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EXPERIMENTAL STUDY OF LAMINATION COLUMN WITH SEVERAL TYPES OF WOOD USING ADHESIVE NAILS AND BOLT

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ABSTRACT

The use of light wood combined with heavy wood can improve the quality of the combinationwood. Apart from being used as laminated beams, a combination of light wood and heavy wood can also be used as a laminated column given compressive loads. Based on SNI 7973-2013, the adhesive that was permitted on built up columns or laminated columns can be in the form of bolts and nails, so this study has also used adhesive nails and bolts. This study purpose to determine the compressive capacity of the laminated column which combines several types of wood. The specimens made were four variations of the laminate column. Furthermore, three layers of wood have been used on one laminated column with heavy wood types on the outermost layer. The results showed that all variations of the laminated column had a higher compressive capacity than the solid column.

Keywords: compressive capacity, lamination column, light and heavy wood

1. INTRODUCTION
a. Background

The deficiency of good quality wood and large diameter is a problem that often arises at this time. So that a lot of research has developed to utilize low-quality local wood and have a growing age that is fast becoming wood for use as structural material. One of these technologies is lamination.

The use of light wood combined with heavy wood can improve the quality of light wood itself (Indriyani, 2018). In this case the use of Meranti wood and Coconut wood as heavy wood is expected to improve the quality of Mahang wood and Nibung wood as light wood.

Besides being used as a laminated beam, a combination of light wood and heavy wood can also be used as a lamination column that accepts compressive loads. In SNI 7973-2013 there are so-called built up columns or laminated columns that use only bolt and nail adhesives. The built up column is a mechanical lamination column or column arranged from couple wooden sections so that it forms a single unit, connected using bolts and nails.

The purpose of this study is to find out the compressive strength of several types of wood and want to know the compressive capacity of built up columns of several types of wood using adhesive nails and bolts.

Determination of column compressive strength is intended to find out which wood type is stronger so that it will be placed in the position of the outermost layer of the built up column.

# 2. LITERATURE REVIEW

a. Compression member

The compression member is a part of construction that experiences a compressive force. A part is called a compression member when the direction of the force pressing the member. This compressive element is often found in truss or frame structures. The frame structure is known as a column.

The planning of the compressive member is more complex than the tension member, because the lateral bending behavior causes a secondary moment beside the axial force.

This buckling behavior is influenced by the slenderness value of the column, which is the comparison of the effective length and the radius of the column gyration.If the slenderness value is very small (*short column*) then the wood fibers in the cross section of the column will fail to press. Contrariwise for the slenderness of the column is very high (*long column*) then the column will fail and the wood fibers have not reached compressive strength or even still in elastic condition (*lateral buckling failure*).

b. Built-Up Column

According to SNI 7973-2013,built-up columns are mechanical lamination columns or columns arranged from couple of wooden so as to form a single unit, connected using bolts and nails. The built-up columns cannot be designed like solid columns even though they have cross section are like solid columns.
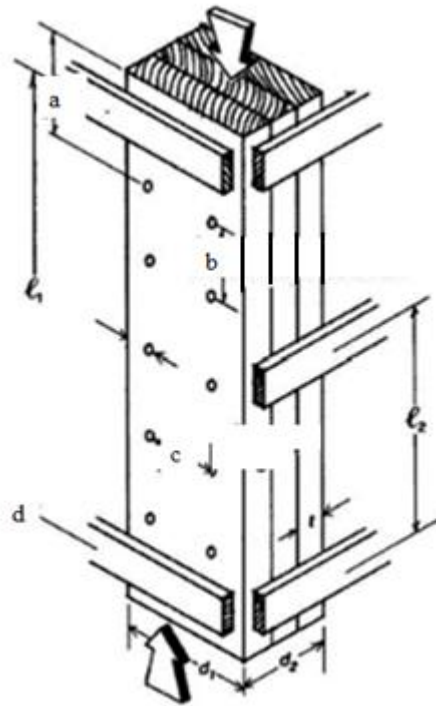
Caption:
a. end distance
b. the distance between the closest connector in one line
c. distance between connector
d. side distance

Figure1Built-Up Column of Mechanical Lamination
(source: SNI 03 -7973 -2013)

SNI 7973-2013 define the clauses that apply to structured columns using nails or bolts with 2 to 5 laminates, namely:
1. For built-up columns which are nailed or bolts with 2 to 5 laminates:
   a. Each laminate has a rectangular cross section and is at least 38 mm thick, (t = 38 mm)
   b. All laminates have the same height (wide face), d
   c. The adjacent laminate faces touch each other
   d. All laminates have a length equal to the length of the column
   e. Must fulfill connection requirements

2. For nailed built-up columns, there are couple conditions as follows:
   a. Adjacent nails are placed from opposite sides of the column
   b. All nails penetrate at least ¾ of the thickness of the outermost lamina
   c. $15D \leq$ end distance$\leq 18D$
   d. $20D \leq$ spacesbetweennails on a line$\leq 6t$
   e. $10D \leq$ spaces between nails$\leq 20D$
   f. $5D \leq$ end distance $\leq 20D$
   g. 2 or more longitudinal rows of nails are provided if d> $3t_{min}$
   Where,
   D   = diameter of nails (mm)

d   = height (wide face) from each lamina (mm)
t_{min} = thinnest thickness of laminate(mm)

3. Provisions for bolts built-up columns
   a. Metal plate or ring plate is provided between the wood and the bolt head, and between wood and nut
   b. The nut is tightened to ensure that the close laminate faces touch each other
   c. For needle leaf wood: $7D \leq$ end distance $\leq 8.4D$, for broadleaf wood: $5D \leq$ end distance $\leq 6D$
   d. $4D \leq$ distance between adjacent bolts in the same row $\leq 6t_{min}$
   e. $1,5D \leq$ spaces between bolt lines$\leq 10D$
   f. $1,5D \leq$ side distance $\leq 10D$
   g. 2 or more longitudinal bolts are allowed with d > $3t_{min}$
   Where,
   D   = diameter of bolt (mm)
   d   = height (wide face) from each lamina (mm)
   t_{min} = thinnest thickness of laminate(mm)

The results of the study of laminated compressive member between Sengon wood (*light wood*) and Petung bamboo (*heavy wood*) showed that the use of the same Sengon wood and Petung bamboo or Petung bamboo was higher, the compressive strength was higher than the

compressive strength of Sengon wood solid (**lezian et al, 2009).**

c. Reference Design

The visual sorting must follow existing standards. The strength value of wood mechanical reference can be seen in Table 4.2.1 in SNI 7973 2013 based on the reference elastic modulus (Ew). The other side, laboratory test results a strength reference can be calculated using Eq. 1.

$$F = \frac{F_{Avg} - (1,645 \cdot STD)}{\gamma_{DL}} \gamma_{KA} \qquad \text{(Eq. 1)}$$

Where:
F_{Avg} : average value
STD : standarddeviation
γ_{DL} : the long time correction factor of loading
γ_{KA} : water content correction factor

The long time correction factor of loading(γ_{DL})takes into account the time-dependent behavior of wood. Wood gives high strength for loading in a short time and vice versa. This correction factor is 1.0 for loading with duration of 10 years. While for testing in the laboratory with a loading duration of about 3 to 5 minutes the correction factor is 1.65. The correction factor for water content is considered to be equal to 1.0 if the average moisture content of the test results ranges from 12% to 15%. (**Awaludin Ali, 2011**).

3. RESEARCH METHODS

a. Toolsand Materials

The wood that has been used was a type of wood that has the same leaf shape. For the first built-up columns made by coconut wood and Nibung wood, both types of wood have leaf shapes like needles. For the second built-up column made by Meranti wood and Mahang wood, both have the same leaf shape.

The adhesives that have been used or permitted in SNI 7973 2013 are bolts or nails. For bolts used 8 mm in diameter with a length of 12 cm, while the nails used are 5 inch.

b. The process of making specimens

The specimens that have been made consist of specimens for testing material properties, solid columns and couple variations of built-up column using 4 types of wood. The built-up column consists of 3 layers with the thickness of each layer 40 mm. The larger quality wood or a larger strength has been placed on the outermost layer. The bolts and nails are used to adhesive between layers with the distance according to the requirements of SNI 7973 2013. The built-up column specimens are made after the moisture content of the material was smaller than 16%. Variations samples and sizes can be seen in Table 1.

Table 1. Variation of sample, size and number of specimens

No	Variation of sample	Sample size (mm)	Number of specimens
1	Solid column Mahang wood (KSMA)	70 x 40 x 700	5
2	Solid column Meranti wood(KSME)	70 x 40 x 700	5
3	Laminate Meranti Mahang by bolt(LMMB)	70 x 120 x 700	5
4	Laminate Meranti Mahang bynails (LMMP)	70 x 120 x 700	5
5	Solid column Coconut wood(KSKA)	70 x 40 x 700	5
6	Solid column Nibung (KSNB)	70 x 40 x 700	5
7	Laminate Coconut Nibungby bolt(LKNB)	70 x 120 x 700	5
8	Laminate Coconut Nibungbynails (LKNP)	70 x 120 x 700	5

Figure 2 The process of making a laminate column

c. Testing

The tests that have been carried out were testing material properties of 4 types of wood as well as compressive testing for solid columns and built-up columns. For testing material properties that have been carried out including moisture content, density, perpendicular and parallelstrength of grain, tensile and flexural strength testing. Furthermore, for the built-up column, a pressure test parallel to the grain has been carried out.

Figure 3 Compression Testing of Built-up columns

4. RESULTS AND DISCUSSION
a. Materialproperties

The results of testing the material properties of four types of wood have shown that Meranti wood density was 0.507, Mahang wood 0.333, Coconut wood 0.39 and Nibung wood 0.21.For the result of grain parallel compressive strength, grain perpendicular compressive strength, tensile strength and flexural strength can be seen in Table 2.

Testing of moisture content has been carried out several times until it meets the specified standard, which must be less than 16%. The next was carried out preliminary testing. Preliminary tests have been carried out and obtained the mechanical properties of wood at standard water content.

Table 2 The results of testing the material properties of four types of wood

Type of wood		Type of Testing				
		Water content (%)	Compressive strength \\ grain (MPa)	Compressive strength ⊥ grain (MPa)	Tensile strength (MPa)	Flexural strength (MPa)
Mahang wood	Average	15.2	19.05	8.72	138.08	54.17
	Deviation Standard		0.68	1.89	43.07	4.75
	Reference Strength		10.87	3.40	40.74	28.09
Meranti wood	Average	15.6	24.20	14.29	221.37	176.93
	Deviation Standard		1.08	0.94	66.16	29.35
	Reference Strength		13.59	7.72	68.21	77.96
Coconut wood	Average	11.6	10.44	37.87	43.53	59.64
	Deviation Standard		3.09	4.86	8.68	18.32
	Reference Strength		3.25	18.11	17.72	17.88
Nibung Wood	Average	13.5	13.02	45.65	30.40	36.39
	Deviation Standard		2.15	4.97	5.32	14.61
	Reference Strength		5.75	22.71	13.12	7.49

From Table 2 it can be seen that the average water content of 4 types of wood ranges from 11.6% to 15.6%, so that preliminary testing can be carried out directly. The results of testing properties show that the Mahang and Meranti wood types have compressive strength of parallel grain higher than the compressive strength of perpendicular grain. In contrast, for the type of coconut wood and Nibung wood has compressive strength perpendicular of grainhigher than the compressive strength parallel of gain.

In addition, it can be seen that the standard deviation that have been obtained were still varied and even quite large. This shows that the average value cannot be used as a reference value to determine the value of the test results. The reason could be due to the uniformity of wood material that was not the same in each part. Finally, the value used as the test result was a strength reference. A strength reference value can be calculated using the Eq. 1.
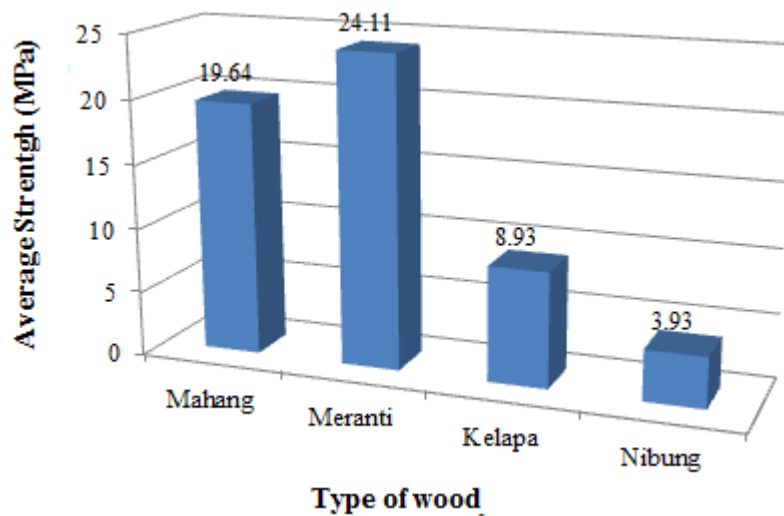
b. Kuat tekan kolom solid

Figure 4 Test results of solid column compressive strength

From Figure 4 it is known that the average compressive strength of Meranti wood was higher than the Mahang wood, which equal to 24.11 MPa. The Coconut wood compressive strength was higher than Nibung wood which equal to 8.93 MPa. The result suitable with **Indriyani, 2018** that Mahang wood has a lower quality than Meranti wood with a Meranti wood MOE value that 2.5 times higher than Mahang wood. So, this is also the initial assumption that Meranti wood will be combined with Mahang wood and Coconut wood will be combined with Nibung wood. For maximum result, has been placed the wood with smaller compressive strength at the middle layer.

c. The compressive strength of built-up and solid column

From the results of testing the built-up column with 4 variations that have been made, couple types of variations cannot reach the maximum load and have not even reached the initial crack, due to the capacity of the equipment used. Only one type of laminate (LKNP) was which reaches maximum load.
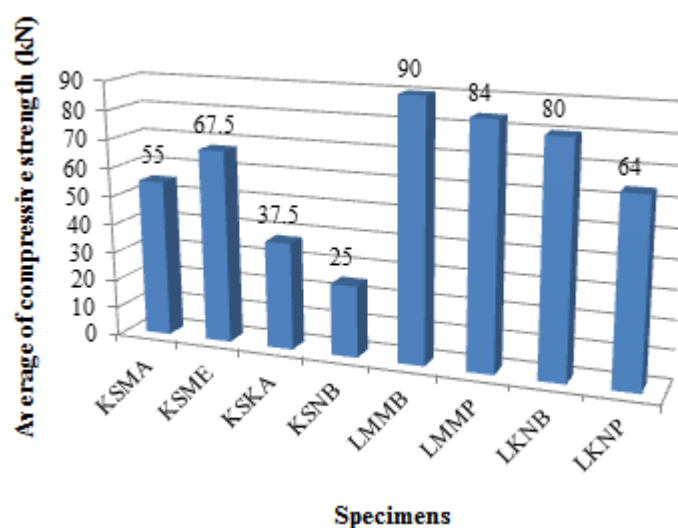
Figure 5 Test results of compressive column

From Figure 5, it can be seen that all the built-up column variations that have been tested have a higher compressive strength than the solid column. For Coconut wood and Nibung wood laminated columns using nail (LKNP) it has a compressive capacity 2.5 times more than Nibung's solid wood column (KSNB). On the other hand, LMMP has a higher compressive capacity than Mahang solid wood columns (KSMA). This proves that combining high quality wood on low quality wood can improve the quality of the light or low wood.

From all types of variations that have been tested, the built-up column using bolt has a larger capacity compared to nail. This happens because the bolts used have better quality than the nails. Another possibility was that the nails cannot glue the layers perfectly so that a slip occurs that causes the column layer unable to work together in receiving the load. This was indicated by the appearance of cracks on the outermost layer which then fracture into the outermost layer. In addition, according to Fengky (2015), the use of nails as a connecting or adhesive cannot increase the capacity of laminated specimens.

5. CONCLUSION

a. From the results of the study, the average compressive strength of Meranti wood was 24.11 MPa, Mahang wood 19.64 MPa, Coconut wood 8.93 MPa and Nibung wood of 3.93 MPa.

b. All of variations of laminate column or built-up column have an average compressive capacity higher than the solid column.

References

Awaludin ali. 2011. Penelitian sifat-sifat fisika dan mekanika kayu Glugu dan Sengon kawasan Merapi dalam rangka mempercepat pemulihan ekonomi masyarakat Merapi pasca letusan Merapi 2010. Diakses tanggal 10 Maret 2016, awaludin.staff.ugm.ac.id/files/2011/03

Fengky S.Y. 2015. Modulus elastisitas dan kekuatan lentur balok kayu laminasi. Jurnal Rekayasa Sipil Vol.11 No.1, 40-43

Indriyani P. 2018. Pengaruh posisi, jumlah layer dan mutu kayu terhadap balok laminasi kayu Mahang dan kayu Meranti. Jurnal Gradasi Vol.2 No.1, 52-60.

Lezian A, dkk. 2009. Pengaruh rasio bambu Petung dan kayu Sengon terhadap kapasitas tekan kolom laminasi. Jurnal teknologi dan kejuruan Vol.32 No.1, 71-78

SNI 7973-2013. 2013. Spesifikasi desain untuk konstruksi kayu. Badan Standarisasi Nasional (BSN).