*Proceedings of International Conference : Problem, Solution and Development of Coastal and Delta Areas*
*Semarang, Indonesia – September 26th, 2017*
*Paper No. C-04*

# The Influence of Position and Number of Longitudinal Connection of Sengon Glulam Beams Towards Strength and Stiffness

**Sutarno[1], T. A. Prayitno[2].AdreasTriwiyono**
tarno_usm@yahoo.com

***Abstract*** **-** The demand of wood as construction material always increases. However, sawn-wood with large size is more difficult to find in the market due to decreasing in stock dimension. In addition, it makes price more expensive. Indonesia has many trees from fast-growing species: however, they have low wood quality, and still limited in usage. To obtain a better performance of fast-growing species as construction material, it needs to be combined to produce glulam. This research observed the influence of position and longitudinal connections of wood glulam beam on strength and stiffness with damage species of sengonglulam beams. Preliminary testing was done to obtain physical and mechanical properties of clear specimen of sengon wood, testing method followed ISO-1995 standard. Fifteen glulam beam specimens whichhad 70 mm wide, 200 mm depth, 3000 mm length were constructed: They represented variations of position and connection work of 0 %, 25 %, 50 %, 75 % and 100 %. Each layer of lumber glued with thermosetting phenol formaldehyde (PA-302) adhesive at pressure 1 up to 1,1MPa for 10 hour pressing time. The static lateral loading steps were done continuously until the beam was damaged. The result indicated that sengonwas V class of strength. Glulam testing showed that in terms of strength and stiffness, the higher the number of connections, the lower the value. The strength reduction percentages of 0%, 25%, 50%, 75% and 100% produced 0%, 13,08%. 28,11%. 29,42%. 70,72 %. Respectively and the degradation of glulam stiffness were 100%. 99,92%. 87,86%. 83,06%. 67,08%. The failure of glulam beam with 0% had a shear followed by flexure damages of 25%, 50%, 75% and 100%. A flexure damage was followed by shear damage.

***Keywords:*** *Paraserianthesfalcataria, Connection, Glulam Beam, Strength, Stiffness.*

## 1. Introduction

Wood is one of the renewable natural resources. It has been used as a construction material for a very long time, before the technology of concrete and steel was developed. Besides meeting architectural demands, wood has several advantages including: great strength, lightweight, earthquake resistant, easy to implement, and relative cheap in some areas. Structural wood is widely applied in the construction of roofs, building frames, bridge girders, train bearings and so on. The need of processed wood as a construction material always increases. According to Susetyowati and Subianto (1998), each year for about not less than 3 million cubic meters of sawn timber is needed for the construction of housing, buildings and others in Indonesia. However, to obtain good quality sawn timber, the relatively large size wood is increasingly difficult to find in the market due to the depletion of natural forest production.

According to Syafi'i (1998), in the future, it is estimated that the potential of wood and natural forest area in Indonesia is decreasing, so the supply of wood raw material is from the production of industrial timber plantation (HTI). The efforts to improve the efficiency of wood's use can be done by using fast-growing wood species that generally have small diameter and low quality. Some developed countries continue to develop glulam beam product with low quality wood type. Glulam Beam is a combination of some woods into a whole. It also has more advantages than solid sawmill timber, great strength, smaller deformation, and larger and longer sections. The utilization of glulam beams with low quality wood will save high quality wood and construction cost. Some studies that have been conducted include: Kasmudjo (1995) which examined the strength of sengon wood adhesive for laminated board, Sutigno et al. (1991) examined the effect of the connection on the mechanical properties will increase when the number of layer increases in sengon wood, Fakri (2000) examined the effect of the number of wood that fills the kruing-sengon glulam beam against strength and stiffness with Urea Formaldehyde resin.

## 2. How to Research

This research used160 sheet of sengon wood from Ambarawa with the size of 3 cm x 8 cm x 3.4m and used Phenol Formaldehyde adhesive from PT. Pamolite Adhesive Industry, Probolinggo, East Java. The drying of sengon wood was done naturally in the wood processing laboratory of Faculty of Forestry UGM. The woods were arranged so that the air flowed in the wood arrangement until it reached 12 percent of moisture content measured by a Moisture Content tool. After the moisture content was reached, the glulam beam was made. The test of physical and mechanical properties was done in accordance with ISO 1995 standards and 36 samples were stated defect-free wood. It included the test of moisture content, density, parallel and perpendicular fibers pressure, bending (MOR), elastic modulus, parallel fibertensile, laminated shear beam with adhesive spreads of 40/MDGL, 60/MDGL, 80/MDGL, and the test of connection tensile which were done three times for each test.

Before glulam beam was made, laminate shear beamtest was done with adhesive variations of 40/MDGL, 60/MDGL, 80/MDGL with 3 samples and its correction in each. From the test, it was found that the optimum adhesive spread was 60/MDGL. Then, 15 glulam beams were made. Dry wood boards with for about 12 percent of moisture content which had been shredded were glued and forged in 1 to 1.1 MPa for 10 hours. The making of wood connection was done before the glulambeam was pressed. Position variation and number of connections on glulam beam were 0%, 25%, 50%, 75%, 100%.

The process of physical and mechanical properties test, density and moisture content test were implemented in physics and mechanics laboratory of Faculty of Forestry UniversitasGadjahMada. The test of the mechanical properties of wood was done in the laboratory of mechanical materials of Engineering Sciences UGM by using moisture meter, oven, scales, caliper and Unistated Testing System (UTS).

Glulam beam testing was done in mechanical laboratory of PAU material, UGM, by using frame tool, dial gauge to measure deflection, transducer to know the loading stages, load cell with 10 ton capacity, 15 ton capacity of Jack Hydraulic to give load on the specimen. The test was done after setting the tools and the test object.50 kg load was given gradually. The deflection read on the dial gauge was noted. Loading was done until collapse occurred.


**Picture 1:** The Image of Glulam Beam Test.

## 3. Research Result and Discussion

The test results of physical and mechanical properties can be seen in table 3. Flexural strength was less than 36 MPa and compressive strength was less than 21.5 MPa. Based on its strength, sengon wood belongs to class V. The shear strength was 4.41 MPainaverage to resist the horizontal shear force of external load. Short span style laminate woodhas the biggest shear force on the axis of the cross section so that the dominant fails to shear.

**Table 1. Test Results of Physical and Mechanical Properties**

| No | Density (t/m3) | Moisture Content (%) | Wood strength | | | | | | Strength Class |
|---|---|---|---|---|---|---|---|---|---|
| | | | Flexure (Mpa) | Pressure (Mpa) | Pressure (Mpa) | tensile (Mpa) | Connection tensile (Mpa) | Shear (Mpa) | |
| 1. | 0.263 | 11.95 | 34.21 | 16.78 | 5.43 | 66.78 | 11.87 | 3.73 | V |
| 2. | 0.289 | 14.22 | 32.41 | 18.58 | 3.79 | 85.49 | 6.11 | 4.64 | V |
| 3. | 0.262 | 14.43 | 30.28 | 16.19 | 4.28 | 83.44 | 10.21 | 4.85 | V |

It can be seen from the table above that tensile strength of the connection was 9.39 Mpa lower than the tensile strength without connection. It will weaken the glulam beam if the connection is in the tensile region. The glulam beam shear strength with the adhesive of 40/MDGL, 60/MDGL, 80/MDGL was obtained average shear strength of 0.901 MPa, 2.512 MPa, 1,983 MPa and retrieved 0.755 MPa, 2,247 MPa, 1,971 MPain the following tests. It was found that the optimal glulam beam adhesive was 60/MDGL.

## 4. The Strength of Glulam Beam

The test results of all variations of position and number of connections from 0%, 25%, 50%, 75% and 100% obtained the average load of the proportional limit, the initial collapse load, the peak load and the decreasing collapsed load so that the beam strength obtained was decreased. The position and number of connections in longitudinal direction were decreased by 89.54%, 81.17%, 84.72%, 83.62%,and78.45%. The average decrease of load can be seen in table. 2. It was found that the more the position and the number of connection, the smaller the strength of glulam beam.

**Table 2. Recapitulation of Glulam Beam Test Results Load**

| No. | Beam Code | Average load | | | | The average of proportional limit Toward Peak load |
|---|---|---|---|---|---|---|
| | | Proportional Limit | initial damage | Peak | collapse | |
| | | (N) | (N) | (N) | (N) | ( % ) |
| 1 | BLS 00 | 21000 | 21500 | 25500 | 2566,67 | 89,54 |
| 2 | BLS 25 | 16333,34 | 16833,34 | 22166,67 | 22166,67 | 81,17 |
| 3 | BLS 50 | 15500 | 16333,34 | 18333,34 | 18500 | 84,72 |
| 4 | BLS -75 | 14833,34 | 15666,67 | 18000 | 18166,67 | 83,67 |
| 5 | BLS- 100 | 5866,67 | 6400 | 7466,67 | 7566,67 | 78,45 |

The percentage decreases in average strength of glulam beam in various positions and the number of connections were 0%, 25%, 50%, 75%, and 100%. It was obtained average power loss of 0%, 13.08%, 28.11%, 29.42%, and 70.72%. It can be seen in table 3 below. It was found that the more variation in position and number of connections, the smaller the power. For connection of 25%, the power loss was very small for about 13.08%. It meant that connection of 25% could still be used on the glulam beam.

**Table 3. Reduction of Glulam beam strength**

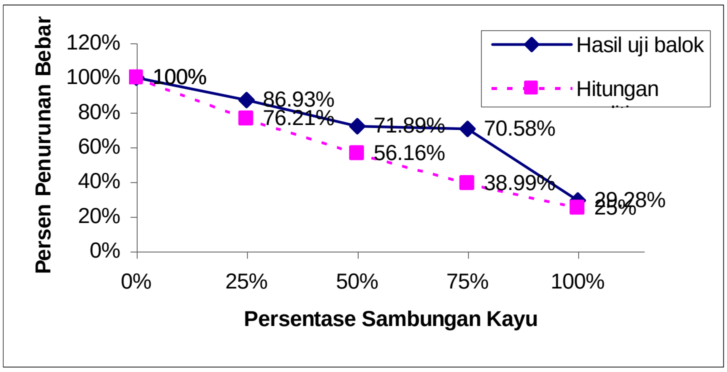
| No. | Beam Code | Maximum load | | Percentage toward BLS 00 | Power Loss |
|---|---|---|---|---|---|
| | | Average | Average | | |
| | | ( Kg ) | ( N ) | ( % ) | ( % ) |
| 1 | BLS 00 | 2550,00 | 25500,00 | **100** | **0.00** |
| 2 | BLS 25 | 2216,667 | 22166,67 | **86.92** | **13.08** |
| 3 | BLS 50 | 1833,334 | 18333,34 | **71.89** | **28.11** |
| 4 | BLS 75 | 1816,667 | 18166,67 | **70.58** | **29.42** |
| 5 | BLS 100 | 756,667 | 7566,67 | **29.28** | **70.72** |

The percentage decreases of glulam beam load from test result compared to percentage decrease of load result of the theoretical calculation for various positions and number of longitudinal direction length were 0%, 25%, 50%, 75%, and 100%. On beam test result, it wasobtained sequential load decreases equal to 100 %, 86.93%, 71.89%, 70.58%, and 29.28%. Theoretically, it was obtained sequential load decreases of 100%, 76.21%, 56.16%, 38.99%, and 25.05%. It was found that between glulam and theoretical beam test there was a difference of the load decrease percentages in sequence according to the position and the number of connections by 0%, 10.72%, 15.73%, 31.59%, and 4.23%. Based on this very small difference, it meant that the count results did not exceed the limits of glulam beam strength. It is shown Table 4 and Figure 2.

**Table 4. The decrease of glulam and theoretical beam load**

| N0 | Beam code | Peak load of the test Average | Test result decrease | Peak load of the theoretical Average | Theoretical result decrease |
|---|---|---|---|---|---|
| | | (N) | (%) | (N) | (%) |
| 1 | **BLS 00** | 25500.00 | 100% | 15380.6699 | **100%** |
| 2 | **BLS 25** | 22166.67 | 86.93% | 11720.8827 | **76.21%** |
| 3 | **BLS-50** | 18333.34 | 71.89% | 8638.0294 | **56.16%** |

| N0 | Beam code | Peak load of the test Average | Test result decrease | Peak load of the theoretical Average | Theoretical result decrease |
|---|---|---|---|---|---|
| | | (N) | (%) | (N) | (%) |
| 4 | **BLS 75** | 18000.00 | 70.58% | 5997.2016 | **38.99%** |
| 5 | **BLS-100** | 7466.67 | 29,28% | 3852.8517 | **25.05%** |

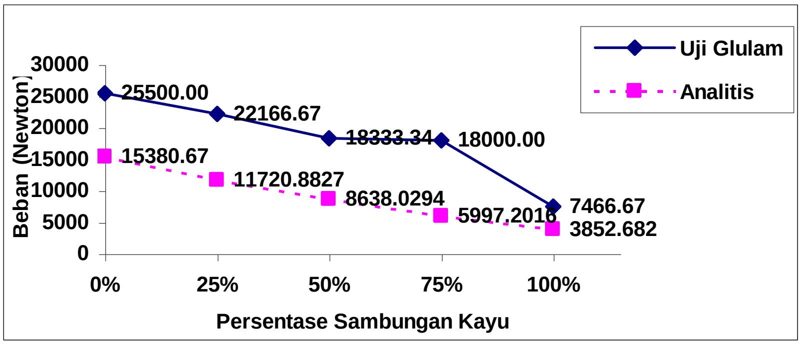



**Picture 2:** Percentage Of Glulam And Theoretical Load Decreases

To determine the strength of the beam theoretically, the capacity analysis was done and found that the average moment was decreased sequentially as 7690.335 Nm, 5860.441 Nm, 4324.162 Nm, 2981.44 Nm, and 1927.341 Nm. The averages of decrease in the analytical load were 15380.6 N, 11720.8 N, 8638.2 N, and 3852.6 N. The shear forces corresponding to the variation in positions and number of longitudinal directions are shown in Table 5 and from FIG. 3. It was obtained decrease averages of beam analytical of 0%, 25%, 50%, 75%, 100% by 60,31%, 52,87%, 47,12%, 33,32% and 51,59%.

**Table 5. Analytical results of glulam's cross-sectional capacity**

| No. | Beam code | Moment | Load | Load x 1.4 | Shear Force | Actual Shear |
|---|---|---|---|---|---|---|
| | | M | P | P' | $F_V$ | Fv |
| | | (N mm) | (N) | (N) | (Mpa) | (Mpa) |
| 1 | **BLS00** | 7690334,94 | 10986,193 | 15380,6 | 4,4100 | 0,790 |
| 2 | **BLS25** | 5860441,337 | 8372,059 | 11720,8 | 4,4100 | 0,690 |
| 3 | **BLS50** | 4324162.500 | 6170,02 | 8638,2 | 4,4100 | 0,590 |
| 4 | **BLS75** | 2981441.406 | 4281,376 | 3852,6 | 4,4100 | 0,490 |
| 5 | **BLS100** | 1927341.000 | 2752,033 | 1926,3 | 4,4100 | 0,390 |




**Picture 3:** The comparison of glulam and analytical strength

The Stiffness of Glulam Beam

From the results of the glulam beam test, there were decreases of stiffness by 667.96 N/mm, 687.46N/mm, 586.85 N/mm, 568.18 N/mm, 448.12 N/mm. The average decrease in percentage for BLS 25% increased the stiffness by 102.9%. Glulam beams of 50%, 75%, and 100% were decreased sequentially by 87.86%, 85.06%,and67.08%. It meant that 25% BLS beam could be used as structures beam due to rigidity increased by 2.9%, as shown in table 6.

**Table 6. Stiffness Decrease of glulam beam**

| NO | Beam Code | Proportional load Limit | Deflection of Proportional Limit | Average Stiffness | Average Stiffness Decrease |
|---|---|---|---|---|---|
| | | (N) | (mm) | (N/mm) | (%) |
| 1 | **BLS 00** | 21000 | 31,92 | 667.96 | 100 |
| 2 | **BLS 25** | 16333,33 | 24,12 | 687.46 | **102.9** |
| 3 | **BLS 50** | 15500 | 26,42 | 586.85 | 87.86 |
| 4 | **BLS 75** | 14833,34 | 26,48 | 568,18 | 85,06 |
| 5 | **BLS100** | 5866,67 | 13,12 | 448,12 | 67,08 |

The decreases of moment and stiffness factors were obtained from various positions and the number of connections. Moment was decreased sequentially of 14116.67 KN/mm, 11316.67 KN/mm, 10966.67 KN/mm, 1033.34 KN/mm, and 3966.67 KN/mm. The stiffness factors were decreased sequentially of 1229.64 KN/M$^2$, 1054.87 KN/m$^2$, 745.23 KN/m$^2$, 516.66 KN/m$^2$, 275.06 KN/m$^2$ of which can be shown in table 7.

**Table 7. Decrease of Moment and stiffness factor**

| No. | Beam Code | Average Moment | Average Curvature (x10$^6$) | Average Stiffness Factor | Average decrease | Average Theoretical/ Test | Theoretical/ Test Average |
|---|---|---|---|---|---|---|---|
| | | (KN-mm) | (1/mm) | (KN/m$^2$) | (%) | | (%) |
| 1 | **BLS 00** | 14116,67 | 11.310 | 1229,64 | **100** | 0,57 | 56 |
| 2 | **BLS 25** | 11316,67 | 10,280 | 1054,87 | **85.78** | 0,53 | 52 |
| 3 | **BLS 50** | 10966,67 | 13,52 | 745,23 | **60.61** | 0,42 | 42 |
| 4 | **BLS 75** | 1033,34 | 19,830 | 516,66 | **42.02** | 0,34 | 34 |
| 5 | **BLS100** | 3966,67 | 14,66 | 275,06 | **22.37** | 0.48 | 49 |

## 5. Conclusions and Suggestions

### Conclusions

Based on the discussion of the research results conducted, it can be drawn some conclusions as follows:

1) The average moisture content of sengon wood was 12% accordance to Indonesia wood adhesive standards. The density was low in 0.271 t/m3 which included in strong class V according to PKKI-61. The Optimum adhesion constancy of phenol formaldehyde was 60/MDGL. The amount of adhesive spread was 322.23 gram/$m^2$. Modulus of elasticity (stiffness) was 5135,38MPawhich meant that the forging of 1 to 1.1 MPa had not passed the elasticity of material.
2) The maximum strength of glulam timber was 32.00 MPa and stiffness of 25.00 Mpa. The various positions and number of connections were o%, 25%, 50%, 75%, and 100%. They were decreased by 100%, 86.93%, 71.89%, 70.56%, and 29.28%. The stiffness was decreased by 100%, 99.92%, 87.86%, 83.06%, 67.08%. It meant that in position and number of connections of 25% and 50%, the decreases of strength and stiffness were relatively small so that it could be used as beam structure.
3) The damage of sengon glulam for all positions and the number of connections dominantly happened because of bending or the damage in the connection of the tensile area. However, loading less makes the percentage of connection sudden damage (shear) greater.

### Suggestions

Some suggestions put forward for further research include:

1) Sengon should be included in strong class IV so that it can add the contribution of structural materials.
2) Wooden structured beam on long spans of sengoncan be contributed, with relative small percentage of connections and placed on the compressive area.
3) Because glulam beam deflection has large percentage and the sudden collapse of the dominant structure (shear) for dry wood has less than 12 percent, the security and caution are needed.
4) The further researches for glulam beam with various kinds of connection constructions and some types of wood with other types of adhesives are needed.

## References


Anonim,1977, *National Design Specification for Wood Construction*, National Forest Product Association, Washington, DC.

Blass, H .J, P. Aune, B.S. Choo, R.Gorlacher, DR.Griffiths, B.O. Hilso, P. Raacher Dan G.

Steeck, (Eds ), 1995 *Timber Engineering Step I*, Fisrt Edition, Centrum Hout, The Nedherlands.

Bodig dan Jayne, 1982. *Mechaniecs of Wood and Wood Composte,*Proceding peningkatan kayu, Bogor.

Bohannan, B dan R.C. Moody,1973, Evolution of Glulam Strength Criteria, *Forest Product*

*Journal*, 23. (6) : 19 –24.

Breyer, D.E,1988, *Design of Wood Structures*, Second Edition. McGraw-Hill, Inc.New York.

Falk, R.H .dan F. Colling, 1995, Laminating Effects in Glued –Laminated Timber Beams, *Journal of Structural Engineering*, .121 (12) : 1857-1863.

Gere, J.M, S.P.Timoshenko,1987, *Mechanics of Materials*, Fist Edition,Wadswort Inc,

Calofornia.
Golyakov, A.D, 1976 Strenth Grading Of Dimension Stock for Glue Wooden Construction, *Lesnoi Zhurnal*, 5 :79 – 82
Hasyashi, T. Dan A. Miyatake, 1998, Procesding of Laminated Veneer Lumber From
Tropical Woods, *Adhesive Tecnology and Bonded Tropical Wood* Product Taiwan Forest Research Institute.
Kilpelainen, H .dan V. Friman, 1975, Effect of Pressing Time Temperature on the Curing and
On The Bond Quality of Phenol- Resorcinol Resin Adhesive, *Paperi-ja-puu* 57 (10) : 655-665.
Kollman. F.F,P, E.W. Kuenzi dan A.J. Stamm, 1975, *Principles of Wood Scince and Tchnology. Vol II. Wood Based Materials*, Springer- Verlag, Berlin.
Koval´ chuk, L.M., dan A.V. Baltrushaitis, 1989, Effect of Wood Defect on the Strength of Glue Structure, *Izvestiya – Vysshikh- Uchebnykh- zhurnal*, 3 : 76-80.
Madsen, B, 1972, Duration of Load Test for Dry Lumber in Bending, *Forest Pruduct Journal*, 23 (2) : 21 –28.
Panshin, A.J and C.D, Zeeuw, 1964, *Texbook of Wood Technology, Volume I-Structure, Identification*, Uses and Properties of The Commercial Woods of The United States Vol. I Second Edition, Mc. Graw Hill Book Company, New York
.Rhude, M.J,1982 Wood Construction, Dalam Merritt, F.S, (E) *Building Design and Construction Handbook*, Fourth Edition: (7-1) –(7-87), Mc Graw Hill Book Company, New york.

Tahir, P .M .H., Sahri, dan Z. Ashari, 1998, Gluability of less Used and FastGrowing Tropical Plantation Hardwood Spesies, *Adhesive Technology andBonded Tropical Wood Product*, Taiwan Forest Research Institute.
Tsoumis, G.1991. *Science and Technology of Wood*, Vannostrand Reinhold Newyork.
Widjaja, P. *1995. Behavior of Trunk Mechanics Composite Structure Bamboo Laminate Phenol*
Anonymous, 1993, *Standard sawmills*, -SNI SK-1993, the Department of Public Works.
Fakhri, 2000 *Effect of Amount Wood Composite Wood Filler Kruing- Sengon Against Strength and*
*Laminate Wood Beams stiffness,* Thesis S-2, GadjahMadaUniversity ,. Yogyakarta.
Karnasudirdja, S, 1989, *Effect of connection upright and tilted at wood laminate Kasigoro*
*the strength and stiffness*, Forest Products Research Institute, Department of Agriculture, Bogor, West Java.
Kasmudjo, 1995, *Assessment of Sipat -Sipat Wood Sengon and Possible Uses Its use*, Ambassador Rimba, XX (179 -180): 41 -46.
Susetyowati AFE and B. Subianto, 1998. The future and challenges of R & D Technology Utilization
Wood, *the first National Seminar MAPEKI,* Faculty of Forestry, Bogor.Syafi'i, W., 1998, The
Importance of Research The Basic Nature of Wood in Efficiency Improvement
Utilization of Forest Resources, *MAPEKI Day Seminar*, Faculty of Forestry, Bogor.
Prayitno TA, 1996, *Wood Gluing*, Faculty of Forestry, GadjahMada University, Yogyakarta.
Prayitno,T A,1995, *Invalidity Gluing*, Faculty of Forestry, GadjahMada University, Yogyakarta.

Prayitno, T. A, 1995, *Personality Testing according to ISO Pisika and Mechanics,* Faculty of
Forestry, UniversityofGadjahMada, Yogyakarta.
Prayitno, T. A, 1996, *a wood adhesive*, Faculty of Forestry, GadjahMada University, Yogyakarta.
Bharata, 1994.*Glue and clamp,* Aksara.Jakarta work. Indonesia.
Fakhri, 2000 *Effect of Amount Wood Composite Wood Filler Kruing- SengonAgainst Strength
AndLaminate Wood Beams stiffness*, Thesis S-2, GadjahMadaUniversity ,. Yogyakarta.
Hartomo, AJ, A. Rusdiharsono, and D. Hardjanto, 1992, *Understanding polymer and adhesives*
Publisher Andi offset, Yogyakarta.
Kasmudjo, 1992, *Nature Falcata Age 5 -7 Years,* Duta Rimba, XVIII, (143-144): 36 -41
Kasmudjo, 1995, *Assessment of Sipat -Sipat Wood Sengon and Possible Uses Its use*
Ambassador Rimba, XX (179 -180): 41 -46.
Karnasudirdja, S, 1989, *Effect of connection upright and tilted at Leucaena wood laminate gong
(Kasigoro) the strength and stiffness,* Forest Products Research Institute, Department of Agriculture, Bogor, West Java.
Mandang, and IKN Pandit, 1997, *Guidelines for the Identification Wood Field,* Porsea Foundation and Center
Employee Training and Human Resources Forestry, Bogor.
Mandang, Kartasujana and Fandit, 1989.*Indonesian wood Atlas* Agency for research and DevelopmentForestry, Bogor.
Martawijaya, A. and I. Kartasujana, 1997, *General Characteristics, Properties and Uses*
*A - Type Wood*Indonesia,Forest Products Research Institute, Bogor.
Pandit, IKN, 1988, *Wood Structure Paraserianthes in connection with Penggunannya,* Thesis
S-2Post Graduate, UGM Yogyakarta.
Prayitno FY 1984, *Wood Technology*, Faculty of Forestry, University of GadjahMada, Yogyakarta
Prayitno TA, 1996, *Wood Gluing*, Faculty of Forestry, GadjahMada University, Yogyakarta.
Prayitno, TA, 1995, *Invalidity Gluing,* Faculty of Forestry, GadjahMada University, Yogyakarta.
Prayitno, T. A, 1995, *Personality Testing according to ISO Pisika and Mechanics,* Faculty of Forestry, UniversityofGadjahMada, Yogyakarta.
Prayitno, T. A, 1996, *a wood adhesive,* Faculty of Forestry, GadjahMada University, Yogyakarta.
Prayitno, T. A, 1998, Use of Wood Unknown, Junky, *the first National Seminar MAPEKI*, Faculty of Forestry, IPB.
Suratman, Sukoadji, 1978. *Construction Wood, Volume I,* Foundation Publisher FIB. IKIP.Yogyakarta.
Soewarsono, 1990, *Use of Research and Development of Forest n.13; Type Weight from Types of Indonesian Wood and Understanding Weighing of Wood for Practice,*Ministry of Forestry, Bogor
Suhendrajati, 1990.*Wood For Structures,* Vol. Department of Civil Engineering, Faculty of Engineering UGM,Yogyakarta.
Somayaji, S, 1995, *Civil Enggineering Materials,* Prentice Hall, Englewood Cliffs, New Jersey.

Suharjono and E. Prikasari, 1994, *Wood Construction,* National Institute of Technology (ITN) Press, Malang.

Surjono and B. Subianto, 1997, wood as a construction material and structure, *set of papers, Seminar*

*The day PKKI-2000.*R & D of Public Works. As well as Laboratory Structure and Materials ITB,Bandung

Susetyowati AFE and B. Subianto, 1998. The future and challenges of R & D Technology UtilizationWood, *the first National Seminar MAPEKI*, Faculty of Forestry, Bogor.

Syafi'i, W., 1998, The Importance of Research The Basic Nature of Wood in Efficiency ImprovementUtilization of Forest Resources, *MAPEKI Day Seminar*, Faculty of Forestry, Bogor.

Wiryomartono et al, 1961, *Wood Construction Regulations* NI-5 PKKI-1961, the Research FoundationInvestigation of Building Problems, Bandung.

Wardhani, 1998, Stickiness and Arrangement of Lamina Wood Water Jack (Artocarpus KemandoMiq)AndPayang (EndospermumdiadenumMiq) with Polyvinyl Acetate and Phenol adhesivesFormaldehyde, *the first National Seminar*