ISSN 2087-3840

WOOD RESEARCH Journal

Journal of Indonesian Wood Research Society

Volume 15, Number 2, Oktober 2024

Volume 15, Number 2, Oktober 2024 ISSN 2087-3840

WOOD RESEARCH Journal

Journal of Indonesian Wood Research Society

Chief Editor

Dr. Ratih Damayanti

Editorial Board Members

Prof. Yusuf Sudo Hadi
Prof. Bambang Subiyanto
Prof. Wasrin Syafii
Prof. Anita Firmanti
Prof. Nobuaki Hattori
Prof. Jugo Ilic
Prof. Edi Suhaimi Bakar
Prof. Sri Nugroho Marsoem
Prof. Imam Wahyudi
Dr. Farah Diba
Dr. Krisdianto
Dr. Ganis Lukmandaru
Dr. Tomy Listyanto
Fanny Hidayati, Ph.D.

Peer Reviewers

National Research and Innovation Agency
Prof. Subyakto
Prof. Myrtha Karina
Prof. Gustan Pari
Prof. Adi Santoso
Prof. Djarwanto
Prof. I.M. Sulastiningsih
Prof. Widya Fatriasari
Dr. Titik Kartika
Dr. Nanang Masruchin
Dr. Ina Winarni
Dr. Ismail Budiman
Dr. Novitri Hastuti
Dr. Gunawan Pasaribu
Dr. Jamaludin Malik
Dr. Dona Octavia
Dr. Maya Ismayanti
Dr. Didi Tarmadi
Dr. Muhammad Adly Rahandi Lubis
Dr. Kurnia Wiji Prasetiyo

IPB University
Prof. I Wayan Darmawan
Dr. Naresworo Nugroho
Dr. Istie S. Rahayu

Bengkulu University
Prof. Ridwan Yahya

Tanjungpura University
Prof. Yuliati Indrayani

Gadjah Mada University
Dr. Ragil Widyorini
Dr. M Navis Rofii
Dr. Hairi Cipta

Mulawarman University
Dr. Rudiantoro Amirta
Dr. Irawan W. Kusuma

Hasanuddin University
Prof. Musrizal Muin

Kyoto University
Prof. Junji Sugiyama
Prof. Toshiaki Umezawa
Prof. Takashi Watanabe
Dr. Misao Yokoyama

Dresden University
Dr. Christian Gottloober

Oklahoma State University
Prof. Salim Hiziroglu

Montpelier University
Prof. Joseph P. Grill

Duzce University
Prof. Cihat Tasciouglu, Ph.D

Kangwon National University
Prof. Nam-Hun Kim

University of Melbourne Prof. Barbara Ozarska

Paris Tech Cluny
Prof. Remy Marchal

Universiti Putra Malaysia
Prof. Edi Suhaimi Bakar

Journal Manager Dian Anggraini Indrawan, S.Hut., MM.
IT Manager Suhardi Mardiansyah, A.Md.
Section Editors & Initial Reviewers Fanny Hidayati, Ph.D.
Dian Anggraini Indrawan, S.Hut., M.M.
Copy & Layout Editor Suhardi Mardiansyah, A.Md.
Proof Readers Prof. Subyakto
Prof. Ganis Lukmandaru
Dr. Krisdianto
Dr. Tomy Listyanto
Treasurer Dr. Firda Aulya Syamani, M.Si.

Comparative Study of Flexural Behavior of Bolted-Laminated and Glue-Laminated Sengon Timber Beams (*Albizia falcataria*)

Yosafat Aji Pranata, Anang Kristianto, & Novi

Abstract

This study aimed to study the flexural behavior of bolt-laminated and glue-laminated sengon (*Albizia falcataria*) timber beams, which are flexural strength, modulus of rupture (MoR), and beam ductility. The study was conducted using an experimental testing method in the laboratory with reference to the ASTM D198. The number of test objects were three consecutively for bolt-laminated beams and glue-laminated beams. Results obtained from this study indicated that the flexural strength of bolt-laminated and glue-laminated sengon timber beams was not significantly different; the flexural strength of bolt-laminated beams were 3.1% higher compared to glue-laminated beams. The MoR and ductility of bolt-laminated beams were 8.4% and 14.2% higher compared to glue-laminated beams. These results indicate that the glue has an impact to the brittle behavior or limited ductility, while the bolts have an impact to make a more ductile beams. The general conclusion is that mechanical laminated timber technology can be an alternative to producing beams with larger cross-sectional sizes compared to solid timber, especially for low-grade wood, so that it can be used as part of the structural elements of buildings.

Keywords: Flexural strength, beam ductility, laminated timber, sengon, ASTM D198.

Introduction

Beams, as one of the main elements of a building besides columns, functioning for withstanding loads, both gravity and lateral loads, in the form of internal forces, namely bending moments and shear forces. The beam deflection must be designed not to exceed the permitted limit so that it meets the stiffness requirements. For the case of wide span beams, a larger cross-section is required according to the needs, while on the other hand, timber, especially low grades, is difficult to obtain because trees with large diameters are limited in number.

Timber lamination technology for building components, especially for beam elements, provides several benefits. It can be solutions for making beams with dimensions and cross-sectional sizes according to demands, thus it can be used as a structural component, for example, beams and columns for building construction. Examples of lamination technology are mechanical laminated timber with bolt that function as shear restraints and chemical laminated wood with glue as an adhesive between timber laminae.

A mechanical or bolt-laminated beam system is a beam composed of two or more laminae with bolts used as a shear-resistant connecting device. By having bolts installed at a certain distance, sliding that occurs between the laminae can be prevented (Pranata *et al*., 2011). A glue lamination beam system is a beam composed of two or more laminae bonded with glue. The function of the glue is to prevent sliding between the laminae due to the load acting on the beam.

This study aims to study the flexural behavior of bolt-laminated and glue-laminated sengon (*Albizia falcataria*) timber beams, which are flexural strength, modulus of rupture, and ductility ratio. Sengon trees are found in many tropical climates such as India, Vietnam, Thailand, Cambodia, Burma, Laos, China, and Indonesia. Sengon wood is classified as Strength Class III, with limited mechanical properties. Sengon trees are profitable in terms of production at a relatively shorter harvest period, which is around 3-6 years (Larasati, 2019; Prijono and Saputra, 2024), and as consequence, the diameter of log is also relatively small.

Researches have tried to increase the strength of sengon wood, namely by processing raw log materials into engineered wood product, for example, Laminated Veneer Lumber (LVL). Study on LVL high beams and its flexural capacity has been conducted (Putri and As'ad, 2015; Handayani, 2016; Awaludin *et al*., 2018; Awaludin and Wusqo, 2021). Effendi and Awaludin (2022) studied the slender LVL beams, and research on LVL beams with non-prismatic cross-sections has also been conducted by Awaludin *et al*. (2019).

Further studies to form beams with a larger cross-sectional size according to needs by using glue lamination technology (chemical lamination) and bolt lamination (mechanical lamination) have been carried out. This product is used as a structural component for wide-span buildings. Beams are joined mechanically using fasteners (Fraserwood, 2024). Research on the flexural capacity, compressive capacity, and elastic modulus of sengon glue laminated wood has been conducted by Fahkri (2001), Lilis (2010), Wulandari and Ami (2022), Mutiara (2022), and Hadi and Lestari (2022). Table 1 shows the results of the flexural strength and the modulus of rupture of solid and glue laminated of sengon timbers.

Table 1. Flexural strength of sengon (*Albizia chinensis*) timber

Timber Products	References	F_b ((MPa)	MoR (MPa)
Sengon (solid)	Wicaksono *et.al.*, 2017	-	20.65
Glue-Laminated Sengon	Anshari *et.al.*, 2018	-	24.31
Glue-Laminated Sengon	Chauf, 2019	14.00	17.00

Materials and Methods

The timber studied is Sengon (*Albizia falcataria*). The behaviors studied include flexural strength, modulus of rupture (MoR), and beam ductility. Flexural strength and MoR are parameters required for design of beam strength capacity, while ductility is a parameter required for design of beam stiffness.

There are several experimental testing methods for beam flexural testing. In this study, the four point bending test method was used according to the ASTM D198-22 (ASTM, 2022) with 1500 mm clear span. The four point bending test method consists of two load points and two support points. With the concept of two load points as shown in Figure 1, empirical data of the force in the pure bending moment can be obtained in the load span section, which is an important parameter for calculating the normal bending stress.

The test specimens of glue-laminated beams and bolt-laminated wood consisted of 4 laminae 60mm x 40mm (lamina thickness is 40mm), so the beam size was 60mm x 160mm. In bolted-laminated beams, the spacing between bolts was 100mm with 10mm bolt's diameter. The function of bolts is to prevent horizontal sliding due to internal forces, namely shear forces.

The number of test objects was 3 (three) for bolt-laminated beams and 3 (three) for glue-laminated beams. All test objects were made in dry conditions (moisture content ranging from 12% to 16%). The flexural strength referred to in this research is the flexural stress calculated under proportional load condition (F_b), while the MoR is the flexural stress calculated under ultimate or peak load.

Flexural Tests

Flexural testing for all specimens are carried out using a Universal Testing Machine (UTM) HT-9501 Electro-Hydraulic Servo (maximum load capacity 1000 kN) with output data in the form of a history curve of the relationship between flexural load and mid-span of beam deformation. Figure 1 shows the test equipment that used in the research.

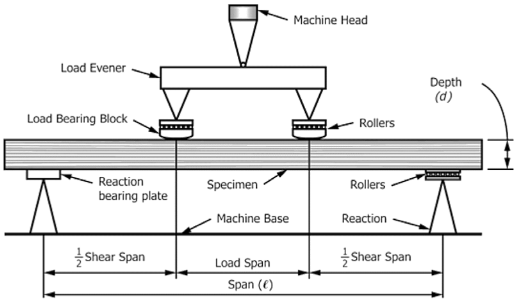

Figure 1. The flexural test in accordance with ASTM D198-22 (ASTM, 2022)

The general equation of normal (flexural) stress (Hibbeler, 2023) can be solved using Equation 1a.

$$\sigma = \frac{M.y}{I_x} \tag{1.a}$$

$$I_x = \frac{1}{12} b.d^3 \tag{1.b}$$

Flexural stress is calculated using Equation 2 (Goodno and Gere, 2021). Flexural strength is one of a material properties of a beam, which is the stress that occurs in a material before it yields in a flexural test using destructive method. In term of yield or proportional point,

$$F_b = \sigma \tag{2}$$

$$M = P_y .a \tag{3}$$

where σ is normal (flexural) stress, F_b is flexural strength (MPa), M is moment at yield point (N.mm), P_y is yield point (N), a is length of ½ shear span (meter) or 500mm in this research (see Figure 1), y is distance from surface area of cross-section to center of cross-section (meter), I_x is the cross-section moment of inertia (m^4), b is the beam width (mm), and d is the beam thickness (mm).

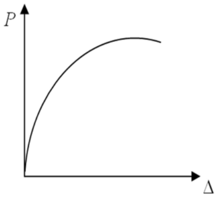

Figure 2. Flexural Load vs Mid-span deformation curve.

Figure 2 shows a schematic history of the flexural load vs mid-span of beam deformation relationship curve obtained from experimental test results. Modulus of Rupture (MoR) is a material property, defined as the stress in a material just in term of ultimate or peak load in a destructive method which is flexure test. MoR represents the ultimate stress experienced within the material at its moment of collapse of specimen.

$$MoR = \frac{M_{ult}.y}{I_x} \tag{4}$$

where MoR is modulus of rupture and M_{ult} is moment at ultimate point (N.m).

Determining The Proportional or Yield Load

In this study, the determination of proportional or yield load uses the reference of SIA 265 Code (SIA, 2003). This is because most of beam members are not able to develop mechanisms of full plastic at failure.

In this study, the definitions of ductility ratio, as a ratio between an ultimate or peak deformation divided by yield or proportional deformation (Jorissen and Massimo, 2011), as shown in Figure 3. The ductility ratio (μ) of beam can be calculated using Equation 5.

$$\mu = \frac{\Delta_u}{\Delta_y} \tag{5}$$

where Δ_y is the displacement in term of proportional or yield load and Δ_u is the displacement in term of ultimate or peak load.

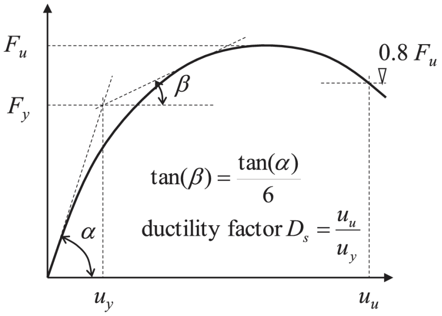

Figure 3. Determining the yield or proportional deformation (uy) according to SIA 265 (SIA, 2003).

Results and Discussion

Figure 4 shows the bending test of a bolt-laminated beams in the laboratory. The specimen has a rectangular cross-section with a width of 60 mm (b) and a height of 160 mm (d), not included in the slender category, so that in testing up to the ultimate or peak load, no buckling and no horizontal deformation occured in the middle of the span. The test results, namely the beam failure pattern, are shown in Figure 5 for the bolt-laminated beam specimens and Figure 6 for the glue-laminated beam specimens.

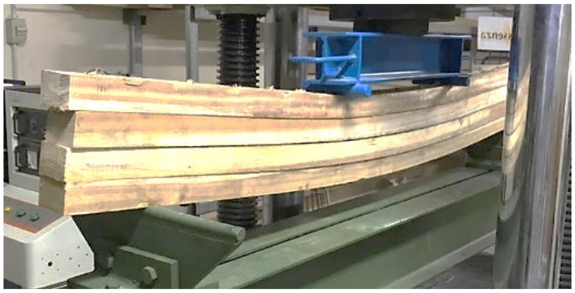

Figure 4. Flexural testing of specimens according to ASTM D198-22 (ASTM, 2022)

Figure 5. Bolt-laminated specimens after flexural tests

Figure 6. Glue-laminated specimens after flexural tests

The test results of all laminated-bolted beams generally consist of simple tension failures that occur in laminates that experience tensile stress. Meanwhile, for the glue-laminated beam test specimens, the failures that occurred were simple tension on first specimen and in the glue part on second and third specimens.

Figure 7 shows the test results of the bending load vs deflection curve of the glue-laminated beams. While Figure 8 shows the test results of the bending load vs deflection curve of the bolt-laminated beams. However, bolt-laminated beams has a smaller stiffness than glue-laminated beams, but exhibits more ductile behavior.

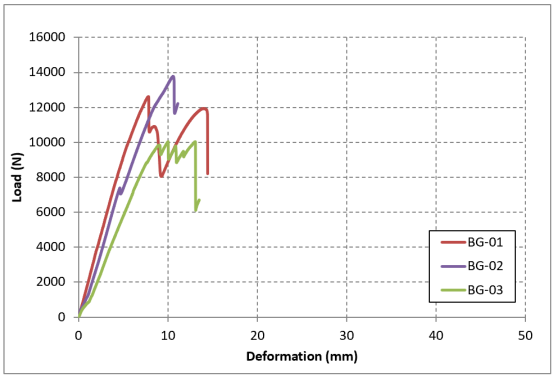

Figure 7. Flexural load vs mid-span of beam deformation curve obtained from glue-laminated timber specimens

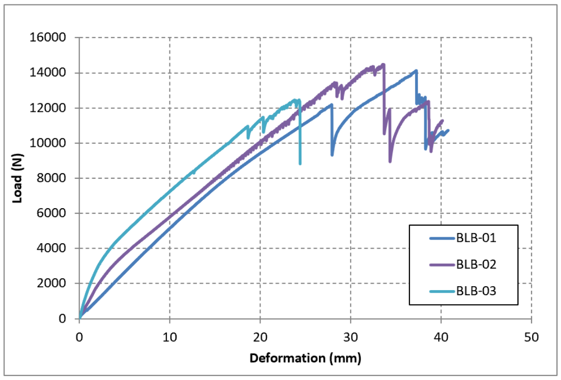

Figure 8. Flexural Load vs Mid-span of beam Deformation Curve obtained from bolt-laminated timber specimens

Table 2. Tests results: Load, Deformation, and Ductility ratio of bolt-laminated timber beams (BLB).

Spec.	P_y (kN)	Δ_y (mm)	P_u (kN)	Δ_u (mm)	μ
BLB-01	10.87	18.43	12.28	24.32	1.32
BLB-02	12.33	25.97	14.32	33.58	1.29
BLB-03	12.19	27.30	14.12	37.24	1.36
Mean	11.80	23.90	13.57	31.71	1.33

Table 3. Tests results: Load, Deformation, and Ductility ratio of glue-laminated timber beams (BG).

Spec.	P_y (kN)	Δ_y (mm)	P_u (kN)	Δ_u (mm)	μ
BG-01	11.78	6.96	12.59	7.83	1.13
BG-02	13.12	9.82	13.75	10.64	1.08
BG-03	9.40	8.33	10.04	10.03	1.20
Mean	11.43	8.37	12.13	9.50	1.14

Table 2 and Table 3 shows the calculation results, namely load at proportional limit conditions (P_y), load at ultimate limit or pak conditions (P_{ult}), deformation at proportional conditions (Δ_y), deformation at peak conditions (Δ_u), and ductility ratio (μ) which was calculated using Equation 5.

Table 4. Results of Flexural Strength and Modulus of Rupture of bolt-laminated timber beams.

Specimen	M_y (kN.m)	F_b (MPa)	M_{ult} (kN.m)	MoR (MPa)
BLB-01	2.72	10.62	3.07	11.99
BLB-02	3.08	12.04	3.58	13.99
BLB-03	3.05	11.90	3.53	13.79
Mean	2.95	11.52	3.39	13.26

Table 5. Results of Flexural Strength and Modulus of Rupture of glue-laminated timber beams.

Specimen	M_y (kN.m)	F_b (MPa)	M_{ult} (kN.m)	MoR (MPa)
BG-01	2.94	11.50	3.15	12.30
BG-02	3.28	12.81	3.44	13.43
BG-03	2.35	9.18	2.51	9.80
Mean	2.86	11.16	3.03	11.84

Table 4 and Table 5 shows the results of the calculation of flexural strength (F_b) which was calculated using Equation 2 and the modulus of rupture (MoR) which was calculated using Equation 4. Proportional limit or yield load (P_y) is the condition when a change occurs from an elastic to an inelastic condition.

The calculation results of ductility ratio (μ) as shows in Table 2 and Table 3 indicated that bolts as mechanical connection devices, namely horizontal shear restraints on laminated beams, provide an impact, namely more ductile behavior than laminated beams bonded with glue. Glue is, however, a brittle material.

Laminated-bolt beams have a flexural strength (F_b) of 11.52 MPa or 17.71% lower than solid beams (Chauf, 2019), while laminated-glued beams have a flexural strength of 11.16 MPa or 20.28% lower than solid beams. This is the impact of the influence of slip between laminae when the load acts on the beam. However, the laminated cross-section will not be the same as the solid cross-section.

Conclusions

Results obtained from this study indicated that the flexural strength of bolt-laminated and glue-laminated Sengon (*Albizia falcataria*) timber beams is not significantly different. The results of the study were that the flexural strength of bolt-laminated beams were 3.1% higher compared to the flexural strength of glue-laminated beams.

The modulus of rupture of bolt-laminated beams were 8.4% higher compared to the modulus of rupture of glue-laminated beams. The ductility of bolt-laminated beams were 14.2% higher compared to glue-laminated beams. These results indicate that the glue has an impact, namely the beam has brittle behavior or limited ductility, while the bolts have an impact, namely the beam behaves more ductile.

The general conclusion is that mechanical laminated timber technology can be an alternative to produce beams with larger cross-sectional sizes compared to solid timber, especially for low-grade wood, so that it can be used as part of the structural elements of buildings.

Acknowledgements

The author received research funding from Universitas Kristen Maranatha, through internal research funding

Scheme B, fiscal year 2023, therefore the author would like to express his deepest gratitude. The author also would like to thank all Structure Laboratory staffs for all their assistance so that testing activities in the laboratory can be completed.

References

American Society for Testing and Materials. 2022. ASTM D198-22 Standard test methods of static tests of lumber in structural sizes, American Society for Testing and Materials, 100 Barr.

Anshari, B., Rofaida, A., Mahmud, F., Pathurahman, Rahmalia, R. 2019. Experimental study on the effectiveness of finger joint with variations in wood species toward bending strength of glulam beams, Proceeding of 7th Sustain Conference in Conjuction with 3rd ICGDTR 2018, IOP Publishing, Volume 361.

Awaludin, A., Shahidan, S., Basuki, A., Zuki, S.S.M., Nazri, F.M. 2018. Laminated Veneer Lumber (LVL) Sengon: An innovative sustainable building material in Indonesia, International Journal of Integrated Engineering, Volume 10, No. 1, pp. 17-22.

Awaludin, A., Irawati, I.S., Shulhan, M.A. 2019. Two-dimensional finite element analysis of the flexural resistance of LVL sengon non-prismatic beams, case studies in construction materials, Volume 10, e00225.

Awaludin, A, Wusqo, U. 2021. Evaluation of flexural behavior of sengon LVL high beam with lateral bracing at both supports (*in Indonesian*), Media Komunikasi Teknik Sipil, Vol. 27 No. 2, pp. 170-178.

Basuki, A., As'ad, S., Putri, S. 2015. Flexural capacity of Laminated Veneer Lumber (LVL) sengon wood beam (*in Indonesian*), Matriks Teknik Sipil, Volume 3 No.1, pp. 51-58.

Chauf, K. 2019. Laminated wood beam combination of sengon and gelugu with nylon twist reinforcement, (in Indonesian), Dissertation (*not published*), University of Brawijaya.

Effendi, M.K. Awaludin, A. 2022. Nonlinear finite element analysis of flexural Laminated Veneer Lumber (LVL) sengon slender beam, Civil Engineering Dimension, Vol. 24 No. 2, pp. 85-92.

Fakhri. 2021. The effect of the amount of wood filler in keruing-sengon wood composite beams on the strength and stiffness of laminated wood beams (Glulam Beams) (*in Indonesian*), S2 Thesis (*not published*), Department of Civil Engineering, University of Gadjah Mada.

Fraserwood. 2024. Key-Laminated Beams, 39500 Government Road PO Box 1782 Squamish, BC Canada V8B 0B3, URL: https://fraserwood industries.com/products/key-laminated-beams, accessed on date December 21, 2024.

Goodno, B.J., Gere, J.M. 2021. Mechanics of Materials 9th Edition, ISBN 978 0 3573 7785 7, Publisher Cengage.

Hadi, Y.S., Lestari, A.S.R.D. 2022. A review of the utilization of wood from plantation forest for glulam (*in Indonesian*), Jurnal Penelitian Hasil Hutan, Volume 1 No. 1, pp:31-36, March 2022.

Handayani, S. 2016. Test analysis of sengon and coconut laminated wood beams (*in Indonesian*), Jurnal Teknik Sipil & Perencanaan, Vol. 18 No. 1.

Hibbeler, R.C. 2023. Mechanics of Materials, 11th edition, Published by Pearson.

Jorissen A., Massimo F. 2011. General notes on ductility in timber structures, Engineering Structures, Vol. 33, pp. 2987-2997.

Larasati, D. 2019. The effect of planting distance on the potential of sengon stands in KPH Kediri, East Java (*in Indonesian*), S1 thesis (*not published*), Department of Forestry, University of Gadjah Mada.

Lilis, T. 2010. Modulus of elasticity and compressive strength of glued laminated timber (Glulam) (*in Indonesian*), Undergraduate Theses (*not published*), Bogor Agriculture University.

Mutiara. 2022. Physical and Mechanical Properties of Glulam from Sengon Wood (*Paraserianthes falcataria*) Based on Wood Grain Direction (*in Indonesian*), S1 thesis (*not publisherd*), University of Mataram.

National Standardization Agency. 2013. Design Specifications for Wood Construction SNI 7973:2013 (*in Indonesian)*, National Standardization Agency.

Pranata, Y.A., Suryoatmono, B., Tjondro, J.A. 2011. The flexural rigidity of Indonesian timber bolt-laminated beams, Proceeding The 2nd. International Symposium of IWORS, Indonesia, 12-13 November 2010, Published by Indonesian Wood Research Society.

Prijono A., Saputra, S.H. 2024. Five-year-old sengon growth on regosol soil in Widodomartani, Sleman, Yogyakarta (*in Indonesian*), Jurnal Wana Tropika, Vol. 14, No. 01.

Swiss Society of Engineers and Architects. 2003. SIA 265 - Swiss Code for Timber Structures, Published by Swiss Society of Engineers and Architects.

Wicaksono, T.M., Awaludin, A., Siswosukarto, S. 2017. Analysis of flexural strengthening of sengon wood beams with sandwich beam composite system (Lamina dan Plate) (*in Indonesian*), Inersia, Volume XIII, No. 2, pp.129-140.

Wulandari, F.T., Amin, R. 2022. Physical and Mechanical properties of laminate boards sengon wood (*in Indonesian*), Jurnal Hutan Tropika, Vol. 17 No. 1, pp.40-50.

Yosafat Aji Pranata
Faculty of Smart Tecnology and Engineering
Universitas Kristen Maranatha
Jl. Suria Sumantri 65, Bandung, 40164, West Java, Indonesia
Tel. : +62-22-2012186 ext. 1212
E-mail : yosafat.ap@gmail.com

Anang Kristianto
Faculty of Smart Tecnology and Engineering
Universitas Kristen Maranatha
Jl. Suria Sumantri 65, Bandung, 40164, West Java, Indonesia
Tel.   : +62-22-2012186 ext. 1212

Novi
Faculty of Smart Tecnology and Engineering
Universitas Kristen Maranatha
Jl. Suria Sumantri 65, Bandung, 40164, West Java, Indonesia
Tel.   : +62-22-2012186 ext. 1212

Volume 15, Number 2, Oktober 2024 ISSN 2087-3840

WOOD RESEARCH Journal

Journal of Indonesian Wood Research Society

Annals of the Wood Research Journal

Wood Research Journal is the official journal of the Indonesian Wood Research Society. This journal is an international medium in exchanging, sharing and discussing the science and technology of wood.

Aims and Scope

The journal publishes original manuscripts of basic and applied research of wood science and technology related to Anatomy, Properties, Quality Enhancement, Machining, Engineering and Constructions, Panel and Composites, Entomology and Preservation, Chemistry, Non Wood Forest Products, Pulp and Papers, Biomass Energy, and Biotechnology. Besides that, this journal also publishes review manuscripts which topics are decided by the Editors.

Imprint

WRJ is published by Indonesian Wood Research Society
ISSN print: 2087-3840
Electronic edition is available at:
http://ejournalmapeki.org/index.php/wrj

Publication Frequency

Journal is published in one volume of two issues per year (April and October).

Peer Review Policy

WRJ reviewing policies are: Every submitted paper will be reviewed by at least two peer reviewers. Reviewing process will consider novelty, objectivity, method, scientific impact, conclusion and references.

General Remarks

Manuscripts will be accepted for publications are those discussing and containing results of research on wood science and technology, and reviews on specific topics, which are decided by the Editors and have not been published elsewhere. Authors are requested to correct the manuscripts accepted for publications as suggested by the Reviewers. Editors could change positions of Figures and Tables.

Manuscripts Preparations

1. Manuscripts must be in English, typewritten using Word, Arial Narrow, single space, 3 cm of left and right margin and 2.5 cm of top and bottom margin of a Letter paper size. Title is printed with a font size of 14 pt, Authors are of 12 pt, and Text is of 10 pt.
2. Manuscripts should be checked for spelling and grammar by a native speaker.
3. Manuscripts compositions:

3.1. Title
3.2. Complete name of Authors
3.3. Abstract
3.4. Key words
3.5. Texts:
Introduction
Materials and Methods Results and Discussion
Conclusions (and Suggestions) References
Name and complete address of Authors
Appendix
4.Other rules:
4.1. Names of wood are followed by Botanical Name.
4.2. Values between are written using this symbol (~), e.g. 3.75 ~ 8.92%.
4.3. Editors could modify Figures without changing their substantial meaning.
4.4. References are arranged from A to Z.
4.5. References in text are written as this example: (Palomar *et al.* 1990; Arancon 1997).
4.6. Examples of writing of References: Altschul, S.F.; T.L. Madden; A.A. Schäffer; J. Zhang; Z. Zhang; W. Miller; D.J. Lipman. 1997. Gapped BLAST and PSI-BLAST: A New Generation of Protein Database Search Programs. Nucleic Acids Res. 25: 3389-3402.

Editorial Address

Research Center for Biomass and Bioproducts,
National Research and Innovation Agency
Jl. Raya Bogor Km 46, Cibinong, Bogor 16911,
Indonesia
Tel/Fax : +62-21-87914511/87914510
E-mail : ejournal.wrj@gmail.com
Web-site : www.ejournalmapeki.org

Example of Table and Figure

Table 1. Effects of temperature on *in vitro* growth of seedlings.

Temp. (°C)	Shoot length (mm)	Number of leaf	Fresh weight (g)
25	59.2 ± 10.6^{c}	4.5 ± 0.8^{a}	0.29 ± 0.13^{a}
27	88.5 ± 9.3^{a}	4.8 ± 0.9^{a}	0.40 ± 0.12^{a}
29	75.0 ± 11.1^{b}	3.8 ± 0.6^{a}	0.30 ± 0.07^{a}

Note: Values (average ± standard deviation) with different letters are statistically significant according to Tukey's multiple comparison test. Data were recorded after 4 weeks of culture. MS medium was used as a basal medium without any PGRs. Number of sample = 10.

Source: Chujo *et al.* 2010.

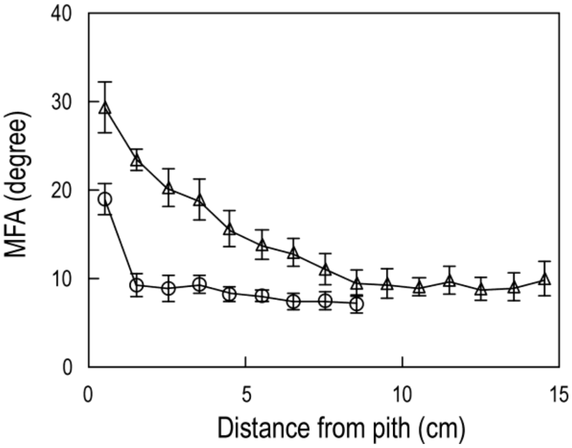

Figure 3. Radial variation of microfibril angle of the S2 layer in tracheid. Open circle, *Agathis* sp.; open triangle, *Pinus insularis*; Bars indicate the standard deviation. (Source: Ishiguri *et al.* 2010)

9 772087 384007