UNIVERSITI PUTRA MALAYSIA

BASIC ENGINEERING PROPERTIES OF LAMINATED VENEER LUMBER (LVL) PRODUCED FROM TROPICAL HARDWOOD SPECIES

H'NG PAIK SAN

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Chairman: **Associate Professor Paridah Md. Tahir, Ph.D.**

Faculty: **Forestry**

One of the reasons for a limited structural usage of LVL in tropical countries is the lack of research and development to establish design criteria for this material. Such information is essential for the development of design values as well as new structural uses of LVL. This study aimed to establish basic engineering properties of LVL produced from selected tropical hardwood species; i.e. Yellow Meranti (*Shorea spp.*), Kedondong (*Canarium* spp), Bintangor (*Calophyllum spp*), White Meranti (*Shorea spp.*), and Keruing (*Dipterocarpus spp*). Tests for static bending, bending shear, tensile and compression parallel to longitudinal axis were carried out using in-grade size specimens. The tests were conducted in accordance with AS/NZS 4357 (Structural Laminated Veneer Lumber). The effects of two important factors; (1) wood species and (2) veneer thickness, on the strength properties of LVL were studied. The results show that Keruing LVL has the highest density (700 – 820 kg/m^3), followed by White Meranti (600-680 kg/m^3), Bintangor (570-590 kg/m^3), Kedondong (545-574 kg/m^3) and Yellow Meranti (510-541 kg/m^3). Using thinner veneers increased the LVL panel density between 2.8% (in Kedondong) to 8.9% (in Keruing). Despite having lower board density, both White Meranti and Bintangor

LVLs had significantly superior engineering properties than those made from Keruing, Kedondong and Yellow Meranti. Keruing LVL performed below the expectation in all the strength properties which was attributed to the poor bond quality observed through the gluebond shear test and scanning electron microscope analysis. The study also indicate that shear strength of the LVL was much more governed by the wood species where denser wood LVL apparently produced lower shear values due to poor adhesion that eventually gives rise to glueline failure. LVL made from thinner veneers performed better than that made of thicker ones with increased strength: 2% to 34.3% in bending; 0.6% to 14.6% in bending shear; 5% to 50% in tensile; and 7% to 45% in compression. The minimum calculated ratios for all species for ultimate tensile strength (UTS) and tensile modulus of elasticity (TMOE) was 0.52 and for ultimate compression strength (UCS) and modulus of rupture (MOR) was 0.69 which are within the range of solid wood. These ratios are used to estimate the tensile and compression strengths using values from static bending test. The grade stresses of LVLs produced in this study was found to have at least one grade higher than the solid wood of the same species published in MS 544 Part 2.

Abstrak tesis yang dikemukakan kepada Senat University Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

SIFAT KEJURUTERAAN ASAS BAGI KAYU VENIR BERLAMINA YANG BIPERBUAT DARIPADA SPESIS KAYU KERAS TROPIKA

Oleh

H'NG PAIK SAN

November 2003

Pengerusi: **Profesor Madya Paridah Md. Tahir, Ph.D.**

Fakulti: **Perhutanan**

Salah satu alasan yang menyebabkan kekurangan minat yang mendalam menggunakkan kayu venir berlamina sebagai bahan kejuruteraan di negara tropika ialah kajian dan pengembangan yang terhad untuk mengubal ciri-ciri pembinaan yang melibatkan bahan ini. Informasi ini penting bagi mewujudkan kegunaan yang tidak terhad bagi kayu venir berlamina. Kajian ini mempunyai tujuan utama untuk menerbitkan sifat kejuruteraan asas kayu venir berlamina yang diperbuat daripada kayu keras tropika; antaranya ialah Meranti Kuning (*Shorea spp.*), Kedondong (*Canarium spp.*), Bintangor (*Calophyllum spp.*), Meranti Putih (*Shorea spp.*) dan Keruing (*Dipterocarpus spp.*). Spesimen bersaiz besar digunakan untuk ujian bagi lentur static, ricih lentur, ketegangan dan kemampatan berdasarkan Standard AS/NZS 4357 (Structural Laminated Veneer Lumber). Dua parameter yang penting ditentukan didalam kajian ini; antaranya (1) kesan daripada spesis kayu dan (2) kesan daripada ketebalan venir. Keputusan menunjukkan kayu venir berlamina yang diperbuat daripada Keruing menpunyai ketumpatan yang paling tinggi (700 – 820 kg/m^3), diikuti oleh Meranti Putih (600-680 kg/m^3), Bintangor (570-590 kg/m^3), Kedondong (545-574 kg/m^3) dan Meranti Kuning (510-541 kg/m^3). Dengan

menggunakan venir yang lebih nipis, ia dapat meningkatkan ketumpatan kayu venir berlamina dari 2.8% (dalam Kedondong) hingga 8.9% (dalam Kering). Kayu venir berlamina yang diperbuat daripada spesis Meranti Putih dan Bintangor mempunyai sifat kejuruteraan yang signifikasi tinggi berbanding yang diperbuat daripada spesis Keruing, Kedondong dan Meranti Kuning. Dalam kajian ini juga, kayu venir berlamina yang diperbuat daripada Keruing didapati mempunyai sifat kekuatan yang tidak dapat didugai lebih rendah berbanding spesis lain. Hal ini mungkin disebabkan oleh sifat pelekatan yang kurang memuaskan telah dijumpai di dalam kayu venir berlamina yang diperbuat daripada Keruing. Pada dasarnya, kayu venir berlamina yang diperbuat daripada venir yang nipis mempunyai kekuatan yang lebih baik kayu venir berlamina yang diperbuat daripada venir tebal: 2% hingga 34.3% dalam lentur statik; 0.6% hingga 14.6% dalam ricih lentur; 5% hingga 50% dalam ketegangan; dan 7% hingga 455% dalam kemampatan. Nisbah minima bagi semua spesis yang dikira bagi UTS dan TMOE adalah 0.52, manakala UCS dan MOR adalah 0.69, di mana kedua-dua nisbah itu jatuh dalam jarak kayu. Berdasakan kepada sifat kekuatan kayu venir berlamina dalam kajian ini, didapati bahawa kekuatan kayu venir berlamina lebih tinggi sekurang-kurangnya satu gred daripada kayunya dalam spesis yang sama berdasarkan tegasan gred yang diterbitkan dalam MS 544 Part 2.

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TABLE OF CONTENTS

CHAPTER

LIST OF TABLES

LIST OF FIGURE

LIST OF ABBREVIATIONS

AFPA	America Forest & Paper Association
ANOCOVA	Analysis of Covariance
APA	The Engineered Wood Association
ASTM	America Standard of Testing Materials
AS/NZS	Australia/New Zealand Standard
CIDB	Construction Industry Development Board Malaysia
CMOE	Compression Modulus of Elasticity
COV	Coefficient of Variances
E	Young Modulus
EWP	Engineered Wood Product
FJ	Finger Jointed
FPL	Forest Products Laboratory
FRIM	Forest Research Institute Malaysia
GLM	General Linear Model
HHW	Mixed Heavy Hardwood
JKR	Jabatan Kerja Raya
L	Longitudinal
LHW	Mixed Light Hardwood
LVL	Laminated Veneer Lumber
MC	Moisture Content
MDF	Medium Density Fiberboard
MHW	Mixed Medium Hardwood
MOE	Modulus of Elasticity
MOR	Modulus of Rupture
MS	Malaysia Standard
MSR	Machine Stress Rated
NER	National Evaluation Report
OSB	Oriented Strand Board

OSL	Oriented Strand Lumber
P	Probability
PF	Phenol Formaldehyde
PLV	Parallel Laminated Veneer
PRF	Permanent Reserved Forest
PSL	Parallel Strand Lumber
R	Radial
RH	Relative Humidity
SAS	Statistical Analysis System
SCL	Structural Composite Lumber
SEM	Scanning Electron Microscope
T	Tangential
TMOE	Tensile Modulus of Elasticity
UCS	Ultimate Compression Strength
UiTM	Universiti Teknologi Mara
UPM	Universiti Putra Malaysia
US	United States
USDA	United States Department of Agriculture
UTS	Ultimate Tensile Strength
WBP	Weather Boil Proof