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PROPERTIES OF LAMINATED VENEER LUMBER MANUFACTURED FROM ACACIA MANGIUM THINNINGS AND RUBBERWOOD (HEVEA BRASILIENSIS)

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PROPERTIES OF LAMINATED VENEER LUMBER MANUFACTURED FROM *Acacia mangium* THINNINGS AND RUBBERWOOD (*Hevea brasiliensis*)

By

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Dedicated to

my beloved Dad, Mum, Brothers, Sisters

and C^2M.

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TABLE OF CONTENTS

Page

Page

LIST OF TABLES

Table		Page

LIST OF FIGURES

Figure		Page

LIST OF PLATES

LIST OF ABBREVIATIONS

ATTC	ASEAN Timber Technology Centre
CV	coefficient of variation
FRIM	Forest Research Institute of Malaysia
ft	foot
hr	hour
LVL	laminated veneer lumber
MC	moisture content
MOE	modulus of elasticity
MOR	modulus of rupture
MTIB	The Malaysian Timber Industry Board
MUF	melamine urea formaldehyde
NaPCP	sodium pentachlorophenate
OD	oven dry
PF	phenol formaldehyde
PRF	phenol resorcinol formaldehyde
SD	standard deviation
TS	thickness swelling
UF	urea formaldehyde
USDA	U.S. Department of Agriculture
WA	water absorption

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PROPERTIES OF LAMINATED VENEER LUMBER MANUFACTURED FROM *Acacia mangium* THINNINGS AND RUBBERWOOD (*Hevea brasiliensis*).

By

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DECEMBER 1994

Chairman : Associate Professor Mohd. Zin Jusoh

Faculty : Faculty of Forestry

This study attempts to assess the properties of structural laminated veneer lumber (LVL) made from low grade raw materials and produced on commercial plywood and LVL lines. Ten-year old *Acacia mangium* (Mangium) thinnings and old-growth *Hevea brasiliensis* (Rubberwood) were peeled to 3.6 mm thick veneers and processed into 15-ply LVL. Two different veneer configurations were used in the LVL fabrication, with melamine urea formaldehyde (MUF), phenol formaldehyde (PF) and urea formaldehyde (UF) as binders. The LVL were subsequently finger-jointed and the bending strength evaluated. The properties of LVL with different proportions of Mangium and Rubberwood were also evaluated. Total green veneer recoveries of about 70% were recorded for both Mangium and Rubberwood, using a 4-ft Meinan Aristo-lathe. In general, Rubberwood demonstrated good compatibility with UF resin, whilst MUF performed better than PF. Veneer configuration did not have significant ($P \leq 0.05$) effect on the mechanical properties of the LVL. Evaluation of the LVL based on the Japanese Agricultural Standard for Structural LVL (1993) showed that besides having negligible delamination and fulfilling the shear requirements for various LVL grades, MUF and PF bonded Rubberwood LVL met the 80E Special Grade, whilst Rubberwood LVL with UF, and all of the Mangium LVL met the minimum modulus of elasticity (MOE) requirement for 120E Special Grade Structural LVL. The modulus of rupture (MOR) were exceedingly high in all cases. The laminating process resulted in about 30% reduction in MOR, but a pronounced improvement in MOE by up to 86%, compared to small clear solid wood. Finger-jointing resulted in 79 to 88% joint efficiency in terms of MOR, with no reduction in MOE. Combination of 10 Mangium plies with five Rubberwood plies (core) passed the 100E Special Grade, whereas pure Rubberwood and combination of six Mangium plies with nine Rubberwood plies (core) only met the requirements for 80E Special Grade. Both physical and mechanical properties of the LVL evaluated showed high uniformity as indicated by their low coefficient of variation (< 10%). The results obtained are positive indications for both Mangium thinnings and Rubberwood to be upgraded for structural uses through processing into LVL.

Abstrak tesis dikemukakan kepada Senat Universiti Pertanian Malaysia untuk memenuhi keperluan Ijazah Master Sains.

SIFAT PAPAN VENIR BERLAMINA (LVL) YANG DIPERBUAT DARIPADA KAYU PENJARANGAN *Acacia mangium* DAN KAYU GETAH (*Hevea brasiliensis*).

Oleh

WONG EE DING

DISEMBER 1994

Pengerusi : Profesor Madya Mohd. Zin Jusoh

Fakulti : Fakulti Perhutanan

Kajian ini bertujuan menilai mutu papan venir berlamina (LVL) yang diperbuat daripada bahan bermutu rendah, dengan menggunakan kemudahan-kemudahan sedia ada di kilang papan lapis dan kilang LVL. Bahan penjarangan dari hutan ladang Akasia (*Acacia mangium*) (umur 10 tahun) dan Kayu Getah (*Hevea brasiliensis*) dikupas menjadi venir (3.6 mm tebal), dan diproses menjadi LVL (15 lapisan) dengan menggunakan melamin urea formaldehid (MUF), fenol formaldehid (PF) dan urea formaldehid (UF) sebagai perekat. Kedua-duanya, iaitu Akasia dan Kayu Getah mencatat pulangan venir setinggi 70% dengan menggunakan "Meinan Aristo-lathe" sepanjang 4-kaki. Walaupun Akasia didapati kurang serasi dengan UF, tetapi Kayu Getah menghasilkan ikatan yang kuat dengan UF. Pada

keseluruhannya, ikatan MUF adalah lebih baik dari PF. Kekuatan LVL didapati tidak dipengaruhi oleh corak susunan venir. Kesan tanggam jejari (finger joint) yang dikaji melalui ujian lentur mencatatkan 79 hingga 88% keberkesanan sambungan bagi modulus patah (modulus of rupture - MOR), tanpa mengurangkan modulus kekenyalan (modulus of elasticity - MOE). Penilaian berasaskan Japanese Agricultural Standard (JAS) LVL untuk Kegunaan Struktur (1993) menunjukkan bahawa, selain daripada mencatat kadar delaminasi yang rendah, LVL yang dihasilkan mencapai gred-gred kekuatan ricih yang berlainan. LVL Kayu Getah yang direkat dengan MUF dan PF mencapai Gred Khas 80E, manakala LVL Kayu Getah dengan UF, dan kesemua LVL Akasia mencapai Gred Khas 120E. MOR kayu pejal telah menurun sebanyak 30% dengan penghasilan LVL, tetapi nilai MOE telah meningkat sebanyak 86%. Kombinasi spesis venir dengan menggunakan 10 lapisan Akasia di permukaan dan lima lapisan Kayu Getah di bahagian tengah mencapai Gred Khas 100E, manakala LVL Kayu Getah dan enam lapisan Akasia campur dengan sembilan lapisan Kayu Getah hanya mencapai Gred Khas 80E. Dalam semua kes, keseragaman kekuatan LVL adalah amat tinggi, dengan variasi koefisien yang kurang daripada 10%. Keputusan kajian menunjukkan Akasia dan Kayu Getah mempunyai potensi yang baik untuk diproses menjadi LVL bagi kegunaan struktur.

CHAPTER I

INTRODUCTION

Background

Over the decades, forestry and forest-based industry have been playing a significant role in the Malaysian economy. The export revenue from timber and timber products has generally been on the rise. In 1992, it contributed approximately RM 10.5 billion representing about 31.3% of the total national commodity export earnings, ranking second only to petroleum and petroleum products (MTIB, 1994). Besides, this sector also provided employment to about 235,000 people or 3% of the country's labour force (Ismail, 1993).

In recent years, the Malaysian wood-based industry experienced phenomenal growth, standing with a total of 1,150 sawmills, 120 veneer/plywood mills, 97 wood moulding and 300 furniture plants (export oriented wooden furniture factories only) in 1992 (Ministry of Primary Industries, 1993). In line with the Government's policy of industrialisation, it is anticipated that the industry will continue to grow, especially towards downstream processing of high value products. By far, it cannot be denied that the availability of cheap and good quality raw materials, i.e., logs and cellulosic materials of suitable forms, is one of the key factors responsible for the development of the Malaysian forest-based industry. The increasing demand of raw material input for the industries, coupled with agri-conversion and clearing of forested-areas for development have however, resulted in accelerated rate of harvesting. This in turn threatens the sustainability of timber yield from the natural forests. The total forested area in Peninsular Malaysia has dropped from 6.45 million ha (49% of the total land area) in 1979 to 5.96 million ha in 1992, with only 2.83 million ha of productive forest. Based on these figures, it can be deduced that about 37.69 thousand ha of forests were lost each year due to the above mentioned activities during the said period (Ismail, 1993).

A comparison of the annual log supply and demand pattern revealed that Malaysia on the whole, will face log deficits after the year 2000. One of the alternatives to guarantee sustainable supply of timber raw materials is through cultivation of plantation timber crops. Whilst many temperate countries are already way ahead into forest plantation, Malaysia only started small scale teak plantation in 1957. Between 1960s and 1970s, about 5,500 ha of tropical conifers (pines and Araucaria) were established. In 1982, Compensatory Forest Plantation Programme was initiated with the object of supplying general utility timber to the wood-based industries. Among the many fast growing tree species promoted in Malaysia, *Acacia mangium* (Mangium) is one of the most dominant species at the moment. Mangium covers some 80% of the total plantation area (51,745 ha) established in Peninsular Malaysia (Hashim et. al., 1990). Compared to the forest plantation trees which are yet to mature, *Hevea brasiliensis* (Rubberwood) is already widely in use commercially, especially in furniture manufacturing. Utilisation of Rubberwood has been reported to increase from about 100,000 m^3 in 1980 to 1.84 million m^3 in 1992 (Ismail, 1993).

Despite having the advantage of being fast growing, the logs of the above-mentioned species, however, have smaller diameters with lower density and higher growth defects (knotty, high growth stress and high percentage of juvenile wood), compared to that from the natural forests. Nonetheless, most of the local industries are already adapting well to the technology of small log processing, where appropriate skills and machinery have been brought in to optimise recoveries. To this end, the main focus of processing has been on the manufacture of wood-based composite products, as it is the only alternative to recover large dimension timber from small-sized logs; be it in the form of glue lamination (veneer and solid wood), or reconstitution of particles or fibres. These manufacturing processes make it possible to produce composites of tailored desirable properties for various end-uses, which in this case is achieved either through appropriate manipulation of raw material inputs and/or process variables.

Justification for the Study

In Malaysia, in 1991 alone, the construction sector accounted for about 60% of the total sawn timber consumption, i.e., some 1,610,600 m^3 out of a total of 2,679,800 m^3 available for consumption (Lockman and Poh, 1992). In light of the expected growth of the housing/construction sector in the country, at least for the next few years, the demand for structural wood products is expected to increase further. However, with the diminishing supply of large-sized logs from natural forests, there would soon be limited solid-sawn timber of sufficiently large dimension for structural uses; or solid timber might then become an unaffordable construction option. There is therefore a need to develop new engineered products from our new future wood resource -- fast growing small diameter logs -- to be used as substitutes for dimensional solid-sawn timber. In the Mangium plantation, thinning operations are being carried out at the ages of two to four and eight to nine. The resultant thinning materials are of small size and low density, and could either be processed into charcoal or composite products such as particleboard or fibreboard. Nevertheless, it has been shown that 8-9 years old thinnings with minimum diameters of about 18 cm are peelable using the existing small log peeling technology (Chai, 1989; Sasaki et al., 1990; Wang et al., 1990; Salim, 1992; Louko, 1993). The veneers were reported to be suitable only for plywood core materials, mainly due to the presence of knot holes and strong colour contrast between sapwood and heartwood. Instead of using these materials as low-cost plywood core-stock as suggested (Gregor, 1993; Louko, 1993), it would however, be far more economical to process them into laminated veneer lumber (LVL) for structural uses, where appearance is not of critical importance, so long as the end product has acceptable dimensional and mechanical properties.

Despite being well established for the manufacture of numerous products, utilisation of Rubberwood has in fact, yet to be fully optimised. In view of the competitive demand for Rubberwood, it is deemed important to further investigate and broaden the other possible end-products, in upgrading its utilisation status and fetching the highest possible value. Besides producing single-species LVL, combination of Mangium and Rubberwood will also result in generation of a new product with specific properties for certain applications.

This study was conducted to investigate the effects of selected processing variables on the properties of interior and exterior grade LVL from the low-grade 10-year old Mangium thinnings and old-growth (25-30 years old) Rubberwood.

Objectives of the Study

This study aims to investigate the effects of some selected processing variables on the properties of LVL made from 10-year old Mangium thinnings and 25-30 years old Rubberwood:

a. mechanical properties of small clear solid wood specimens of Mangium and Rubberwood;
b. green end veneer recoveries for small diameter logs i.e., Mangium thinnings and Rubberwood;

c. properties of 15-ply mono-species LVL made from 3.6 mm thick Mangium and Rubberwood veneers bonded with melamine urea formaldehyde (MUF), phenol formaldehyde (PF) and urea formaldehyde (UF) resin adhesives;

d. the effects of veneer configuration (symmetrical/non-symmetrical) on physical and mechanical properties of Mangium and Rubberwood LVL;

e. the bending strengths of finger-jointed 2438 mm (8-ft) long Mangium and Rubberwood LVL;

f. the effects of Rubberwood LVL reinforcement using 3 and 5 plies of Mangium veneers in the tension-compression zones; and

g. to compare the properties of LVL manufactured with the requirements stipulated in Japanese Agricultural Standard (JAS) for Structural LVL (1993).