furthermore, this wood was a major trade good during the 17th century, when it was exported from Southeast Asian nations (especially Siam) to Japan.

The sappan plant is being used worldwide for a large number of traditional medicinal purposes. This plant produces brazilin that is found to be responsible for several of its biological activities (Badami *et al.*, 2004). Modern day research confirmed its cytotoxic from heartwood (Badami *et al.*, 2003), antitumor from part used stem and heartwood (Dhawon *et al.*, 1980 and Itokawa *et al.*, 1990 in Badami *et al.*, 2004), anti-inflammatory from heartwood (Hikino *et al.*, 1977 in Badami *et al.*, 2004), anti-coagulant properties (Takaoka and Tagakaki, 1995), and blood vomiting cure and drug treatment after childbirth (Aulia, 2002). According to Aviratnant & Pongpan (1983) and Yadava *et al.* (1978) in Badami *et al.* (2004), the essential oil obtained from the leaves and 95% ethanol and water extracts of the wood showed strong antibacterian activity against *Bacillus subtilis*, *Staphylococcus aureus*, *Salmonella typhosa* and *Escherichia coli*. Prawirosujanto (1977) and Sugati (1981) say that the bark of this plant had been used for folk medicine as anti-diarrhea, anti-microbial, expectorant, anti-pyretic, cataract and tonic.

Based on the above description, the research needs to be done in order to examine the use of sappan plant as the other medicine's ingredients. In connection with that the objectivity of the research is to know the influence of ethanol extract from sappan wood on blood glucose level of white rats.

MATERIALS AND METHODS

Plant materials

Sappan wood or kayu secang (*Caesalpinia sappan* L.) was collected from Kemangkon village, Purbalingga, Central Java and was identified at Herbarium Bogoriense, Research Center for Biology, Cibinong. Authentic specimen was deposited at same Institution. Experimental animal was male white rat (*Ratus ratus*) Winstar strain with 2.5 to 3 months old and weight 200 – 300 g. The animals before being tested were fed for 14 days to get the expected weight (Malole and Purnomo, 1989).

Sample preparation

Preparation of extract: 1 kg powder of air dried of sappan wood was macerated by ethanol 95% until the solvent covered the surface of plant material for 24 hours. After 24 hours, filtered and filtrate was concentrated under vacuum (*rotary-evaporator*). This work was repeated 2 or 3 time until the colorless solvent was obtained. Filtrate was combined and concentrated. Then, the extracts were dried by *freeze dryer* to get dry sappan extracts.

1% CMC suspension: 1 g CMC was balanced on watch glass, develop in mortar by hot water and grind until homogenous and added distil water to 100 ml.

1% glucose stock solution: 1 g Glucose anhydrate was balanced exactly, put in 100 ml volumetric flask and added 50 ml aquadest, shake and added aquadest to 100 ml, and shake well until the glucose solved. Removed to 150 ml Beaker added 2 % active carbon, then shake well and heated for 30 minutes on waterbath, then filtered and keep in the infuse bottle.

Standard glucose solution: 1% glucose stock solution was pipette by 5, 10, 20 and 40 ml, respectively and put in 100 ml volumetric flasks, and each added distil water to 100 ml, shake well to homogenous. From this dilution glucose concentration 50, 100, 200 and 400 mg/dl was obtained and each in 100 ml vials.

100% glucose injection solution: 100 g Glucose monohydrate was balanced accurately, put in 100 ml volumetric flask, added 50 ml aquadest and shake well to homogenous and then added aquadest to 100 ml. Filtered and removed to 200 ml vial and sterilized in autoclave at 120°C for 20 minutes.

Treatment schedule

Testing extracts: the ethanol extract was treated with various concentration 10, 20, 30, 40 dan 50 mg/200 g BW (Body Weight). These concentration was made from the dry ethanol extract of sappanwood.

Preliminary testing: preliminary testing was aimed to get the normal glucose level in blood on rat when suffering hyperglycemic condition, after administering of glucose solution (100 %) and various concentration of sappan extracts 50, 100, 200 and 400 mg/dl by intravenous injection on tail lateral vena.

Glucose tolerance testing: glucose tolerance testing had been carried out by administering glucose solution 100% with dose 0,1 g/200 g BW i.v. Each group consists of six number testing animals (rat), which was added perorally. The extract of sappan wood was administered by various doses: 10, 20, 30, 40 dan 50 mg/200 g BW, respectively and distil water was used as negative control (K -), while chlorpropamide 50 mg/200 g BW as positive control (K +). Blood Glucose level in rat was measured 1 hour before to seven hours after treatment.

+	+	+	+	+	+	+	+	+
-1	0	1	2	3	4	5	6	7

Note:

-1 = Glucose level in blood in fasting

0 = Glucose level in blood in treatment [glucose, extracts, Negative control (-), positive control (+)]

1 to 7 = Glucose level in blood after treatment

Blood was taken via tail venous, centrifuged and one drop of blood serum was dropped on glucose strip test and let it for one minute for dying. Measuring the glucose level was done by Reflolux S (Accutrend GC). The data of blood glucose level was calculated by statistical analysis (ANOVA) by making the curve of glucose level versus period (time) correlation. From the curve could be calculated

“Area Under the Curve₀₋₇ or AUC₀₋₇ “ of each testing groups of animals with accuracy (P= <0.05) (Sudjana, 1982).

RESULTS AND DISCUSSION

The blood glucose level of each testing animal after administering glucose solution (100%) with various doses of 50, 100, 200, and 400 mg/dl via tail literal venous on hyperglycemic condition was measured and calculated. The results showed the blood glucose level in testing animals increased as well as the increase of doses. That blood glucose level on testing animals increased to 49; 103.83; 196.50 and 374.70 mg/dl (Table 1). Hyperglycemia conditions of rat blood was most striking when given 100% glucose solution at a dose of 400 mg/dl and average increment in glucose levels was 7 times higher than the 50 mg/dl.

Table 1. Preliminary recovering test of glucose level in blood of testing animals by Reflolux

No.	Glucose level (mg/dL)			
	50	100	200	400
1	47	100	208	387
2	57	104	166	362
3	50	114	199	368
4	48	99	203	373
5	49	103	189	376
6	47	106	194	382
Average	49	103,83	196,50	374,70
S.D	2,08	5,55	7,67	8,32
Recovery (%)	98,00	103,83	98,25	93,68
CV (%)	5,70	5,34	3,90	2,22

The determination results of the interval time of hyperglycemic condition in rat (mg/dl) showed the differential blood glucose level in testing animals. The average of blood glucose level was 110 – 145 mg/dl. The hyperglycemic condition was reached in 3 hours after treatment (Table 2).

Table 2. Determination of the interval time of hyperglycemic condition in rat (mg/dl)

Period (Hours)	Groups			Average
	1	2	3	
-1	114	117	117	116
0	124	137	129	130
1	130	140	135	135
2	137	144	142	141
3	138	152	145	145
4	121	132	128	127
5	113	127	120	120
6	108	120	114	114
7	105	115	110	110

It appears the rat's average blood glucose levels differences before the hyperglycemic conditions. Differences were seen in the rats control (-1) and rats in fasting conditions given distilled water added chlorpropamide drugs 50mg/200 gr body weight (Table 2). The interval time required for adjustment after the food is absorbed (ingestion) by administering 100% glucose solution was 1-2 hours. After that time the blood glucose levels will rise from an average of the range when fasting (114-117) mg/dl to (137-152) mg/dl at the time of hyperglycemic. The condition of blood glucose after extract treatment and anti-diabetic drugs chlorpropamide added, dropped to averagely (124-137) mg/dl.

The results of average blood glucose level in testing animals after treatment (in mg/dl) gave difference level, it depended on extracts doses. The difference of blood glucose levels got in hyperglycemic condition between control groups and fasting groups (-1) and extract treatment groups. Negative Control groups showed average of blood glucose level 145 mg/dl at three hours after treatment and groups II to VI (extract 10-50 mg/200 g BW) showed decrease of blood glucose level 100- 137

mg/dl, while positive control gave 102 mg/dl. Those results showed that treatment of ethanol extract of sappan wood by administer doses gave remarkable effect of blood glucose level in rat and also reduced of glucose level in blood compared to negative control and positive control. Treatment of dose 30 mg/200 g BW (103 mg/dl) gave the similar effect to positive control (102 mg/dl), while dose 50 mg/200 g BW gave more lower blood glucose level (93 mg/dl) than positive control. Statistical analysis of those results gave significant differential between blood glucose level of administered extract doses versus period in all treatment ($P < 0.05$) (Table 3 & Fig. 1). Treatment of doses 20 – 50 mg/200 BW also gave the anti-diuretic effect on testing animal. The research showed that the administered dose 30 mg/200 g BW of the ethanol extracts equal the positive control.

Table 3. Average glucose level after treatment (mg/dl)

Groups	Period (Hours)									
	-1	0	1	2	3	4	5	6	7	
I	116	129	141	145	137	129	123	117	115	
II	118	126	1140	137	134	124	126	123	121	
III	116	122	220	126	119	116	121	124	125	
IV	117	120	124	110	103	112	120	123	124	
V	115	123	120	104	98	107	115	120	121	
VI	115	117	120	100	93	110	118	119	120	
VII	117	120	123	107	102	108	114	120	122	
Fcalculation	1,10	1,78	1,40	3,70	10,10	3,00	1,20	1,60	2,30	
Ftable	2,85	2,85	2,85	2,85	2,85	2,85	2,85	2,85	2,85	

Note:

- Group I : Negative control (distil water)
- Group II : Extract ethanol of sappanwood 10 mg/200 g BW
- Group III : Extract ethanol of sappanwood 20 mg/200 g BW
- Group IV : Extract ethanol of sappanwood 30 mg/200 g BW
- Group V : Extract ethanol of sappanwood 40 mg/200 g BW
- Group VI : Extract ethanol of sappanwood 50 mg/200 g BW
- Group VII : Positive control (Chlorpromide 50 mg/200 g BW)

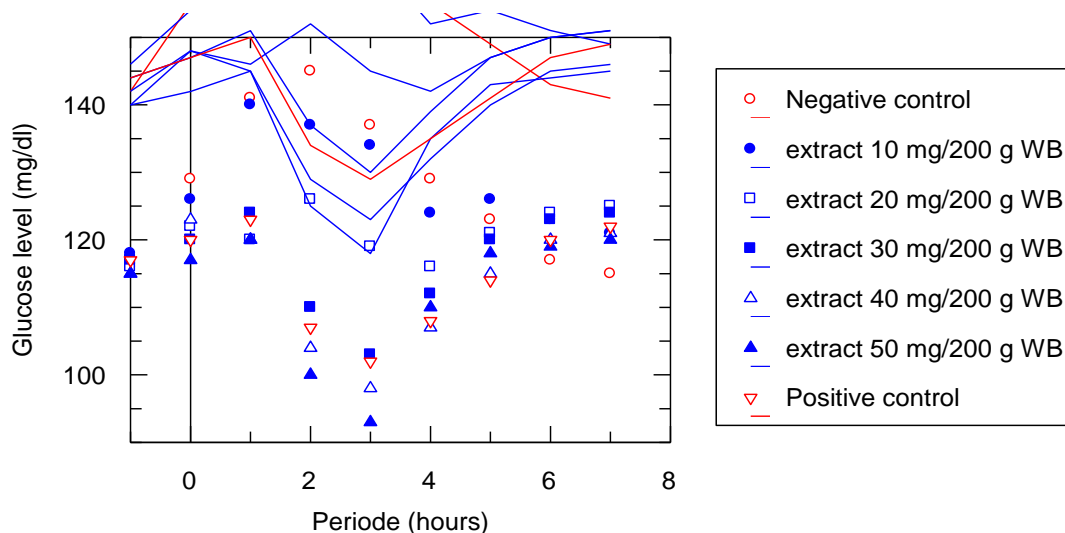


Fig. 1. Curve of glucose level in rat blood after treatment.

The mechanism of ethanol extract of sappanwood in decreased blood glucose level could explain as follows:

1. Fructose-2,6-bisphosphate (F-2,6-BP), a gluconeogenic intermediate, plays a critical role in hepatic glucose output by regulating gluconeogenesis and glycolysis in the liver. Increasing hepatic glucose output is one of the major mechanisms of hyperglycemia in diabetic patients.
2. Brazilin, an active component of sappan, decreases blood glucose in diabetic animals.

In this study, the effect of brazilin on gluconeogenic intermediate production and enzyme activity were examined to investigate the hypoglycemic mechanism of brazilin. As said by You *et al.* (2005) that brazilin increased the production of F-2,6-BP in hepatocytes by elevating intracellular levels of fructose-6-phosphate (F-6-P) and hexose-6-phosphate (H-6-P) to enhance insulin receptor function and lower blood sugar.

CONCLUSIONS

From this experiment showed the remarkable results on anti-diabetic effect on all treatment doses. Administering dose 30 mg/200 g BW (103 mg/dl) gave the similar effect to positive control (102 mg/dl), while dose at 50 mg/200 g BW gave more lower blood glucose level (93 mg/dl) than positive control.

Statistical analysis of those results gave significant differential between blood glucose level of administered extract doses versus period in all treatment ($P = < 0.05$). Administering dose 20 – 50 mg/200 BW also showed the anti-diuretic effect on testing animal.

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Benefits of Danau Sentarum National Park for the Surrounding Community

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ABSTRACT

As an ecosystem which support almost overall needs of human being, Danau Sentarum National Park (DSNP) have so many benefits. However, the benefits generated by ecosystems are not recognized by the community. This has resulted in the ecosystem is not maintained and kept in order to continue producing these benefits. And even tend to using the ecosystem excessively and threaten the sustainability. The research was conducted by using survey method. Three hamlets were purposively selected. Respondents were randomly selected from each hamlet with total number of 60 respondents. The results showed that there are so many benefits produce from ecosystem DSNP. Benefits from ecosystems are goods and services. Benefits can be categorized as ecological, economic, social and cultural. Not all of the benefits which generated by the ecosystem of DSNP perceived by community. This research concludes there are so many benefits of DSNP for the surrounding community. Considering that authors suggest that government intervention through development program should seriously take benefit into consideration, careful management of the ecosystem should be done to take sustainability for the ecosystem.

Keyword: benefits, Danau Sentarum National Park, community

INTRODUCTION

Danau Sentarum National Park (DSNP) is the 2nd Ramsar Site in Kapuas Hulu Regency, West Kalimantan Province, Indonesia. DSNP is area of freshwater lakes and lowland swamp forest. DSNP was established in 1985 as the Danau Sentarum Wildlife Reserve (Giesen 1987), and became to a national park in 1995 (Wadley 2006) and on 4 February 1999 by decree SK 34/Kpts-II/1999 includes the 132,000 ha. DSNP has natural beauty, high biodiversity, traditional fishery and local people's culture are property that can be managed sustainably for the benefit of community.

High biodiversity are more than 500 species of plants have been identified (Giesen 2000). The predominant vegetation is swamp forest. The forest is flooded for much of the year by seasonal lakes; these lakes support a high diversity of fish, some 211 species (Kottelat and Widjanarti 2005). The lakes also buffer the flow of the Kapuas, thus reducing flooding along the longest river in Indonesia (Klepper 1994). Reptilian and amphibian fauna include crocodiles (Frazier 2000), turtles (Walter 2000), monitor lizards and snakes. The number of bird species is 237 (van Balen and Dennis 2000). With the exception of proboscis monkeys (Sebastian and Dennis 2000) and orangutans (Russon et al. 2001). This site of high biodiversity is home to approximately 10,100 people (Indriatmoko, 2010) who depend on its natural resources for their livelihoods.

This study has two objectives: first, to identify the benefits from ecosystem of DSNP; and second, to categorize the benefits.

METHODS

Research site is DSNP, exactly in Semitau Section which located at 00°42' - 00°53' LU dan 111°55' - 112°7' BT. The three villages are selected for the study with purposive sampling, considering the village are permanent fishing villages, have organization of fishermen, and have the rule in the use of natural rivers and lakes. The villages are: Laut Tawang represented by Kenelang fishermen, Sekulat by Pengembung fishermen and Desa Dalam by Tekenang fishermen.

Identification do with function analysis. Function analysis deals with the translation of ecosystem characteristics into a comprehensive list of goods and services (De Groot *et al.* 2002). It was used to describe and determine the magnitude of the actual and potential availability of the main ecosystem services in ecological and bio-physical terms. Categorization do with function valuation. Function valuation

deals with the assessment of the ecological, socio-cultural and economic benefits (or values) of the goods and services identified in the function analysis (De Groot et al., 2002; Farber et al., 2002; Lette and de Boo, 2002). In this paper, we focus benefits based on the community perception in the park.

Primary data were collected through interviews using a questionnaire and field observation. Respondent selected by random sampling, every village represented by 20 fishermen. Data analysis do descriptive analysis based on the questionnaire answer and categorized based on the function of benefit.

RESULTS AND DISCUSSION

Identification benefits

Identification DSNP benefit analysis conducted by the characteristics of ecosystem function that is translated into a list of goods and services (De Groot et al. 2002). It is useful to look at and determine the availability of current and potential ecosystem in the context of ecological and biophysical. DSNP is a wetland of international, according Schuyt and Brander (2004) there are 4 (four) functions of wetlands are: regulatory functions; function (carrier); production functions, and information functions. From the results of identification that has been done then the benefits of TNS are:

a. Maintenance of biodiversity

DSNP an important habitat for flora fauna fan. To measure the importance of maintenance of biodiversity, the value of (ecological) is determined by the diversity, uniqueness and integrity.

- Diversity: TNS has a high diversity of ecosystems, which is a key area for conservation on the island of Borneo. Peat swamp forests and lakes are home to 266 species of fish, and 147 species of mammals, or 67% of mammal species found in Borneo; 26 species of reptiles; 311 species of birds which is about 20% of the bird species found in Indonesia. Meanwhile, it is also home to plants totaling 794 types (species) belonging to 99 familia (Giesen 2000), including 136 species of orchids.
- Uniqueness: there are several endemic species in DSNP, for animals, namely: 1 species of reptiles, 5 species of birds, 26 species of mammals, 78% of freshwater fish species there are endemic freshwater Borneo. Meanwhile, the number of plants there are 59 endemic genera (Giesen 1987), and there are also species of unusual water grass and 30-43 species are endemic (Giesen & Aglionby 2000). Plants are distinctive and original tembesu / tengkawang (*Shorea beccariana*). There are also lowland forest plants such as jelutung (*Dyera costulata*), ramin (*Gonystylus bancanus*), meranti (*Shorea sp.*), Keruing (*Dipterocarpus sp.*), and ironwood (*Eusideroxylon zwageri*).
- Integrity: The park covers 132,000 hectares and is comprised of the core zone, which is a series of interconnected seasonal lakes (approximately 82,000 ha), the surrounding area was dry land. However, the management of the park has faced numerous problems, such as illegal logging activities (Wadley 2006) and is now emerging is palm oil plantations, most of which are in the buffer zone. While in the area is over-fishing activity and the increase of population is high enough. In addition, some species are endangered due to the illegal extraction of orangutans, labi-labi, birds, etc.

b. Regulating water supply

In DSNP there are two rivers i.e. Tawang rivers and Leboyan rivers. Tawang River is a river that connects the Kapuas river with lakes in DSNP, while the Leboyan river connected with Embaloh river in upstream. Annual rainfall in DSNP fluctuated around 3900 mm per year. While in the surrounding hills and mountain from 4.500 to 6.000 mm per year (Aglionby 2000). Due to high rainfall levels, the majority of low-lying areas in the basin was flooded in the wet months. The lakes act as buffer for Kapuas River system, flood prevention in wet season and stock of water level in the dry season. Environmental damage in DSNP very influential on downstream areas, as has happened lately is that more and more frequent flooding downstream.

Although the lake water colored red with peat deposits in and around the lake (Ansari 2006), but it is a major water source for the community to domestic interests. Almost all of the people who live in the DSNP use water for their daily needs. The water supply is in DSNP also a transportation artery for the people living in the region, as a whole community to use water transportation for daily activities. Tawang and Kapuas river flow is a potential for hydroelectric power (hydropower), and as a potential raw

water for the needs of people around the Kapuas river flow and sub-districts nearby. This potential has been initiated by doing micro-hydro power projects in several places in DSNP (Indriatmoko 2010).

c. Recreation

The uniqueness and the privilege of DSNP an attraction for domestic and foreign countries. DSNP has 3 main entrances, i.e. entrance Semitau (Tawang River), entrance Lanjak (Lanjak River) and entrance Jongkong (Batang Putus River). From this third entry of the natural attractions in the form of landscapes, flora and fauna, ecosystems, culture and artevak can be accessed smoothly.

Artevak can be seen in the Sedik River, Pelaik River and Ukit-ukit is *betang house* (long house). The Malay island is the area believed by local Malay community as a *keramat* place. To watch and enjoy the natural landscape can be done with boating in center of lake, or from the top of the Tekenang hill and Semujan hill. The other potential for wildlife tourism are bird watching, and watch the proboscis monkey social life every morning and evening, water birds and other mammals. The potential in the form of unique flora can be seen by canoe between the crevices of trunks and trees that grow in the stagnant swamp forest or witness the beauty of flora in the heat forest on Semujan hill. Potential social culture can be seen in the form of customs of local Malay communities in fishing and fish processing, the traditional raising bees and harvesting honey, and customs of the Iban, Kantuk and Embaloh in doing their ritual ceremonies and see how where local people make goods and woven wicker. Based on the utilization of the existing potential tourist activities that can be developed are: special interest tourism, water tourism, village and culture tourism, environmental education and outdoor recreation (DSNP 2011).

d. Carbon storage

DSNP is an active site of peat-forming habitats. According to Anshari (2010), peat in DSNP began to take shape in the final quarter, and has played an important role in the global carbon cycle past and present. Total carbon storage in peat swamp forests TNDS estimated at 33.5 million tons, equivalent to approximately 122.6 million tons of C.

Because tropical peat organic matter derived from wood; timber extraction, conversion of peatlands and peat swamp forest fires in tropical peat can disturb the peat function. Not only reduce the function of carbon storage, but also threaten the ecological function of peatland ecosystems as a major carbon reservoir. Peat fires reduce the depth of peat, and directly convert the peat into gas. Peat forest conversion to agriculture (such as oil palm and rubber plantations) usually requires draining the swamp, and once the water depth decreased, accelerate the rate of decomposition of peat. High water table is critical to prevent rapid aerobic decomposition and loss of organic carbon. To prevent that, it's need the sustainability and integrity of DSNP.

e. Warehouses of natural resource

Various natural products produced in DSNP i.e. fisheries, forestry, agriculture, and non-timber forest products. The fisheries sector has become the major for communities in DSNP. Fish from DSNP are (40-60%) of freshwater fish in West Kalimantan (DSNP 2011). Timber products is mainstay for the community to make home building and other purposes, even had a target of illegal logging. The other utilization of natural resources are the source of fruits, vegetables, rattan, medicines, dyes, ropes and firewood. Agricultural activities in the form of the farming DSNP is generally done by moving the Dayak community in the highlands. The main crop paddy cultivation interspersed with other types of crops such as corn, cucumbers, and others are generally for self-consumption.

Non-timber forest products produced in DSNP very diverse. However, the mainstay of this forest is honey Honey produced by wild bees (*Apis dorsata*). Wild bees are coming to the area on a seasonal basis when the trees start flowering which took place between the months of November to March. There are 3 types of honey produced by bees by type of spring: Putat flower honey, Masung flower honey and mix d different types of flowers honey. Non-timber forest products such as rattan, Bemban, pandan, medicinal plants, plant dyes have been used long ago by the community. Non-timber forest products are raw materials for crafts, fishing gear, household goods, and fabric leather, medicine, material consumption and other needs.

f. Spaces for living

DSNP with an area of 132 000 ha is a space for various activities of living things that live in it. DSNP containing human settlement, which existed before DSNP formed. There are 45 permanent villages and 10 non-permanent villages, which is a place for human life and their activities. Human presence in the DSNP indicates aquaculture, energy production and the interaction between living things that exist. As a living space, not only for human beings but also other living things such as habitat for various species of flora and fauna diversity.

The existence of living beings in symbiosis with the natural environment is a space for research, recreation and others. So DSNP give and provide a variety of scientific, aesthetic and spiritual information.

Categorization ecosystem benefits of DSNP

Based on the identification, it is known that the benefits generated by TNDS are goods and services. Goods and services when viewed from the utility, can be grouped on goods and services that are used and not used. And when viewed from the existing market, can be grouped goods and services that are marketable and not marketable yet. It can be illustrated in the matrix are as follows:

U s e f u l l	<i>Usefull Not marketable</i>	<i>Usefull Marketable</i>
	<i>Not use Not marketable</i>	<i>Not use Marketable</i>
	Marketable	

Fig 1. Good and services classification from DSNP based on their use and market

Based on community perception, the benefit of DSNP ecosystem mainly for economic. Malay communities whose live in DSNP area were have the background as a fishermen and wild honey beekeepers. DSNP area are place for community looking for fish as main livelihood, and wild honey as a side income.

Productivity of fish in Sentarum estimated to between 97.5 - 162.5 kg / ha. Dudley (1996) estimated fish production can be generated from the DSNP around 10.000-13.000 tons / year. Till now, Kapuas Hulu is still a provider of the largest freshwater fish for the province of West Kalimantan. Estimated to be approximately between 40-60% of supply freshwater fish from the region of West Kalimantan. The various of fish caught and traded predominantly of Sentarum about 25 species. The fish was traded such as fresh fish, processed fish (salted fish, smoked fish / smoked fish, crackers fish) , and ornamental fish. Fresh fish is usually traded for local consumption, processed fish and ornamental fish were collected to collector. Processed fish sold to stores, ranging from Kapuas Hulu to Pontianak and ornamental fish sold to entrepreneurs ornamental fish for export abroad. In addition to capturing nature, people also keep the fish in the cages. More than 90% of the fish cages are Toman (*Chana micropeltes*), followed by fish Jelawat (*Leptobarbus hoevenii*) and Betutu (*Oxyeleotris marmorata*).

The other utilization of natural resources from animals is forest honey. Forest honey is produced by wild bees (*Apis dorsata*). Wild bees are coming to the region seasonally when the trees start flowering between November-March every years. Wild bees are perching and nesting on trees (20-50 high feet). That trees are called "*Lalau*". There is also nesting on made wood and fitted by community on trees, known as name "*Tikung*". Tikung are place in "*Periau*" region. Besides "*lalau*" and "*tikung*", there is also bees are nesting in the branches of hardwood, known as "*repak*".

There are 3 types of honey produced by bees based on type of spring, (1) nectar Putat, (2) nectar Masung and (3) a mixture of different types of flower. Yields of honey bees on a '*lalau*' reached 140 kg,

while the yield of honey per 'tikung' can reach 20 kg of honey per nest, with the production of an average of 6 kg. Estimated total honey that can be harvested and obtained each year from 'lalau', 'tikung' and 'repak' are 20-25 ton (Mulder et.al, 2000).

In addition, people also use the lake as a source of water to meet domestic needs. Lake water is also a medium for transport. Water transport is the only transport that is used by people in the area to connect both within the region and outside the region.

From the forest, people still use the wood to build a house and make a boat. Besides that, firewood for cooking are also taken from the forests in the region. Meanwhile, non-timber forest products are used by the community such as rattan, bemban, pandan, medicinal plants, and plant dyes. Non-timber forest products are used as raw material for crafts, fishing gear, tools, household goods, and fabric leather, medicine, material consumption and other needs.

The value of ecosystems is roughly divided into three : ecological, socio-cultural and economic (De Groot *et al.* 2002; Farber *et al.* 2002; Limburg *et al.* 200;, Howart and Farber, 2002; Wilson and Howarth, 2002). So, benefit from DSNP ecosystem based on community can divided into economic, ecological, and socio-cultural:

1) Economic value

Various species of fish is a major economic benefits to fishing communities. Besides that, the results of forest honey is a side income that also provide relatively high economic value to the communities. Both of this product have clear market prices, and be the main livelihood for communities. While other forest products, generally still used subsistence and still do not have a market price or limited marketing.

2) Ecological value

The capacity of ecosystems to provide goods and services depends on the related ecosystem processes and components providing and limits of sustainable use are determined by ecological criteria such as integrity, resilience, and resistance. Natural ecosystems play an essential role in the regulation and maintenance of ecological processes and live support systems on earth. In order for humans to continue to benefit from regulation functions, we need to ensure the continued existence and integrity of these natural ecosystems and processes. Water regulation as medium for transport and water supply as provision of water for consumptive use are example for ecological value that perceived today by community in DSNP.

3) Socio-cultural value

Social values and perceptions play an important role in determining the importance of natural ecosystems, and their functions, to human society. Social reason are mentioned as playing important role in identifying important environmental functions. The socio-cultural value mainly relates to the information functions i.e.; housing ("rumah panggung" and "lanting"), travel to natural ecosystems for eco-tourism, heritage value of natural ecosystems and features.

CONCLUSIONS

Ecosystem DSNP produce various kinds of goods and services whose benefits can be felt by the community both inside and outside the region. Based on ecosystem function, there are four ecosystem function generated from DSNP: ie: regulatuon, carrier' (habitat), production and information. Meanwhile, based on the value and benefits, can be categorized into 3 (three): economic value, ecological value and socio-cultural value. Most of the benefits has not been directly felt by the communities, such as the benefits of water as a medium transport or water supply for domestic use. Because of the indirect benefits, they are often not recognized until they are lost or disturbed. Therefore the sustainability of the region should be maintained so that the functions of ecosystems and their benefits remain available to the community.

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The Cocoa Processed Waste as a *Bactrocera carambolae* Attractant

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ABSTRACT

Bactrocera carambolae is an important pest on fruit trees and vegetables. One control measure that has been practiced, which is considered to be relatively safe for human and other organisms, is the use of attractant food bait for fruit flies. One of such attractant baits is the processed beer waste. This kind of attractant bait has inspired the potency of other wastes to be observed as attractant. The cocoa processed waste is the potential to be food attractant for *Bactrocera carambolae*. The aim of the research was to identify the attractant volatile compounds in the cacao processed waste and beer processed waste. The volatile compounds are identified by GC-MS using methanol solvent and strengthened by infrared analysis. The chemical analysis showed that the cocoa processed waste contains six volatile compounds attractant.

Keywords: Cocoa processed waste, *Bactrocera carambolae*, attractant

INTRODUCTION

Bactrocera spp. (Diptera: Tephritidae) are an important pests on fruit trees and vegetables. They have a wide range of host plants including mango, orange, guava, red pepper, citrus, melon, cucumber, jackfruit and starfruit or carambola (Suputa et al. 2006). Their attacks cause damage and reduce the production up to 40-100%. The high attack caused by a suitable climate for the development of the life cycle of fruit flies and continuous cropping conditions in the field.

The presence of fruit flies reported in many countries including, Malaysia, Southeast Asia, South Thailand, Singapore, Suriname, Andaman Islands, French (Siwi et al. 2006), Queensland, Australia (Staples et al. 2007), Japan (Wakabayashi & Cunningham 1991), Vietnam (Vijaysegaran et al. 2005), Mexico (Michelle et al. 2008), Suriname (Muller 2005), Malaysia (Chua & Khoo 1995), Thailand (Chinajariyawong et al. 2003) and Indonesia (Siwi et al. 2006). This pest in Indonesia spreads on the islands of Java, Lombok, Sumbawa East, and Kalimantan (Siwi et al. 2006).

Its control measures so far are unsuccessful, because the larvae reside inside the fruit while the adults are free-living. The attack *Bactrocera* spp. may reduced with various ways. One control measure practiced, which is considered relatively safe for human and other organisms, is the use of attractant food bait. One of such baits is the processed beer waste, which contain protein hydrolysates as attractant (Lloyd & Drew 1997; Vijaysegaran 1989). Protein hydrolysates are preferably female fruit flies. This kind of food bait has inspired the potency of other wastes to be observed as attractant.

The study was conducted to observe several different wastes, i.e. cocoa, tofu, fish, brem (a Balinese liquor made of rice), milk, molasse, arrack, vinase and sludge (waste of sugar processing) as fruit fly attractant. Beer waste and protein hydrolysates were used as positive controls. The result showed that cocoa processed waste is the potential to be food attractant for *Bactrocera carambolae*. The liquid cocoa waste that is processed by heating and proteolytic enzymes can attract *Bactrocera carambolae* fruit fly in the laboratory. Its contains 12,98% protein (Indriyanti & Suputa 2008). The aim of the research was to identify the attractant volatile compounds in the cacao processed waste.

METHODS

The cocoa waste was processed before used, refers to the Lloyd & Drew (1997) methods which are modified. The cocoa waste was boiled in open vessel to reduce the volume by approximately 50%. The waste was too acid pH 3, its neutralized with sodium hydroxide to pH 6-7. The waste was given papain

concentration 0.1%. The waste was stirred until tender and then put in the oven with a temperature of 50°C for 24 hours. The cocoa processed waste was ready to be tested to *B. carambolae*.

Mass rearing of *B. carambolae* conducted in the laboratory. Larval stage of *B. carambolae* fed by artificial media. Composition refers to the artificial food (Ashraf 1978) which are modified. The artificial media composed of 43.2 grams of sugar, 10.8 grams yeast, 0.3 grams sodium benzoate and 180 ml of water, all are mixed. The mixture was added 185 grams of wheat bran. Then the artificial media was ready to feed *B. carambolae* larvae. Temperature and humidity in the laboratory were 26-28°C and 68-78%, respectively.

The attractancy test of *B. carambolae* was conducted in a cage, size of 30x40x40 cm. The cocoa processed waste was diluted with water (1:1) and given at petri dish 10 cm diameters. The age of adult flies when tested was 7-9 days, previously fed only sugar and water.

The analysis of attractant volatile compounds was using Gas chromatography-mass spectroscopy (GC-MS) and functional groups analysis using infra red. The samples of cocoa processed waste and beer waste (as positif control) were analyzed volatil compounds using GC-MS with methanol as solvent. Before its analyzed with GC-MS, the samples were refluxed using methanol: aquadest (90%: 10%) for 5-6 hours at a temperature 40-50°C, the solvent was then removed by distillation at 60-100°C, until all solvent is lost. The samples of cocoa processed waste, beer waste and pure protein hydrolyzates (as positif control) were analyzed functional group using infra red (IR prestige-21, Shimadzu).

RESULTS AND DISCUSSION

The cocoa waste was processed by heating and proteolytic enzymes can attract *Bactrocera carambolae* fruit fly in the laboratory. The cocoa processed waste produced volatile compounds which attract *B. carambolae*.

The results of GC-MS chromatograms of samples cocoa processed waste and beer processed waste (positive control) showed that the cocoa processed waste produced 22 volatile compounds and 25 volatile compounds in beer processed waste. Those waste produce a lot of volatile compound because both come from natural materials. The identification results of functional groups on the three ingredients (protein hydrolyzate, cocoa processed waste and beer processed waste) were obtained the same five functional groups namely: esters, amides, alkenes, alcohols and alkyne.

The functional group of volatile compounds generated from cocoa processed waste were: alcohol group a total of 52.31%, 16.64% alkenes, esters 8.24%, 3.36% alkyne, and 1.36% amide. Beer waste consists of ester group a total of 39.58%, 23.43% alcohol, 10.81% alkenes and 5.14% amide.

The same functional groups in all three materials are then associated with the results of GC-MS chromatogram of cocoa processed waste and beer processed waste. There were six volatile compounds which are attractants released from cocoa waste processed and 16 volatile compounds from beer waste. Those volatile compounds are strongly suspected as a component of *Bactrocera* fruit fly attractant.

The chemical analysis showed that the cocoa processed waste contains six attractant volatile compounds were: (5.96% ethyl-2-hydroxy propanoate, 2.28% cis-7-dodecanyl acetate, 1.36% acetamide compounds, 16.64% 3,5 dihydroxy-2-methyl-5,6-dihydropyrane, 52.31% hydroxymethylfurfural, and 3.34% 1-undecyne derivates.

The data showed that the attraction *B. carambolae* to cocoa processed waste due to a mixture of various volatile compounds. Volatile compounds is one important cue for tephrit flies during host search (Fletcher and Prokopy 1991). Adult flies can detect volatile compounds from the fruit are removed from a distance of several meters, using the olfactory organ stimulus (Aluja et al. & Prokopy 1992).

CONCLUSION

The cocoa processed waste can attract male and female *B. carambolae*, due its contain protein, sugar, amonia and six volatile compounds attractant.

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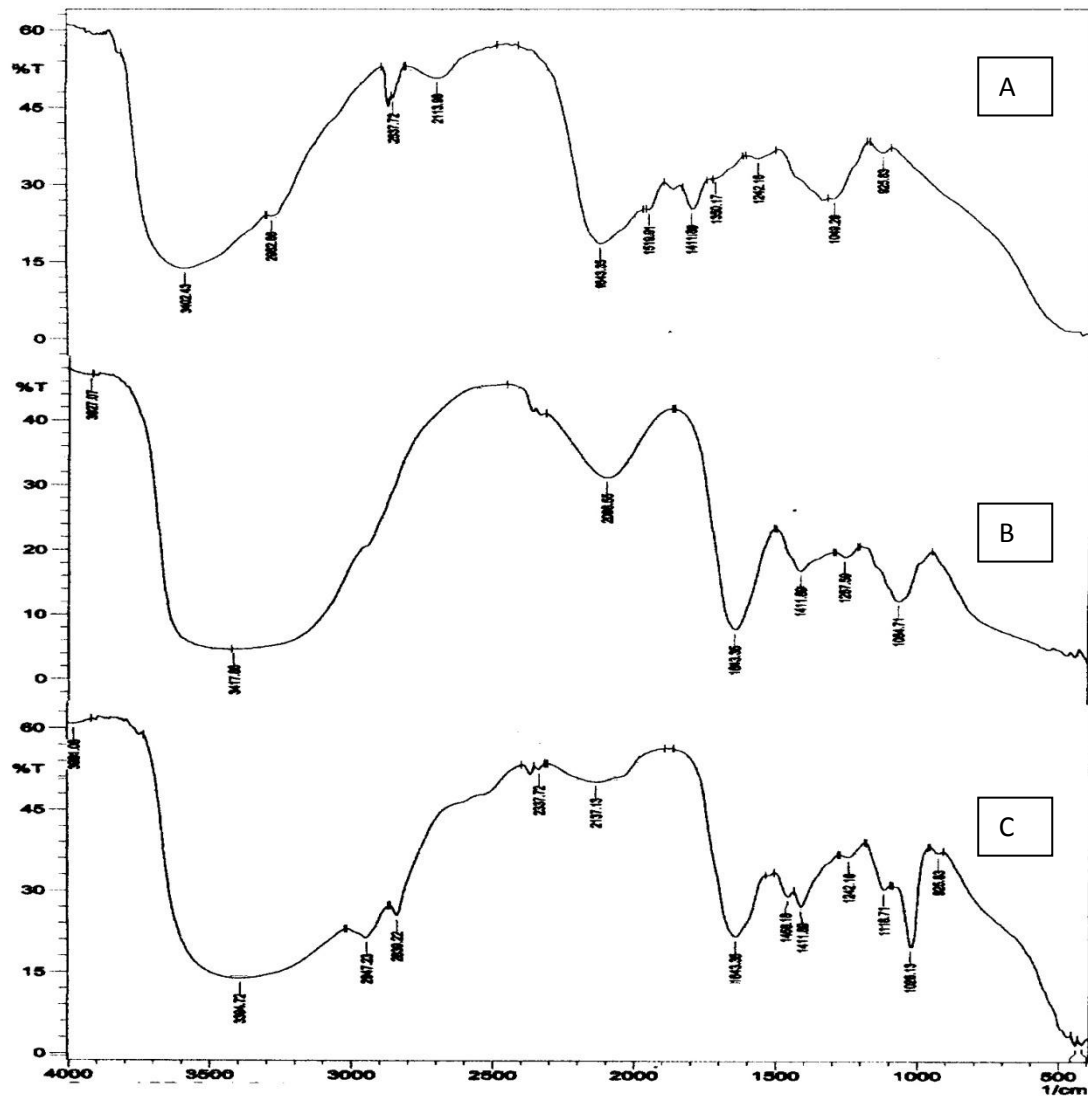


Figure 1. Infra red spectra of samples: pure protein hydrolyzates (A), cocoa processed waste (B) and beer waste (C)

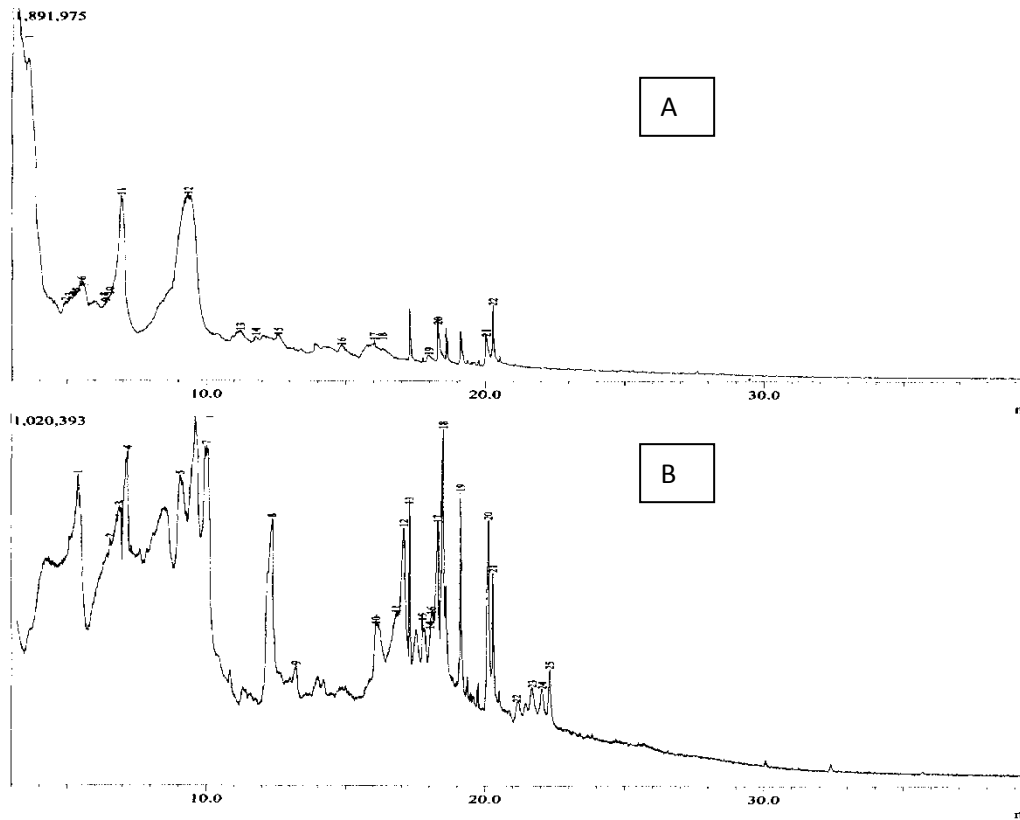


Figure 2. GC-MS chromatogram of cocoa processed waste (A) and beer processed waste (B)

Stand Growth Development and Site Index Curves for Bakko (*Rhizophora mucronata* Lam.) Plantation in the Eastern Sinjai, South Sulawesi

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ABSTRACT

This paper represent report on stand growth and site index of bakko (*Rhizophora mucronata* Lam.) plantation in the the Eastern Sinjai, South Sulawesi. The purpose of this paper is to describe stand growth development pattern of this species as a based to derive site index curve . Parameters of the model were estimated using the bakko plantation in the two localities i.e. Tongke-tongke and Pangasa, Eastern Sinjai, South Sulawesi. Data were collected from 49 temporary plots distributed in whole plantation coastal area of those two villages on various soils or substrates with stand ages ranging from 2 to 30 years. Dominant tree height and age from the whole data set is utilized to describe stand growth development using a non linier model of Chapman-Richards. The dominant height-over-age curve is then used to predict the dominant height development of the stand. Based on this guiding curve, prediction of the dominant height at 15 years as reference age was determine which used to derive site index curves below and above the reference curve. The site index curve is typical of anamorphic curve consists of seven levels site index ranging from site index 9 to 17 with 2 m interval. For the 49 plots the average site index estimated value is 10.35 m with a range 6.82 to 14.64 m representing almost the entire range of bakko plantation stand site productivity in this coastal area.

Key words: growth dcvelopment, *Rhizophora mucronata*, dominant height, non linear model, site index.

INTRODUCTION

Bakko (*Rhizophora mucronata* Lam) is the most common mangrove species planted in coastal area in South Sulawesi. Plantations become more pronounced after the mangrove natural stands undergone a massive clear cut for timber, fuelwood and conversion to tambak (brackish water pond) development.

The largest plantation initiated by local fisherman community located in the Eastern Sinjai Sub District, concentrated mainly in the village of Tongke-tongke and Pangasa, along the coastal delta of South Bone Gulf (Figure 1). Bakko was grown for fuelwood production as an economically-valuable cash crop and coastal environmental protection purposes. The plantation was initiated through villagers entrepreneurship without any government intervention. So far to day hundreds of hectare of this plantation cover the coastal area in form of even aged group stands. Plantation establishment was involving more 150 households. Individual villagers have an average of less than 1 ha plantation (range 0.1 to 2.5 ha). To supply the need of plantation demand, *Rhizophora* propagules are readily available from existing older stands around the village. According to the villagers, the indirect, environmental benefits as a results of the existing plantation are presence abundant crabs, shrimp fry, and various fish around the plantation site. In addition, their village was protected from a high water arising from a tsunami near Flores island in December 1993 that would otherwise have destroyed their dwellings (Nurkin, 1995).

This paper described stand growth development and site index curve of those plantation through a direct measurement of stand dimension. Its objective is to provide data and information on site index curves developing from height growth performance.

SITE INDEX MODEL

Site index curves are widely used for forest management purposes. i.e plantation suitability on forested land development evaluation, production forecasting, evaluating alternative stand treatments, and yield control. Most of site index curves are developed through stand height-age relationships.

It had been recognized through a vast quantity of literatures that the height of trees of a given species of a given age is more closely related to the capacity of a given site to product wood of that species than any other tree dimensions measure. Height of free grown trees is less affected by density or

space between trees. Better sites produce taller trees for a given age indicating a high productivity of land for that species.

Goudie & Moore (1987) summarized the Eichorn's stating that the relationship between volume and dominant height is constant across a reasonably broad range of site qualities. Variation within this relationship is mainly caused by differences in stand density. Therefore the dominant height of trees in forest stand at a specific age is common to be utilized as a quantitative indicator of site quality, that have been widely used in forest ecological and silviculture studies.

Growth patterns of dominant height with age is a first step to develop site index curve. The shape of growth pattern provides a guide or, average curve through the center of height-age data from measurements of dominants tree heght and age. Depend on species growth length or a reference or rotation base age then arbirtrarily selected (e.g 10 to 20 years for fast growing species and 50 years or more for those of typically slow growing species). The development of stands of higher or lower site is estimated by a simple proportional scaling up or down over over the the length of the guide curve. This curve is a typically of anamorphic curve that assume inflection points occur at the same age on all sites, and that young stand will grow and develop become olders similar to those of sampled stands. The site index curve of a stand could be determined by locating the average dominant height and age and projecting forward or tracing backwards in time along the a curve to the reference age. The estimated height at reference age is the site index.

For the purposes of development of height over age model, the non liniear with sigmoid shape of Chapman-Richards is the most common and consider more appropriate for pure,even aged stand than he others model (Goudie and Moore, 1987; Richards 1959; Zeide, 1993). The form of the model is written as,

$$\text{DOMHT} = b_0(1-\exp(-b_1A))^{b_2}$$

DOMHT is dominant height, A is age and b_0 , b_1 , and b_2 are parameters. Asymptote represented by b_0 , growth rate indicated by b_1 parameter, and vertical location of the inflection point determined by b_2 . A guide curve for anamorphic form then could be constructed using those three parameters. To generate proportional site index curves are generated by modifying the dominant height aquation to the following form:

$$\text{DOMHT} = b_0' \cdot \text{SI} (1-\exp(-b_1 \cdot \text{age}))^{b_2}$$

Where b_0' is equal to the b_0 devided by predicted dominant height at reference age.

METHODOLOGY

Prior to taking stand measurements, plantation location were examined through village office records. Potential sampling location, representing a various stand ages and condition were examined and identified through official records of village office and by direct observation under the guide of plantation owners. The forty nine temporary sample plots were located in those two coastal villages. Stands were then sampled according to the following selection criteria: (1) trees are not disturbed and free from injures (2) trees that near the settlement and fish-ponds were excluded to be sampled. Since the younger stands (2 to 5 year old) are homogeneous over the entire area, 5 x 5 m plots, were used for stand measurements. The older stand were sampled with 10 X 10 m plot.

In each plot the height of 10 tallest trees were measured using Haga altimeter. The average height of these 10 trees then recorded as a single value of upper height representing dominant height of trees. In addition to the height, diameter at breast height for each tree were also measured. Stand age was obtained from the year of plantation establishment records available from the plantation owner.

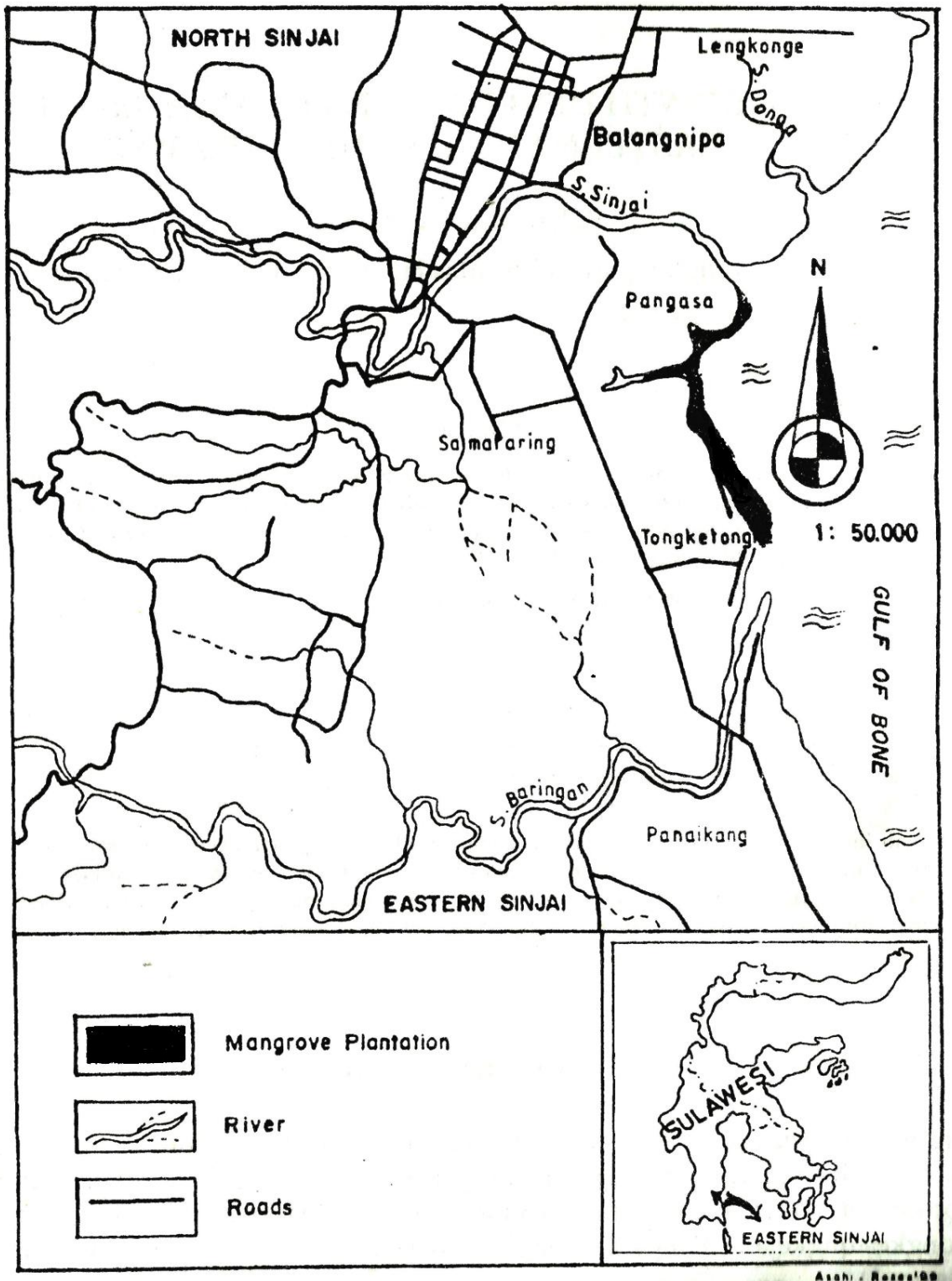


Figure 1. Location of mangrove plantation in the Eastern Sinjai

RESULTS AND DISCUSSION

Through the data analysis, the three parameter estimate are:

$$b_0 = 14.394$$

$$b_1 = 0.100$$

$$b_2 = 1.214$$

The predicted dominant height then is expressed in the equation as:

$$\text{DOMHT} = 14.394(1 - \exp(-0.100.A))^{1.214}$$

The analysis of variance of data processing is summarized in Table 1.

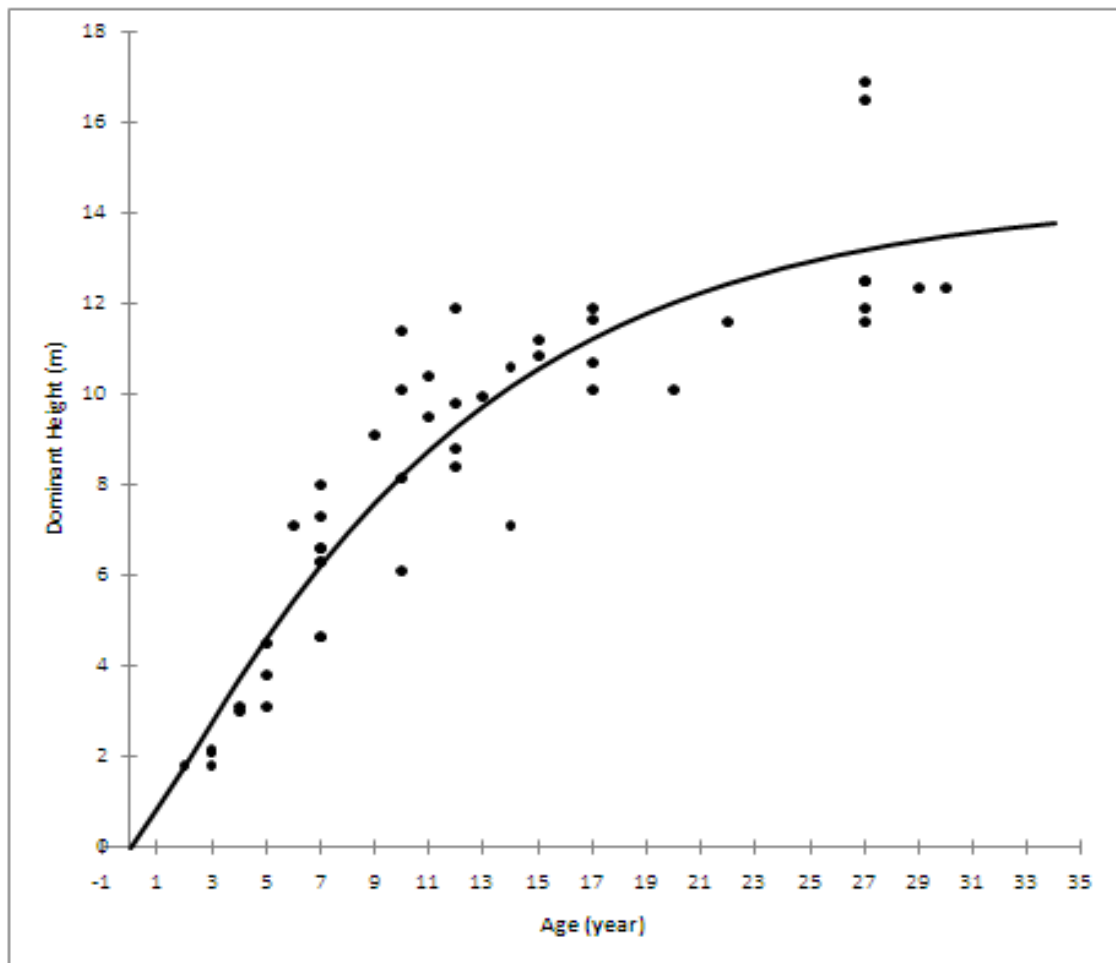
Table 1. Analysis of variance of the non linear regression of dominant height over age with Chapman-Richards model

Source	Sum of Square	Df	Mean Square
Regression	4054.803	3	1351.601
Residuals	98.991	40	2.152
Uncorrected Total	4153.795	49	
Corrected Total	703.743	48	

R squared = .859

It is shown from the Tabel 1 that the non linear regression equation developed in this study has high R^2 value (.859) which indicates a good precision. Plotting the predicted value of dominant height against stand age showed a realistic representation of bakko stand growth in this coastal area. In addition, residual plots did not show any bias. This suggested that the three parameter values were satisfactory for deriving a guide curve.

The model then used to derive stand growth curve using Microsoft Excell 2007 along with the field measurement data as shown in Figure 2. Stand growth pattern as shown is a typical of sigmoid curve. It is apparent that stand height grow rapidly during the early age to 15 year period. It is in this period of growth, MAI of tree dimension higher than any other growth period (Table 2). Similar growth development pattern were also has been found in previous study by Nukin in this area (Nurkin, 1999).



———— predicted ■ field observation

Figure 2. Dominant height plotted against stand age

The predicted dominant height is expressed in the equation as :

$$\text{DOMHT} = 14.39.SI(1-\exp(-0.100.\text{age}))^{1.214}$$

The average age of stand data collected in this study was 12.65 and ranged from 2 to 30 years, the reference age for site index prediction was selected at 15 years. Since bakko mostly utilized for small poles and fuelwood the selected reference age could be assigned as rotation length. The predicted dominant height at this reference age is 10.59 meters with the average dbh of 8.59 cm. The guide for anamorphic curve was derived by modifying the dominant height equation to the following form:

$$\text{DOMHT} = b_0'.SI(1-\exp(-b_1.\text{age}))^{1.214}$$

Where b_0' is equal to the b_0 divided by predicted dominant height at reference age. The inclusion of this value result in,

$$\text{DOMHT} = 1.359.SI(1-\exp(-0.100.\text{age}))^{1.214}$$

This model then was used to derive anamorphic curves with seven site index values using Microsoft Excel 2007. The seven values ranging from 10 to 40 meters and two meters distance from one site index curve to another (Figure 3).

For all plots the average of site index estimated value is 10.35 meters with a range of 6.82 to 14.64 meters, and this represents almost the entire range of bakko plantation stands productivity in this coastal area. When site index values were plotted using a bar chart, frequency classes describing distribution exhibited a bell shape with slightly skewed to the right. This indicated that site index data were approximately normally distributed.

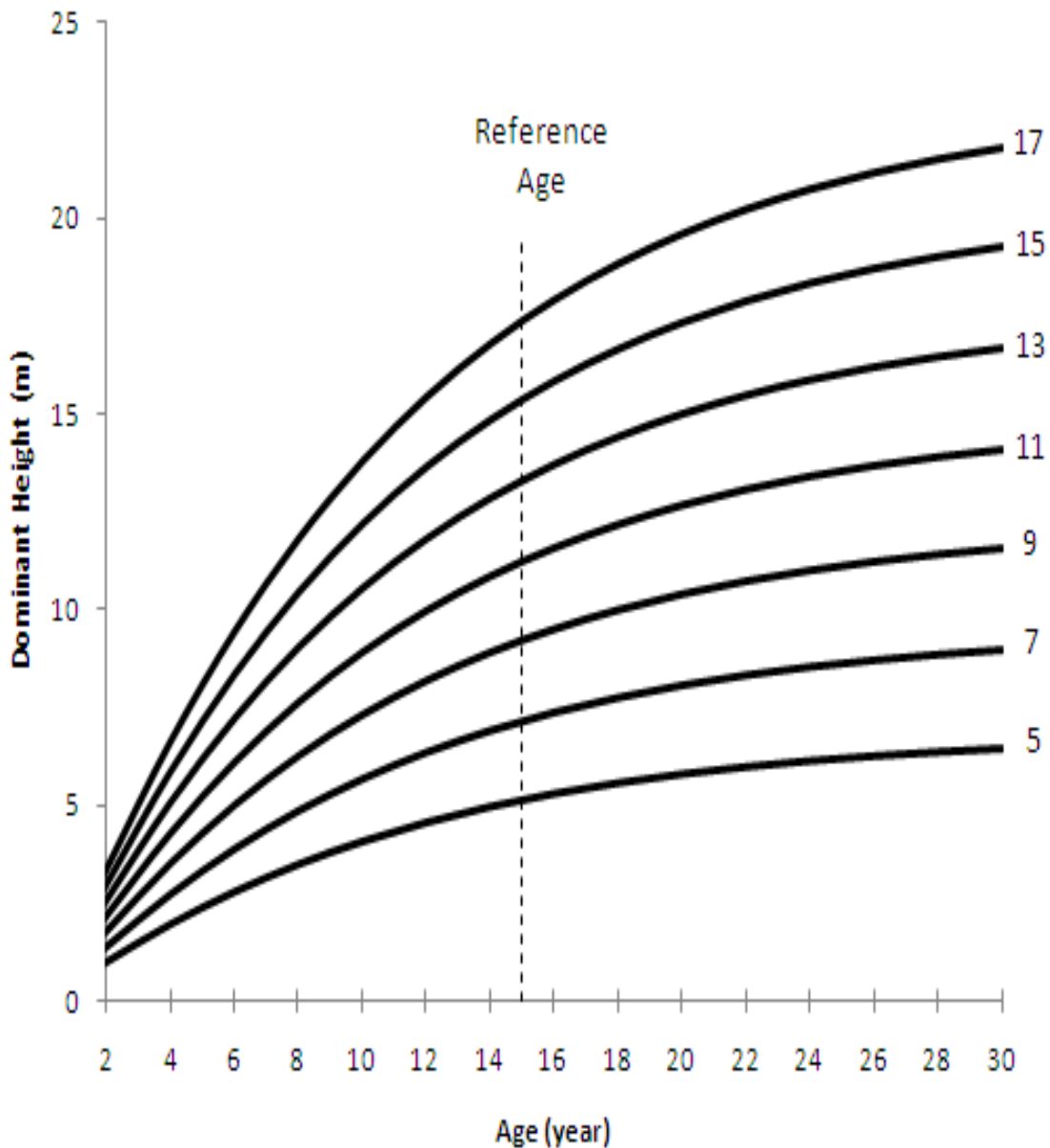


Figure 3. Site index curves prediction for bakko (*R. mucronata*) plantation in the Eastern Sinjai

Table 2. shows mean annual increment (MAI) of both diameter and total height. The overall MAI of diameter of those six stand age groups were less than 1 cm (between 0.35 – 0.86 cm). At younger ages both MAI of diameter and height increase rapidly as the stand age increases. As the stand ages reach 20 years old MAI decrease slowly.

Table 2. Mean Annual Increment (MAI) of Diameter and Total Height of *R.mucronata* Plantation in the Eastern Sinjai

Stand Age (yrs)	M A I			
	Diameter (cm/yrs)		Dominant height (m/yrs)	
	Average	Range	Average	Range
5	0.60	0.57-0.63	0.76	0.62-0.90
10	0.53	0.35-0.86	0.89	0.61-1.04
15	0.43	0.39- 0.76	0.73	0.69-0.88
20	0.43	0.36-0.60	0.55	0.46-0.58
30	0.41	0.37-0.47	0.41	0.37-0.51

Mangrove plantation in the Eastern Sinjai is a typical of short rotation fuelwood cultivation. The growth of both diameter and total height of stand provided in Table 2 reflecting the rate growth of the species. Stand height growth model shows that incremental planting revising sharply rising at the period 5 to 15 years of stand age. Yield and MAI data of plantation, supporting by similar intensive cultivation with the same species agree with this stand growth development analysis.

Earlier measurement in this plantation showed that MAI of stand volume reach 20-25 cu m per year over 5 – 10 years stand age (Chemonics, 1993). These figures based on calculation where *Rhizophora* planted with 50 x 50 cm spacing, giving 40,000 trees per ha. Before thinning at about 10 year MAI of volume were 14.5 cu. m per ha. (for a plot of 5 year old stand plot), 10,4 cu. m (7 year stand plot), and 26.6 and 13.2 cu. m respectively for two plot of 10 year old stand. It was suggested that thinning should be applied earlier to increase individual tree volume.

Huberman (1959) provided earlier record of *R.mucronata* growth. He pointed out a study of mangrove growth in Malaysia shown that *Rhizophora* stand grew slowly reaching cutting size 15 – 18 m in height and 46 -76 cm in girth at 20 -30 years.

Similar to this mangrove intensive plantation with short rotation is a special form of clear cutting and plantation of *R.mucronata* in 1920's or earlier, practiced in Manila Bay (Bromn & Fisher in Agaloos, 1994; Waston, 1928). The planting spacing used of 40 to 100 cm gave the final density of 22,060 to 25,620 trees per ha. The yield reported that two seven year stand yielding at the rate of 92 cu. m per ha and one height year old stand produced 147 cu m per ha. Estimates mean MAI for a mixed MAI for a mixed plantation of *R.apiculata* and *R.mucronata* was 18.4 cu.m.

Bakko is planted in open area including on mud flats of coastal area. Agaloos (1994) and Teas (1979) stated that for best development, *R.mucronata* required full Sunlight, because it is a pronounced light demander and intolerant of shade. Thus plantation site should be in open area. No recommendation under the shade of older trees. Tomascik et al. (1997) and Watson (1928) summarized earlier works and concluded that bakko grows on wide salinity ranges. It grows on deep mud within the influence of rivers, not on sea face. Typical soil of soil under the stand is always dark color rich in humus with slight but not obvious admixture of fine sand, particularly in the higher stretches where there is a sandy subsoil with good soil aeration. In stiff clay *Rhizophora* will not thrive.

In attempt to understand the ecological interaction of all site factors to site index it is importance to study if the site index is related to any local coastal environmental factors. These particularly environment including soil or substrate characteristics such as textures and their distribution in profile, salinity, and organic matter content. Inundation classes and salinity as well site position related topographic factors coastal geomorphology and microclimate are also should be included in model or they are utilized as a stratification factors when a study to be focused on soil or substrat effects on site productivity of bakko. Bakko site index ranks relationships with those certain local environment parameters then can be used to predict growth performance of bakko in particular coastal area. Through field identification and mapping of local environment delineation of important factors in determining site index ranks can be mapped to be utilized as a guide to concentrate plantation of bakko on more suitable sites.

CONCLUSIONS

Even aged stand height growth development and site index estimation curves were developed for bakko plantation in the Eastern Sinjai. The developed model using temporarily plots of pure stand plantation. The derived site index curves is typically of anamorphic and use and index age of 15 years. The reference age of 15 years is more appropriate for short rotation. The site index curves provide expression of stand growth under current management. In coastal area with similar local environment and management condition this curves could be utilized directly for bakko stand productivity assessment. Although the derived site index curves has reflected stand current growth performance over this local coastal area, it is suggested that for the curves improvement in the future, stand growth attributes measurement is collected from permanent sample plots. In attempt to understand the ecological interaction of all site factors to site index it is importance to study if the site index is related to any local coastal environmental factors particularly substrate or soils characteristics. When the particular characteristics could be identify related to site productivity, plantation then should be concentrated on more suitable site for growth with high productivity of bakko.

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Anatomical Features of Wood from Some Fast Growing Red Meranti

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ABSTRACT

The purposes of this study on some potential species grown in central part Kalimantan are to identify the anatomical features of some red meranti (*Shorea parvifolia*, *Shorea platyclados*, *Shorea johorensis*, *Shorea leprosula*), to find out the variation anatomy properties such as texture, sapwood-heartwood ratio, juvenile periods on some red meranti and also to determine their tree growth and wood quality. Sample was taken from PT SBK in central Kalimantan at base stem with altitude 1.3 m from ground. Sample was made at each 1cm from pith to bark (radial direction). Sample preparation For fiber dimension, was made with size dimension 1mm x 1mm x 20mm, while proportion cell 1cm x 1cm x 1cm. Measurement of microfibril angle was used by polarized microscope and SEM. The macroscopic features results showed that red meranti has characteristics as follows : vessel solitary, radial multiple, tangential diameter 175-208 μ , axial parenchyma concentric bands, vasicentric, diffuse and scanty paratracheal, rays : 1-2 distinct size, multiseriate, straight grain orientation and tangential line canal resins. Red meranti has texture medium-coarse. Sapwood and heartwood ratio *Shorea leprosula* (24,91%:75,09%), *Shorea parvifolia* (38,5%:61,5%), *Shorea johorensis* (21,48%:61,78%), *Shorea platyclados* (38,22%:61,78%). Microscopic features vessel, parenchyma, fiber percentage *Shorea leprosula* (8,35%, 26,87%, 63,85%), *Shorea parvifolia* (11,91%, 29,34%, 56,76%) *Shorea johorensis* (9,45%, 27,20%, 63,08%) *Shorea platyclados* (7,44%, 35,06%, 56,04%). Fiber dimension fiber length, cell diameter, cell wall thickness *Shorea leprosula* (0,91 mm; 22,68 μ m; 1,81 μ m) *Shorea parvifolia* (1,05 mm; 21,52 μ m; 1,84 μ m) *Shorea johorensis* (0,88 mm; 20,51 μ m; 1,76 μ m) *Shorea platyclados* (1,15 mm; 21,18 μ m; 1,83 μ m).

Keywords: Red meranti, *Shorea leprosula*, *Shorea parvifolia*, *Shorea johorensis*, *Shorea platyclados*, macroscopic features, Microscopic features.

INTRODUCTION

Kessler and Sidiyasa (1999) state that the genus *Shorea* includes about 194 species where more than 135 species were located in Borneo (Kalimantan). Symington (1943) and Desch (1941) recognized 4 section in *Shorea* from the taxonomical and wood anatomical viewpoint respectively. While Ogata *et al* (2008) state that the genus *Shorea* is divided into 4 to 10 or more section according to different author. The 4 section of the genus *Shorea* are red meranti, yellow meranti, white meranti and balau.

Section white meranti consist of 30 species, widely distributed from India eastward to Moluccas. It is called meranti putih in Malaysia and Indonesia because the wood is whitish. Section yellow meranti consist of 40 species distributed in lowland forest of Borneo, Sumatra and Malaya. Section red meranti consist of 75 species distributed in lowland forest of Malaya, Borneo, Sumatra and Philippines. Red meranti generally attain a height 50 to 60 m with large diameters and straightness stem. Red meranti wood has a medium weight, easy to work and used for various purposes. This is the most important timber for plywood. The last section is balau which consist of 45 species widely distributed from India to Moluccas, including Malaya, Borneo, Sumatra and Philippines. In Kalimantan usually called Bangkirai and Yakal in Philippines.

Red meranti has so many species in this section that the reddish heartwood colour is fairly variable according to the species. Practically they are classified into light red meranti and dark red meranti. We called fast growing meranti because they have bigger stem diameter (more than 20cm) at the age of average 7 to 10 years. The objectives of this study are to find out the anatomical features of 4 fast growing red meranti like *Shorea leprosula*, *Shorea parvifolia*, *Shorea platyclados* and *Shorea johorensis* and also find out the variation anatomy properties such as texture, sapwood-heartwood ratio, juvenile periods on 4 red meranti.

MATERIAL AND METHODS

Research Materials

- a. Meranti wood (*Shorea parvifolia*, *Shorea platicladus*, *Shorea johorensis*, *Shorea leprosula*) from PT SBK, Central Kalimantan.
- b. Silol (C₅H₁₀), *Canada balsam*, aquadest and glacial acetic acid

Research Tools

- a. Chainsaw, cutter, loupe, microtomes, glass preparates, pipette
- b. Volumetric flash, digital scales, oven, desiccator, kaliper
- c. Test tube, object glass, hot plate, preparates box
- d. Microscope fluorescence BX 51 software *Image Pro Plus V 4.5*.

Methods

1. Samples preparation

- Sample was taken from PT SBK in central kalimantan at base stem with altitude 1.3 m from ground.
- Sample was made at each 1cm from pith to bark (radial direction).
- For fiber dimension, sample was made with size dimension 1mm x 1mm x 20mm, while proportion cell 1cm x 1cm x 1cm

2. Measurement Procedure

a. Macroscopic properties

- Observation of macroscopic properties by wathcing carefully at transversal, radial and tangensial section with loupe 15-18x.

b. Microscopic properties

- Observation of mlcroscopic properties at transversal, radial and tangensial section.under microscope fluorescence BX 51
- Measurement cell proportion and fiber dimension are using software image pro plus 4.5

c. Sapwood and Heartwood Ratio

- Sapwood and heartwood ratio was calculate by compare wide area of sapwood and heartwood with total area transversal surface.

$(\% \text{Sapwood}) = \frac{TA - HA}{TA} \times 100\%$	$(\% \text{Heartwood}) = \frac{HA}{TA} \times 100\%$
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HA : Heartwood Area

TA : Total Area Transversal Surface

d. Wood Texture.

- Wood texture was determinated by using measurement vessel diameter and fiber diameter.
- Criteria of size dimension of vessel diameter and fiber diameter as follows :

Table 1. Clasification wood texture

Wood Texture	Vessel diameter	Fiber diameter
Fine (Smooth)	< 100 μ	< 30 μ
Moderate	100 – 200 μ	30– 45 μ
Coarse	> 200 μ	> 45 μ

e. Juvenile Period

- Determination juvenile period was using analysis the graph of fiber length at radial direction from pith to bark.

RESULT & DISCUSSION

A. Macroscopic features of Red Meranti

Table 2. Macroscopic features of *Shorea parvifolia*, *Shorea platyclados*, *Shorea johorensis*, *Shorea leprosula*

Wood Features	Species			
	<i>S. parvifolia</i>	<i>S. platyclados</i>	<i>S. johorensis</i>	<i>S. leprosula</i>
Growth ring	Appear	Appear	Not appear	Not appear
Vessel				
• Distribution	Solitary, multiple radial	Solitary, multiple radial	Solitary, multiple radial	Solitary, multiple radial
• Diameter	208.07 μ	183.72 μ	185.30 μ	175.22 μ
• Frequency	3-6 / mm ²	3-5 / mm ²	3-5 / mm ²	5-8 / mm ²
Parenchyma	Concentric bands, Scanty paratrakeal Vasicentric, diffuse	Concentric bands Scanty paratrakeal Vasicentric, diffuse	Concentric bands Scanty paratrakeal Vasicentric, diffuse	Concentric bands, Scanty paratrakeal Vasicentric, diffuse
Rays				
• Size	1 size	2 Distinct size	2 Distinct size	1size
• width (t)	Multiseriate	Multiseriate	Multiseriate	Multiseriate
Grain orientation	Straight	Straight	Straight	Straight
Canal resins				
• Present	Present	present	present	present
• Distribution	Tangential lines	Tangential lines	Tangential lines	Tangential lines

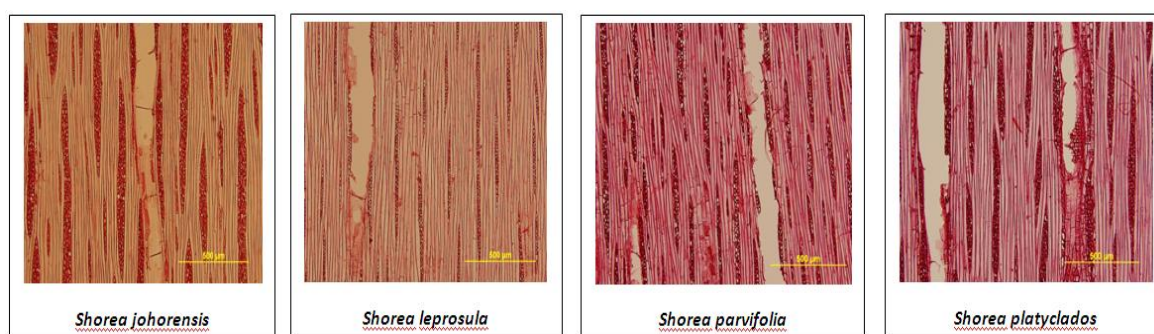


Figure 1. Tangential surface of red meranti

Macroscopic features of red meranti has sapwood colour pale yellowish white, pale yellow while the heartwood colour pale pinkish yellow, pale pinkish Brown, dark brown or reddish Brown. Growth ring is appear some times not according to the species. Growth ring appear in *Shorea parvifolia* and *S. platyclados* but not appear in *Shorea johorensis* and *Shorea leprosula*. Vessel distribution is solitary and multiple radial 2-3, Grain orientation usually straight some times interlocked..

Rays multiseriate 1-8 seriate. Rays shows 2 distinct sizes (*Shorea johorensis* and *Shorea platyclados*) and shows 1 size in *Shorea parvifolia* and *Shorea leprosula* (Fig. 1).

Axial parenchyma usually scanty paratracheal or vasisentric surrounding vessel or diffuse according to the species or specimen. It is rather difficult to identify the diffuse parenchyma by using hand lens. Axial parenchyma also founded in concentric bands surrounding the axial resin canals.

Axial resin canals in more or less continuous tangential lines at interval 0,2 to 0,5 mm (Fig. 2). Usually axial resin canals present or not according to the species or specimen. Table 2 shows that axial resin canals present in all red meranti (*Shorea leprosula*, *Shorea johorensis*, *Shorea parvifolia*. and *Shorea platyclados*) but some times not present in *Shorea leprosula*.(Fig. 2).

B. Microscopic Features of Red Meranti

Table 3. Fiber dimension of red meranti

Red Meranti	Fiber length (mm)	Fiber diameter (μ)	Lumen diameter (μ)	Cellwall Thickness (μ)
<i>Shorea leprosula</i>	0,91	22,68	19,03	1,81
<i>Shorea parvifolia</i>	1,05	21,52	17,84	1,84
<i>Shorea johorensis</i>	0,88	20,51	16,97	1,76
<i>Shorea platyclados</i>	1,15	21,18	17,50	1,83

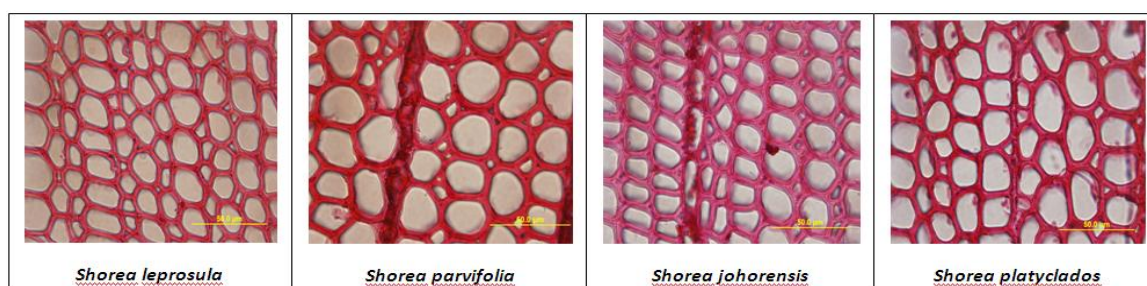


Figure 2. Transversal surface of red meranti

Tabel 4. Cell proportion of red meranti

Red Meranti	Fiber (%)	Vessel (%)	Parenchyma (%)	Rays (%)	Resin canals (%)
<i>Shorea leprosula</i>	63,85	8,35	14,71	12,16	0,92
<i>Shorea parvifolia</i>	59,37	11,76	13,75	14,01	1,09
<i>Shorea johorensis</i>	61,41	9,77	11,73	16,67	0,41
<i>Shorea platyclados</i>	65,27	7,85	13,09	12,99	0,78

Microscopic features: Vessel frequency 3-8/mm² usually 3-5 / mm² . Maximum tangential diameter of solitary vessel is 208 μ (*Shorea parvifolia*) with minimum tangential diameter 175 μ (*Shorea johorensis*). Vessel proportion 7,85-11,76% (*S.parvifolia* the highest; *Shorea platyclados* the lowest). diameter 175,22-208,07 (*S.parvifolia* the biggest);

Cell proportion, fiber is dominan compare other cell, more than 50%. The range fiber proportion is about 59,37-65,27%. The highest fiber proportion 65,27% (*Shorea platyclados*) with minimum fiber proportion 59,37% (*S.parvifolia*). Fiber length red meranti 0,88-0,91mm (*Shorea platyclados* the longest; *Shorea johorensis* the shortest).; Diameter is about 20,51-22,68 μ . Cell wall thickness is about 1,76-1,84 μ .

Rays multi seriate with range 1-3 to 1-8 seriate mostly 1-3 to 1-5 seriate according to the species or specimen. Sometimes rays also has tendency to 2 distinct sizes (*Shorea platyclados* ; *Shorea johorensis*). Rays proportion 12,16 - 16,67%. Highest proportion rays 16,67% (*Shorea johorensis*) and lowest 12,16 % (*Shorea leprosula*)

Axial parenchyma proportion is about 11,73-14,71%. Highest proportion axial parenchyma founded in *Shorea leprosula* (14,71%) the lowest proportion in *Shorea johorensis* (11,73%). Axial parenchyma usually scanty paratracheal or vasicentric surrounding vessel or diffuse according to the species or specimen. Axial parenchyma also founded in concentric bands surrounding the axial resin canals.

C. Sapwood & Heartwood Ratio of Red Meranti

Table 5. Sapwood and Heartwood Ratio of Red Meranti

Red Meranti	Heartwood (%)	Sapwood (%)
<i>Shorea leprosula</i>	24.91	75.09
<i>Shorea parvifolia</i>	38.50	61.50
<i>Shorea johorensis</i>	21.48	78.52
<i>Shorea platyclados</i>	38.22	61.78

Sapwood colour pale yellowish white, the heartwood colour pale pinkish brown, dark brown or reddish brown. Heartwood and sapwood ratio from the table above shows that heartwood proportion is lower than sapwood in all red meranti species. Maximum heartwood ratio is 38.50 % (*Shorea parvifolia*) with minimum heartwood ratio 21.48 % (*Shorea johorensis*) whereas maximum sapwood ratio is 78.52 % (*Shorea johorensis*) with minimum sapwood ratio 61.50 % (*Shorea parvifolia*).

Process of heartwood formation is influenced several factor like age, wáter supply and weather. Pandit (2000) state that heartwood formation can be faster when the tree faced lack of wáter. Red meranti from Kalimantan has hábitat with tropical rain forest which rainy and has high wáter supply so it has impact to the heartwood formation, and the consequence red meranti has the lower heartwood ratio than sapwood. Besides that the age of the red meranti in this research is still young (10 yeras old)

D. Wood Texture of Red Meranti

Table 6. Clasification WoodTexture of Red Meranti

Red Meranti	Vessel Diameter	Texture	Fiber Diameter	Texture
<i>Shorea leprosula</i>	175.22 μ	Rather Coarse	22,68	fine
<i>Shorea parvifolia</i>	208.07 μ	Coarse	21,65	fine
<i>Shorea johorensis</i>	185.30 μ	Rather Coarse	20,51	fine
<i>Shorea platyclados</i>	183.72 μ	Rather Coarse	21,43	fine

Table 6 shows that vessel diameter of red meranti 175,22-208.07 μ . The largest tangential diameter *Shorea parvifolia* (208,07 μ) are classified as coarse texture. Whereas tangential diameter others red meranti (*Shorea leprosula*, *Shorea johorensis*, *Shorea platyclados*) is about 175,22- 185,30 μ (below 200 μ) so this 3 red meranti classified as rather coarse wood texture.. Based on Pandit (2000) classification, wood texture all red meranti has rather coarse texture except *Shorea parvifolia* (coarse texture).

Table 6 shows that fiber diameter of all red meranti is about 20-51-22,68 μ . Maximum fiber diameter (*Shorea leprosula*) just only 22,68 μ so based on Pandit (2000) classification, wood texture all red meranti are classified as fine wood texture.

E. Juvenile Periods of Red Meranti

Tabel 7. Fiber length of 4 red meranti from pith to bark

Red Meranti	Fiber Length from pith to bark (mm)							
	R1	R2	R3	R4	R5	R6	R7	R8
<i>Shorea leprosula</i>	0,91	0,95	1,02	1,01	1,03	1,10	1,12	1,17
<i>Shorea parvifolia</i>	0,87	0,96	1,00	1,06	1,10	1,12	1,14	1,15
<i>Shorea johorensis</i>	0,69	0,81	0,86	0,93	0,94	0,95	0,96	0,97
<i>Shorea platyclados</i>	1,07	1,14	1,15	1,16	1,17	1,18	1,19	1,20

Compared to mature wood, juvenile wood characterized by wide ring, short fiber, thin cell wall, high microfibril angle (Bath, 2001). In this study juvenile period on red meranti will be determined by using the change or variation of fiber length from pith to bark. Usually juvenile wood shows rapid increase fiber length in the pith area and getting more slow increase fiber length to the bark.

From Figure 3 shows that fiber length of *S. parvifolia* *S. leprosula* and *S. platyclados* still increase from pith to bark. It is indicate that 3 red meranti are still in juvenile periods. Otherwise the fiber length of *Shorea johorensis* shows rapid increase from pith until R5 and then shows relative stable to constant since R5 to R8 near the bark. This phenomena indicate that transition zone from juvenile wood to mature wood has been started at R5/6.

Tabel 8. Microfibril angle of 4 red meranti from pith to bark

Red Meranti	Microfibril angle from pith to bark (mm)						
	R1	R2	R3	R4	R5	R6	R7
<i>Shorea leprosula</i>	40.5	46.2	41	33.2	30.4	27.4	28.6
<i>Shorea parvifolia</i>	37.4	39.5	37.5	35.7	25.8	26.9	25.5
<i>Shorea johorensis</i>	45.0	40.9	36.9	38.1	32.2	31.6	26.5
<i>Shorea platyclados</i>	31.9	34	40.7	33.2	31.7	27.4	25.4

Table 8 shows that microfibril angle of red meranti *Shorea leprosula* decrease from pith to bark from 40,5 to 28,6 $^{\circ}$. *Shorea pavifolia* decrease from pith to bark from 37,4 to 25,5 $^{\circ}$. *Shorea johorensis* decrease from pith to bark from 45 to 26,5 $^{\circ}$ and *Shorea paltyclados* decrease from pith to bark from 31,9 to 25,4. All red meranti has maximum microfibril angle near pith and gradually decreased to bark.

Figure 4 shows that the decreased microfibril angle is still continue down to bark. This phenomena of microfibril angle from pith to bark indicate that all red meranti is still in juvenile periods. Mcgraw, 1986; Bendtsen and Senft, 1986 in Kretschmann, 1997 reported that in *Pinus taeda* microfibril angle at juvenile wood is about 25-35 $^{\circ}$, mostly up till 50 $^{\circ}$ near the pith and decreased till 5 $^{\circ}$ – 10 $^{\circ}$ near the bark.

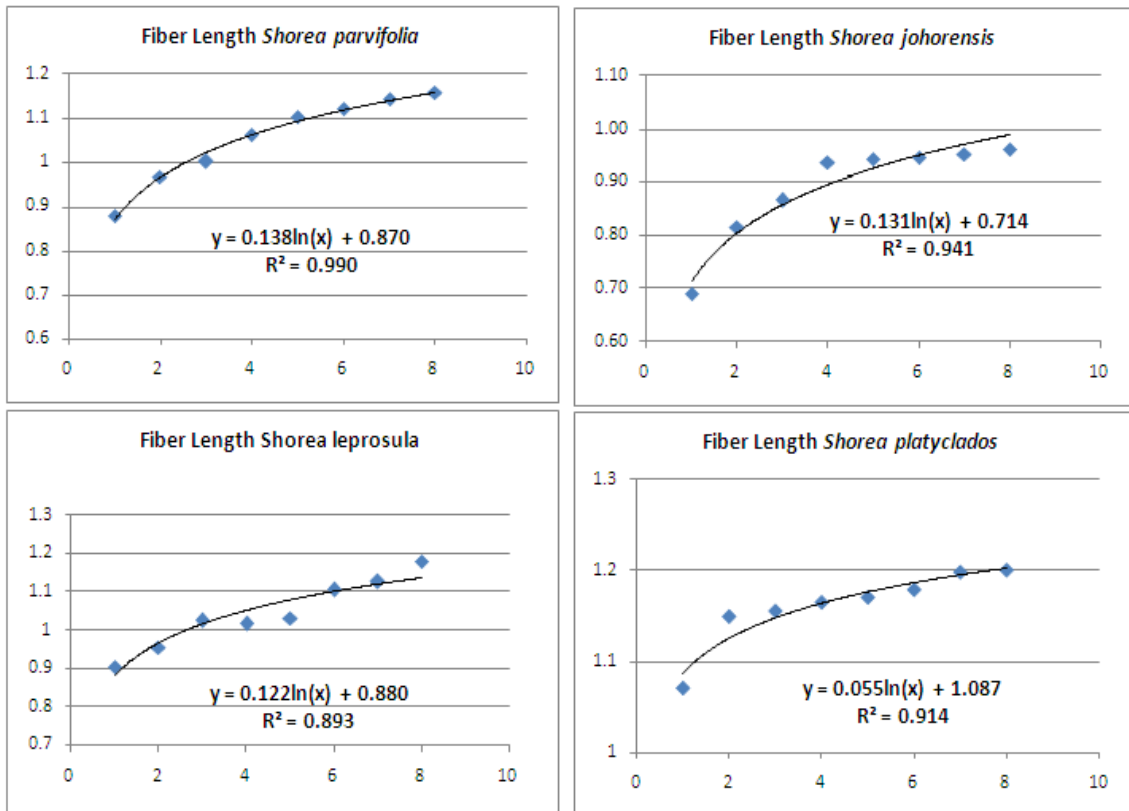


Figure 3. Fiber length of red meranti

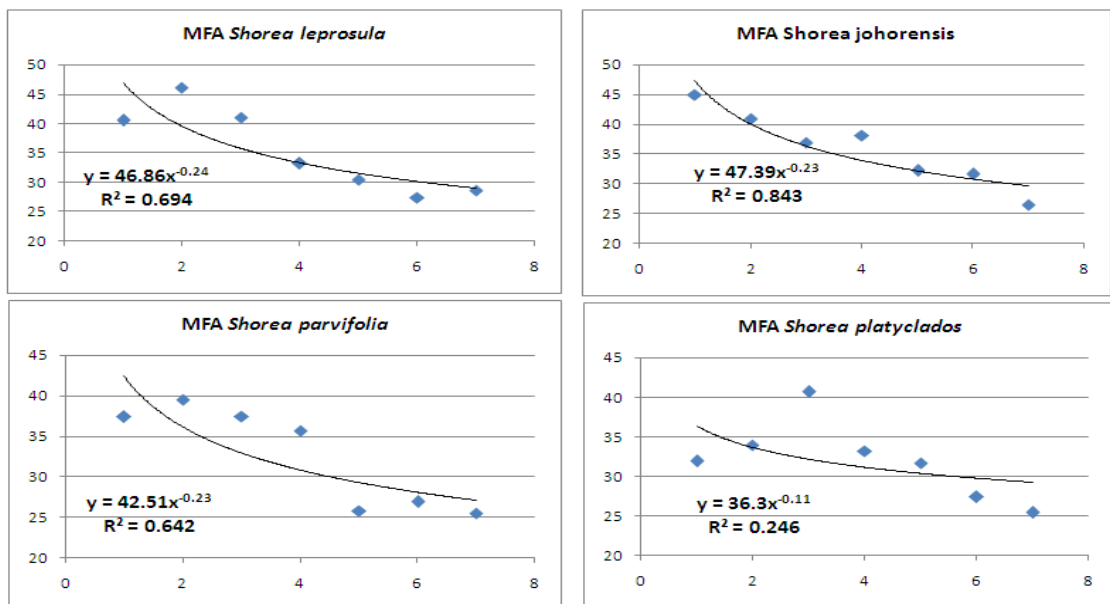


Figure 4. MFA of red meranti

CONCLUSIONS

1. Macroscopic features of red meranti has :
 - Sapwood colour pale yellowish white, the heartwood colour pale pinkish Brown, dark brown or reddish Brown.
 - Growth ring is appear some times not according to the species.
 - Vessel solitary and multiple radial 2-3,
 - Grain orientation usually straight, some times interlocked.
 - Rays multiseriate 1-8 seriate. Rays shows 2 distinct sizes (*Shorea johorensis* and *Shorea platyclados*) and shows 1 size in *Shorea parvifolia* and *Shorea leprosula*.
 - Axial parenchyma usually scanty paratracheal or vasicentric surrounding vessel or diffuse. Axial parenchyma also founded in concentric bands surrounding the axial resin canals.
 - Axial resin canals in more or less continuous tangential lines.
2. Microscopic features red meranti :
 - Vessel frequency 3-8/mm² usually 3-5 / mm². Maximum tangential diameter of solitary vessel is 208 μ (*Shorea parvifolia*) with minimum tangential diameter 175 μ (*Shorea johorensis*). Vessel proportion 7,85-11,76% (*S.parvifolia* the highest; *Shorea platyclados* the lowest).
 - Cell proportion, fiber is dominan compare other cell, up than 50%. Fiber proportion 59,37-65,27%. Maximum fiber proportion 65,27% (*Shorea platyclados*) with minimum fiber proportion 59,37% (*S.parvifolia*). Fiber length red meranti 0,88-0,91mm (*Shorea platyclados* the longest; *Shorea johorensis* the shortest).; Fiber diameter 20,51-22,68 μ . Cell wall thickness 1,76-1,84 μ .
 - Rays multi seriate with range 1-3 to 1-8 seriate mostly 1-3 to 1-5 seriate according to the species or specimen. Sometimes rays also has tendency to 2 distinct sizes (*Shorea platyclados* ; *Shorea johorensis*). Rays proportion 12,16 - 16,67%. Highest proportion rays 16,67% (*Shorea johorensis*) and lowest 12,16 % (*Shorea leprosula*).
 - Axial parenchyma proportion is about 11,73-14,71%. Maximum proportion axial parenchyma founded in *Shorea leprosula* (14,71%) the lowest proportion in *Shorea johorensis* (11,73%).
3. Heartwood proportion is lower than sapwood in all red meranti species. Maximum heartwood ratio is 38.50 % (*Shorea parvifolia*) with minimum heartwood ratio 21.48 % (*Shorea johorensis*). Maximum sapwood ratio is 78.52 % (*Shorea johorensis*) with minimum sapwood ratio 61.50 % (*Shorea parvifolia*).
4. Wood texture red meranti is classified as moderate to rather coarse. Based on vessel diameter all red meranti has rather coarse texture except *Shorea parvifolia* (coarse texture). Based on fiber diameter all red meranti are classified as fine wood texture
5. Based on analysis the graph fiber length, red meranti (*S. parvifolia* *S. leprosula* and *S. platyclados*) are still in juvenile periods. Red meranti has minimum fiber length near pith and showing increase from pith to bark. Otherwise the fiber length of *Shorea johorensis* shows increase near the pith and at critical poin (R5) shows relative stable until constant near the bark. This fenomena indicate the transition zone from juvenile wood to mature wood.
6. All red meranti has maximum microfibril angle near pith and gradually decreased. Based on analysis of microfibril angle from pith to bark all red meranti (*Shorea johorensis*. *S. parvifolia* *S. leprosula* and *S. platyclados*) are still in juvenile periods, because the graph shows that the decreased microfibril angle is still continue down to bark.

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Anatomical Features Red Meranti (*Shorea leprosula*, *Shorea parvifolia*) between Natural Forest with Intensive Silviculture

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ABSTRACT

Less study has been carried out to characterize the tree growth and quality of lesser known and lesser used timber species grown in community forest or natural forest. In this study, two red meranti which grown from natural forest and intensive silviculture in central Kalimantan were identified their anatomical features. The objectives of this study are to find out the anatomical features of two red meranti (*Shorea leprosula*, *Shorea parvifolia*) between natural forest with intensive silviculture and also find out the variation anatomy properties such as texture, sapwood-heartwood ratio, juvenile periods on two red meranti (*Shorea leprosula*, *Shorea parvifolia*) from natural forest with intensive silviculture. Sample was taken from PT SBK in central Kalimantan at base stem with altitude 1.3 m from ground. Sample was made at each 1cm from pith to bark (radial direction). Sample preparation For fiber dimension, was made with size dimension 1mm x 1mm x 20mm, while proportion cell 1cm x 1cm x 1cm. Measurement of microfibril angle was used by polarized microscope and SEM. The results showed, macroscopic features of red meranti both from natural forest and intensive silviculture has same characteristics : vessel solitary, radial multiple, parenchyma scanty paratracheal, rays 1-2 distinct size, multiseriate, straight grain, resin canal concentric bands/tangential lines. Red meranti from intensive silviculture (*Shorea parvifolia* and *shorea leprosula*) has texture rather coarse till coarse compare with natural forest. *Shorea leprosula* and *Shorea parvifolia* from natural forest has thicker cell wall and also has smaller vessel diameter compared from intensive silviculture. Sapwood heartwood ratio red meranti from intensive silviculture has bigger sapwood than natural forest in *Shorea leprosula*.

Keywords : red meranti, silviculture intensive, natural forest, anatomical features, *Shorea parvifolia* and *shorea leprosula*

INTRODUCTION

In the last decade the situation of Forestry in Indonesian has not been exhilarating. Ministry of Forestry reported that extensive deforestation occurs about 0.6 – 1.9 million ha between 2001 and 2005 (Ministry of Forestry, 2007). Meanwhile the logs production from natural forest decreased abruptly from around 19 – 30 million m³ in the decade of 1991 – 2000 to be around 3.5 – 6.4 million m³ between 2003 and 2007. This condition affects on the decreasing of production of plywood, sawntimber and other wood products due to the less supply of commercial timber species from natural forest.

Efforts have been carried out to overcome the lack of commercial timber supply. Forest plantations were built in several places with a total area of 335 thousand hectares in 2007 (Anonymous, 2007). In few forest concession companies, one of them are PT. Sari Bumi Kusuma, intensive silviculture is developed by strip planting system using various fast growing meranti.

Less study has been carried out to characterize the tree growth and quality of lesser known and lesser used timber species grown in community forest or natural forest. In this study, two red meranti which grown from natural forest and intensive silviculture in central Kalimantan were identified their anatomical features. The objectives of this study are to find out the anatomical features of two red meranti (*Shorea leprosula*, *Shorea parvifolia*) between natural forest with intensive silviculture and also find out the variation anatomy properties such as texture, sapwood-heartwood ratio, juvenile periods on two red meranti (*Shorea leprosula*, *Shorea parvifolia*) from natural forest with intensive silviculture.

MATERIAL AND METHODS

Research Materials

- c. Meranti wood (*Shorea leprosula*, *Shorea parvifolia*) from natural forest and intensive silviculture
- d. Alcohol (C₂H₅OH), Perhidrol (H₂O₂), Safranin
- e. Silol (C₅H₁₀), *Canada balsam*, aquadest and glacial acetic acid

Research Tools:

- e. Chainsaw, cutter, loupe, microtomes, glass preparates, pipette
- f. Volumetric flash, digital scales, oven, desiccator, kaliper
- g. Test tube, object glass, hot plate, preparates box
- h. Microscope fluorescence BX 51 software *Image Pro Plus V 4.5*.

Methods

1. Sample Making

- Sample was taken from PT SBK in central kalimantan at base stem with altitude 1.3 m from ground.
- Sample was made at each 1cm from pith to bark (radial direction).
- For fiber dimension, sample was made with size dimension 1mm x 1mm x 20mm, while proportion cell 1cm x 1cm x 1cm

2. Measurement Procedure

a. Macroscopic properties

- Observation of macroscopic properties by wathcing carefully at transversal, radial and tangensial section with loupe 15-18x.

b. Microscopic properties

- Measurement cell proportion and fiber dimension are using software image pro plus 4.5

c. Sapwood and Heartwood Ratio

- Sapwood and heartwood ratio was calculate by compare wide area of sapwood and heartwood with total area transversal surface.

$(\% \text{Sapwood}) = \frac{\text{TA} - \text{HA}}{\text{TA}} \times 100\%$	$(\% \text{Heartwood}) = \frac{\text{HA}}{\text{TA}} \times 100\%$
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HA : Heartwood Area

TA : Total Area Transversal Surface

d. Wood Texture.

- Wood texture was determinated by using measurement vessel diameter and fiber diameter.
- Criteria of size dimension of vessel diameter and fiber diameter as follows :

Wood Texture	Vessel diameter	Fiber diameter
Fine (Smooth)	< 100 μ	< 30 μ
Moderate	100 – 200 μ	30– 45 μ
Coarse	> 200 μ	> 45 μ

e. Juvenile Period

- Determination juvenile period was using analysis the graph of fiber length at radial direction from pith to bark.

RESULT & DISCUSSION

A. Macroscopic and Microscopic Features of Red Meranti

Table 1. Macroscopic features of red meranti

Wood Features	Natural forest (Nf)		Intensive Silviculture (Is)	
	<i>S. leprosula</i>	<i>S. parvifolia</i>	<i>S. leprosula</i>	<i>S. parvifolia</i>
Vessel				
• Distribution	Solitary, multiple radial	Solitary, multiple radial	Solitary, multiple radial	Solitary, multiple radial
• Diameter	160.36 μ	182.10 μ	175.22 μ	208.07 μ
Parenchyma	Concentric bands, Vasicentric, scanty paratrakeal	Concentric bands, Vasicentric, Scanty paratrakeal	Concentric bands, Vasicentric, Scanty paratrakeal	Concentric bands, Vasicentric, Scanty paratrakeal
Rays				
• Size	2 Distinct size	1size	2 Distinct size	2 Distinct size
• width (t)	Multiseriate	Multiseriate	Multiseriate	Multiseriate
Grain orientation	Straight Interlocked	Straight Interlocked	Straight Interlocked	Straight, Interlocked
Canal resins				
• Present	Present	Present	Present	Present
• Distribution	Concentric bands	Tangential lines	Concentric bands	Tangential lines

Macroscopic features of red meranti has sapwood colour pale yellowish white, pale yellow while the heartwood colour pale pinkish yellow, pale pinkish Brown, dark brown or reddish Brown. Growth ring is appear some times not according to the species.. Vessel solitary and multiple radial 2-3, Grain orientation usually straight some times interlocked..

Rays multiseriate 1-5 seriate. Rays shows 2 distinct sizes (*Shorea leprosula* both Nf and Is, *Shorea parvifolia*-Is) and shows 1 size in *Shorea parvifolia*-Nf (Fig. 1).

Axial parenchyma usually scanty paratrakeal or vasicentric surrounding vessel according to the species or specimen. Axial parenchyma also founded in concentric bands surrounding the axial resin canals.

Axial resin canals in more or less continuous tangential lines at interval 0,2 to 0,5 mm (Fig. 2). Usually axial resin canals present or not according to the species or specimen. Table 2 shows that axial resin canals present in all red meranti (*Shorea leprosula*, *Shorea johorensis*, *Shorea parvifolia*. and *Shorea platyclados*) but some times not present in *Shorea leprosula*.(Fig. 2).

Table 2. Fiber dimension

Red Meranti	Source	Fiber length (mm)	Fiber diameter (μ)	Lumen diameter (μ)	Cellwall Thickness (μ)
<i>Shorea leprosula</i>	Intensive silv	1,042	22,68	19,04	1,820
	natural forest	1,081	22,88	18,84	2,020
<i>Shorea parvifolia</i>	Intensive silv	1,095	21,65	17,94	1,851
	natural forest	0,955	27,16	23,15	2,005

Microscopic features: Vessel frequency 3-8/mm² usually 3-5 / mm² . Maximum tangential diameter of solitary vessel is 208 μ (*Shorea parvifolia*) with minimum tangential diameter 175 μ (*Shorea johorensis*). Vessel proportion 7,85-11,76% (*S.parvifolia* the highest; *Shorea platyclados* the lowest). diameter 175,22-208,07 (*S.parvifolia* the biggest);

Rays multi seriate with range 1-3 to 1-8 seriate mostly 1-3 to 1-5 seriate according to the species or specimen. Sometimes rays also has tendency to 2 distinct sizes (*Shorea platyclados* ; *Shorea johorensis*). Rays proportion 12,16 - 16,67%. Highest proportion rays 16,67% (*Shorea johorensis*) and lowest 12,16 % (*Shorea leprosula*)

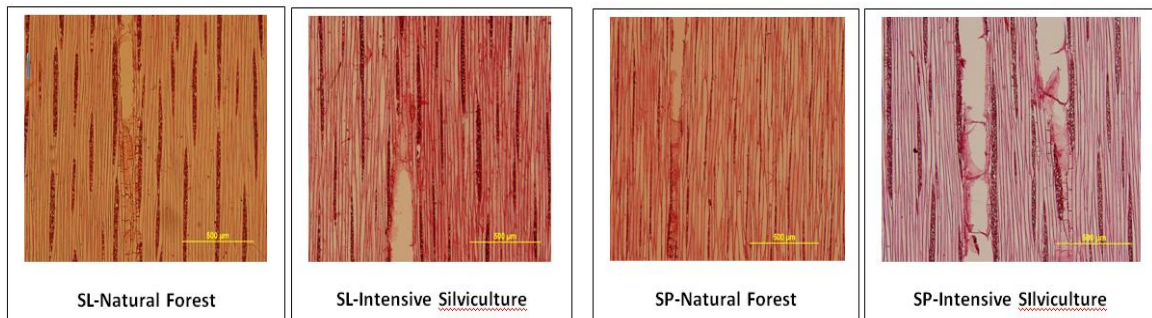


Figure 1. Tangential surface red meranti from natural forest and intensive silviculture

Tabel 3. Cell proportion of red meranti

Red Meranti	Source	Vessel (%)	Parenchyma (%)	Rays (%)	Fiber (%)	Resin canals (%)
<i>Shorea leprosula</i>	Intensive silv	8.34	14.70	12.16	63.85	1.05
	natural forest	7.85	13.09	12.99	65.27	0.78
<i>Shorea parvifolia</i>	Intensive silv	11.75	13.75	14.01	59.38	1.04
	natural forest	8.012	11.70	11.35	68.01	0.90

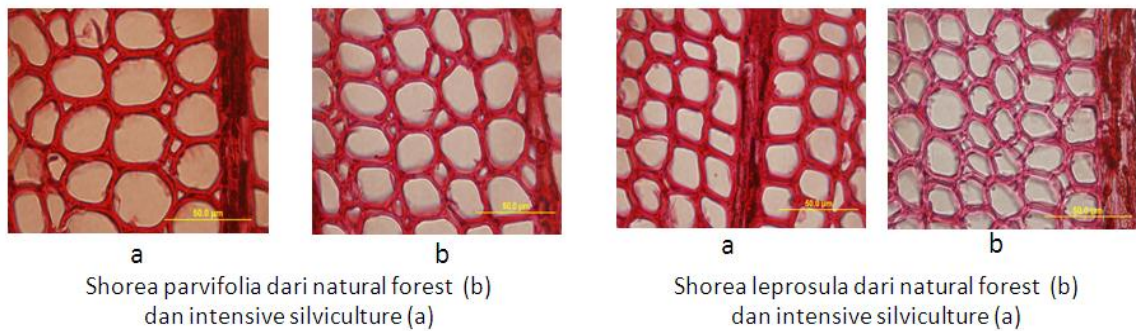


Figure 2. Transversal surface red meranti from natural forest and intensive silviculture

Cell proportion, fiber is dominant compare other cell, up than 50%. The range fiber proportion is about 59,37-65,27%. The highest fiber proportion 65,27% (*Shorea platyclados*) with minimum fiber proportion 59,37% (*S.parvifolia*). Fiber length red meranti 0,88-0,91mm (*Shorea platyclados* the longest; *Shorea johorensis* the shortest).; Diameter is about 20,51-22,68 μ . Cell wall thickness is about 1,76-1,84 μ .

Axial parenchyma proportion is about 11,73-14,71%. Highest proportion axial parenchyma founded in *Shorea leprosula* (14,71%) the lowest proportion in *Shorea johorensis* (11,73%). Axial parenchyma usually scanty paratracheal or vasicentric surrounding vessel or diffuse according to the species or specimen. Axial parenchyma also founded in concentric bands surrounding the axial resin canals.

B. Sapwood & Heartwood Ratio of Red Meranti

Tabel 4. Sapwood & Heartwood Ratio of Red Meranti

Red Meranti	Source	Sapwood (%)	Heartwood (%)
<i>Shorea leprosula</i>	Intensive silviculture	75.09	24.91
	natural forest	55,78	44,22
<i>Shorea parvifolia</i>	Intensive silviculture	64.40	35.60
	natural forest	64.10	35.90

Measurement result of sapwood heartwood ratio red meranti from intensive silviculture has bigger sapwood than natural forest in *Shorea leprosula*. Heartwood and sapwood ratio from the table above shows that heartwood proportion is lower than sapwood in all red meranti species both from intensive silviculture and natural forest.. Maximum heartwood ratio is 44.22 % (*Shorea leprosula* from natural forest) with minimum heartwood ratio 24,91 % (*Shorea leprosula* from natural forest). Maximum sapwood ratio is 75.09 % (*Shorea leprosula* from natural forest) with minimum sapwood ratio 55,78 % ((*Shorea leprosula* from natural forest).

Sapwood & Heartwood Ratio is has significant different on *shorea leprosula* between intensive silviculture and natural forest, but not different on *shorea parvifolia*

C. Wood Texture of Red Meranti

Table 5. Clasification WoodTexture of Red Meranti

Red Meranti	Source	Vessel Diameter	Fiber Diameter	Texture
<i>Shorea leprosula</i>	Intensive silviculture	175.22 μ	22.68 μ	Fine to rather coarse
	natural forest	160.36 μ	22.88 μ	Fine to rather coarse
<i>Shorea parvifolia</i>	Intensive silviculture	208.07 μ	21.67 μ	Fine to rather coarse
	natural forest	182.10 μ	27.16 μ	Fine to rather coarse

Based on vessel diameter, red meranti from intensive silviculture (*Shorea parvifolia* and *shorea leprosula*) has texture rather coarse till coarse compare with natural forest which has texture moderate/medium. Based on fiber diameter, red meranti both from natural forest and intensive silviculture (*Shorea parvifolia*) has average diameter below 30μ, so that all of red meranti has fine texture.

E. Juvenile Periods of Red Meranti

Tabel 6. Fiber length of *S. leprosula* from pith to bark

Red Meranti	Source	Fiber Length							
		R1	R2	R3	R4	R5	R6	R7	R8
<i>Shorea leprosula</i>	Intensive silviculture	0.903	0.953	1.023	1.015	1.031	1.104	1.126	1.179
	natural forest	0.901	0.946	0.979	1.077	1.15	1.192	1.196	1.198

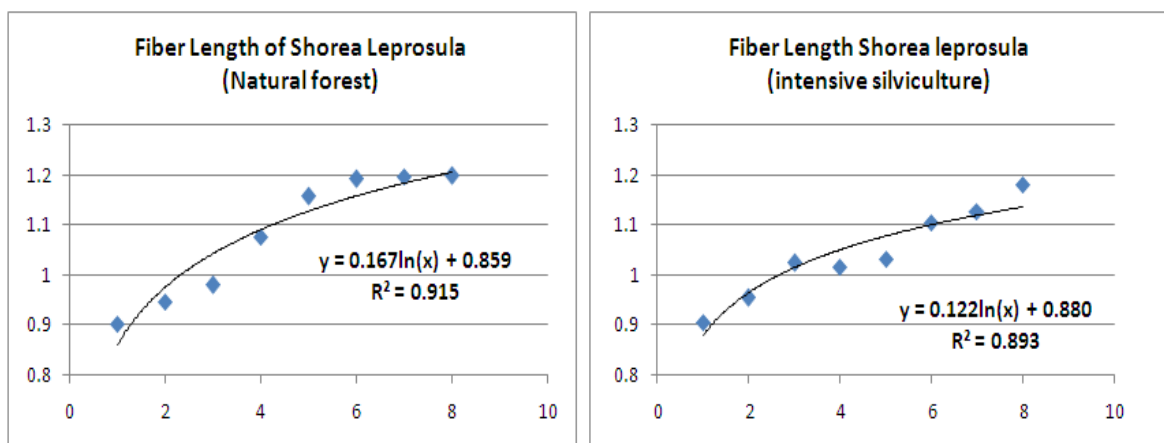


Figure 3. Fiber length of *S. leprosula* from natural forest and intensive silviculture

Red meranti (*Shorea leprosula*) both from natural forest and intensive silviculture has minimum fiber length (0,09mm) near the pith and maximum fiber length near the bark (1,2mm) . The fiber length shows gradually increase from pith to bark. The graph of red meranti above (Fig. 3) shows that fiber length

of *Shorea leprosula* both from natural fores and intensive silviculture still increase from pith to bark. It is indicate that red meranti *Shorea leprosula* are still in juvenile periods

Tabel 7. Fiber length of *S. parvifolia* from pith to bark

Red Meranti	Source	Fiber Length								
		R1	R2	R3	R4	R5	R6	R7	R8	R9
<i>Shorea parvifolia</i>	Intensive silviculture	0.878	0.965	1.00	1.06	1.103	1.120	1.142	1.156	1.170
	natural forest	0.779	0.881	0.903	0.918	0.934	0.951	1.031	1.036	1.038

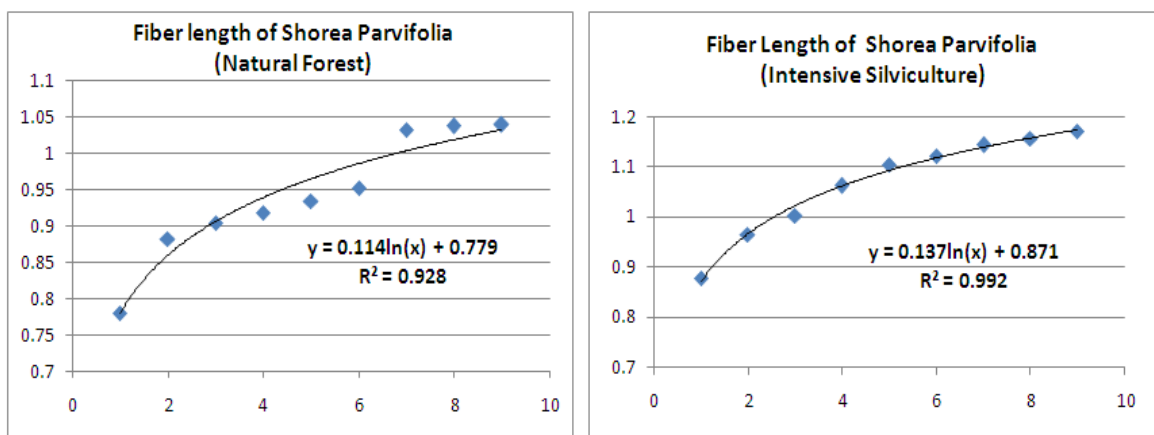


Figure 4. Fiber length of *S. parvifolia* from natural forest and intensive silviculture

Red meranti both from natural forest and intensive silviculture has minimum fiber length (0,78-0,87mm) near the pith and maximum fiber length near the bark (1.0-1,2mm) . The fiber length shows gradually increase from pith to bark. The graph of red meranti above (Fig. 4) shows that fiber length of *S. parvifolia* both from natural fores and intensive silviculture still increase from pith to bark. It is indicate that red meranti *S. parvifolia* are still in juvenile periods

CONCLUSIONS

- Macroscopic features of red meranti both from natural forest and intensive silviculture has same characteristics : vessel solitary, radial multiple, parenchyma scanty paratracheal, rays 1-2 distinct size, multiseriate, straight grain, resin canal concentric bands/tangential lines.
- Microscopic features red meranti has 2 differences between natural forest and intensive silviculture that is cell wall thickness and vessel diameter. Both shorea leprosula and shorea parvifolia from natural forest has thicker cell wall and also has smaller vessel diameter compared from intensive silviculture.
- Result of sapwood heartwood ratio red meranti from intensive silviculture has bigger sapwood than natural forest in *Shorea leprosula* . But it's not different in *shorea parvifolia*.
- Based on vessel diameter, red meranti from intensive silviculture (*Shorea parvifolia* and *shorea leprosula*) has texture rather coarse till coarse compare with natural forest which has texture moderate/medium. Based on fiber diameter, red meranti both from natural forest and intensive silviculture (*Shorea parvifolia*) has average diameter below 30 μ , so that red meranti has fine texture.

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Research and Development of Anti-seismic Device Using Variety of High-performance Steels for Wooden House

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ABSTRACT

In Japan one of the most important agendas for wooden house is to enhance earthquake-proof performance. Under the background, purpose of our investigation is to develop the steel damper devices for wooden houses. Remarkable point is that the first is energy absorption due to the plastic strain of the low yield point steel for New Houses, and the second is damping force of the high tensile strength steel for Repair Houses. By using these features, we propose the steel damper devices which have an advantage in the workability and high strength bearing wall. In order to evaluate seismic performance of these damper devices, we conducted both the static loading test and the shaking table test using full-scale wooden frames reinforced with steel damper devices. As a result, we could make sure of high performance of the each steel damper device in the strength, the ductility and the energy absorption

Keyword: Wooden house , Steel damper device , Low yield point steel, High tensile strength steel, Damping property

1. INTRODUCTION

In Japan, we have a lot of experience in the big earthquake, as exemplified by the Great Hanshin-Awaji Earthquake in 1995 , the Great East Japan Earthquake in 2011, the earthquake resistance of the building is urgently needed. Earthquake-resistance has been done as a nation. Wooden house with low earthquake resistance are still left many, particularly seismic strengthening of these wooden houses is required to be carried out as soon as possible.

For wooden houses in this study, we develop anti-seismic device using a variety of high-performance steel resistant to earthquakes, and we propose to improve the seismic performance of wooden houses with variety of high-performance steels against earthquakes. The reason for using steel to earthquake resistance performance is as follows. 1). Proven that there is a very inexpensive and durable material, 2). High energy absorption performance and high strength and high rigidity can be expected.

Steel was adopted in the first is a low yield point steel. We have developed two types about "Brace type(wall type)" and "Open type(window type)", included: Low Yield Point Steel "High strength and damping devices (product name: Shake cut) ." They have some features of both high rigidity and energy absorption performance due to the low yield point steel undergoes plastic strain of low load, the characteristics of the steel. Steel was adopted in the second high-tensile steel. We have been designed to take advantage of the tensile strength with High Strength Steel:" seismic retrofitting equipment (product name: K-frame)." In addition, by stacking on top of the existing metal siding, it has more high strength and high stiffness performance.

In order to evaluate the seismic performance of " High strength and damping devices with low yield point steel, Brace type and Open type ", " seismic retrofitting equipment with high-tensile steel, K-frame ", we performed experiments static loading tests and dynamic shaking table tests on specimens incorporated into wooden framework. From these experimental results, confirm strength of earthquake-resistant equipments, strength, stiffness, energy absorption performance, we are contributing to the improvement of the seismic performance of wooden houses with "High strength and damping devices" and "seismic retrofitting equipment".

2. THE EARTHQUAKE RESISTANCE OF HOUSING IN JAPAN

2.1 Expected large-scale earthquake

When you extract a few earthquakes typical of forecast that has been created by the Earthquake Research Committee Headquarters for Earthquake Research Promotion in 2008, it is expected the probability of Kanto Earthquake of Kanto region including Tokyo will occur and 70% within 30 years, it is assumed that the size of the earthquake the magnitude 6.7 to 7.2. There is the highest probability earthquake that the Tokai earthquake in the Tokai region, between Tokyo and Nagoya, will occur is expected to be 87% within 30 years, it is assumed that the size of the earthquake the magnitude 8. The probability of earthquake Tonankai, including Nagoya is expected to occur 60-70% within 30 years, it is assumed that the size of the earthquake the magnitude 8.1. It is assumed that the size of the earthquake when the earthquake occurred Tonankai - Tokai is linked with the magnitude 8.27. In addition, the probability of Nankai earthquakes in Shikoku is expected to occur in 50% within 30 years, it is assumed that the size of the earthquake the magnitude 8.4.

The Tokai earthquake damage estimation is assumed to be about 9200 people overall death toll. The Tonankai and Nankai earthquake damage estimation is assumed to have an overall death toll of about 17 800 people.

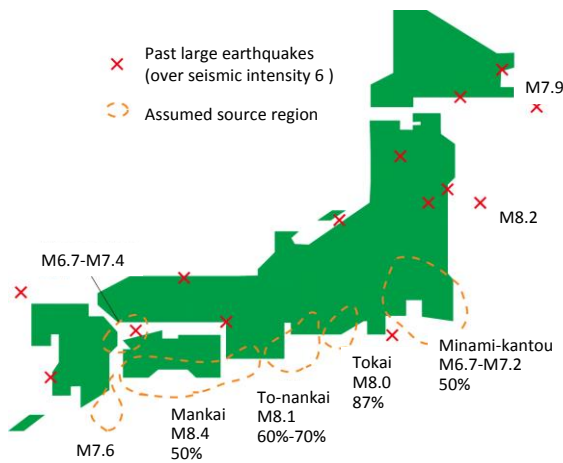


Table.1. Estimate of the number of deaths

	Tokai Earthquake	Tonankai and Nankai earthquake
Total number of deaths	9,200	17,800
Number of deaths due to building collapse	6,700	6,600

Fig.1. Prediction map of Japan earthquake

2.2 Rate of seismic wooden houses, the earthquake resistance of future policy

In 2003, about 47 million out of the total number of housing units, the housing situation of earthquake in Japan, the seismic has become an unsatisfactory about 11.5 million units, shock resistance and inadequate housing for the 25% are estimated. Wooden house is a door 24.5 million of approximately 52% of the total number of housing, which seismic resistance is determined to be insufficient to them in the door about 10 million, accounting for 40% of the entire house, even the 21% of the total number of housing.

The Japanese government has set a goal to the enforcement of the "Law on the Promotion of the Seismic Retrofit of Buildings" in 2006, and 90% to the current 75% rate for the earthquake resistance of housing in 2015. In 2010, followed by "New Growth Strategy" is issued, conversion into stock-oriented housing policy is advocated, it is shockproof to 5% the proportion of inadequate housing has been targeted.

Table.2. Anti-seismic rate and Target rate

(1000Houses)

	Total number of households	Below the standard	Lack of seismic rate(%)	Within the standard	Achievement rate(%)
2003	47,000	11,500	25	35,500	75
2008	49,500	10,500	21	39,000	79
2011	49,500	7,920	16	41,580	84
2012	(49,500)	7,400	15	42,100	85
2020	(49,500)	2,500	5	47,000	95

3. DESIGN OF VARIOUS DEVICES USING HIGH-PERFORMANCE STEEL

3.1 Development of 【 damping device with low yield point steel 】

In the design and development of anti-seismic device used as a damper ($TS \geq 270N/mm^2$, $YP \geq 190N/mm^2$, $42\% \geq EL$) low yield point steel, plastic deformation caused by repeated from low strength steel for low yield point earthquake use in the performance and energy absorption, energy absorption performance of the overall deformation capacity steel member. Energy due to the absorption of these earthquakes, we decided that holding down the development of the building shaking. When compared to viscous damper elastic, advantages of using steel as a damper, there is a feature that combines high rigidity and at the same time that has a energy absorbing performance.

A hole drilled in the center of the low yield point steel plate (2.3mm) to allow deformation even under a low yield strength, low yield point steel damper is designed to be belt-like shape between the two holes. In addition, we have designed a cover out-of-steel plate (1.6mm) deformation from both sides so as to hold the damper low yield point steel, to plastic deformation shear force efficiently to minimize out-of-plane deformation of the damper low yield point steel. Performance at the same time energy absorption by plastic deformation, has been designed to be largely due to these initial stiffness.

The whole device combination has been fixed Insert the "diagonal" direction of 45 degrees from the lower left and right ends of the diagonal members receiving member.

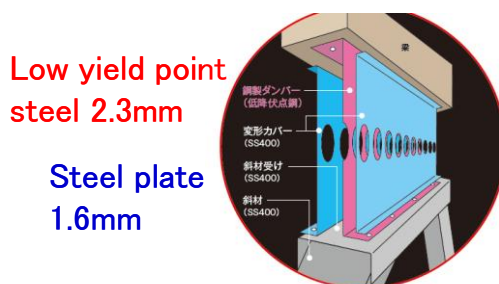


Fig.2. Detailed drawing device

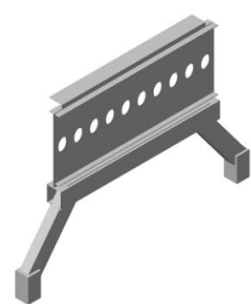


Fig.3. Combination of the entire device

Wooden fixed to the "device" wood screws under the beam is fixed at the top of the low yield point steel damper, and fixed with wood screws on the inside of the lower end of the diagonal members of the two on the sides.

The following is a mechanism of energy absorption by plastic deformation "device" which is fixed in the cylindrical surface. If you are against earthquake, the building is leaning to the left from the right first, (1) beams Wooden takes a horizontal force from right to left, moving horizontally the weight of the superstructure that is also applied from the top. Then, (2) top damper low yield point steel device, which is

fixed to the beam, but moving from right to left as well as the movement of the beam, the lower damper low yield point steel is fixed to the receiving member diagonal there is no movement of material through the oblique right direction is fixed to the pillars on both sides. It has become a mechanism for shear force is applied to the low yield point steel damper For this reason, make a partial energy absorption band shape of the damper causes a shear deformation. If the earthquake is tilted from left to right is the opposite building. The low yield point steel damper will have a large energy absorption from side to side repeatedly shearing deformation.

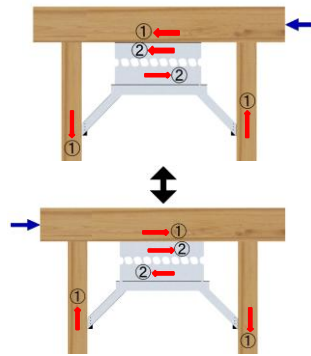


Fig.4. Energy absorption mechanism of damping device

Low yield point steel, Structural steel ($TS \geq 400\text{N/mm}^2$, $YP \geq 295\text{N/mm}^2$, $18\% \geq EL$) is ZAM that has been adopted high corrosion resistance (zinc - plated layer of magnesium 3% - 6% aluminum). ZAM corrosion resistance has a superior performance as compared to about 4 times the amount of hot-dip galvanized steel sheets in the same deposition. We will be referred to as "damping device with low yield point steel" as "High strength and vibration control devices" in this paper.

In the development of the damping device we have performed two types of product design. The first one is "Brace type" for earthquake resistance by incorporating a high rigidity and high strength steel braces. The second is "Open type" that established the "device" under the beam at the top and base, the central part and the opening window wall to be provided.

3.2 " Brace type " with 【 damping device with low yield point steel 】

Show the functionality and performance of the "Brace type." "Brace type" has established a low yield point steel damper on the base and under the beam, has set up a steel braces worked in steel structural steel damper between the two places. Suppressing the bending deformation of the wooden pole by strength rigidity of Braces steel because of the braces made of steel in central wooden pole, the energy absorption performance of steel yield point, low performance due to high strength and high rigidity in addition has. Established as a condition of "Brace type", width direction is compatible with W910 pillar core interval. Since the device devices, steel braces are each independently height direction is the distance to the bottom beam can be installed from above the base is at least 2625mm. So that no part of the wooden columns and beams to prevent the destruction, wood screw fixing is withdrawn, we have designed.



Fig.5. "Brace type" W910

3.3 "Open type" with 【 damping device with low yield point steel 】

Show the functionality and performance of the "Open type." In the adoption of this brand new but useful, while retaining the seismic retrofitting of the opening of the ventilation, day-lighting when retrofitting is possible. As a standard product, "Open type" is the width direction is designed with three types of W910mm and W1365mm W1820mm corresponding to allow the length of the opening. Since the central part pillar has become the opening destruction so as to prevent at the interface between the diagonal members, designed to measure the balance of strength between the damper low yield point steel shaft and wood, "Open type" experiments I repeated to confirm the specifications.



Fig.6. "Open type" W910, W1363, W1820

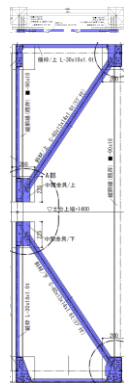
3.4 Development of "K-frame" with 【 retrofitting equipment with high-tensile steel 】

"K-frame" development concept of retrofitting equipment with high-strength steel is to design a load-bearing wall for high strength in the space, such as the base material thickness metal siding.

Should usually be carried out seismic retrofitting is we must construction material, etc. and new exterior bearing walls anew from Wooden once removed from the inner wall material and the existing siding. Seismic reinforcement device newly developed is characterized in that the construction can be directly on top of the existing wall material without having to remove the existing siding on them. "K-frame" can fit on the same layer as thick as furring construction material base of new metal siding, which is a new exterior finishing materials. "K-frame" has been designed to function with the junction of the pillar and foundation hardware if there is a problem with the bonding of the existing building foundations and pillars.



W910



How to adjust height



Fig.8. Layer construction

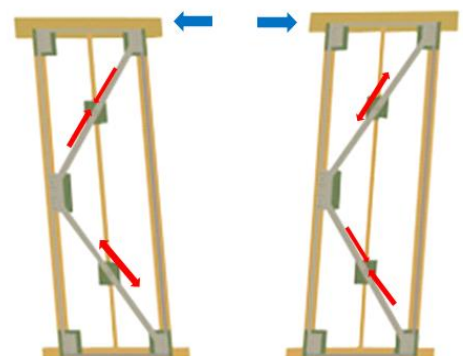


Fig.9. Seismic mechanism

Diagonal part of the type "K-frame" adopts high-strength steel ($TS \geq 490N/mm^2$, $YP \geq 365N/mm^2$, $16\% \geq EL$), the rest of the steel member using structural steel. Structural steel and high strength steel with high corrosion resistance by plating ZAM as well as damping device with low yield point steel has been adopted (zinc - plated layer of magnesium 3% - 6% aluminum).

Show the functionality and performance of the "K-frame." "K-frame" is frame up and down two triangles are transported to site pre-assembled at the factory. One frame weight is about 6kg, it is enough to lift with one hand. Consists in bearing walls were bonded to the outside surface of the wooden framework to type K in combination with two up and down the frame triangle in the field. "K-frame" is bonded to the bearing wall that was out of the plane of the wooden framework to type K in combination with two up and down the frame triangle. Diagonals of the frame in which each triangle has been processed into the high-tensile steel lip channel steel of 1.6mm thickness, and is fixed with screws to the hardware of the end diagonal drill. Installation of "K-frame" corresponds to the interval W910 core pillar width direction. For the height, the entire K frames because it is composed of two members the frame triangle, according to the distance of the beam and the base for different building, he has to allow adjustment dimension between the upper and lower.

Diagonal bracing in the top and bottom of each frame triangle of K frame is subjected to compression and tensile strength in the direction of the earthquake. Strength when the compressive force is applied to the diagonal members to contribute to the high rigidity of this initial order, in situations where the building was largely inclined during large earthquakes is maintained by high strength tensile strength to the diagonal.

When the slope of the building was increased by an earthquake, Diagonal compression side buckled to the out-of-plane direction. Performs a load test on the specimen that covered with siding metal on the top surface of the "K-frame", never was buckled diagonal destroy extruding the metal siding.

4. PERFORMANCE TEST DAMPING DEVICE WITH LOW YIELD POINT STEEL

4.1 Specimen and test method outline

We propose two kinds of damping device with low yield point steel ("Brace type W910" and "Open type W910") and one comparative of structural plywood W910. The installation model of a damper is shown in Fig.10. Understand structural characteristic of three dampers by the static loading test and shaking table test of full-scale wooden frames reinforced with dampers.

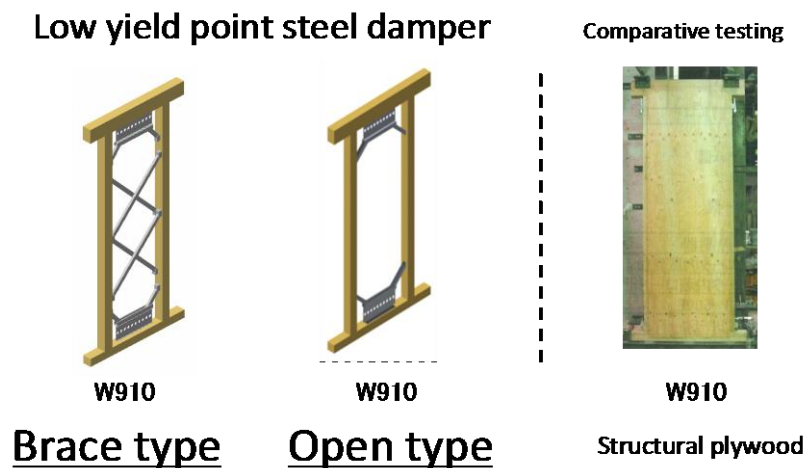


Fig.10. Specimens model (damping device with low yield point steel)

4.2 Static loading test and Shaking table test

Static test model is shown in Fig.11. Load cyclic schedule of static loading test is as being shown in Table 3. Figure shows the superposition of the static test Load displacement relationship of each body each test. By examination, it is a sine wave about an input wave.

Table.3. Load cyclic schedule of static loading test

Input amplitude(rad)	1/450	1/300	1/200	1/150	1/100	1/75	1/50	1/30	1/17.5
frequency(Hz)	0.05			0.03			0.01		



Fig.11. Static loading test

Dynamic test model is shown in Fig. 12 Load cyclic schedule of shaking table test is as being shown in Table 4. Figure shows the superposition of the static test Load displacement relationship of each body each test.

Table.4. Load cyclic schedule of shaking table test

Wave excitation
Microtremor measurement (300sec)
White noise wave (Maximum acceleration 50gal)
Sine wave 30cycle (Maximum acceleration 30gal)
Kobe wave 20% (Maximum acceleration 163.6gal)
Kobe wave 40 (Maximum acceleration 327.2gal)
Kobe wave 60% (Maximum acceleration 490.8gal)
Kobe wave 80% (Maximum acceleration 654.4gal)
Kobe wave 100% (Maximum acceleration 818gal)
If it does not reach the safe limit is repeated 100% Kobe wave further.

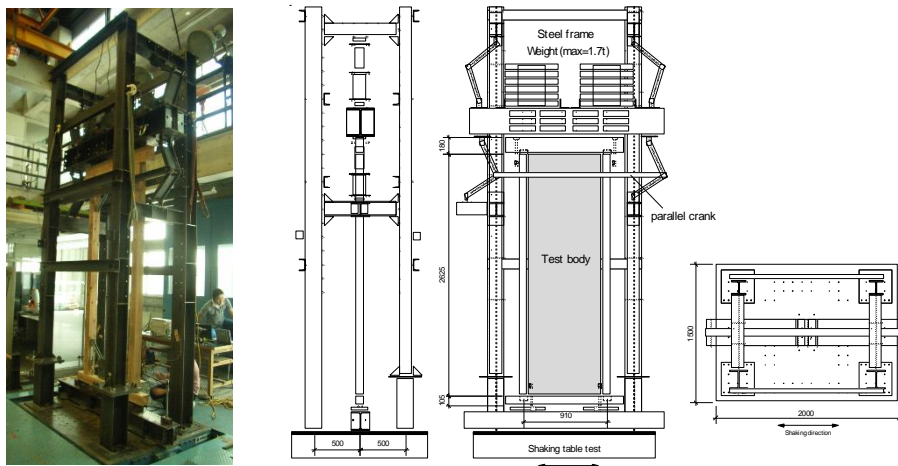


Fig.12. Shaking table test

4.3 Comparison of the examination results of Static loading and Shaking table

The superposition of Load displacement relationship of "Brace type W910" specimen is shown in Fig.13, and "Open type W910" specimen is shown in Fig.14, and also "Structural plywood W910" specimen is shown in Fig.15. Here you can see a stable record loop without a decline of strength without Structural plywood. Comparing to "Open type W910" and "Structural plywood W910", we have figured out that the strength can increase more than twice bigger by installing brace "Brace type W910".

And there is no velocity-dependent seismic devices with " damping device with low yield point steel " However ,disruption of plywood around the nail and nail withdrawal, the plywood specimens viscous effect appears as rate dependence of yield strength due to an increase in but dynamic test than the static test.

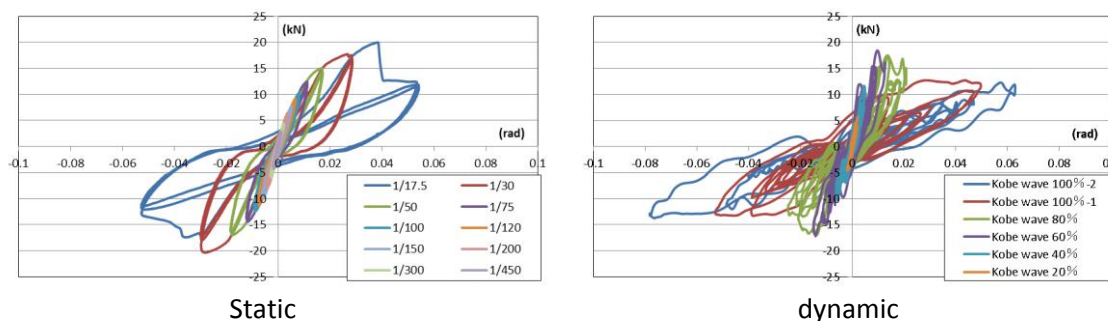


Fig.13. Brace type W910 (Load displacement relationship)

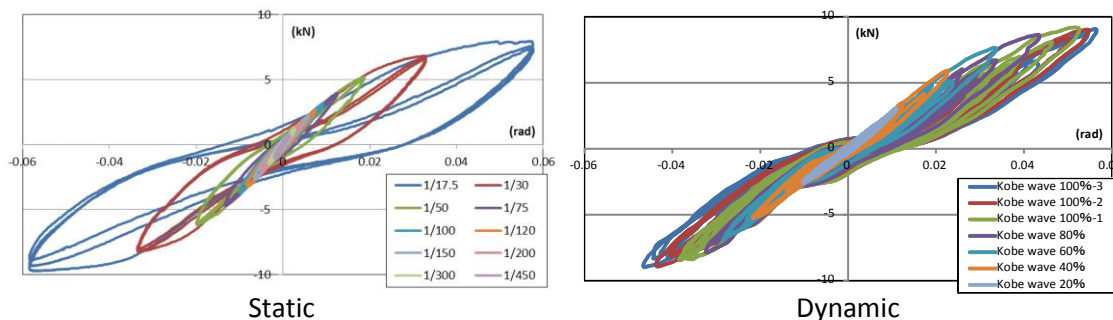


Fig.14. Open type W910 (Load displacement relationship)

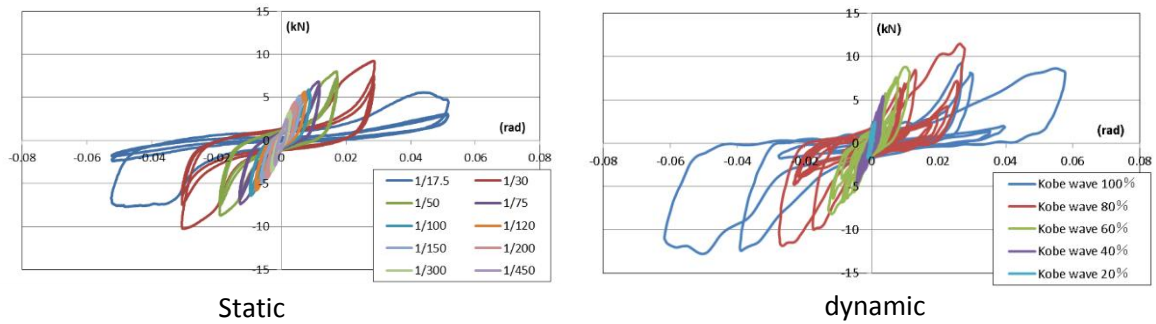


Fig.15. Structural plywood W910 (Load displacement relationship)

In Fig.16 and 17, figure of energy consumption and cumulative energy consumption is shown by shaking table test. Compared with the "Brace type"(damping device with low yield point steel) and "Structural plywood" for energy consumption, low yield point steel shows the energy absorption performance of more than 2 times exceeds the maximum drift angle 1/50rad. Compare the "Open type" (damping device with low yield point steel) and "Structural plywood" also cumulative energy consumption, shows times more energy absorbing performance 1/20rad maximum drift angle [80% Kobe wave].

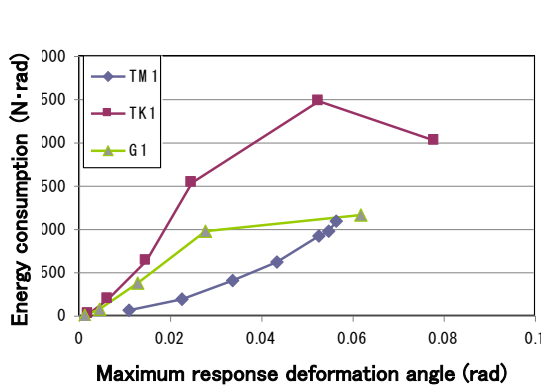


Fig.16. Energy consumption

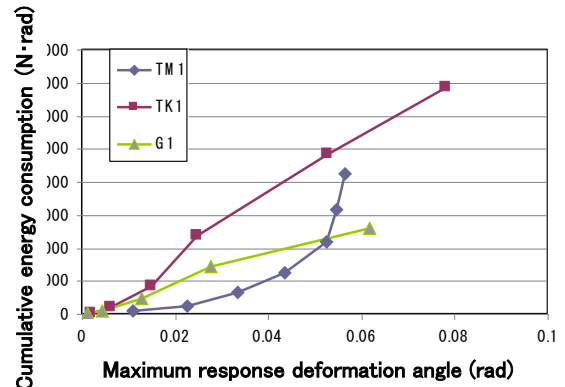


Fig.17. Cumulative energy consumption (Kobe wave excitation)

5. PERFORMANCE TEST RETROFITTING EQUIPMENT WITH HIGH-TENSILE STEEL

5.1 Specimen and test method outline

We propose two kinds of retrofitting equipment with high-tensile steel ("K-frame W910" and "K-frame + Metal siding W910") and one comparative of structural plywood W910. The installation model of a retrofitting equipment is shown in Fig.19. Understand structural characteristic of three specimens by the static loading test of full-scale wooden frames. And for reference, we made shaking table tests



Fig.18. Specimens model (retrofitting equipment with high-tensile steel)

5.2 Static loading test

Load cyclic schedule of static loading test is as being shown in Table 5. Static test system and shaking table test are the same as the low yield point steel test. Static test model and shaking table test are shown in Fig.12, Fig.13, Table 4. Figure shows the superposition of the static test Load displacement relationship of each body each test. By examination, it is a sine wave about an input wave.

Table.5. Load cyclic schedule of static loading test

Input amplitude(rad)	1/450	1/300	1/200	1/150	1/100	1/75	1/50	1/30	1/17.5
frequency(Hz)	0.05			0.03			0.01		

5.3 Comparison of the examination results of "K-frame" and "K-frame + Metal siding "

The superposition of "K-frame " and "K-frame + Metal siding" specimen, load displacement relationship, equivalent viscous damping factor, 1 cycle energy loss is shown in Fig.20, Fig.21.

Load deformation relationship, "K-frame " is the initial stiffness and strength, but not increase once by the diagonal compression buckling, then we will continue to increase in strength by diagonal tensile side. On the other hand "K-frame + Metal siding ", the stagnation caused by buckling strength does not occur because the out-of-plane deformation of the diagonal by compressive force is bound by metal siding. Although there was no destruction to the out-of-plane direction of extrusion of metal siding with diagonal, destruction situation was due to cracking of wood from the surrounding base wood screw fixing hardware foundation pillars fixed by the test hardware without foundation.

Figures have been stable but slightly larger because many of the "K-frame + Metal siding " than "K-frame" for the equivalent viscous damping constant is diagonal is constrained buckling. Towards "K-frame + Metal siding " from the "K-frame" is also one cycle energy loss is larger for cracking wood screw around during large deformation.

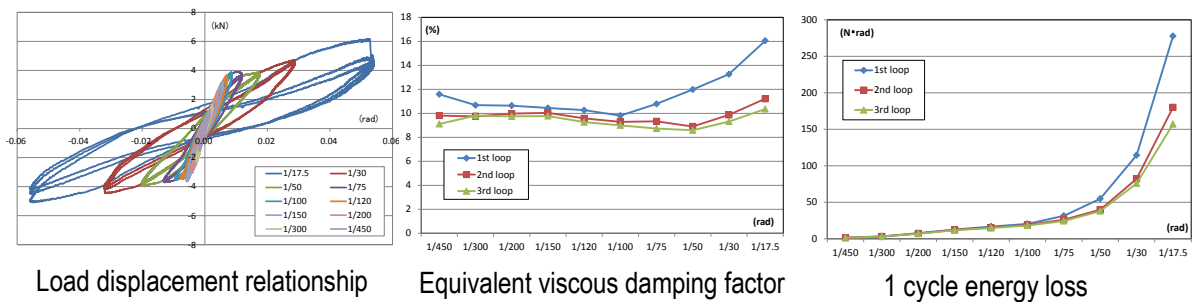


Fig.19. K-frame W910 (examination results)

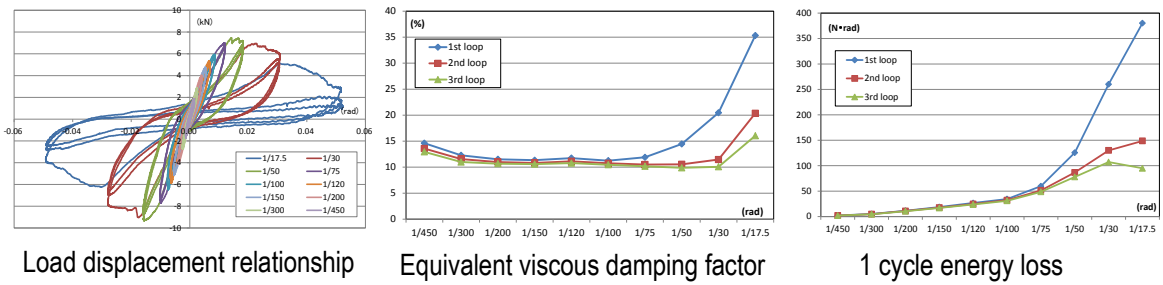


Fig.20. K-frame + Metal siding W910 (examination results)

6. ANALYTICAL STUDY OF HOUSE MODEL RETROFITTED BY DAMPING DEVICE WITH LOW YIELD POINT STEEL

6.1 Model plans

In previous chapters has been confirmed experimentally mechanical performance of "device and equipment product" was designed and developed. In this chapter we see the effect by applying the "damping device with low yield point steel" to the actual wooden house.

Existing house Model 1 is a common two-storey wooden house 100 m². Performance evaluation of score before the reinforcement is 0.69. Load-bearing elements of the existing house has exterior wall is made of structural plywood + plasterboard ,inner wall is made of plaster board+ plaster board . Model 2 is intended to score after retrofitting is 1.0 using the "Brace type"and "Open type". Model 3 is intended to score after retrofitting is 1.0 using a gypsum board generally carried out in retrofitting.

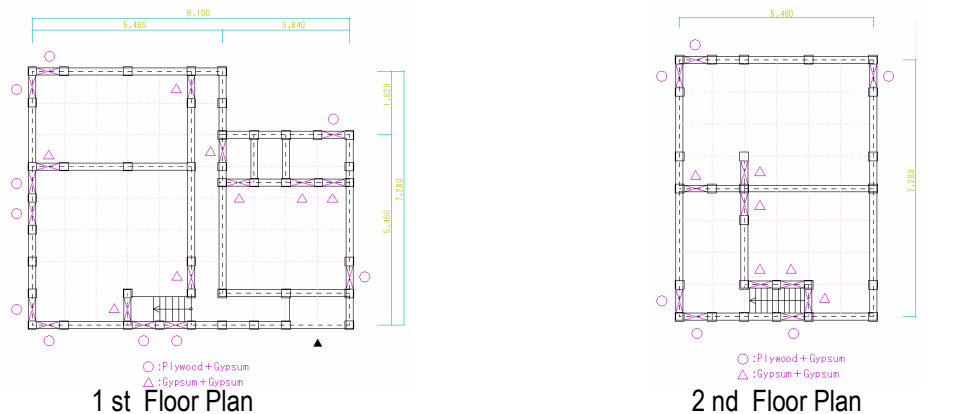


Fig.21. Model 1:existing buildings (0.69 score)

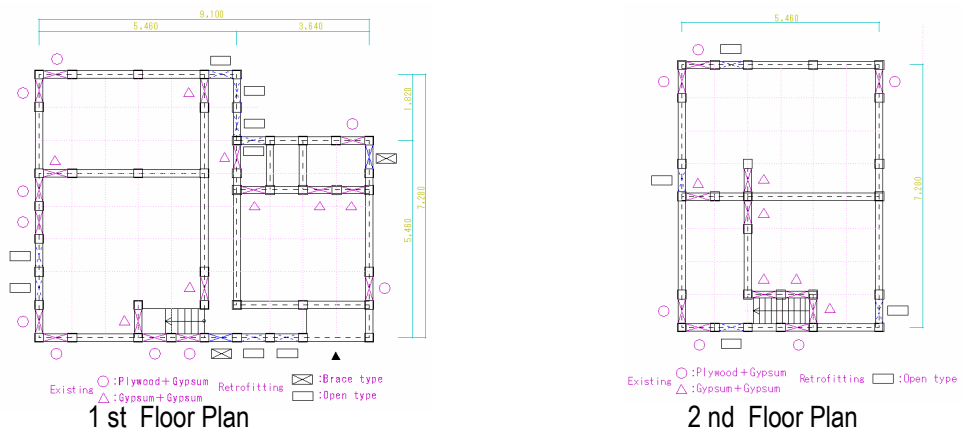


Fig.22. Model 2:Retrofitting / damping device (1.01 score)

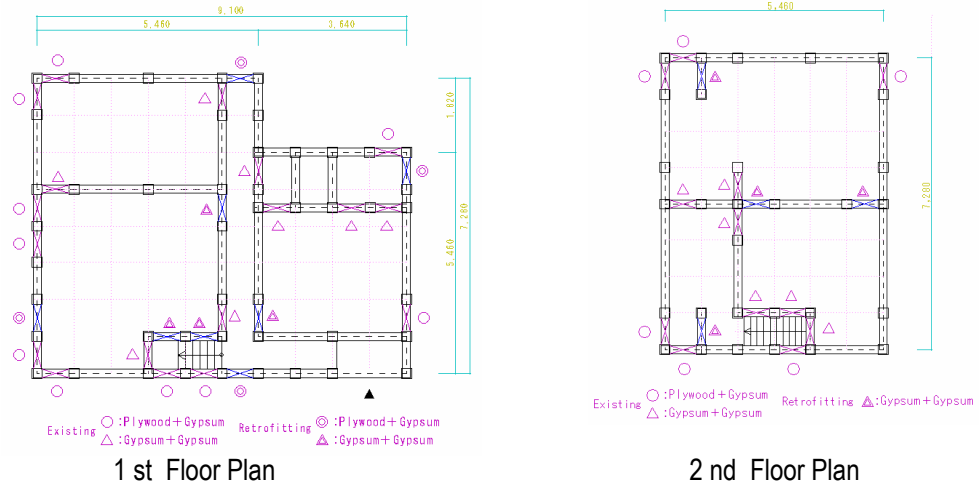


Fig.23. Model 3:Retrofitting / Structural plywood(1.00 score)

6.2 Mechanical model of analysis

In this Analysis, we use the mechanical model based on extended normalized characteristic loop(ENCL model) for restoring force characteristics of bearing wall for wooden house and damping device.

ENCL model is constituted by two lower formulas.

$$\text{Loading loop expression } L_1(x) = (B \cdot |x|^{n_1} + 1 - B) \cdot x \mp A(x^4 - 1) \quad (1)$$

$$\text{Unloading loop expression } L_2(x) = (B \cdot |x|^{n_2} + 1 - B) \cdot x \pm A(x^4 - 1) \quad (2)$$

Fig24. shows comparison of the load displacement relationship of experimental results and mechanical model. This figure shows that ENCL model can be imitating the experimental result with sufficient accuracy.

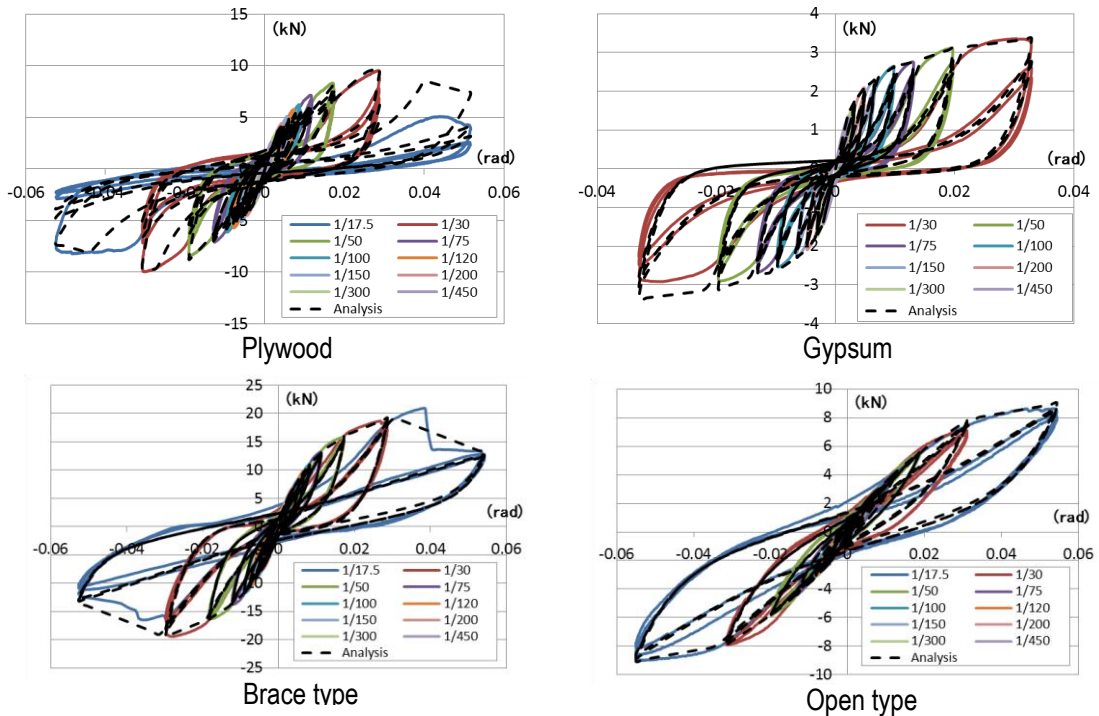


Fig.24. Comparison of the load displacement relationship

Table 5: Input earthquake waves

Name	Maximum acceleration(gal)	Maximum velocity(kine)
Kobe NS Lv2	495	50
Elcentro NS Lv2	507	50
Hachinohe NS Lv2	497	50

6.3 Two lumped-masses model and input waves

The analysis of the 2-story house used two lumped-masses model. The details of the model are shown in the fig.25. The input data of the analysis are three kinds of standardized earthquakes shown in table5.

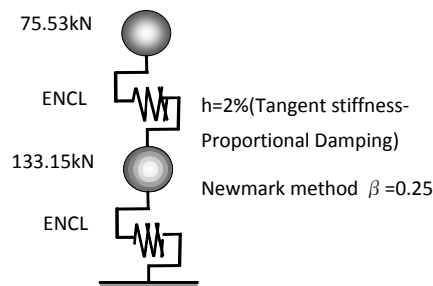


Fig.25. Two lumped-masses model

6.4 Analysis results

1) Comparison of the maximum response deformation angle

Fig.3 shows the analysis results about a comparison of the maximum drift angle of each model. Model2 reinforced with damping devices shows the lower response of 1st story than Model3 reinforced with bearing wall.

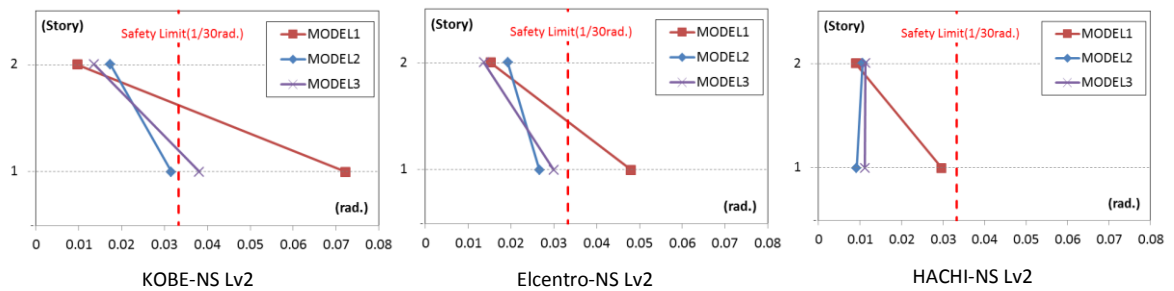


Fig.26. Comparison of the maximum response deformation

2) Time history comparing of cumulative energy consumption about 1st story / Elcentro-NS Lv2

The analysis result of each model shows a comparison of the time history comparing of cumulative energy consumption. Fig.3 is the analysis results of each model in the Elcentro NS Lv2 as a representative. The accumulation of the energy is about the same about three models. As for model 2, the damper device absorbs approximately 30% of overall energy.

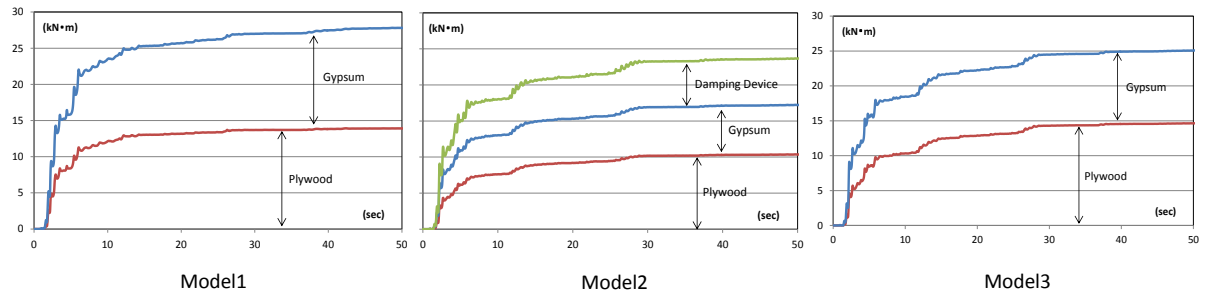


Fig.27. Time history comparing of cumulative energy

7. CONCLUSIONS

In order to improve the earthquake resistance of wooden houses, designed anti-seismic devices using high-performance steels with low yield point steel and high-strength steel, we have to understand the mechanical properties of the static test and dynamic test. Furthermore, we see the effects of the design seismic retrofitting by "High strength and vibration control devices" in the existing housing model.

The main results obtained in this study are as follows.

- We have confirmed that there is a high energy absorption performance to clarify the seismic performance of "high strength high energy absorbing device" using a low yield point steel, compared with shear walls with plywood.
- We have confirmed that the further increase in seismic performance in combination with metal siding for "retrofitting equipment with high-tensile steel".

From the above results, we found the possibility that various anti-seismic device with a variety of high-performance steel contribute to the improvement to the seismic performance of wooden house.

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The Utilization of Water Extracted *Eucalyptus Globulus* Bark As A Scavenger for Copper and Zinc Removal from Aqueous Solutions

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ABSTRACT

This study aimed to examine the utilization of bark from *Eucalyptus globulus* Labill as a bioadsorbent for Cu^{2+} and Zn^{2+} in solution. The bark powder was previously treated using hot water extraction in order to remove colouring compounds within the bark. Untreated and water-NaOH extracted eucalypt bark were tested for comparing the role of extractives in the metal removal. Batches of each sample were then soaked in heavy metals solutions (10, 20, 40 and 80 mg/L of a single metal element - Cu^{2+} and Zn^{2+}). After an hour of shaking and filtering the suspension, the solute was analyzed for residual metal using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) to determine the efficiency of each sorbent in binding the metal cations from the solution. The result showed that hot water extraction treatment on eucalypt bark enhanced its adsorption efficiency for heavy metal removal. However, hot water extraction treatment did not significantly increase the adsorption capacity of eucalypt bark for Cu^{2+} and Zn^{2+} . It is suggested that water extracted eucalypt bark demonstrated the ability of the bark to remove Cu^{2+} and Zn^{2+} increases in the absence of water soluble extractives. Meanwhile, water-NaOH extracted eucalypt bark highlighted the importance of high molecular weight tannins, hemicelluloses and lignin content in metal removal. In conclusion, eucalypt bark has the potency to reduce copper and zinc concentration from water.

Keywords: *Eucalyptus globulus* bark, heavy metals, bioadsorbent, adsorption efficiency, adsorption capacity, water soluble extractives, water extraction treatment

1. INTRODUCTION

Bark is defined as all tissues produced outside the vascular cambium. Although it only comprises a small proportion of a living tree, bark consists of complex anatomical structures and chemical components (Sakai, 2001).

Bark includes one of a range of timber residues generated abundantly by forest industries. Bark accounts for approximately 40% of wood residues produced from softwood processing, followed by woodchips (30%) and sawdust (20%) (Bootle, 2005).

Due to its complex chemical properties, large amounts of bark are generally disposed of, leading to environmental concerns. However, in several industries, bark is used domestically as a heat and energy source and is also marketed as groundcover materials or for briquette manufacture.

Heavy metal concentrations may be reduced from contaminated solutions using treated bark. Given chemical components of bark are able to interact with heavy metal ions, the use of bark as a natural adsorbent may prove feasible. Martin-Dupon *et al.* (2006) reported that bark components (polysaccharides, lignins and tannins) contain carboxylic, hydroxyl and phenolic groups with strong affinity for metal ions. Bark has been found to have a number of chemical components, predominantly tannins which are capable of precipitating pollutants such as oils, salts, dyes, proteins and heavy metals from water and wastewaters (Martin-Dupon *et al.*, 2006; Lohani *et al.*, 2008). Hemicelluloses and pectin are both capable of binding copper, zinc, lead and cadmium (Hu *et al.*, 2010).

Leaching of tannin compounds hampers the use of bark as a substrate for treating water contaminated with heavy metals. Tannins further pollute water bodies, potentially creating environmental problems.

Many studies have been conducted to fix the colouring compounds within the bark, preventing them from leaching. Bark was treated with formaldehyde under acidic conditions to inhibit tannin and other colouring compounds leaching from the bark (Palma *et al.*, 2003; Pant, 2006). Chow (1972) and Oh and Tsabalala (2007) used high temperature heating to avoid the release of colouring compounds, leaving the

insoluble polymers fixed in bark. These treatments improve the ability of bark in binding heavy metals with the presence of extractives or tannins fixed within the bark.

In this study, in contrast, used bark with the absence of water soluble extractives for heavy metal removal. Water extraction treatment prior to the application of the bark as heavy metal adsorbent is expected to minimize the release of colouring compounds and increase the bark ability to bind heavy metal cations. This study aims to elucidate the effectiveness of water extracted eucalyptus bark in removing Cu^{2+} and Zn^{2+} from water solution. Also, it investigates the role of water soluble extractives in binding the metal cations.

2. METHODS

2.1 Preparation of bark

Eucalyptus globulus Labill. bark was collected, oven dried at 40°C for 3 days and ground using a Rustech hammer mill. Bark powder with particle size passing through a 1.25 mm sieve was collected.

2.1.1 Water extraction of bark

Bark (25 g) and distilled water (500 cm³) were put in a 1000 cm³ glass beaker. The suspension was heated at 80°C with stirring for 1 hour. The suspension was filtered using Whatman No. 1 filter paper and the filtrate collected while the bark was washed with hot water until the substrate passing through the filtered glass was free of any colour. Bark free of water soluble extractives was dried in an oven at 30°C for 3 days prior to storage in an airtight plastic bag.

2.1.2 Water-NaOH extraction of bark

Air dried eucalypt bark (10 g) that had been extracted with hot water was placed in a 1000 cm³ glass beaker. The bark was treated with 1% NaOH (500 cm³) at around 97-100°C for 1 hour with a constant stirring. After 1 hour the contents of the beaker were filtered. The filtered residue was washed with 500 cm³ of hot water, followed by 10% acetic acid (250 cm³) and finally hot water. The acidity of the residue was checked with blue litmus paper. The residue was dried in an oven at 30°C for 3 days and stored in an airtight plastic bag.

2.2 Chemicals

The analytical grade of metal salts, copper sulphate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) and zinc sulphate ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$), were used. A range of metal ion concentrations (10, 20, 40 and 80 mg/L) for each salt solution were prepared. NaOH solution (1%) was used for extraction. Distilled water was used for all aqueous solutions in the experiment.

2.3 Assessment of various adsorbents for copper and zinc removal

Using batch conditions, untreated and water extracted eucalypt barks were weighed (1 g) and placed in a 100 cm³ tube. Single solutions of copper and zinc -sulphate (20 cm³) with metal concentrations of 10, 20 and 40 mg/L were added. Each solution was analyzed in triplicate. The suspensions were shaken using a Ratek orbital mixer (speed 5) at room temperature for 1 hour to ensure equilibrium. The adsorbent was filtered through Whatman No. 2 filter paper.

The filtrate (10 cm³) was collected and centrifuged (Heraeus Multifuge 4 KR) at 3000 rpm for 5 minutes to separate any remaining bark powder. The liquid phase was subsequently collected for analysis by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). Three tubes of heavy metal solution (10 cm³) were also prepared as the control solutions.

2.4 Determination of chemical components binding metal cations

This experiment was conducted to determine the chemical components contributing to metal chelation. The samples used in this test were untreated eucalypt bark, water extracted and water-NaOH extracted eucalypt bark. Copper sulphate solution (20 cm³) with copper concentration of 40 mg/L was added to adsorbent (1 g). The suspension was shaken for 1 hour, the suspension filtered off and the filtrate (10 cm³) collected for ICP analysis.

2.5 Analytical determination of residual heavy metal ions

The collected solutions were analyzed for remaining residual metal concentration using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) to determine adsorption efficiency and capacity of each material in binding metal cations from solution.

$$\text{Adsorption efficiency (\%)} = \frac{(C_0 - C_e)}{C_0} \times 100$$

$$\text{Adsorption capacity, } q_e, \text{ (mg/g)} = \frac{(C_0 - C_e)V}{W}$$

Where C_0 = initial concentration of metal cation added to sample (mg/L)

C_e = final concentration of metal cation at equilibrium (mg/L)

V = volume of solution collected at equilibration (L)

W = oven dry weight of the sample (g)

2.6 UV-VIS spectroscopy for tannin detection

The samples were analyzed by UV-VIS spectrometry to determine their water soluble extractive (tannin) content. Bark (0.1 g) was placed in a plastic tube (12.5 cm³) with distilled water (10 cm³). The suspension was shaken for 1 hour and then filtered through a filter paper (porosity 3). The filtrate (1 cm³) was collected in a cuvette and analyzed by a UV spectrophotometer (Helios α , Thermospectronic). Absorbance at wavelength of 280 nm was recorded. Each sample was measured in triplicate.

2.7 Statistical analysis

Data was analyzed using One-way ANOVA from SPSS 16 and Microsoft Excel for significant differences between variables (significance $P = 0.05$). Graphs were generated using Microsoft Excel, while histogram was resulted from SPSS 16.

3. RESULT AND DISCUSSION

3.1 Assessment of water extracted eucalypt barks for copper and zinc removal

The ability of eucalypt bark to adsorb copper and zinc was assessed for adsorption efficiency and adsorption capacity for both metal ions. Adsorption efficiency is defined as the percentage of the amount of metal ion adsorbed in a liter of solution. Adsorption capacity is the amount of metal ion adsorbed per gram of adsorbent.

The adsorption efficiencies and capacities for Cu²⁺ and Zn²⁺ by untreated and water extracted eucalypt bark are outlined in Figures 1 and 2. The data was the average result from three replicates.

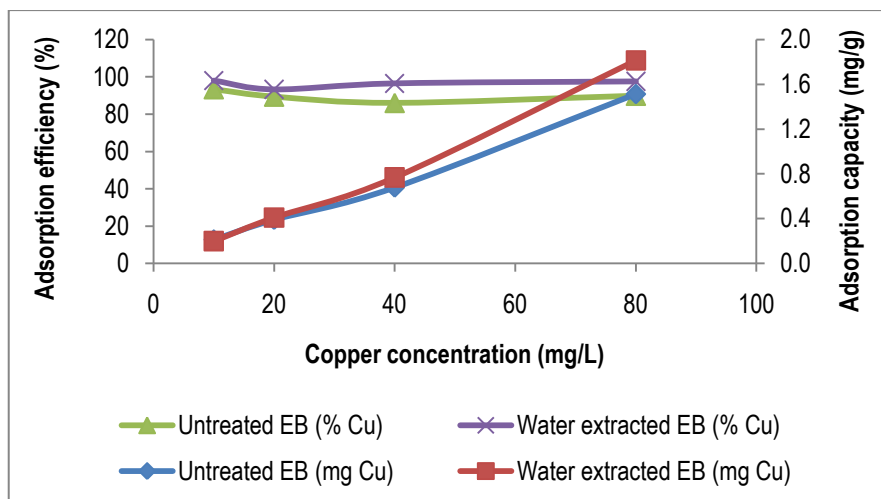


Figure 1. Adsorption efficiency and capacity of eucalypt bark for copper removal

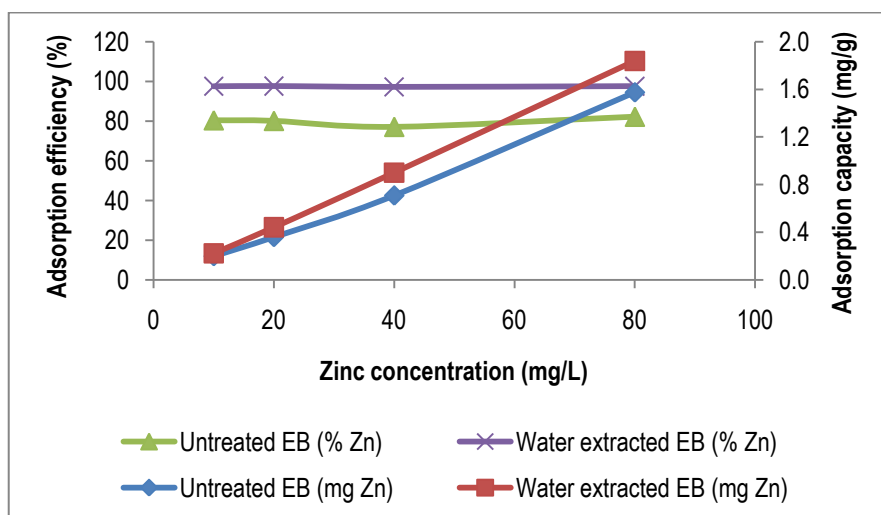


Figure 2. Adsorption efficiency and capacity of eucalypt bark for zinc removal

Figure 1 and Figure 2 show that both untreated and hot water extraction treated eucalypt bark adsorbed averagely more than 85% of Cu^{2+} and 75% Zn^{2+} from the metal solutions. Water extracted eucalypt bark had significant higher adsorption efficiency for Cu^{2+} and Zn^{2+} respectively, compared to the corresponding untreated bark. Statistical analysis ANOVA, confirms that there were significant differences between water extracted and untreated eucalypt bark on adsorption efficiency for Cu^{2+} , which is respectively 96.3% and 87.7% on average (Figure 1). Similarly, hot water extraction treatment on eucalypt bark significantly improved the percentage of Zn^{2+} adsorbed per liter metal solution (97.5%) in comparison to the adsorption efficiency of untreated bark for Zn^{2+} (80%) (Figure 2). This result suggests that hot water extraction treatment on eucalypt bark enhances adsorption efficiency of the bark for heavy metal removal.

However, there was no significant difference in the amount of metal cation adsorbed by untreated and water extracted eucalypt bark. Based on Figure 1, water extracted eucalypt bark bound averagely similar amount of Cu^{2+} (0.44 mg/g) to the corresponding untreated bark (0.40 mg/g). This trend was also observed for Zn^{2+} adsorption, in which water extracted eucalypt bark had comparable adsorption capacity (0.48 mg/g) to that of untreated bark (0.39 mg/g) (Figure 2). Statistical analysis showed that the adsorption capacities of water extracted eucalypt bark for Cu^{2+} and Zn^{2+} was not significantly different from untreated bark ($P=0.356$).

Water extracted bark was assumed to be free of water soluble extractives (including phenolic compounds), implying that tannin is probably not the sole component providing sorption sites for heavy metal ions. When extractives leach from bark, the function of tannic phenolic compounds may be negligible in binding metal cations in this study. This observation is based upon literature stating that hot water dissolves water soluble polyphenols (low molecular weight condensed tannins), flavonoids, phenolics and water soluble carbohydrates or sugars (Sakai, 2001; Palma *et al.*, 2003). Therefore, low molecular weight polyphenols can be removed by hot water extraction.

Bark extracted with hot water may therefore only have cell wall macromolecules (as residual components) and high molecular weight condensed tannins providing sorption sites for metal complexes. For this reason, functional groups from cell wall components and some high polymer tannins play an important role in adsorbing Cu^{2+} and Zn^{2+} cations.

The binding sites provided are the hydroxyl and carbonyl groups of cellulose; hydroxyl, carbonyl and acetyl groups of hemicelluloses; acidic carboxylic groups borne by polysaccharides; and phenolic, hydroxyl, methoxyl and carbonyl groups of lignin as well as hydroxyl groups of condensed tannins (Martin-Dupont *et al.*, 2006; Demirbas, 2008; Yu *et al.*, 2008).

These results reveal that with the absence of water soluble extractives, the adsorption efficiency of eucalypt bark improved significantly. Yet the amount of metal cations adsorbed per gram bark did not increase significantly. However, the advantage of using this sorbent is that when contact with metal solution, the bark did not leach any colours which contaminate aqueous environments. Also, water soluble extracts can be isolated for a range of purposes, including tannin adsorbents for heavy metals, proteins and oils, natural additives and a chemical source.

3.2 The role of extractives (phenolics) in binding heavy metal cations

In order to elucidate which component provides binding sites for metal ion attachment, water extracted eucalypt bark was further extracted with NaOH solution. The water-NaOH extracted eucalypt bark was exposed to 40 mg/L Cu^{2+} solution to examine its capacity in binding the metal cation. Untreated and water extracted eucalypt bark were also tested for comparison.

Assuming that untreated bark contains all the chemical components, water extracted bark contains some components with the absence of water soluble extracts, including some tannins and hemicelluloses (sugars). Water-NaOH extracted bark is bark without high polymer condensed tannins and other polyphenols insoluble in water.

Previously, the sorbents were analyzed using a UV-VIS spectroscopy to measure the level of solubility (colour description) of the substrates in water based on the absorbance of 280 nm. The measurement is based upon spectral quantification of phenolic or tannin compounds (Antonie *et al.*, 2004).

The absorbance of water soluble extractives of each sorbent is summarized in Table 1. The data recorded for each sample was the average of three measurements.

Table 1. Absorbance of filtrate of various substrates at 280 nm

No.	Adsorbents	Absorbance (A) of filtrate at 280 nm
1	Eucalypt bark	0.58 ^a
2	Water extracted eucalypt bark	0.09 ^b
3	Water-NaOH extracted eucalypt bark	0.04 ^c

*Different letters shows significant difference at the 0.05 level

A histogram comparing the ability of untreated and treated eucalypt bark to chelate Cu^{2+} is presented in Figure 4. The data displayed was the average result from three replicates.

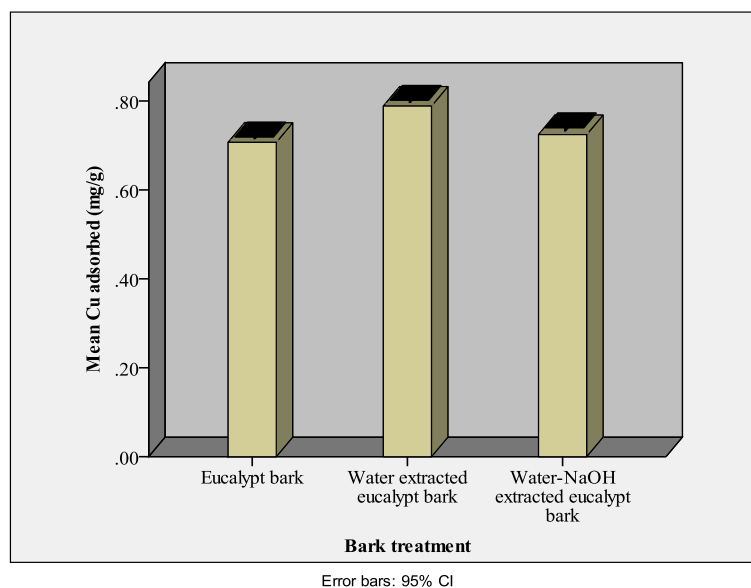


Figure 3. Copper adsorption by untreated, water extracted and water-NaOH extracted eucalypt bark

Eucalypt bark extracted with hot water exhibited the highest copper binding capacity (0.79 mg/g). In contrast, untreated bark with all components present removed the lowest amount of Cu^{2+} (0.71 mg/g).

Water-NaOH extracted bark removed 0.72 mg/g Cu^{2+} (Figure 4). A One-way ANOVA test confirmed that there was a significant effect of each treatment on eucalypt bark Cu^{2+} sorption capacity ($p < 0.05$).

Figure 4 shows that water extracted eucalypt bark adsorbed the greatest amount of copper ion compared to the other substrates. This is most likely due to the absence of water soluble extracts deriving colours (as indicated in Table 1), including low molecular weight tannins (phenols) and some water soluble sugars.

Extractives are located in the lumen of surface cells. Leaching of extractives from the bark gave rise to an extensively increased surface area of macromolecules in the cell wall and spaces between cells. This allows the functional groups present in high molecular weight condensed tannins, pectins and macromolecules (lignin, cellulose and hemicelluloses) to be more accessible for the metal cations.

These conditions were also most likely responsible for untreated eucalypt bark showing lower capacity for Cu^{2+} uptake than the corresponding bark that had been extracted with water and water-NaOH. When water soluble extractives remain present within the bark, filling the lumen cell surfaces, metal ions can only interact with the functional groups provided by the extractives until the saturated point is reached. Consequently, the binding sites of the cell wall surface components may be blocked or difficult to access by the metal cations and thus less Cu^{2+} adsorbed.

Following water extraction, bark was extracted with hot 1% NaOH solution to remove high molecular weight tannins and other polyphenols insoluble in water. Figure 4 shows that after being treated with the alkali solution, there was a substantial depletion in the amount of Cu^{2+} adsorbed by water extracted bark. This observation implies that there is a compound responsible for attaching metal cations that has been removed during alkali extraction, decreasing the metal binding capacity of the bark.

High molecular weight condensed tannins or phenolic acids may leach during 1% NaOH extraction, resulting in water-NaOH extracted bark containing low concentration of high polymer tannin. Lower absorbance values generated by UV spectroscopy analysis (Table 1) support this observation. Other compounds possibly removed by the alkali extraction are polyflavonoids, suberin monomer, some hemicelluloses and pectins (Sakai, 2001). Fradinho *et al.* (2002) reported that neutral sugar and uronic acid of hemicelluloses were removed under alkali extraction.

Conversely, compounds such as phenols, uronic acids and sugars of hemicelluloses were described by Martin-Dupont *et al.* (2006) as essential compounds for enhancing the ability of bark to adsorb metal ions. Loss of these compounds could possibly explain the decrease in the copper adsorption of water-NaOH extracted eucalypt bark.

Another bark component that could possibly be removed during NaOH extraction following water extraction is lignin. Fradinho *et al.* (2002) reported that low methoxyl content was found in alkaline extract suggesting a depletion of not only hydroxyl and phenolic species but also methoxyl and carboxylic groups after alkali extraction. This results in less adsorption sites for the formation of metal complexes.

In summary, eucalypt bark treated by water-NaOH extraction, with the absence of high molecular weight extractives (including high polymer condensed tannins), provided evidence that certain phenolic compounds dissolved by the alkali solution play important roles in metal cation chelation, in addition to the functional groups present in cell wall components.

4. CONCLUSIONS

The conclusions that can be drawn from this study are as follows:

1. Water extracted eucalypt bark adsorbed significantly higher amount of Cu²⁺ (96.3%) and Zn²⁺ (97.5%) compared to the corresponding untreated bark (87.7% and 80%, respectively).
2. Hot water extraction treatment did not significantly increase the adsorption capacity of eucalypt bark for Cu²⁺ and Zn²⁺ removal.
3. Water extracted eucalypt bark demonstrated that the ability of bark to remove metal ions increases in the absence of water soluble extractives (low molecular weight tannins).
4. The advantages of water extracted eucalypt bark are that the generation of bark adsorbent which does not contribute contaminated leachate to aqueous environments but has a higher affinity for metal cations and the isolation of the water soluble extract that may have further utility.
5. Water-NaOH extracted eucalypt bark highlighted the importance of high molecular weight tannins, hemicelluloses and lignin content in metal removal.

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Cluster Analysis of Six Parental Oil Palms in Indonesian Oil Palm Research Institute

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ABSTRACT

Oil palm is an out bred plant species which has diverse characters. Information of genetic diversity of parental palms used in breeding programme will help breeder in making crossing design to create populations with desired characters. The higher the genetic distance of parental palms crossed, the greater the genetic variability of the offspring. The aim of this study is to obtain genetic similarity information of 6 parental palms, collection of Indonesian Oil Palm Research Institute (IOPRI) using Random Amplified Polymorphic DNA (RAPD). The results showed that the six parental palms had 49% genetic similarity. The palms were clustered into two groups with 69.5% (parental palm A, B, and C) and 62% similarity levels (parental palm D, E, and F).

Key words: cluster analysis, oil palm, RAPD.

INTRODUCTION

Oil palm is an out bred plant species which has diverse characters. In oil palm breeding programme, combination of characters in new generations is expected to be better than in their parental palms. Lower genetic distance between parental palms, higher the diversity of their progeny. One of methods to assess the genetic distance in DNA level is by *Random Amplified Polymorphic DNA* (RAPD) marker. RAPD has been applied in studies of several plants, such as in detection of cadmium stress in *Egyptian clover* and *Sudan grass* (Aly, 2012), genetic diversity of *Sonchus* spp. (Elkamali *et al.*, 2012), *fingerprinting* of soil streptomycetes isolate (Boroujeni *et al.*, 2012), and test of chrysanthemum DNA extraction (Hasan *et al.*, 2012). This marker has also been used in oil palm to detect dura, tenera and pisifera fruit type (Sathish dan Mohankumar, 2007), to detect normal and abnormal fruit of tissue culture clone (Toruan-Mathius *et al.*, 2001), genetic linkage analysis on backcross I population (Hura, 2004), genetic diversity of oil palm Tenera Interpopulation (Situmorang, 2004) and to provide genetic relationship between parents and their hybrids and to identify markers useful for purity hybrid testing identify (Tarigan, 2006).

Cluster analysis is an analysis of grouping based on similarity level (Yuniastuti *et al.*, 2005). Cluster analysis has been used to understand the similarity level of normal and abnormal fruit of oil palm tissue culture clones (Toruan-Mathius *et al.*, 2001; Yuniastuti *et al.*, 2005), grouping of oil palm based on origin or population type (Mayes *et al.*, 2000), grouping of *Pongamia pinnata*, as a legume tree which has potential as biodiesel source (Kesari *et al.*, 2010), genetic diversity of parental and progenies of hybrid tomato with regard to heterosis effect and combining ability (Mirshamsi *et al.*, 2008), genetic relationship of soybean in Thailand (Tantasawat *et al.*, 2011), and genetic similarity of sunflower (Gvozdenović *et al.*, 2009).

Genetic distance study is important in breeding programme, for material genetic screening and to assess superior crossings (Melchinger *et al.*, 1990). Genetic similarity of parental material is also useful to assess resulted hybrid genetic variation, level of heterosis and combining ability (Mirshamsi *et al.*, 2008). RAPD application in genetic distance analysis of oil palm material collection of IOPRI has been reported by Yenni *et al.* (2002), Setiyo *et al.* (2000), Asmono (1998) and Setiyo *et al.* (2001). The objective of this experiment is to obtain genetic similarity information of six parental oil palms collection of IOPRI by cluster analysis, using RAPD.

METHODOLOGY

Plant material analysed were six parental oil palms A, B, C, D, E, and F, collection of IOPRI. From each individual parental palm, it was taken 0.3 g of 5 spear leaves from left and right respectively, for CTAB DNA extraction (Orozco-Castillo *et al.*, 1994). Amplification protocol was adapted from William *et al.* (1990).

Polymerase Chain Reaction–RAPD (PCR-RAPD) composition was 24 µl in total per reaction which contained of 14.3 µl ddH₂O, 2.5 µl of 10x PCR reaction buffer, 2.5 µl of 10 mM dNTP *mix*, 2.5 µl of 50 mM MgCl₂, 1.0 µl of 10 µM random primer, 0.2 µl of 5 unit/µl taq DNA polymerase (Invitrogen), and 1.0 µl of DNA stock with 10x dilution. PCR programme was as follows: predenaturation (94^o C for 1 minute), denaturation (94^o C 1 for minute), annealing (37^o C for 1 minute), extention (72^o C for 2 minutes), last extention(72^o C for 4 minutes), and last storage condition at 4^o C. The number of cycles for denaturation until extention step was 45 cycles. The PCR products was fragmented by electrophoresis with 0.8% agarose in 1x TAE. Fourteen RAPD primers were used in initial screening to determine which primers would be used for cluster analysis.

Data Analysis

DNA band was scored as biner data, with 1 as present and 0 as absent. A marker was identified based on primer name and the amplification size was assessed by 1 kb DNA ladder (Promega) Cluster analysis was done using Genstat 12 (Payne *et al.*, 2009), with group average and Jaccard coefficient of similarity.

RESULT AND DISCUSSION

From fourteen RAPD primers, there were only 3 selected primers for subsequent analysis, which were OPG 02, OPG 19, dan OPH 04 (Table 1). They were selected based on polymorphism level among the parental palm samples and the quality of RAPD product. The highest level of polymorphism was shown by OPG 02 and the lowest by OPG 09, with the average polymorphism level of the three primers were 4. Result showed that not all of the primers were used for subsequent analysis, which was also reported by Boroujeni *et al.*, (2012), which from 20 RAPD primer screened, it was only OPAB-9 selected based on amplification product and level of polymorphism to soil streptomycetes isolate.

Table 1. RAPD primers used to amplify the six parental palms DNA

No.	RAPD primer	DNA sequence (5' to 3')	Number of polymorphic bands
1.	OPG 02	GGCACTGAGG	5
2.	OPG 19	GTCAGGGCAA	3
3.	OPH 04	GGAAGTCGCC	4
Average			4

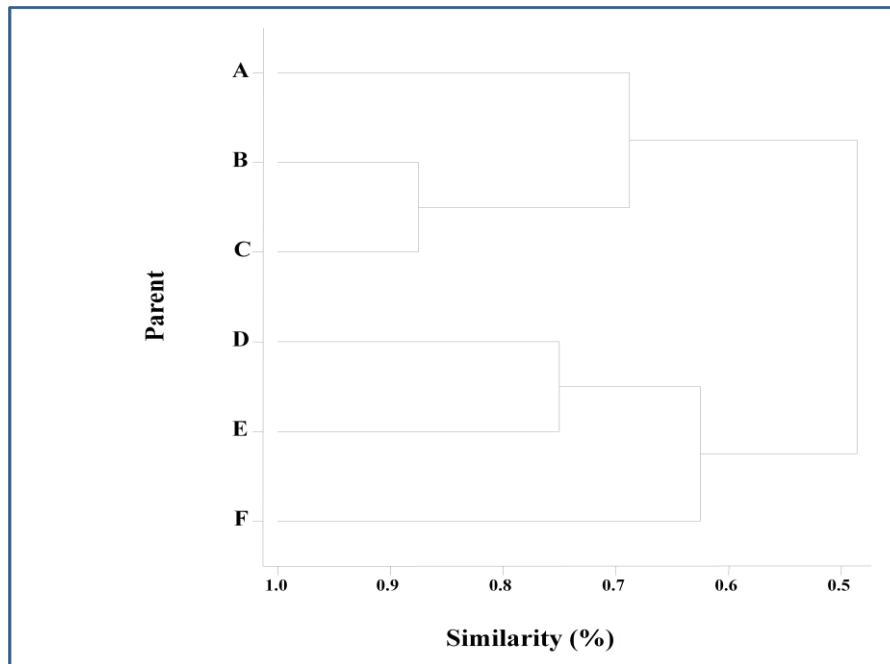


Figure 1. Group of the six parental palms based on genetic similarity

Cluster analysis showed that the six parental oil palms collection of IOPRI had 49% genetic similarity (Figure 1). There were 2 groups which were group I with 69.5% genetic similarity (parent A, B dan C) and group II with 62% genetic similarity (Parent D, E dan F). It showed the genetic relationship among the parental oil palms. Individuals in the same group had higher similarity or close genetic relationship compared to individuals in different groups. Crossing of individuals in different group will produce offspring with great genetic variability. For example in this case, greater offspring genetic variability will be obtained from crossing of A and F, rather than B and C.

Genetic diversity of a population is based on individual's DNA polymorphism and as a source for adaptation of populations to changing environment (Elkamali *et al.*, 2012). According to Tantasawat *et al.* (2011), genetic diversity and genetic relationship provide efficient use of genetic material, especially for genetic improvement of soybean genotypes in Thailand. It is expected that cluster analysis done in this study will help oil palm breeder to understand genetic relationship of the six IOPRI's parental palms analysed, to take decisions for germplasm management and crossing works.

CONCLUSION

Six parental oil palms collection of IOPRI had 49% genetic similarity, clustered into two groups which had 69.5% and 62% genetic similarity. This results provide information for germplasm management and crossing works.

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ABSTRACT PAPERS

Wood Structure and Fiber Quality Comparison Among Normal-, Tension- And Opposite Wood Portions of Kawista (*Limonia Acidissima* L.)

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ABSTRACT

The study dealt with the variation in wood structure and fiber quality of kawista (*Limonia acidissima* L.) from Bima, West Nusa Tenggara. The main sample was normal-, tension-, and opposite wood portions of kawista from one disk 3 cm thick of one tree. The tree age was not known, but the tree diameter at breast high was around 18 cm. The disk was then divided into three portions. From each portion, the wood sample of each growth increment was taken duplet in radial direction; one for anatomical study and the other for fiber measurement. Anatomical structure was observed through microtome specimen, 20 µm thick by Reichert sliding microtome following the list of *International Association of Wood Anatomist Committee*, while fiber morphology was measured through maceration specimen following the procedural standard of *Forest Products Laboratory* method. Quantitative data were then analyzed using t-student test. Fiber quality class especially for pulp and paper manufacturing was evaluated following Indonesian fiber quality by Rahman and Siagian and also compared to that of mangium. Result showed that macroscopic characteristics of normal-, tension-, and opposite wood portions were similar in general: yellowish to brown color, no boundary between heartwood and sapwood, growth rings distinct, moderate coarse in texture, interlocked in grain, smooth enough in surface but has no luster, hard enough and odorless. Anatomical characteristics of normal-, tension-, and opposite wood portions were also similar in general, except for rays parenchyma composition and oily channels: up-right cell was found only in the opposite wood; oily channels were found only in the normal wood. Fiber length is 1007 µm in average. Based on its fiber dimension derivative values, kawista is a good potential for pulp and paper manufacturing, better than mangium.

Keywords: Kawista, normal wood, opposite wood, tension wood, fiber quality

Wood Properties of Three Fruit Trees Planted in Central Kalimantan, Indonesia

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ABSTRACT

The objective of this study is to evaluate the wood properties of fruit trees for their utilization. A total of three trees namely jambu bol (*Syzygium* sp.), rambutan (*Nephelium lappaceum*) and durian (*Durio zibetinus*) planted in Desa Tanjung Paku, Central Kalimantan, Indonesia (0°45'00"S, 112°05'54.8"E) were used for the experiment. Stem diameter, tree height and stress-wave velocity were measured. Core samples (5 mm in diameter) were collected from these trees for evaluating the anatomical characteristics (vessel diameter, cell wall thickness of wood fiber and cell length), wood properties (moisture content, basic density and compressive strength parallel to grain) and also the chemical content (holocellulose, α -cellulose, and Klason lignin). Anatomical characteristics and wood properties were measured at 1 cm interval from pith to bark. Mean stem diameter was 11.8 cm, 15.9 cm and 29.3 cm for *Syzygium* sp., *N. lappaceum* and *D. zibetinus*, respectively. Mean values of stress-wave velocity were 3.16 km/s, 3.95 km/s and 3.63 km/s for *Syzygium* sp., *N. lappaceum* and *D. zibetinus*, respectively, suggesting that *N. lappaceum* wood might have the highest longitudinal Young's modulus among the three species. Mean values of compressive strength parallel to grain were 29.4 MPa, 37.8 MPa and 32.0 MPa for *Syzygium* sp., *N. lappaceum* and *D. zibetinus*, respectively. Therefore, among the three species, *N. lappaceum* might show the relatively high mechanical properties of wood.

Keywords: Anatomical characteristics, *Durio zibetinus*, *Nephelium lappaceum*, *Syzygium* sp., wood properties

Anatomical Properties And Wood Density Of Rubberwood (*Hevea brasiliensis*) From Three Different Planting Densities

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ABSTRACT

Rubberwood (*Hevea brasiliensis*) is the most popular species used for furniture production and wood composite panel products i.e medium density fibreboard (MDF) and particleboard. A study was conducted on rubberwood monoclonal seedlings (RRIM 623) planted with three different planting density i.e 500 trees/ha (PDI), 750 trees/ha (PDII) and 1,000 trees/ha (PDIII) obtained from Rubber Forest Plantation in Gemas, Negeri Sembilan. The objective was to assess the anatomical properties and density of rubberwood from different planting density. The samples were taken from three (3) different trees from each planting density. All data were analysed using Analysis of Variance (ANOVA) and Least Significant Difference (LSD) at 0.05 confidence level ($p \leq 0.05$). The anatomical features of this rubberwood was quite similar to typical structure of the rubberwood. The vessels were diffuse, solitary and multiples with round to oval shape. Apotracheal and paratracheal parenchyma were both present. The tangential sections showed that the rays were 2 to 4 cells wide and heterocellular rays and simple perforation plates separating the vessel elements were observed in radial section. Planting density of 750 trees/ha (PD II) recorded longer fibre length, larger fibre diameter, thicker fibre wall thickness, wider vessel diameter and higher fibre proportions. A decreasing trend towards the top was observed in the fibre diameter of all three planting densities. It is suitable for utility of timber due to longer fibre length and thicker cell walls. Density of PD I showed higher value than PD II and PD III. PD I has great dimensional stability than the other planting densities. Based on the anatomical properties and wood density, the wood samples obtained from PD II and PD I showed the better overall quality of rubberwood.

Keywords: Rubberwood, planting density, wood anatomical properties, wood density

Wood Properties of Young Trees of Two Shorea Species Planted in Central Kalimantan, Indonesia

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ABSTRACT

Shorea is an economically important tree species in the humid Asian tropics for producing timber. *Shorea leprosula* and *S. macrophylla* belong to the light red meranti group. Their wood are widely used for plywood. In the present study, their anatomical characteristics and wood properties were examined for 5-year-old *S. leprosula* and *S. macrophylla* trees planted in Central Kalimantan, Indonesia (0° 41' S, 112° 12' E and 0° 41' S, 112° 13' E, respectively). Experimental stands were located in the concession area managed by a commercial timber company. The trees were planted by "line strip planting silviculture system". In the system, trees were linearly planted at 2.5 m intervals and the distance between lines was about 20 m. Stem diameter and height of trees were measured for 30 trees in each species. The mean values of stem diameter were 11.6 ± 2.7 cm for *S. leprosula*, and 15.9 ± 4.4 cm for *S. macrophylla*, respectively. In addition, core samples were collected from 5 trees with larger stem diameter in each species (16.0 ± 0.7 cm for *S. leprosula*, and 20.2 ± 1.4 cm for *S. macrophylla*, respectively) for measuring the anatomical characteristics (cell length and cell morphology), basic density, and compressive strength parallel to grain. The mean values of basic density and compressive strength were 0.31 ± 0.02 g/cm³ and 20.8 ± 3.0 MPa for *S. leprosula*, and 0.28 ± 0.03 g/cm³ and 18.4 ± 2.8 MPa for *S. macrophylla*, respectively. Although the stem diameter was almost similar, the ANOVA test showed significant differences in basic density and compressive strength among 5 trees in both species. From the results obtained, it was suggested that wood properties, such as basic density and compressive strength, are independent of growth characteristics in both *S. leprosula* and *S. macrophylla*.

Keywords: *Shorea leprosula*, *S. macrophylla*, stem diameter, basic density, compressive strength parallel to grain

The Dynamics of Radial Growth of Three Selected Tropical Tree Species Studied through Knife-cutting Method

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ABSTRACT

Tropical trees which lack distinct growth ring have caused difficulty in estimating the growth rate of those trees. This has resulted in limited knowledge concerning tropical tree growth pattern and their rate of increment. This study is aimed at assessing the radial growth and cell production rate of three selected tropical species which are *Macaranga gigantea*, *Endospermum diadenum* and *Dipterocarpus costulatus* with different diameter at breast height. Knife-cutting method was adopted in this study. A knife was inserted through the bark into the outer xylem of a tree to wound the cambium and removed immediately. Wood discs containing wound area were collected from living trees after a period of time. Transverse sections of 20-25 μm in thickness were obtained through sliding microtome and dehydrated in a graded series of ethyl alcohol before staining with safranin and fast green. Dibutyl phthalate xylene (DPX) was used as a mounting medium for the preparation of permanent microscope slides. The species-related anatomical response to wounding was identified and used to define the time of marking. Results show that radial growth rate and cell production rate varied across species and tree size. *M.gigantea* and *E.diadenum* showed faster growth rate than *D.costulatus* especially in small diameter classes. *D.costulatus* had the lowest growth rate and cell production rate. Both pioneer species are thus considered to grow faster in smaller stem size than larger stem size, while the studied succeeding species grow faster in larger stem size than smaller stem size.

Keywords: Anatomical response, growth ring, pinning method, radial growth, tropical trees

Anatomical Characteristics of the 10 Indonesian Wood Species

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ABSTRACT

The anatomical characteristics of the ten Indonesian wood species (Gmelina, Jeunjing, Mangium, Durian, Gandaria, Jengkol, Kupa, Mangga, Nangka and Rambutan) were investigated by optical microscopy. All the species were diffuse-porous with solitary and radial pore multiple. In Mangium, however, tangential pore multiple was observed as well. Tangential diameter of pore was larger than that of radial one except for Jeunjing and Nangka. Nangka showed the largest tangential diameter of pore among the species. Vessel number per mm² of Mangium, Gandaria and Kupa was higher than that of the other species, especially Kupa which showed the highest vessel number. The tangential width of axial parenchyma cell in Gmelina, Mangium, Kupa and Mangga was larger than that of wood fiber, while the other species showed the opposite trend. Mangium was the largest in tangential width of axial parenchyma cell. Rays were homocellular composed only of procumbent cell in Gmelina, Jeunjing and Rambutan. Heterocellular rays composed of procumbent cells in the body and one row of upright and/or square in the margin are observed in Gandaria. Mangium, Durian, Jengkol, Kupa, Mangga and Nangkabody showed heterocellular rays composed of procumbent cells in the body and mostly 1~2 rows of upright and/or square cells in the margin. Crystals existed in Durian, Gandaria, Jengkol, Jeunjing, Mangga and Rambutan and silica in Jeunjing and Mangga.

Keywords: Tropical wood, anatomical properties of Indonesian wood, planted Indonesian species, promising Indonesian species

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Determination of Juvenile and Mature Transition Age for Sengon and Jabon Wood

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ABSTRACT

Wood as an important forest resource in the tropic has been processed in large quantity to fulfill an increasing need of both local and international consumers. To satisfy the increasing demand for wood products, much of the future wood supply will be from fast-growing tree species grown on managed plantations (community forest, plantation forest). These fast-growing wood species will tend to be harvested in short age rotations and will contain higher proportions of juvenile wood. This research article discusses the extent, occurrence, and characteristics of juvenile of Sengon and Jabon woods based on fiber length and MFA. Segmented modeling approach was used to estimate the age of transition, and the SAS non-linear procedure was employed to identify the juvenile to mature wood transition point. In an attempt to determine the juvenile and mature transition age for Sengon and Jabon, 6 trees were sampled in three age classes (5, 6, and 7 year) from a community forest in Sukabumi, Bogor. Disks of 2 cm thick were collected at 1.3 meters from each tree to determine density, natural durability, strength, fiber length and MFA. Wood density was measured along radii from pith to bark by X-ray densitometry. Fiber length and microfibril angle (MFA) were measured on isolated segmented rings of 1 cm width from pith to bark by visual interpretation on maceration and microtome samples. The segmented regression models and visual interpretation of radial patterns of variation in fiber length and MFA reveal that juvenility in Sengon and Jabon extends up to 6 years and 9 years, respectively. Fiber length, microfibrillar angle, and vessel diameter/percentage appear to be the best anatomical indicators of age demarcation between juvenile and mature wood, although maturation age often varies among the properties. The projected figures for the proportion of juvenile wood in Sengon and Jabon at breast height at age of 7 year are 80–100% and 100%, respectively.

Keywords: Fibre length; microfibril angle; juvenile wood; mature wood; Jabon, Sengon

Variation in Anatomy, Morphology and Chemistry of *Musa acuminata* var. *truncata*

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ABSTRACT

The cell structures and chemical composition from different parts of *Musa acuminata* var. *truncata* plant (leaf sheath, leaf blade, and midrib/petiole) had been carried out. The leaf sheaths were further divided into three portions (top, middle and base) and each portion was divided into three sections (inner, middle, and outer) and observed under image analyzer and SEM for its fibrous structure and morphological properties. Chemical constituents were tested according to TAPPI standard methods and FTIR. Each section and part of leaf sheaths did not vary anatomically but significantly different in their morphological properties. It was verified that the chemical composition of the studied fractions of banana plant varies significantly. Leave blades have extreme high lignin content of 26.97% compare to midrib 13.02% and leaf sheath of 10.20%. Anatomically, leave sheath exhibit the longest fibre length (3.45mm), fibre width (20.4µm) and lumen width (13.89µm) while chemically they possess the highest alpha cellulose (62.58%).

Keywords: Chemical composition, anatomy, morphological, cellulose, lignin, *Musa acuminata* var. *truncata*

Occurrence, Dimension, and Distribution of Siliceous Inclusion and Calcium Crystal in Kapur (*Dryobalanops aromatica* Gaertn.f.)

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ABSTRACT

Depositions of mineral inclusion in woody plant were well documented. Most literature reported crystal in leaf, floral organ, fruit and buds, and few in roots, wood, petiole and bark. However, the distribution pattern and dimension have not been adequately documented. These species deposited siliceous inclusion causing difficulty in wood milling. This study attempts to investigate the occurrence, distribution, morphology, and dimension in most tree part such as leaf, petiole, wood, pith, bark and root of *Dryobalanops aromatica* timber. Siliceous inclusion was found to have smooth and rough globular, aggregate and irregular shape. The results indicated that siliceous inclusion was deposited in wood ray parenchyma and pith, occasionally in the axial parenchyma of bark and wood. Druse crystal coexisted with siliceous inclusion in phloem ray parenchyma and cortex of bark. Siliceous inclusion was deposited in epidermis, while crystal was found in palisade and spongy mesophyll, cortex of midrib and petiole, and occasionally in parenchyma cell surrounding vascular bundle of petiole. With respect to distribution in trunk, the amount of siliceous inclusion increased towards the inner and inconsistent pattern in longitudinal direction. The size of siliceous inclusion was increased in radial direction, and decreased in the longitudinal direction of trunk. Druse in the leaf blade has smaller size than in petiole. Both inclusion sizes found in the bark of root were decreased in size when deeper into the soil, while in the bark of trunk, it was found to be decreased in the longitudinal direction. The result of this study can be used as diagnostic for this species, and distribution and dimension data can be a good reference for wood utilization.

Keywords: Calcium crystal, dimension, distribution, *Dryobalanops aromatica*, EDXA, occurrence, siliceous inclusion.

Anatomical Structure of Jabon Merah dan Jabon Putih Woods

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ABSTRACT

Anatomical structure and fiber characteristics of two species of Rubiaceae namely jabon merah (*Anthocephalus macrophyllus* (Roxb.) Hav.) and jabon putih (*A. chinensis* (Lamk) A. Rich. ex Walp. synonym to *A. cadamba* Miq.) were studied and compared to each other. All samples were taken from healthy tree, one tree for each species. Tree age was not known, but the tree diameter at breast high was around 84 cm in case of jabon merah and around 78 cm for jabon putih. From each tree, a disk of basal portion 3 cm thick was extracted. Wood sample 1 cm long was then taken duplet from pith to bark consecutively; one for anatomical observation and the other was for fiber measurement. Wood anatomical was observed through microtome specimen, 20 µm thick by Reichert sliding microtome following the list of *International Association of Wood Anatomist Committee*, while fiber morphology was measured through maceration specimen following the procedural standard of *Forest Products Laboratory* method. Result showed that anatomical characteristics of jabon merah and jabon putih differed in case of wood color, texture, luster, hardness, number of vessel cells in radial multiple arrangement, frequency of vessel, tangential diameter of vessel, seriate and frequency of ray parenchyma and fiber length. These two species have similarity in case of growth ring, wood grain, figure, perforation plate, inter-vessel pitting and axial parenchyma. Furthermore, tyloses, crystals and silica grains were absent in these two wood species.

Keywords: Jabon merah, jabon putih, *Anthocephalus macrophyllus*, *A. cadamba*, *A. Chinensis*

Effects of Environmental Factors on Anatomical Characteristics and Wood Properties of *Tectona Grandis* Planted In Indonesia

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ABSTRACT

The objective of this study is to clarify the effects of environmental factors on the anatomical characteristics and wood properties of teak (*Tectona grandis*) trees. A clone of 12-year-old trees planted at two different sites, Cepu and Ciamis, Indonesia was used for the experiment. Core samples (5 mm in diameter) were collected from 3 trees in Cepu and 2 trees in Ciamis for measuring their anatomical characteristics (vessel diameter and cell wall thickness of wood fiber) and wood properties (basic density (BD), moisture content, and compressive strength parallel to grain). These two sites have different environmental conditions: initial spacing, topography, and mean temperature are the same, but precipitation in Ciamis (2740 mm/year) is two times higher than in Cepu (1436 mm/year). The mean stem diameter in Ciamis (23.1 cm) showed significantly higher than that in Cepu (17.1 cm). The mean value of BD was 0.51 ± 0.03 g/cm³ and 0.52 ± 0.02 g/cm³ for Cepu and Ciamis, respectively, where no significant difference in BD was found between the two sites. This tendency was similar to the other anatomical characteristics and wood properties measured in the present study. It can be concluded that environmental factors, especially for precipitation had significant effect on the growth characteristics such as stem diameter, but not on anatomical characteristics and wood properties.

Keywords: *Tectona grandis*, basic density, moisture content, compressive strength, anatomical characteristics

Seasonal Cambial Activity of *Macaranga gigantea* from Tropical Rainforest of Malaysia

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ABSTRACT

The lack of distinct growth rings and the continuous growth of tropical trees are widely assumed due to limited studies done in such trees. The understanding of tropical tree growth patterns and their response to climate is essential for ecological interpretation and silvicultural systems. This study is thus aimed at characterizing the cambial activity of *Macaranga gigantea* and its dependence on climate in order to describe its climatic responses. This pioneer species is selected based on its importance in forest regeneration. Dendrometer measurement and collection of intact wood blocks were carried out in lowland tropical rain forest from August, 2010 to June, 2011. Samples including bark and wood were embedded in Epoxy resin before sectioning through sliding microtome. Sections were then stained with Periodic Acid-Schiff's (PAS) reaction. Dendrometer measurement showed that radial growth increment was different each months. The cambial activity was determined by the numbers of cambial and enlarging zone cells. A greater number of cells indicate greater cambial activity. Cambial activity was active during high rainfall period except in February and reduced its activity during dry months. However, cambial activity was active for the major parts of the observation year. The variation of cambial zone cells in *Macaranga gigantea* showed that cambial growth of this species was sensitive to environmental factors especially of rainfall.

Keywords: Growth ring, cambial activity, climatic response, tropical rainforest, *Macaranga gigantea*

The Increased Stiffness Caused of Shear Moduli Value on Glulam Timber Beam

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ABSTRACT

Glulam was composed from laminas with different elastic moduli. In general, the beam stiffness is obtained only by taking into account the effect due to bending moment. At certain dimension, the stiffness has greater value when taking into account the effect of shear forces. The beam stiffness is only by taking into account the effect due to the bending moment is called apparent stiffness, and account the effect due to bending moments and shear forces are called true stiffness. The wood used in this research was mangium, at the age of 8 years approximately. The dimension of glulam beam were 60 mm width, 160 mm depth, and 2400 mm length approximately, and it was arranged from seven-ply laminas. Polyurethane as Water Based Polymer Isocyanate was used for adhesive. The bending laboratory test for glulam beam was conducted based on the regulation as arranged by the ASTM D198-5a (2008), "Standard Test Methods of Static Test of Lumber in Structural Sizes". The purpose of this study was to analyze the apparent stiffness, the true stiffness, and calculate the increased value. The results showed that the stiffness of glulam beam increased 10.43% when also taking into account the influence of the deflection due to shear forces in addition to bending moment.

Keywords: Deflection, glulam, shear moduli, stiffness

Compression Behavior of Space Truss Elements of Bamboo

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ABSTRACT

The shape of a bamboo tube with partitions, called the nodes, have a special mechanical properties, where the strength of the nodes and the different internodes. Bamboo tensile strength equivalent to steel, while the low shear strength parallel to the fiber is easily broken. Therefore, bamboo culms are suitable when used for truss construction (Dewi, 2005). In addition, the use of bamboo in the form of a culm, has added value in aesthetic factor. Constraints in the utilization of bamboo culm bamboo is to design bamboo connection which is solid, especially in order to accept tension and compression. Compression elements are important parts in the calculation of construction, because the strength of compression element deepens not only on their cross-sectional area and compressive load, but also the cross-sectional shape and length of the bar. This study aims to determine the compressive strength of space truss elements of bamboo in length 60 cm, 80 cm, 100 cm and 120 cm. Bamboo used in this study was the bamboo ropes (*Gigantochloa apus*) derived from Depok, West Java and it has 40±5mm diameter. The number of samples for each treatment were 8 pieces. Test results on samples with length of 60 cm, 80 cm, 100 cm and 120 cm giving an average value of the maximum compressive load respectively 2776 kgf, 2736 kgf, 1409 kgf and 1799 kgf. From the test results, it can be concluded that the maximum compressive load of the largest obtained in the 60 cm elements and the smallest maximum compressive load occurs in samples with a length of 100 cm.

Keywords: Space truss, bamboo space truss elements, compression load

The Difference of Fixation Mechanism between Close System Compression and Phenol Formaldehyde Impregnation of the Inner Part of Oil Palm Trunk (*Elaeis guineensis* Jacq)

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ABSTRACT

Nowadays, the post-harvest oil-palm trunk is still underutilized due to its poor characteristics in dimensional stability, strength, durability and machining properties, especially those of its inner part. To improve these properties, compression technique of the inner part of oil palm trunk has been carried out using (1) close system compression (CSC) and (2) resin impregnation using phenol formaldehyde (PF). The aim of this research was to investigate the fixation mechanism difference between these two methods. Inner part of oil palm trunk with density of 0.31~0.34g/cm³ was pressed with compression level of 50% of original thickness, obtaining density of 0.57g/cm³. Four different temperatures were used in method (1), i.e. 120, 140, 160, 180°C with time variation of 10, 20, 30, 40min. Testing parameters measured were recovery of set (RS), weight loss (WL), modulus of elasticity (MOE), modulus of rupture (MOR), crystallinity index and Fourier Transformer Infra-red (FTIR). In method (2), specimens were impregnated with 20% PF by immersion for 24h; by vacuum pressure at 600mmHg for 1h; and vacuum pressure at 600mmHg for 1 h continued by pressure of 10kg/cm² for 30min. Prior to pressing at 50% compression level at 135°C for 10min, test samples were dried at 60°C for 15h. In this method, weight gain parameter (WG) was also used. The results showed that for method (1), fixation can be achieved at 180°C for 30min or 200°C for 20min with WL=12.59%. Even though there was loss of weight, its values of MOE and MOR were increased from 9.426 and 69.50kg/cm² prior to pressing to 25.298 and 200.61kg/cm² respectively after fixation. The improvement of these mechanical properties was not only caused by the 50% compression level but also by the increase of crystallinity index from 26.86% to 49.51%. Fixation using method (2) was achieved by vacuum and pressure treatment with WG=50.94%. This made the density to increase to 0.94g/cm³ which was also affected by the 50% compression level. The values of MOE and MOR were extremely increased to 47.069 and 504.46kg/cm² respectively. CSC treatment using temperature over 180°C degrade hemicelluloses and lignin components of wood cell wall, causing the internal stresses in the microfibrils were released and fixation was achieved. Fixation with PF impregnation was due to polymerization process or curing of PF in the voids of parenchymatous ground vessels in the inner part of oil palm trunk. This was confirmed by the only intensity changes of the groups of O-H, C-H and C=O on method (1), while on method (2) there was an addition of O-H group from phenol that was derived from PF, less C-H group and the disappearance of C=O group.

Keywords: Fixation, close system compression, PF impregnation, oil palm trunk.

Green Composites Based on Plant Oils and Cellulose Fibers

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ABSTRACT

Using biomass as starting material for chemicals and plastics contributes to global sustainability without depletion of scarce resources, because of their large potential to substitute petrochemical derivatives to bio-based ones in industries. Natural plant and animal oil sources are found in abundance in the world; and hence, are expected as an ideal alternative chemical feedstock. Inexpensive triglyceride natural oils have been utilized extensively for coatings, inks, plasticizers, lubricants, resins and agrochemicals in addition to their applications in food industry. Since most of oil-based polymeric materials do not show properties of rigidity and strength required for structural applications by themselves, these oils were used as a toughening agent to produce interpenetrating networks. This study deals with composites from epoxidized plant oils and cellulose fibers. A high-performance bio-based composite material, a cellulose nanofiber-reinforced oil polymer-based composite, was synthesized by impregnating microfibrillated cellulose (MFC) sheet with a mixture of epoxidized soybean oil (ESO) and a curing agent under reduced pressure, followed by thermal curing. The ESO / MFC composite exhibited the high storage modulus in the rubbery region of the ESO polymer, while the ESO polymer showed the enormous drop of storage modulus around its glass transition temperature, strongly suggesting the large reinforcement effect by the MFC nanofiber. The tensile modulus and strength at break of the composites were much superior to those of the ESO polymer or the MFC sheet. Furthermore, another bio-based composite was developed from epoxidized plant oil and kenaf fiber sheet by similar synthetic procedures.

Keywords: Plant oil; cellulose fiber; kenaf; composite

Bend Curve Characteristics of PF Resin Treated Oil Palm Wood (*Elaeis guineensis* Jacq.)

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ABSTRACT

It has been revealed that oil palm wood (OPW) can be used as wood alternative material upon properly treated. The properties and appearance of OPW can be improved through impregnation treatment with low molecular weight phenol formaldehyde resin (Lmw-PF), resulting in excellent material suitable for furniture and other special applications. It is often said that for such applications, the materials are used in- or needs to be shaped curve, but the treated OPW is a very rigid material. Although resin treated, OPW can be made curved in the process, but no comprehensive study on this matter has been reported yet. Therefore, the objective of this study was to know how far the treated OPW can be bent (without any defect) and how it should be done. In this first stage study, there are two variables made (the initial thickness of the sample, and the MC of the sample before final microwave heating) and three parameters were observed (external defects, internal defects and curve fixation angle). The results showed that the treated OPW can be bent curved, and both variables gave significant effect to the minimum acceptable curvature radius of the sample. It was evident that a smaller diameter curve needs thinner initial thickness of the sample, and a minimum curvature radius of 40 mm can be made to the sample with 10-13 mm initial thickness at MC before microwave heating of 70-80%.

Keywords: Impregnation, bend curve, thickness, microwave heating, treated oil palm.

V-Grooving: A New Efficient and Practical Method for Converting Cylinder Shaped Bamboo Culms into Flat Sheets for Laminated Bamboo Timber Production

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ABSTRACT

Bamboo is the fastest growing woody plant and the most environmental-friendly material that has incredible strength, regenerative properties, and natural aesthetic beauty. In terms of wood, the most important part of bamboo is its culm, which consists of nodes and hollow cylindrical internodes. One of the most important application of bamboo culms are for laminated bamboo timber (LBT) production. For this, bamboo culms have been processed through the “splitting-squaring” technique, in which the cylindrical culms are cut into small splits which are then squared and planed piece by piece to become strips before finally bonded together into bamboo boards. However, this process is time consuming and many materials are wasted. Hence, a new efficient and practical method, the so called V-grooving method and the machine thereof, has been developed. This work reports how the method and the machine work. The performances of the machine in converting the cylindrical bamboo culms into wide, flat bamboo sheets are also highlighted.

Keywords: Bamboo culm, internode, laminated bamboo timber, V-grooving method, flattened culm.

Study on Peeling Veneer of Poplar Cultivar: Analysis of Cutting Forces and Surface Quality of Veneers

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ABSTRACT

To improve the quality of wood, one of the main ways is to find better genetic selection of trees. One species with high potential in terms of this approach is poplar (*Populus* spp.) which is its stands coming from hybridization. Fourteen new poplar cultivars were studied in order to create the referential of poplar quality. This report presents the results of their ability to peeling and an analysis of the quality of its products, veneers. The logs were peeled into veneers. Peeling process was differentiated by radial position, sapwood and false heartwood. Analyses of variances were used to interpret the data obtained by moisture content, cutting forces, measuring fuzzy grain, and waving veneers. The type of cultivar affected significantly the moisture content, cutting forces, fuzzy grain, and waving veneers. Among those cultivars, the Dvina shows a poor ability to peeling and surface quality of veneer. The radial position is significantly affecting moisture content, cutting forces, and fuzzy grain. Sapwood has better ability of peeling and surface quality of veneer than false heartwood.

Keywords: Poplar, cultivar, veneer, peeling, and quality

Reinforcement Method for Japanese Traditional Buildings by Installing of Frame Structure with High Performance Shear Wall

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ABSTRACT

Many Japanese old traditional buildings have a problem in safety for earthquake-proof performance. While it is difficult to install high performance shear walls for reinforcement of the buildings, because they are not fixed to the foundation and not possible to hold down the rotation of the shear walls caused by an earthquake. On the other hand, if there is an appropriately reinforced horizontal beam, it can transmit lifting-up force from shear wall to the distant column by bending. Then relatively smaller amount of dead load may be capable to hold down the column. This idea was evaluated by the elemental test results and then confirmed by the frame test. The composed beam made by nailing boards at both side of double beams was tested in bending to obtain stiffness and strength. The shear wall was developed using board nailed over one side of the inner lattice frame, which achieved high strength and ductility in elemental wall test, which showed both component worked effectively to make up for each disadvantage. The reinforcement system which consists of various combination of shear wall and composed beam was tested in horizontal loading while applying constant vertical force of 30kN in total at the head of both column. As a result, total frame system showed sufficient performance against horizontal force. The friction slip was observed at the leg of the wall when the outermost column was subjected to lift-up force. This suggested a complicated stress distribution phenomena due to the load transmission by bending moment of the composed beam.

Keyword: Japanese, traditional building, shear wall, frame structure, reinforcement

Fibrillation of Pulp from Oil Palm Frond and Vetiver Root

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ABSTRACT

Oil palm frond is left behind when harvesting oil palm bunches, while vetiver root is the by product from vetiver essential oil industry. Those materials are economical lignocellulosic resources. To extract cellulose from lignocellulosic materials, lignin and hemicellulose have to be separated by pulping and bleaching process. The disintegration of cellulose fibres into their structural components (microfibrils) has found industrial interest, in line with the tendency of fibrillated cellulose utilization as reinforcing agent in composite materials. In this study, we investigate the oil palm frond and vetiver pulp fibrillation using high speed blender, ultra turrax or ultrasonicator. Fiber's morphology was observed with scanning electron microscope (SEM) to analyze fiber diameter size. X-ray diffraction test was conducted to measure the cellulose crystallinity.

Keywords: Ultraturrax, ultrasonicator, cellulose fiber diameter, cellulose crystallinity

Manii (*Maesopsis eminii*) Plywood Quality for Various Adhesive and Extender Content

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ABSTRACT

The development of plywood industries were so fast. Manii (*Maesopsis eminii*) is one of the fast growing species. It can be used as one of the alternative raw materials for plywood. Using manii as plywood material need many component. Adhesive is the main component of that. It can be combined with extender in various content. The raw material used is finir manii. Plywood consists of three layers with long and width of 30 cm. Layers were formed with cross fibers. Then adhesive was added with various glue spread: 150 g/m², 175 g/m², and 200 g/m². Every glue spread had different various content: 8%, 10%, and 12% with four repeated. Hot-pressing was used with 10 kgf/cm² during five minutes at 115°C. Then, conditioning was done during 14 days. Physical test include density and moisture content whereas mechanical test was bonding strength. The results were also compared with JAS 2003 for plywood. Physical test of manii plywood meet JAS 2003 standard over all. Range of moisture content is about 9-11%, and density is about 0,43-0,51. Bonding strength of manii plywood parallel fiber meet the JAS 2003 standards in both wet and dry conditions. Bonding strength of JAS 2003 standard is more than 8,24 kgf/cm². Range bonding strength of the straight fiber based on dry test condition is about 7-15 kgf/cm², the values for the result can not meet JAS 2003 standard. Bonding strength of the straight fiber based on wet test can not meet JAS 2003 standard, with a range of about 5-8 kgf/cm².

Keywords: Finir manii, glue spread, extender

Properties Enhancement of Oil Palm Wood through Impregnation-and-Diffusion Process with Lmw-PF Resin

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ABSTRACT

It was reported that the properties of oil palm wood (OPW) can be improved through resin impregnation treatment process which consist of drying, impregnation, re-drying and densification process. This treatment filled the cell lumens with resin and contributes to physico-mechanical properties improvements of the material. It is also reported however, that better properties improvement of wood can be achieved when the resin penetrates into the cell walls instead of the cell lumens. Therefore, the impregnation-and-diffusion resin treatment was introduced for OPW in this study. The process consisted of drying, resin impregnation, resin diffusion, drying and curing. After the impregnation with Lmw-PF, the samples were kept soaked under resin for different period of time. The objectives were to determine the effect of the resin concentration and diffusion period on the physico-mechanical properties improvements of OPW. Weight percent gain increased significantly with resin concentration, however, it was not consistent with an increase in diffusion period. Young's Modulus at the compression parallel to the grain and shear strength increased among the treated OPW. It was observed that the impregnation-and-diffusion treatment gave better properties improvement than just the impregnation treatment.

Keywords: Oil palm wood, impregnation, diffusion, impregnation-and-diffusion, cell walls.

Nanofibers from Ijuk and Oil Palm Empty Fruits Bunch

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ABSTRACT

Blackish coarse ijuk fibers from sugar-palm tree, *Arenga pinnata*, and oil palm empty fruits bunch (OPEFB) produced in Indonesia were used in this study for convenient preparation of nanofibers. Each of the raw fibers was oxidatively treated twice in aqueous solution by autoclave at 120 °C for 20 min and washed with water. After the second treatment, both fibers became soft and constituent unit fibers were recovered easily by treatment with an electric mixer. Neutral sugar compositional analysis indicates effective removal of xylan and remaining of cellulose in the residues. Original ijuk consists of arabinose (0.68 %), galactose (0.16 %), glucose (68.88 %) and xylose (30.28 %), while in the treated ijuk, glucose (98.39 %) and xylose (1.61 %). In the case of OPEFB, original and treated fibers consist of arabinose (1.81 %), galactose (0.95 %), glucose (54.38 %) and xylose (42.85 %), and glucose (91.01 %) and xylose (8.99 %), respectively. By this simple treatment lignin contents lowered from 40.66 % to 5.59 % (ijuk), and 24.43 % to 4.55 % (OPEFB), respectively. Production of cellulose skeletons was also evidenced by solid state ¹³C CP/MAS NMR spectroscopic analysis (Figure1); conversion from lignocellulosic nature in the original samples to cellulose in the treated samples. We want to refer further about treatments for conversion into nanofibers and their properties.

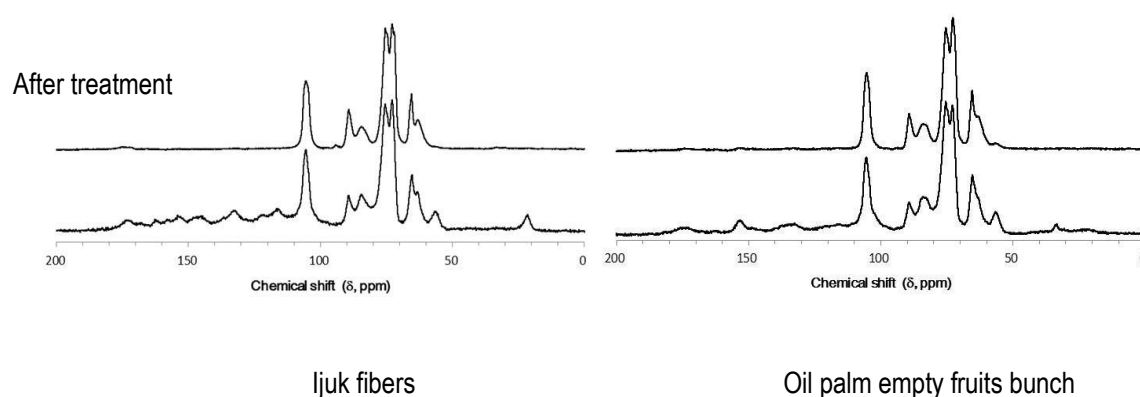


Figure 1. Effects of treatment on CP/MAS ¹³C-NMR spectra of ijuk and oil palm fruits bunch fibers

Keywords: Nanofibers, ijuk fibers, oil palm empty fruits bunch, convenient preparation

Higher Elongated Fibers Reinforced Polyester Composites

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ABSTRACT

Coconut fibers and Ijuk fibers are unique fibers with higher elongation, more than 40%. In this study, the effect of alkali treatment 5%, critical fiber length (5 mm, 1 cm and 5 cm), as well as hybrid fiber (100:0; 30:70; 50:50; 70:30; 0:100) at 40% fiber loading which coconut and ijuk fibers, respectively, was evaluated to produce high strain polyester composites. It is reported that coconut fibers has higher elongation than Ijuk fibers, it also has higher surface roughness. Alkali treatment 5% improved the mechanical properties of the composites, which the higher fiber length is the higher flexural strength. It is not necessary to improve the strain of the polyester composite by adding the elongated fiber without improving the interface between the matrix and the fiber. The effect of hybridization fiber into mechanical properties of composites was also presented.

Keywords: Coconut fibers, Ijuk Fibers, polyester, composite

Preparation of Nanofiber from Korean White Pine and its Reinforcing Polyurethane Polymer for Nanocomposite

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ABSTRACT

Composite material development efforts for the high performance and eco-friendly properties will continue around the world due to the climate change related environmental regulations. Especially the research area based on natural materials such as "cellulose nanofiber" attributed to lignocellulosic materials has attracted much attention in academia and industry. These natural plant fibers have many advantages including specific strength, toughness, energy recovery rate, price, and harmless property to human compared with other man-made fibers. Furthermore they can be applied to bio-composite materials. They can substitute the glass fiber reinforced polymer composites (GFRP) that have been used in construction and automotive industries. Cellulose nanofiber manufacturing methods can be classified as follows: 1) obtaining directly from the primary cell wall, 2) using the bacterial treatment, 3) adjusting the surface, and 4) chemical or mechanical fibrillation etc. However, these processes require a lot of cost and risk of contamination and are difficult to obtain as pure cellulose. Till now, high efficient and cost effective processes have not been reported while a variety of ways to produce nanocellulose are being tried. Korean white pine (*Pinus koraiensis* S. et Z.) is the main plantation species of South Korea and occupied approximately 10% of coniferous forest. To make it nano-scale fibers the steam and ozone treatments are used that can be helpful in the aforementioned mechanical fibrillation methods due to the effect of loosening cell wall structure. The obtained fibers were reinforced using polyurethane(UWS-145) polymers and investigated the morphological, physicochemical, and mechanical properties in the study.

Keywords: Nanofiber; nanocomposite; steam; ozone; Korean white pine

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Physical and Mechanical Properties of Bamboo Oriented Strand Board Made from Steamed Pretreated Bamboo Strands under Various Bamboo Species and Resin Content

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ABSTRACT

Oriented Strand Board (OSB) is a structural panel product that can be made from wood and other lignocellulosic materials i.e., bamboo. The objectives of this research were to develop high performance of bamboo oriented strand board (BOSB) prepared from steam pretreated bamboo strands under various bamboo species and resin content. Strands were prepared from Betung bamboo (*Dendrocalamus asper* (Schult.F) Backer ex. Heyne), Andong bamboo (*Gigantochloa verticillata* (Willd.) Munro), and Ampel bamboo (*Bambusa vulgaris* Schrader ex Wendland). Prior mixing with adhesive, the strands were steamed using autoclave at a temperature of 126° C, 1.4 kg/cm² pressure for 1 hour. The strands were then dried in oven at a temperature of 60 °C to reach the moisture content (MC) around 5%. Commercial phenol formaldehyde (PF) resin was used in the amount of 6%, 8% and 10%. Paraffin was used in an amount of 1%. The physical properties (i.e., density, MC, water absorption (WA), and thickness swelling (TS)), mechanical properties (i.e., modulus of elasticity static (MOEs), modulus of rupture (MOR), internal bond (IB), and screw holding power (SHP)) were evaluated. Nondestructive test of MOE dynamic (MOEd) parameter was also evaluated. The results were also compared with CSA 0437.0 (grade O-2) standard for OSB. Physical and mechanical properties of BOSB were much affected by bamboo species and resin content. BOSB prepared from Betung bamboo strand showed better physical and mechanical properties compared to BOSB prepared from Andong and Ampel bamboos. The higher resin content applied resulted in the better performance of BOSB. Based on nondestructive testing (i.e., stress waves) the best relationship of MOR-MOEd and MOEs-MOEd (95% confidence level) were obtained from parallel and perpendicular to the grain direction, respectively. Based on resin consumption consideration, BOSB prepared from steamed Betung bamboo strands with 10% PF resin content based on perpendicular to the fiber surface and based for parallel to the fiber surface were BOSB Andong and Ampel strands with 10% PF resin content can be applied to produce BOSB with excellent physical and mechanical properties. All the parameters measured met the requirement of CSA 0437.0 standard for grade O-2 panels.

Keywords: Bamboo oriented strand board, Betung bamboo, Andong bamboo, Ampel bamboo, steam, phenol formaldehyde.

An Overview of Microfibrillated Cellulose Reinforced Polylactic Acid Composites

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ABSTRACT

The rising oil prices and a growing concern towards environmental issues have motivated many scientists to develop product from bio-based materials. Recently, cellulose nanofibers-reinforced bioplastic has been studied with the aim of developing sustainable 'green composites'. Among bioplastics, polylactic acid (PLA) has a great potential to replace petroleum-based plastics because of its high stiffness and strength. PLA is a versatile polymer made from renewable agricultural raw materials that are fermented to lactic acid. However, the main drawback of semi-crystalline type of PLA for industrial application is the longer injection molding cycles compared with conventional polymers such as polypropylene (PP). This paper provides an overview of recent progress made in the area of microfibrillated cellulose (MFC) reinforced PLA composites which consisted of evaluating the effect of MFC reinforcement on the thermal and mechanical properties of PLA, investigating the thermo-mechanical properties of MFC-reinforced PLA having different degree of crystallinity, and accelerating the injection molding cycle of PLA by the synergetic effect of MFC and nucleating agent.

Keywords: Microfibrillated cellulose, PLA, biocomposite, thermo-mechanical properties

Properties of OSB Made from Several Bamboo Species under Various Resin Content with and without Steamed Treatment

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ABSTRACT

The objective of this research was to evaluate the effect of steam treatment and resin content on physical and mechanical properties of bamboo oriented strand board (BOSB) made from Betung bamboo (*Dendrocalamus asper* (Schult.F) Backer ex.Heyne), Andong bamboo (*Gigantochloa verticillata* (Willd.) Munro), and Ampel bamboo (*Bambusa vulgaris* Schrad.Ex Wendl). Three-layered BOSBs bonded with 6%, 8% and 10% phenol formaldehyde (PF) resin with the core layer orientation perpendicular to the face and back layers. The densities of *D. asper*, *G. verticillata*, and *B. vulgaris* bamboos were 0.49, 0.68, and 0.58 g.cm⁻³, respectively. The strands were steamed at 126° C at 1.4 kg.cm⁻² pressure for 1 hour and then air-dried. The strand ratio for face, core, and back was 1:1:1. Paraffin was added in amount of 1%. Target density of BOSB was 0.70 g.cm⁻³. The results indicated that the dimensional stability (i.e., thickness swelling) and strength (i.e., modulus of elasticity/MOE, modulus of rupture/MOR both parallel and perpendicular to the grain direction and internal bond/IB) of BOSB were much affected by the resin content and steamed treatment. BOSB prepared from steamed treatment bamboo strands were much better than BOSB prepared from untreated bamboo strands. The higher the resin content the better the physical and mechanical properties of BOSB. Almost all parameters measured of BOSB made from *D. asper*, *G. verticillata* and *B. vulgaris* bamboos strands with or without steamed treatment bonded with 6 % PF resin except the value of MOE which is perpendicular to the grain direction met the requirement of CSA 0437.0 (Grade 0-2) standard. All parameters measured of BOSB made from steamed strands of *D. asper* bamboo bonded with 8 % PF resin and BOSB made from steamed strands of *G. verticillata* and *B. vulgaris* bamboos strands bonded with 10 % PF resin exceeded the requirement of CSA 0437.0 (Grade 0-2) standard.

Keywords: Bamboo oriented strand board (BOSB), Betung bamboo, Andong bamboo, Ampel bamboo, steamed treatment, resin content

Optimization of Adhesives Mixture between Melamine Formaldehyde (MF) and Water Based Polymer Isocyanate (WBPI) for Composite Board Made from Wood Waste and Corrugating Carton

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ABSTRACT

This research is expected to create high quality composite boards made from waste wood and corrugated carton which can be used as a reference for the development of composite boards production. The objective of this research is to determine the optimum adhesives mixture between MF and WBPI. The materials used in this research was wood waste in the form of wafers, waste corrugated carton, MF and WBPI. The treatment was MF : WBPI ratios of 1:0, 1:1, 1:2, 1:3, 1:4 and 0:1. The adhesive content was 10% based on particle and corrugated carton oven dry weight. The composite boards consisted of three layers, face and back layers of corrugated carton and core layer of wood particle. The target density was 0.7 g/cm³. The boards were hand formed and hot pressed at 170°C for 12 minutes. The pressure was 25 kgf/cm². Totally, there were 30 composite boards produced and tested according to JIS Standard A 5908 – 2003. Based on the research results, it can be concluded that: (1) Composite boards bonded by MF and WBPI with 4:1 ratio resulted higher quality compared to those of others. (2) The produced composite boards can be used as a reference for the development composite board made from wood waste and corrugated carton in pilot project scale. (3) Physical and mechanical properties of the composite boards except thickness swelling fulfill JIS Standard A 5908-2003.

Keywords: Composite board, melamine formaldehyde, water based polymer isocyanate, wood waste, corrugating carton.

Determination of Optimum Paraffin Content In Composite Board Production Made of Wood Waste and Corrugated Carton

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ABSTRACT

Previous researches showed that the utilization of paraffin improved significantly the composite boards dimensional stability. The purpose of this research is to determine the optimum levels of paraffin content in composite boards production made of wood and corrugated carton. The composite boards were produced using wood waste consisting of various species, three layers corrugated carton for face and back layers of the composite boards. The wood waste was converted to wafer using a disk flaker machine and dried to 2-5% of moisture content. The corrugated carton was cut to a size of 30 cm x 30 cm. The composite boards were bonded by WBPI:MF adhesives in the 1:4 ratio at 10% level based on particle and corrugated carton oven dry weight. The composite boards were hand formed and hot pressed with a specific pressure of 25 kgf/cm² for 12 minutes. The paraffin levels were 0% (control), 2%, 4%, 6%, and 8% based on particle and corrugated carton oven dry weight. The composite boards size was 30 cm x 30 cm x 1 cm with 0.7 g/cm³ target density. The composite boards were tested according to JIS A 5908:2003 standard. The research results show that: (1) The composite boards properties classified as high quality according to JIS A 5908 – 2003; (2) Utilization of paraffin influence the dimensional stability of the composite boards; (3) The optimum paraffin level was 6%; (4) Moisture content of the produced composite boards were lower compared to the ordinary composite boards.

Keywords: Wood waste, corrugated board waste, paraffin levels, composite board.

Wet/Dry Cycling and Fiber Loading Effect on Mechanical Properties of Cement Composites Mixed by Kraft Pulp - Fiber of Sengon (*Paraserianthes falcataria*) Wood

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ABSTRACT

Pulp fiber-cement composites have found practical application in recent decades in the commercial market to replace the hazardous asbestos fibers. For exterior applications, the effects of cyclical wetting and drying on cement composite performance must be studied. The research objective was to investigate the influence of fiber loading on the cement composites prior to and after wet/dry cycling treatment. Kraft pulp loading was consisted of 3, 5, and 7% of volume fraction of composite. The target density of composites produced was 1.5 g/cm³, and water to cement ratio of 0.50 based on weight. Cement composites were formed into 30 cm x 2.5 cm x 2.5 cm mold (length x width x thickness). After 24 hours, the samples were opened from the mold. There were two curing system of samples. Firstly, the samples were placed in a water tank at 18 ± 2 °C for 28 days and then tested for mechanical properties. Secondly, the samples were placed in the same condition and followed by wet/dry cycling for 6 times and then tested for the mechanical properties. Mechanical characteristics were observed according to ASTM C293-94 for flexural strength and ASTM C116-90 for compression strength and then tested by Universal Testing Machine (UTM). The addition of pulp fiber and wet/dry cycling gave linear effect significantly for mechanical properties of composites, the higher fiber loading on the cement composites, the lower flexural and their compression strength. In addition, the wet/dry cycling treatment lowered the flexural strength, but not on the compression strength of composites.

Keywords: Fiber loading, kraft pulp of sengon wood, cement composites, wet/dry cycling, flexural and compression strength

Characteristics of Bamboo Particleboard Bonded with Citric Acid

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ABSTRACT

Reducing the consumption of synthetic resin adhesives becomes one of the important points, considering the global environment. This research was designed to investigate the possibility of using citric acid as an adhesive on bamboo particleboard. The effect of citric acid concentration and pressing condition on the board's properties were then analyzed. Bamboo particles were used as raw materials. The concentration of citric acid used in this research were 0% (binderlessboard), 10%, and 20%. Bamboo particleboards were then made using hot pressing system at temperature of 200°C and 220°C for 10 and 15 minutes. The physical and mechanical properties of boards were then evaluated based on JIS (Japanese Industrial Standard) A 5908. The preliminary results showed that the addition of citric acid could increase the properties of bamboo particleboards.

Keywords: Bamboo, citric acid, binderlessboard, natural adhesive, particle

Physical and Mechanical Properties of Cross Laminated Timber Made of Jabon (*Anthocephalus cadamba*) and Afrika (*Maesopsis eminii*) : Influence of Wood Species and Level of Adhesives

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ABSTRACT

The objectives of this research were to determine and to compare the physical and mechanical properties of CLT made of two wood species, namely; jabon (*Anthocephalus cadamba* Miq.) and afrikan wood (*Maesopsis eminii* Engl.). There were three levels of isocyanate (IC) adhesives, 280 g/m², 310g/m² and 340 g/m². Pressed at 12 kg/cm² for 3 hours at room temperature. ASTM D 143 (2005) was used as standard for physical and mechanical properties of the CLT and *Japanese Agricultural Standard for Glued Laminated Timber Notification* No. 234 (2003) for delamination test of the CLT. The result of this study showed that level of adhesives improved the physical and mechanical properties of CLT.

Keywords: Physical-mechanical properties, jabon, Afrika wood, Cross Laaminated Timber (CLT)

Effects of Pulping Variables and Fiber Loading on the Properties of Oil Palm Frond-Impact Polypropylene Composites

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ABSTRACT

To enhance the use of byproducts from the oil palm industry, a study on the manufacturing of oil palm frond (OPF) pulped-impact polypropylene (iPP) composites was conducted. Mechanical and chemical process were used to obtain the OPF pulps, and each was incorporated into the compound by 20% and 30% wt. Maleic-anhydride-modified PP (MAPP) of 5% wt was attempted into the compound. The iPP, MAPP and OPF pulp were blended using kneader. The effects of OPF pulp types on the tensile, flexural and impact properties of iPP composites were investigated. Studies on the morphological properties of iPP composites were also conducted. The iPP-bleached OPF pulp composite showed good results in comparison with other composites. The changes in the mechanical and morphological properties with different fiber loading were discussed.

Keywords: Impact polypropylene, maleic-anhydride-modified PP, OPF pulped, iPP composites, mechanical properties

Effect of Annealing Treatment to the Mechanical Properties of Kenaf Polypropylene Composites

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ABSTRACT

Natural fibers composite was manufactured from kenaf pulp fiber and polypropylene (PP). Single fibers (pulp) shown improves fiber dispersion in the PP matrix; however it decreases the toughness of composite. Therefore the addition of elastomer, such as EPDM (ethylene propylene diene monomer) rubber, could decrease the modulus of matrix which has improved the toughness of composites. Furthermore, the decreasing of the modulus being solved in this study by conducted the composites in the annealing system. Composites were annealed at 100°, 130° and 150°C for 20 hours. The mechanical properties such as flexural strength, tensile strength and its modulus were evaluated. The surface failure of composites was analyzed using FE-SEM (Field Emission-Scanning Electron Microscopy). It is reported that annealing system could increase the modulus of the composites.

Keywords: Kenaf pulp fibers, polypropylene, annealing, composite

Ozone Treatment of Spent Media from *Auricularia polytricha* Cultivation as a Pretreatment for Enzymatic Saccharification and Subsequent Ethanol Production

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ABSTRACT

Spent medium (SM) after mushroom cultivation is one of a potential materials for the fermentable sugar and ethanol production. However, the residual lignin content in SM is still high. Thus, the residual lignin in SM should be removed for increasing the yield of fermentable sugars by the enzymatic saccharification. Ozone is known as the powerful oxidizing reagent and can degrade lignin. In the present study, therefore, ozone was applied to degrade the residual lignin in SM after the cultivation of *Auricularia polytricha*. Fresh media (FM) which consisted of wood meal (*Falcataria moluccana*, *Tectona grandis*, and *Shorea* sp.), rice bran, and CaCO₃, and SM after 130-day cultivation of *A. polytricha* were treated with ozone at 6% concentration for 1 hour. FM, SM, FM after ozonization (FMO), and SM after ozonization (SMO) were used for chemical analysis (ethanol-toluene extracts, Klason lignin, holocellulose, and α -cellulose) and enzymatic saccharification. Enzymatic saccharification was done by using Meicelase (Meiji Seika, Tokyo, Japan) for 48 hour at 40°C. The amounts of reducing sugars were determined by the DNS method. The monosaccharides were quantified using a high-performance anion-exchange chromatograph (DX-500, Dionex, U.S.A.). Hydrolyzates from SM and SMO were used for ethanol fermentation by *Saccharomyces cerevisiae* NBRC 0216 for 48 h at 30°C. The amount of ethanol was determined by gas chromatography (HP 6890 series GC system, Agilent, U.S.A.). After ozone treatment, lignin content of SM (5.5 to 21.9%) decreased to 1.3 – 8.7% in SMO. The decreased ratio was higher than that of cellulose (-3.9 to 13.4%). Hydrolysis weight decrease and reducing sugar content increased from SM to SMO. There were significant negative correlations between lignin content and hydrolysis weight decrease or reducing sugar yield. The SMO of *Shorea* sp. gave the highest glucose and ethanol yield, 15.5g/100g dry biomass and 13.2g/100g dry biomass, respectively. Ozone treatment could increase the reducing sugar (118.3 to 126%) and ethanol yields (40 to 121.4%) compared to SM.

Keywords: Spent medium, ozone treatment, enzymatic saccharification, bio-ethanol.

Synthesis and Characterization of Xylan and Glucomannan Ester Derivatives

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ABSTRACT

Xylan is the most abundant hemicellulose with mainly beta-(1→4) linked xylose and it gains increasing importance for the basis of new biopolymeric materials. Xylan was esterified with different acyl groups and products were analyzed by NMR, DSC, TG, GPC and WAXD analyses. Films and nanofibers can be processed and esterification of xylan resulted to an improvement in thermal stability. DSC results revealed that the crystallization temperature of PLLA shifted to a lower temperature when blended with 1% xylan ester. Spherulites of xylan ester/PLLA grown after isothermal crystallization were observed to be smaller and denser compared to that of PLLA. Furthermore, we isolated glucomannan from konjak and succeeded to obtain thermoformable material from glucomannan ester derivatives.

Keywords: Xylan, glucomannan, ester derivatives, films, bio-based crystallization agent

Antimicroorganism Potential of Crude Saponin Isolated from *Lepisanthes amoena*

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ABSTRACT

There are many plants that have been reported to possess antibacterial activity. Among them are some from Sapindaceae family. Sapindaceae family has 2,215 species in 147 genera. Some plants from this family, such as *Sapindus mukorossi*, *Dodonaea viscosa*, *Allophylus africanus*, and *Paullinia cupana* have been used traditionally as oral health care. One of the species in this family that is found in East Kalimantan is *Lepisanthes amoena*. In this study, the antimicroorganism of crude saponin isolated from *Lepisanthes amoena* extracts towards mutan streptococci (*Streptococcus mutans* and *Streptococcus sobrinus*) growth were determined. The results showed that *Lepisanthes amoena* extracts could inhibit the growth of mutan streptococci. The expression level of inhibitory effect on the growth of bacteria was reduced by increasing the concentration of extract. This result indicates that saponin from *Lepisanthes amoena* extract may prove to be a useful and potential role in controlling dental plaque development.

Keywords: *Lepisanthes amoena*, growth, streptococci

Antidiabetic Activity of *Toona sinensis* Bark Extract in Alloxan-induced Diabetic Rats

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ABSTRACT

Toona sinensis is a plant which have some medical effects. Its leaf and bark have been reported to have antioxidant effects, using in vivo and in vitro tests. The aim of this study was to know the antidiabetic activity of 70% ethanol extract of *T. sinensis* bark in alloxan-induced diabetic Sprague-Dawley rats. The bark meal was extracted with 70% ethanol in water. The antidiabetic activity of the extract at doses of 150 mg/kg rat body weight (BW) and 300 mg/kg BW was compared to that of the standard glibenclamide (at the dose of 2.5 mg/kg BW). The blood glucose levels were measured using an electronic glucometer. The results showed that extraction of *T. sinensis* bark using 70% methanol in water yielded 4.8% of dry extract. Phytochemical test of the extract showed the presence of alkaloids, flavonoids, phenolics, saponins, and tannins. The analysis of blood glucose level showed that the dose of 150 mg/kg BW bark extract treatment gave much higher blood glucose level lowering effect, which was 70.82%, compared to that of glibenclamide and the dose of 300 mg/kg BW with 68.92% and 51.96% of the blood glucose level lowering effect, respectively.

Keywords: *Toona sinensis*, bark extract, antidiabetic activity, alloxan-induced diabetic rats

The Resistance of Bamboo Oriented Strand Board Made from Mixing Bamboo Strands against Termites and Powder Post Beetle Attacked

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ABSTRACT

The objective of this research was to evaluate the resistance of bamboo oriented strand board (BOSB) made from mixing bamboo strands against subterranean termite (*Coptotermes curvignathus* Holmgren), dry wood termite (*Cryptotermes cynocephalus* Light) and powder post beetle attacked. Three layered OSBs were produced. The strand composition for face, core, and back was 25%, 50% and 25%, respectively. Three (3) bamboos species were used namely Betung bamboo (*Dendrocalamus asper* Schult.F) Backer ex. Heyne) (B), Andong bamboo (*Gigantochloa verticillata* (Willd.) Munro) (G) and Ampel bamboo (*Bambusa vulgaris* Schrad. Ex Wendl.) (L). Nine (9) combinations of BOSBs were prepared from these bamboos, namely 1) B/B/B; 2) B/G/B; 3) B/L/B; 4) G/G/G; 5) G/B/G; 6) G/L/G; 7) L/L/L; 8) L/B/L; and 9) L/G/L. Commercial MDI adhesive was used to bond the strands to BOSB in amount of 5%. Paraffin was added in amount of 1%. The resistances of BOSBs against *C. curvignathus* and *C. cynocephalus* termites were evaluated in accordance to Indonesia standard (SNI 01. 7207-2006). The resistance of BOSBs against powder post beetles was evaluated using semi-field test. The results indicated that the resistance of BOSBs against *C. curvignathus* increased 2 times compared to the solid bamboo. All the bamboo solid used belongs to "poor" (level 4) and after converted into BOSBs the resistance increased to become "resistance" (level 2). Conversely, the resistance of BOSBs against *C. cynocephalus* attacked decreased 2 times compared to the solid bamboo. All the bamboo solid used belongs to "very resistance" (level 1) and after converted into BOSBs the resistance lowered to become "moderately resistance" (level 3). Whether BOSBs prepared from single species bamboo or mixing bamboo strands had similar resistance to *C. curvignathus* and *C. cynocephalus* attacked. The species of powder post beetle attacked the BOSBs was *Anobium* sp. The resistance of solid bamboo against *Anobium* sp was varied. The average weight loss of *D. asper*, *G. verticillata* and *B. vulgaris* bamboos were 3.19%, 17.39% and 25.36%, respectively. The average weight losses of BOSBs were in the range of 2.85-3.87%. *G. verticillata* and *B. vulgaris* bamboos belong to very susceptible to *Anobium* sp attacked. After converted into BOSBs their resistances were increased around 5 times. The BOSBs prepared from single species bamboo or mixing bamboo strands had similar resistance to *Anobium* sp.

Keywords: Bamboo oriented strand board (BOSB), Bamboo, Subterranean termite, drywood termite, powder post beetles

Resistance of Three Wood Species from Community Forest to Subterranean Termite Attack

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ABSTRACT

Wood from community forest usually has lower resistant to termite attack than wood from natural forest because it has a lot of juvenile wood. To lengthen the service life, preservative is needed for its preservation process. The purpose of this study is to investigate the resistant of three wood species from community forest, namely rubber-wood (*Hevea brasiliensis*), mahogany (*Swietenia macrophylla*) and mindi (*Melia azedarach*), which were preserved with boron (boric acid 45% and boraks pentahedrate 54%) with concentration of 1.5%, 3.0% and 4.5% BAE. Preservation process consisted of two methods namely 10 days immersion, and 2 hours steaming following 2 days immersion, and for comparison purpose the control wood without treatment was included. The research was conducted in laboratory according to Indonesian standard and the grave yard as a field referring to Hadi et al (2012). The results showed that both preservation methods were effective in increasing wood resistant to subterranean termite for laboratory test. Rubber-wood with has resistance class V increased to be class II with 4.5% concentration, mahogany from class III increased to be class I with 4.5% concentration, and for mindi from class IV increased to be class I with 3% concentration or more. In the field test preservation with boron was not effective, so boron is assumed for interior goods such furniture, handycraft, and housing equipment.

Resistance of Composite Polymer Chitosan-Microfibrils of Oil Palm Empty Fruit Bunches Against Subterranean Termites

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ABSTRACT

Because deforestation is getting worse today, many do researches on alternative materials to substitute wood. Empty bunches of oil palm was one potential alternative materials and it is easily obtained. Environmental issues also concern the world so that the materials used to make composite boards prioritizes environmentally friendly materials. Chitosan is a natural polymer which is widely available in nature and potentially substitutes polypropylene in the manufacture of composite boards. The purpose of this research is to increase the durability of composite boards with chitosan as a substitution polypropylene. Type of board that used in this study was a thermoplastic composite board made from empty bunches of oil palm microfibrils and polypropylene. The natural polymer chitosan is used as a substitution material of polypropylene with content 0%, 20%, and 40% by weight of the polypropylene used in the manufacture of composite board. The density of composite boards tested was 1 g / cm³. The test refers to JIS K 1571-2004. With a fairly high density that is 1 g / cm³ the termites will be difficult to consume composite board and from the results of tested for 3 weeks it is known that the average weight loss of sample ranged from 5.91% -6.62%. Based on the SNI 01.7202-2006 composite board included in the class II is resistant to termite attack. The test results 77.33% mortality to content 0% chitosan; 92% to 20% chitosan content, and 97.33% for the chitosan content of 40%. For test results obtained feeding rate 44.92; 51.17; 52.62 (mg / head / day) in a row for chitosan content 0%, 20% and 40%. Of the three tests, it can be concluded that chitosan was able to substitute polypropylene in the manufacture of the composite board and the product have a high level of the durability.

Keywords: Composites board, polypropilen, chitosan, subteranian termites

Green Aromatics from Catalytic Fast Pyrolysis of Tropical Fast Growing Meranti Biomass

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ABSTRACT

Studies on the decomposition of tropical fast growing meranti biomass to produce aromatic compounds through catalytic and non-catalytic fast and slow pyrolysis were performed by pyrolytic-gas chromatography/mass spectroscopy (Py-GC/MS) and transmission electron microscope (TEM) - electron energy-loss spectroscopy (EELS). Py-GC/MS and TEM-EELS analysis shown that the fast pyrolysis increased the decomposition of meranti biomass, in which the presence of ZSM-5 catalyst, the liquid products from wood decomposition were then diffused into the pore of ZSM-5 catalyst to form aromatics which was estimated as benzene, toluene, styrene, naphthalenes and indanes.

Production of Bioethanol from Jabon Wood: Chemical Component and Pulping Properties Characterization

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ABSTRACT

Jabon (*Antochepalus cadamba*) is a fast growing species possibly having versatile utilities. Possible utilization of the wood includes cellulose-based bioethanol, pulp and paper products and other form of biofuel such as wood pellet and wood briquette. Present work is intended to evaluate the pulping properties of the wood along with the evaluation of the physical and optical properties of its pulp. The wood was converted into pulp by the use of kraft pulping processes with various levels of chemical charge and H-factor. Due to its low density, jabon wood required a mild pulping condition to result in satisfying pulp properties. Further works is required to determine the most appropriate bleaching conditions of the currently resulting pulp.

Keywords: *Antochepalus cadamba*, kraft pulping, acid soluble lignin, pulp properties.

Chemical Alteration of *Musa acuminata* var. *Truscataby* White Rot Fungi

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ABSTRACT

The ability of fungi to degrade lignocellulosic materials is due to their highly efficient enzymatic system. However, many of these fungi have the ability to not only depolymerize and metabolize lignin but also to degrade cellulose and hemicellulose. This study aims to investigate the differences between white rot fungi species, namely, *Pycnoporussanguineus*, *Oxyporuslatemarginatus*, *Coriolusversicolor*, and *Rigidoporusvinctus*, in chemical constituent changes on the pseudostem of *Musa accuminata* var. *truscata*. The sterilized banana pseudostem chips were inoculated with each fungus separately and incubated for 1, 2 and 4 weeks. *P. sanguineus* was found to be the best fungus among the three species because it degraded mainly on lignin and extractives but less on holocellulose and alpha-cellulose. On the other hand, *O. latemarginatus* was found to degrade all the chemical contents, while *C. versicolor* and *R. vinctus* appeared less efficient in banana degradation. It appeared that the suitable pre-treatment duration was two weeks, which was due to the lower amounts of degraded holocellulose and alpha-cellulose.

Keywords: *Pycnoporussanguineus*, pre-treatment, *Musa acuminata* var. *truscata*, chemical alteration, *Oxyporuslatemarginatus*, *Coriolusversicolor*

A Review on the Utilization of Plant Extractives for Medicinal Products

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ABSTRACT

Extractives refer to particular substances in wood, which are easily soluble in various organic solvents as well as in cold water. The extractive contents in wood are small only about 1 – 10%, and vary with its position in the host tree. Indonesia as one of the tropical countries is endowed with biodiversity of its vegetations. Exploration conducted at several Indonesia's forest regions has revealed that there are more than 150 plant species that yield extractives, which further can be utilized as medicinal raw materials dealing with human health. This paper describes the characteristics and uses of various extractives yielded by 15 plant species, expectedly beneficial as medicinal raw materials or products for human health.

Keywords: Plant extractives, plant species, characteristics and uses, medicinal products

Soft Rot Decay of Acetylated Rattan (*Calamus manan*)

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ABSTRACT

The resistance of acetylated rattan against soft rot and other soil inhabiting micro-organisms was compared to beech and Scots pine woods. *Calamus manan* grown under rubber tree canopy aged 10 and 13 years was acetylated to different levels by reaction times (0.25 to 30 hour) and was tested to soft rot decay for 32 weeks. The untreated rattan turned to dark colour and end-tapered but the acetylated rattan was still intact. Acetylated rattan aged 10 and 13 years at decay protection thresholds of 15.4 % and 16.2 % WGs (weight gain) were fully protected, as shown by both weight loss and strength criteria. The static bending properties of untreated rattan decayed by soft rot were significantly lower than acetylated rattan.

Keywords: Acetylation, cultivated, rattan, soft rot, static bending properties

Resistance of Boron-treated Bamboos Using a Modified Boucheri Method against Beetles

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ABSTRACT

This study was aimed at evaluating the resistance of bamboos against beetle attack after boron treatment using a modified Boucheri method, being called MOBURI. The MOBURI method can employ gradual pressures using apparatus equipped with adjustable nozzles. Four commercial tropical bamboos species (*Gigantochloa atter*, *Dendrocalamus asper*, *Bambusa vulgaris*, and *Schizostachyum brachycladum*) with the moisture content of $\geq 30\%$ and the size of 12-14 cm in diameter and 4 m in length were prepared for treatment. The bamboo was impregnated with commercial boron in three different concentrations based on its commercial solvent (5, 7.5 and 10%). Samples were treated using the modified Boucheri under the pressure of 5 kg/cm² for a time period giving the preservative solution to be evenly distributed along the length of the bamboo. Following the treatment, the retention and distribution of boron from the base to the top part of bamboo were determined using atomic absorption spectrophotometer (AAS). The resistance of treated bamboo against beetles was then evaluated using *Lyctus Brunneus* in laboratory test. The results showed that the effective time for even distribution of boron from the base to the top part of bamboo ranged between 51 and 139 minutes, depending on bamboo species. The result indicates that the MOBURI method is effective to distribute the boron preservative along the length of treated bamboo. The impregnation of bamboo with 5% boron solution using the modified method resulted in the best performance against *Lyctus Brunneus* beetle attacks.

Keywords: Bamboo, Boron, Preservation, Modified Bouchery, Beetle

Termite Resistance of Medium Density Fiberboard Produce from Renewable Biomass of Pineapple Leaf Fiber

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ABSTRACT

The development of composite fiberboards made from Pineapple leaf fiber (*Ananas comosus*) and their resistance to termite attack has been investigated. Two different types of boards (uni-oriented and cross-oriented) consisting of three layers were prepared using a combination of low molecular weight and high molecular weight phenol-formaldehyde (PF) resin for impregnation and adhesion purposes. Additional boards with the same structure were prepared using high molecular weight PF resin only. Wood specimens were then subjected to laboratory termite resistance tests using the subterranean termites, *Coptotermes formosanus* Shiraki according to the JIS K 1571 standard method (JIS, 2004). Differences in the termite resistance between the board types were caused by the presence of the low molecular weight PF resin for the impregnation of the fibers, however, fiber orientation had no effect on termite resistance of the specimens.

Keywords: Pineapple leaf fiber, Medium Density Fiberboard (MDF), Phenol resin, Termite resistance

Deterioration of Dowel Bearing Properties of Timber due to Fungal Attacks

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ABSTRACT

The effect of wood decay on dowel bearing properties of *Melia azedarach*, *Swietenia mahagoni* and *Pterospermum javanicum* was investigated in this study. Wood decay due to fungal attacks, *Schizophyllum commune* Fr, was simulated for one year and dowel bearing properties evaluation was conducted at three time spots: initial, six and twelve months. A half-hole test configuration was implemented on the wood bearing specimens and decay was initiated only at contact area between wood specimen and steel dowel of 12 mm in diameter, other surfaces of the wood specimens were sealed. The results showed that decay caused an increase of moisture content and decrease of oven-dry weight of the wood specimens. After one year decay period the greatest mass loss or decrease of oven-dry weight was found in *Melia azedarach* (7.86%) followed by *Swietenia mahagoni* (5.90%) and *Pterospermum javanicum* (2.25%). Wood decay deteriorated the bearing strength of those three wood species. Average decrease of bearing strength after six and twelve months of decay period was 24% and 40% (for *Melia azedarach*); 18% and 38% (for *Swietenia mahagoni*); 10% and 29% (for *Pterospermum javanicum*). In addition, bearing stiffness of the wood specimens decreased after experiencing decay though they are nearly the same after six and twelve months of decay period.

Keywords: bearing properties, decay, fungal attacks, mass loss, timber

Natural Resistance of Red Meranti (*Shorea* sp.) from Natural Forest and Plantation Forest against Subterranean Termite (*Coptotermes curvignathus* Holmgren)

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ABSTRACT

The use of red meranti to supply the needs of human life is not matched by the availability of timber supply from natural forest. Changes in timber supply from natural forest to plantation forest provide changes to the timber produced. Timber produced from plantation forest have the characteristics of fast growing, short rotation, small diameter, has a low mechanical physical properties, and low durability. Therefore, it is necessary to study the differences in the natural resistance of red meranti (*Shorea* sp.) from natural forests and plantation forest against subterranean termite (*Coptotermes curvignathus* Holmgren). This study uses red meranti from natural forest and plantation forest in West Kalimantan, with diameters 30 cm. Sampling is based on the origin of wood (natural forest and plantation forest), position of the trunk (top trunk and bottom trunk), and wood section (heartwood and sapwood). Tests conducted by the method of force feeding test against subterranean termite with reference to JIS K 1571-2004 standard. Natural resistance of wood can be determined from the percentage of sample weight loss and termite mortality. The results showed that the origin of wood and wood section affected significantly weight loss and termite mortality. While the position of the trunk does not affect sample weight loss and termite mortality. Red meranti from natural forest has higher natural resistance than the red meranti from plantation forest against subterranean termite. Furthermore, heartwood has higher natural resistance than the sapwood.

Keywords: Red meranti, natural forest, plantation forest, natural resistance, subterranean termite

Response Surface Analysis of *Polyalthia longifolia* Shonn. Pulp Using Ethanol Organosolv Process

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ABSTRACT

Ethanol pulping as a potential substitute for kraft and other conventional chemical process that can reduce environmental problems related to sulfur emission and it had been proven effective on several timber species. The objective of this research is to observe the optimal pulping process of *Polyalthia longifolia* Shonn. using ethanol organosolv pulping. Optimization of pulping process was performed by using the second order polynomial design in response surface analysis method with SAS 9.1. version. Factor can be used in this experiment using ethanol concentration (55, 65, 75%; v/w); pulping temperature (100, 115, 130°C); pulping time (60, 90, 120 minute); concentration of acid catalyst H₂SO₄ (0.9, 1.1, 1.3%; v/w); and ratio of wood and liquor (1:4, 1:6, 1:8; v/w). The parameters to be observed are screen yield, kappa number (SNI-14-0494-1989-A), ethanol consumption, tensile index, burst index, tear index (SNI-14-0489-1989-A) and brightness (%ISO). Optimal process was achieved at optimal condition that five parameters collaborated and detected by response surface analysis diagram. The optimum value of ethanol concentration, pulping temperature, pulping time, catalyst concentration and wood to liquor ratio were 75%, 115°C, 90 minute, 1.1%, 1:6, respectively. This process had critical point where the pulping process didn't provide good pulp, especially yield and its properties. The critical point of ethanol concentration, pulping temperature, pulping time, concentration of acid catalyst and wood to liquor ratio were 65%, 107.5°C, 105 minute, 1.15% and 1:5.5, respectively.

Keywords: Ethanol organosolv, *Polyalthia longifolia* Shonn., response surface analysis, optimal process, critical point

Natural Resistance of Red Meranti (*Shorea Sp.*) from Natural and Plantation Forest Against White Rot and Brown Rot Fungi

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ABSTRACT

Red meranti (*Shorea sp.*) supplies from natural forests is decreasing, so nowadays many plantations are established. There is suspicion if natural resistance of red meranti against white rot fungi and brown rot fungi between natural forests and plantations is different. The purpose of this study was to determine the natural resistance differences of red meranti from natural forests and forest plantations, the position of top and bottom trunks, heartwood and sapwood parts as well against white rot and brown rot fungi. Red meranti from natural and plantation forests were divided into two trunks position that is top and bottom of trunks then trunks were cutted based on its heartwood and sapwood parts. Wood samples were tested using the decay method based on JIS 1571 (2004) by using *Trametes versicolor* for white rot fungi and *Fomitopsis palustris* for brown rot fungi. The results showed that color changes of wood samples before and after testing is very visible. Color of wood samples decayed by *Trametes versicolor* became brighter while *Fomitopsis palustris* made color of wood samples darker. The results of Anova using a 95% probability, indicating that there are highly significant different between the position of trunks, wood parts, and the interaction between trunks position vs. wood parts vs. woods origin toward the weight loss percentage of wood samples and there is a significant different between wood origin toward the weight loss percentage of wood samples. Red meranti wood samples from natural forest are more resistant than plantation against white rot and brown rot fungi. Top of the trunks position and the sapwood parts are more resistant against white rot and brown rot fungi compared to its bottom of the trunks and its heartwood. Results also showed that the weight loss percentage of a wood samples caused by white rot fungi is greater than brown rot fungi.

Keywords: Natural resistance, red meranti (*Shorea sp.*), white rot, brown rot, natural forest, plantation.

Resistance of Three Wood Species from Community Forest Preserved with Boron Compounds Againsts Subterranean Termite Attack

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ABSTRACT

Many people used juvenile woods to fulfill their needs, so they did not get good quality woods, and the consequence is a short service life. One of the ways of increasing the service life is the preservation process. The purpose of this research was to determine the resistance of three wood species from community forest preserved with boron compounds (boric acid 45% + borax 54%) with a concentration of 1.5%, 3%, and 4.5% BAE. Wood species used were Rubber wood (*Hevea brasiliensis*), Teak (*Tectona grandis*) and Kihujan (*Samanea saman*) and preservation used is boron compounds (boric acid 45% + borax 54%) with a concentration of 1.5%, 3%, and 4.5% BAE. Preservation methods used were cold soaked for 10 days, steaming 2 hours following by cold soak 2 days and vacuum. This research was conducted in the laboratory regarding to Indonesian standard and the field test regarding to Hadi *et al.* (2010). The result showed that both preservation methods were effective increasing wood resistant to subterranean termite for laboratory test. The preservation methods used steaming 2 hours following by cold soak 2 days was the best method. In the field test, preservation for rubber wood with Boron was not effective, so boron is assumed for interior goods such as furniture, handicraft, and housing equipment.

Keywords: Laboratory and field tests, subterranean termite, boron compound, preservation.

Optimalization for Paper Product Case Study at PT. Pindo Deli Pulp and Paper Unit Paper Machine 12

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ABSTRACT

Increasing domestic consumption has been an important factor of the development of pulp and paper industry in Indonesia. However, pulpwood availability limits that development. This situation demands pulp and paper industry to operate efficiently. One of the techniques that can be used is a linier programming. This technique will determine an option product mix and allocate resources such as pulpwood, production capacity, machine by time, and product demand optimally while maximizing company profit. The study conducted at PT. Pindo Deli Pulp and Paper Unit Paper Machine 12 which produce six product categories such as Brief Card (BC), Base Paper (BP), Drawing Paper (DP), Wood Free (WF), Pre Print (PPR), and Stiffner Board (SB). The result showed that company production and profit would increase by 18% and 56% respectively if company applies linier programming techniques.

Keywords: Pulp and Paper, Optimization, Linier Programming, Efficiency

Profitability Analysis and Market Chain of Benzoin in Sampean Village, Humbang Hasundutan District, North Sumatera

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ABSTRACT

The benzoin forest in Indonesia were traditionally managed to produce benzoin resin, one of non-timber forest products. Lack of farmer's access to the market and a fluctuated benzoin resin prices were major disincentives in the benzoin forest management. This study was conducted at Sampean village, Humbang Hasundutan district, one of major benzoin forest location in North Sumatera, and tried to determine a production cost of benzoin resin, calculate a farmer's profit, analyze farmer's share and describe benzoin resin market chain. The results showed there are about 60 families with total benzoin forest area of 350 ha at Sampean village. Of which, 15 families were then interviewed and observed. An average benzoin forest area managed by each family was about 5 ha with benzoin resin production of 201.6 kg per year (super benzoin of 134.4 kg and tahir benzoin of 67.2 kg). The production cost to produce those benzoin resin were estimated about Rp4.99 million/year. With benzoin resin prices of super of Rp90 thousand/kg and of tahir of Rp50 thousand/kg, each farmer would generate a revenue of Rp15.46 million per year, or a profit of Rp10.47 million per year. If farmers take into account their labor spent in this activity as part of their production cost, then total production cost increase to Rp13.99 million per year. Hence, farmer's profit was drastically declined to Rp1.47 million/year, which was much lower compared with profit/income generated from other sectors, such as agriculture (rice plant) and crops (coffee estates). The results also showed there were 2 kinds of benzoin resin market chains, a main line (farmers – local collectors – district collectors – processors – exporters) and a secondary line (farmers – district collectors – processors – exporters). The most efficient of market chain and the highest farmer's share was found at a secondary line. They were Rp43 thousand/kg and 69.29% for super benzoin, respectively; and Rp 34 thousand/kg and 62.22% for tahir benzoin, respectively.

Keywords: benzoin forest, benzoin resin, production cost, farmer's share, market chain, non-timber forest products.

An Inventory Control Analysis of Raw Materials in Paper Industry: a Case Study at PT. Pindo Deli Pulp Paper Machine 12, Karawang Jawa Barat

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ABSTRACT

Every company must establish a good inventory control policy. Inventory control ensure goods are received at the right time and right amount. If the inventory is too big it would increase costs incurred by a company, whereas if the inventory is too small there would be a risk such as stock out or consumer demand not be met. The research aims to identify, analyze, and evaluate the inventory control system for materials at PT. Pindo Deli Pulp and Paper, and plan inventory control system for the year 2012. Material Requirements Planning (MRP) with techniques such as Lot for Lot (LFL), Economic Order Quantity (EOQ), Least Unit Cost (LUC), Least Total Cost (LTC) were investigated and then compared with company's methods for determining optimum inventory. To plan inventory control for 2012, the paper production in 2012 was first estimated using the time series techniques such as Moving Average (MA), Weight Moving Average (WMA), Single exponential smoothing, and Linear Regression with or without Seasonal Data and followed by using MRP techniques. LFL technique was found to be the best MRP system since it generates the lowest inventory cost. Application of this technique would save about US\$1,45 million in years 2011, a 5,35% saving. Meanwhile, for years 2012, LTC technique would be the best MRP system. It would save about US\$1,86 million, a 7,79% saving. LTC was then recommended since it has a least inventory cost and can avoid stock out.

Keywords: Material Requirements Planning (MRP), inventory system, forecasting, pulp and paper.

Significance of Urban Forest in Makassar (A Preliminary Study)

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ABSTRACT

The urban forest is one of the important component to maintaining environmental condition in the city. The dense population, presence of the industrial area, as well as increasing population of vehicles are sources of carbon emissions. Therefore, there is a necessary vegetated land to reduce the negative impacts of any activities in the urban areas. Urban forest is frequently viewed as a means to improve the beauty of the city. Whereas, the most important role of urban forests is to maintain environmental condition. Therefore, the application of ecological principles in the development of the urban forest is a fundamental issue. This paper discusses the importance of the application of ecological principles in the planning and management of urban forests in Makassar. According to government regulation, Makassar as a metropolitan city need around 1758 ha urban forest (10% based on the total area). But in current condition, the total area of urban forest only 35.4 ha or 0.2% based on the total area of Makassar. Therefore to create a healthy and convenient environment of the city, developing urban forest intensively by applying ecological principles is very important. Considering the very limited availability of land state, the participation of the community in the development of urban forests is very needed.

Keywords: Urban forest, ecological principles, Makassar

Medicinal Plant Tali kuning (*Tinospora dissitiflora* Diels) and Its Future Perspective for Developing Anti-Malarial Phytomedicine or Other Phytomedicinal Herbal Products

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ABSTRACT

Tali kuning (*Tinospora dissitiflora* Diels) is a climbing plant with yellow sap or stem and this traditionally used for medicinal plant in alleviating malaria diseases. Berberine, a famous yellowish alkaloid having structural formula of $C_{20}H_{18}NO_4$, has been isolated from the medicinal plant of Tali kuning (*Tinospora dissitiflora* Diels) collected from Manokwari, West Papua. This bioactive compound was isolated from the chloroform fraction of methanol extract of stem wood powder of this medicinal plant. Column chromatography (CC) and preparative thin layer chromatography (PLC) eluted with benzene:chloroform: ethyl acetate, 5:4:1, and 5:4:2, respectively, were used. Further CC was employed to purify an isolated compound and eluted with benzene and methanol (5:3). Concentration of berberine from methanol extract of stem wood powder was also conducted using ¹H-NMR in single measurement, then a comparison with well known berberine producer, *Phellodendron amurense* Rupr, was also made. Concentration of berberine in methanol extract of Tali kuning was higher (12.04% based on air dried wood meals), than that in well known producer of berberine of *Phellodendron amurense* Rupr (8.06 %). Literature studies indicated that berberine has widely biological and pharmacological activities, but its anti-malarial activity against *Plasmodium falcifarum* either *in vitro* or *in vivo* was reported inconsistently. The synergisms among bioactive compounds in Tali kuning probably play key roles on its anti-malarial activities. It is because malarial diseases and symptoms are very complex. Therefore, in future utilization of Tali kuning, development of anti-malarial phytomedicine from Tali kuning are needed to be explored and soundly possibly. Also, the productions of phytomedicinal herbal products of this medicinal plant are likely feasible. However, to support this further utilization, several biological and pharmacological assessments should be reported firstly, before these products are taking place for commercialization.

Keywords: Tali kuning, berberine, anti-malaria, phytomedicinal herbal products

Utilization of Small Diameter Logs for Jepara Furniture Production

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ABSTRACT

Furniture industries in Indonesia are facing a serious problem regarding wood availability. The most commonly used wood for high quality furniture productions are teak and mahogany wood, especially in Jepara regency. The objective of this report is to provide information on options for products made from low quality, small diameter logs and small dimensions become more dominant in Indonesian furniture raw material supply. Research results show clearly that the raw material supply (teak and mahogany) for Jepara furniture industries decreased sharply from year to year in terms of quantity and quality. In addition, the price of the raw material increased significantly year by year. This condition forced furniture industry in Jepara to find alternative raw material for their furniture industry. One of the alternatives raw material is using alternative species, small diameter logs, and small dimensions wood harvested from plantation and community forest. Nowadays, small diameter logs/small dimension wood from various wood species have been used as chair, table, mirror and calligraphy raw materials.

Keywords: Small diameter logs, small dimension wood, Jepara furniture, teak, mahogany.

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POSTER

Antifungal Activities of Some Components of Teak Wood Extractives

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ABSTRACT

Teak (*Tectona grandis*) wood under natural condition is recognized to exhibit antifungal activities. The role of individual components that contribute to those properties, however, is still unexplored. This research is aimed at evaluating teak extracts and their components against five fungi species : *Trametes versicolor*, *Fomitopsis palustris*, *Rhizopus oryzae*, *Cladosporium cladosporioides*, and *Chaetomium globosum*. Materials used in this study were wood powder from teak heartwood (72 years). The successive extraction used reflux by three solvents: *n*-hexane, ethyl acetate and methanol. Bioassay-guided investigation by measuring the growth rate of each fungi on potato dextrose agar (PDA) medium led to the fractionation of *n*-hexane soluble extract. Column chromatographic fractionations resulted to the isolation of tectoquinone, deoxylapachol, squalene and one unknown compound (C1). The *n*-hexane and EtOAc extracts were potent mycelial growth inhibitors for *Rhizopus oryzae* (76-78%) and *Cladosporium cladosporioides* (65-73 %), while MeOH extract had higher antifungal activities against both *Trametes versicolor* (80.2 %) and *Chaetomium globosum* (83.3 %). In the compound levels, the results were varied in which deoxylapachol could exhibit all fungi species except for *Chaetomium globosum*, whereas tectoquinone merely deterred the growth of *Rhizopus oryzae* (58.9 %).

Keywords: *Tectona grandis*, antifungal activities, extractive, tectoquinone, deoxylapachol

The Changes of Anatomical Structure on Betung Bamboo Pretreated by Mixed Culture of White Rot Fungi

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ABSTRACT

The previous observation of anatomical structure of pretreated betung bamboos of single culture of white rot fungi was reported, however the changes in their morphological, macroscopic and microscopic structure pretreated by mixed culture of white-rot fungi have yet been reported. This morphological data will be compared to the previous data. Fresh, and barkless 2 years old betung bamboo (*Dendrocalamus asper*) chips, 1.6 cm in length were inoculated in 10% of white-rot fungi inoculums stock for 30 and 45 days in room temperature. White rot fungi utilized in this study were *Trametes versicolor*, *Pleurotus ostreatus* and *Phanerochaete chrysosporium*. The pretreated chips were mercerized (Forest Product Laboratory method) to analyze not only the fiber and vessel dimension, but also its derivative fiber. The fibers were then observed for the macroscopic and microscopic images using microscope. The fiber dimension of bamboo was affected by the white-rot fungi types, and the incubation time; and its derivative fiber also showed these phenomenon. There is no significant difference degradation pattern caused by these pretreatment based on the microscopic and macroscopic images.

Keywords: Morphological fiber and its derivative, microscopic and macroscopic images, betung bamboo, mixed culture of white-rot fungi

Quality Analysis of Several Types Composite Board

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ABSTRACT

Several types of composite product include particle board, plywood, OSB, MDF and blockboard. The big number of each product is not followed with the spreading of information about its quality. Information about quality of each product is important to know. This information can be determined through determination quality of composite board based on research about physical properties, mechanical properties and biodegradability from subterranean termites (*Coptotermes curvignathus*). Materials used in this research are six types of composite product, they consist of particle board made from wood waste and bamboo mat (CWB), Medium Density Fiberboard (MBF), Oriented Strandboard (OSB), particle board, plywood and blockboard. The test piece shall be in accordance with Japanese Industrial Standard (JIS) A 5908 : 2003, JIS 5905 : 2003, Japanese Agricultural Standard (JAS) SE-1 for plywood, ASTM D 1307-1999, and Sornnuwat 1996. Results of the research show the values of quality of the six types composite board. The physical properties show that board density has a range value of between 0,85-0,43 with the highest in MDF. Moisture content has a range value between 7,46-14,20% with the highest value in plywood. Swelling in thickness after immersion in water for 24 hours has a range value of between 1,94-11,89% with the highest value in OSB. The mechanical test shows that modulus of rupture (MOR) has a range value of between 11,76-40,28 N/mm² with the highest value in plywood. Modulus of Elasticity (MOE) has a range value of between 690,48-4903,57 N/mm² with the highest value in plywood. Bonding strength has a range value of between 0,22-0,70 N/mm² where plywood has the highest value. Degradability properties test based on weight loss percentage and termites mortality show high value, and the level of resistance range was classified between "non resistant" until "moderately resistance". In this research, CWB is disliked relatively by subterranean termites if compared to solid wood because of the adhesives inside the board. The best quality from the six types of CWB is board; showing the best value on physical, mechanical and biodegradability test. CWB shows the best performance in this research.

Keywords: Composite board, physical, mechanical, *Coptotermes curvignathus*

Lignin Characteristics of Unusual Eccentric Growth Branch of *Eusideroxylon zwageri*

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ABSTRACT

Angiosperms commonly developed tension wood which has exhibited eccentric thickening growth in the upper side of leaning stem or branch. However, unusual eccentric growth was shown in the lower side of *Eusideroxylon zwageri* branch. To clarify the characteristics of this special reaction wood, the chemical structure of branch wood were investigated by Klason lignin determination, alkaline nitrobenzene oxidation, and ozonation method. The result showed that Klason lignin content increased from the upper side towards the lower side of wood disc, which was generally found in compression wood. Moreover, the distribution of chemical structure of lignin were similar to that of tension wood, which was characterized by higher syringy/guaiacyl ratio and higher *erythro/threo* ratio of β -O-4 structure with the decreased in lignin content along the periphery of the wood branch from the lower side to the upper side.

Keywords: β -O-4 structure, *erythro/threo* ratio, syringy/guaiacyl ratio, branch wood, *Eusideroxylon zwageri*

Enhanced Enzymatic Hydrolysis of Oil Palm Empty Fruit Bunch Fiber by Combined Co-culturing White-rot Fungi and Alkaline Pretreatment

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ABSTRACT

Biological pretreatment of lignocellulosic materials have been conducted for many years and they showed improvement in enzymatic hydrolysis. However, this pretreatment reduce biomass recalcitrance effectively in long time. The aim of this study was to investigate the acceleration for enzymatic hydrolysis of Oil Palm Empty Fruit Bunch (OPEFB) fiber using combined co-culturing white-rot fungi and alkaline pretreatment. First, OPEFB fiber was pretreated with co-culturing two white-rot fungi *T. versicolor* and *P. crysosporium* for 15 and 30 days, then treated with sodium hydroxide 0.25 N for 30-240 minutes respectively at room temperature. After, the samples were washed until neutral, then it was hydrolyzed using a commercial cellulase preparation with enzyme loading of 20 Filter Paper Units (FPU)/g substrate. Result from this preliminary study can identify with the optimal conditions based on the sugar yields from enzymatic hydrolysis.

Keywords: Oil palm empty fruit bunch, biological pretreatment, white-rot fungi, alkaline pretreatment, enzymatic hydrolysis

Characteristics of Cellulose Nano-paper Sheet Prepared by Mechanical Fibrillation Methods from Forest Biomaterials

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ABSTRACT

Cellulose nanofiber from forest biomaterials is an interesting material constituent of high strength and high aspect ratio, which easily forms networks through interfibril secondary bonding including hydrogen bonds. This has been exploited in the preparation of new materials, which extend the range of properties for existing lignocellulosic materials. These are known to have excellent physical and mechanical properties, especially tensile strength. Recently, the research on how to overcome strong recalcitrance for the efficient separation of nano-scaled fibers from cell wall has been extensively conducted around the world. Various fibrillation methods have been reported, including chemical treatments such as acid hydrolysis. However, this chemical fibrillation method can lead to pollution of cellulose. Furthermore, it results in low mass production yield. This research is to find out the efficient production process for cellulose nano-fiber focusing on eco-friendliness, low cost and mass production yield. The experimental material was Korean white pine (*Pinus koraiensis* S. et Z.). Steam treatment has been well known for removing a part of hemi-cellulose. Steam penetrates into the interfiber bond, then these makes defiberization easier with strong shear force. Also nano-scaled fibers were made through strong ozone's oxidative degradation function along with shear force. Prepared products were applied to nano-paper sheet and tensile properties were investigated. Morphological investigation showed that steam and ozone activated the interface and fibril became separated gradually. Specific surface area increased as disk-milling time increased furthermore, 1.3 times increase of SSA was observed by delignification. TGA analysis shows that heat stability increased with steam, whereas ozone decreased heat stability a bit. The result of the application to nano-paper sheets reveal that the transparency of the paper sheet was greatly improved by ozone oxidation treatment. Also, tensile strength was sharply increased and then level-off as disk-milling time increased.

Keywords: Korean white pine; cellulose nanofiber; nano-paper sheet; ozone; steam

Acknowledgement: This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education, Science and Technology(2010-0023185).

Physical and Mechanical Characteristics of the 10 Indonesian Wood Species

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ABSTRACT

The physical and mechanical characteristics of the ten Indonesian wood species (Gmelina, Jeunjing, Mangium, Durian, Gandaria, Jengkol, Kupa, Mangga, Nangka and Rambutan) were investigated on the basis of the Korean Standard method. Density, shrinkage, compressive strength parallel to the grain and hardness were measured. Additionally, heating value and ash content were investigated in this research. Mangium, Gandaria and Rambutan showed higher density. Mangium, Gandaria and Mangga showed lower shrinkage, and the ratio of tangential/radial was low in Jeunjing, Kupa and Mangga. The compressive strength parallel to the grain and hardness were high in Mangium and Nangka. Lastly, the most valuable results of combustion characteristics were observed in Mangium, Kupa and Nangka. These species showed higher heating value and lower ash content.

Keywords: Tropical wood, physical and mechanical properties of Indonesian wood, planted Indonesian species, promising Indonesian species.

Acknowledgement: This study was carried out with the support of 'Forest Science & Technology Projects (Project No. S121212L150100)' provided by Korea Forest Service.

Habitat Use and Diet in Female Moor Macaques (*Macaca maura*), an Endangered Primate Species Endemic to Sulawesi

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ABSTRACT

Environmental conditions and adequate availability of food resources may affect the reproductive outcome of female mammals. Energetic requirements are especially hard on female primates (long gestation, lactation, carrying of the infant), possibly affecting conception rate which, in the long-term may affect local population size. We investigated how diet, activity budgets, and habitat use may differ in different reproductive states in free-ranging female moor macaques in Karaenta (BABUL NP). Monkeys were followed 6 days/week for 7 months (August 2010-February 2011) and behavioral data collected via scan sampling. Female moor macaques consume a wide array of foods (74 plant and fungi species), but are predominately frugivorous (82%), relying heavily on fig fruits (30%). Females in the peri-ovulatory phase showed the most dietary diversity in terms of different items consumed (plants, fungi, and insects), while pregnant females showed the most diversity in terms of plant parts eaten. Activity budgets differed depending on vertical use of the habitat and reproductive state: lactating females spent most of their time on the ground (the most represented stratum, 51%) with predominant activities being locomotion (38%) and social interactions (32%); periovulatory females tended to be at higher strata (2-10 meters) where main activities were foraging and feeding (46%).

Keywords: *Macaca maura*, activity budget, diet, reproductive state.

Testing The Sinergistics Effects of *Pseudomonas fluorescens* Isolates and Arbuscular Mycorrhiza Fungi in Improving Seedling Growth and Wood Quality of *Paraserioathes falcataria* (L.) Nielsen

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ABSTRACT

Paraserianthes falcataria (L.) Nielsen in Indonesia called “Sengon” is a leguminous tree species widely grown for timber and used in reboisation program in Indonesia. The application of beneficial microorganism is an interesting alternative to improving the seedling growth and wood quality, and might be an alternative or supplement to chemical fertilizers and fungicides. Fluorescent pseudomonads have several advantages compared to other bio-effector agents and attracted particular attention among scientists. Strains of *Pseudomonas spp.* isolated from the rhizosphere are promising as seed inoculants in innovative agriculture to promote plant growth and crop yield and reduce various plant diseases. The main objective of the present study was to investigate the synergistic effects of *Pseudomonas fluorescens* isolates and arbuscular mycorrhiza fungi (AMF) to support seedling growth and wood quality of *Paraserianthes falcataria* (L.) Nielsen. Single *Paraserianthes* seed was cultivated in pots each of which contained 2 kg C-loess soils/sand mixture (3:1) with *Pseudomonas fluorescens* isolates, namely; PF1, PF5, LL2, LL4, T11, T14, AN3, AN5, AM2, and SS2 (5 ml suspension/pot), respectively, *Glomus intraradices* (250 gr infected soil/pot) or none of both as control. 50 N, 50 P, 100 K, 50 Mg kg⁻¹ soils were fertilized. Model of studies were conducted as a pot experiment in the greenhouse. Soil inoculation with Pseudomonad isolates and AMF in a combined inoculation significantly improved mycorrhizal Infection and the root and shoot biomass production of *Paraserianthes* compare to single AMF inoculation and untreated control. These results suggest that both microorganisms are suitable as bio-effector agents that may ameliorate plant growth and healthy. These ten isolates will be selected for further studies on their effects in improving the growth and the wood quality of *Paraseriathes* in field conditions.

Keywords: *Pseudomonas fluorescens*, *Paraserianthes falcataria* (L.) Nielsen, Arbuscular

Isolation and Identification of Anticancer Compounds From Methanolic extract of Surian Heartwood (*Toona sinensis* Roem)

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ABSTRACT

The aims of this research were to determine the prospective extract from the continuous extraction of Surian heartwood in n-hexane, ethyl acetate and methanol solvents based on yield and *in vitro* anticancer activities (antioxidant and antiproliferation Hela cervical cancer cell lines, Raji lymphoma cancer cell lines and Vero normal cell lines), fractionation, isolation and determine the prospective fraction and isolate, apoptosis detection and identification anticancer compound isolated from prospective fraction. The result showed the methanolic extract as prospective extract because it has the highest yield (5,36%), the highest antioxidant activity (EC_{50} 6,30 $\mu\text{g/mL}$), medium antiproliferation to Raji cancer cell lines (IC_{50} 47,25 $\mu\text{g/mL}$) and not toxic to normal cell lines (IC_{50} 437,57 $\mu\text{g/mL}$). Fraction 3 of methanolic extract was selected as prospective fraction because it is a dominant fraction (yield :21,81%), has high antioxidant activity (EC_{50} 6,92 $\mu\text{g/mL}$) and has antiproliferation Raji cancer cell lines (IC_{50} 67,40 $\mu\text{g/mL}$). Msin 3.3 from fraction 3 of methanolic extract is anticancer compound because it has high antioxidant activity (EC_{50} 6,30 $\mu\text{g/mL}$), moderate antiproliferation to Raji cancer cells (IC_{50} 22,57 $\mu\text{g/mL}$) with apoptosis mechanism, and not toxic to normal cells (IC_{50} 396,33 $\mu\text{g/mL}$). The structure elucidation indicates the Msin 3.3 as (+)-catechin.

Keywords: *Toona sinensis*, anticancer, antioxidant, antiproliferation, Raji cancer cell lines, Hela cancer cell lines, Vero cancer cell lines.

Investigating of Saponin from *Lepisanthes amoena* Leaves Extracts

Lepisanthes amoena

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ABSTRACT

There are many plants that have been reported to possess antibacterial activity. Among them are some from Sapindaceae family. Sapindaceae family has 2,215 species in 147 genera. Some plants from this family, such as *Sapindus mukorossi*, *Dodonaea viscosa*, *Allophylus africanus*, and *Paullinia cupana* have been used traditionally as oral health care. One of the species in this family found in East Kalimantan is *Lepisanthes amoena*. The foam will appear when the leaves shrubbed. We believe that secondary metabolites, such as saponin is contained in the leaves. In this study, we conducted the semi quantitative analysis of saponin and isolate the crude saponin from *Lepisanthes amoena*.

Keywords: *Lepisanthes amoena*, saponin

Physical and Anatomical Characterisation of Three Malaysian Bananas

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ABSTRACT

Any by-product from biomass plantation can be converted into wood based products. Understanding the raw material properties is one of the crucial parts in determining the end user of the products. Unutilised pseudo-stem, leaves and midrib from banana plantation were studied. This study concentrated on three common Malaysian banana species, *Musa paradisiaca* spp, *M. accuminata* var. *truncata*, and *M. sapientum* spp which abundantly leave after fruit harvesting. Their physical, anatomical and morphological properties were investigated. Pseudo-stem was divided into three portions (top, middle and bottom) and each portion disc was then divided to three parts (inner, middle and outer). Physically, the tallest banana tree is *M. paradisiaca* spp with a height of 8.2 m and average diameter of 0.44 m. On each banana species, the diameter decreased from bottom to top. Anatomically, each banana parts and portions of pseudostem were identically different in sizes and diameter of cells. The midrib consists of similar cells with pseudostem where leaf consists of different cells structure. Average fibre length of banana was 3.21– 3.9 mm and width of 0.17 – 0.26 mm. In pseudostem, fibre lengths increase from top to bottom. Compared to each part, pseudostem fibre is the longest of leaves and midrib fibre.

Keywords: banana pseudostem, midrib, leaf, anatomy, fibre morphology, fibre bundle

APPENDIXES

Committee, chairs and key organizers
of
The 4th International Symposium of Indonesian Wood Research Society
Quality Plaza Hotel, Makassar - Indonesia, November 7-8, 2012

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The 4th International Symposium of Indonesian Wood Research Society Quality Plaza Hotel, Makassar - Indonesia, November 7-8, 2012

November 7 (Wednesday)

- 10.00-12.00 : Registration of participants
12.00-13.00 : Lunch
13.00-13.30 : Opening of the symposium
13.30-14.30 : Keynote Speeches (Panel Session)
Prof.Dr.Dodi Nandika
(Bogor Agricultural University, Indonesia)
Prof. Nobuaki Hattori Ph.D.
Japan Wood Research Society/ Tokyo University of Agriculture
and Technology
14.30-14.45 : Photo Session
14.45-15.45 : Parallel Session I
15.45-16.15 : Coffee Break
16.15-17.15 : Parallel Session II
19.00-21.00 : Banquet

November 8 (Thursday)

- 08.30-09.30 : Keynote Speeches
Dr. Iman Santoso
(Head of Research and Development Agency, Ministry of Forestry,
Republic of Indonesia)
Prof. Remy Marchal Ph.D
(Arts et Metiere Paris Tech. and CIRAD, France)
09.30-10.00 : Coffee-break
10.00-10.25 : Invited Speaker
10.25-11.25 : Parallel Session III
11.25-12.25 : Parallel Session IV
12.25-13.30 : Lunch
13.30-14.30 : Parallel Session V
14.30-16.00 : Parallel Session VI
16.00-16.30 : Coffee-break
16.30-17.00 : Closing of the Symposium

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