The Flexural Strength of Laminated Bamboo Composite Beam
Agus Priyanto¹, Iskandar Yasin², Dewi Sulistyorini³

¹²³Department of Civil Engineering, Universitas Sarjanawiyata Tamansiswa
↵iskandartamansiswa@gmail.com

Abstract

For dry conditions the petung bamboo oven has an average tensile strength of 1900 kg/cm² without books and 1160 kg/cm² with books. Average compressive strength of petung bamboo is 2769 kg/cm² for the base, 4089 kg/cm² for the middle and 5479 kg/cm² for the end. If wood and bamboo species are used as composite beams, it is expected to be able to save on the use of high quality wood and lower costs. Glulam beam specimens were made as many as 12 pieces. The variation of cross section of glulam beams is based on the number of dimensions of thickness of bamboo lamina against glulam beams. For pure sengon sliding blocks the highest percentage of wood damage in the amount of adhesive is 50/MDGL. The more the amount of adhesive is anchored, the higher the adhesive strength of the glulam beams. The highest average strength was achieved in the ratio of bamboo to beams by 25 percent, and the lowest in the ratio of bamboo to beams by 75 percent. But in general the increase in the strength of the glulam beams is influenced by an increase in the ratio of bamboo to glulam beams. For beams with a ratio of 50 percent bamboo and 75 percent, sengon wood collapses first. Glulam beam stiffness factor has increased, where the highest stiffness factor is achieved in the ratio of bamboo to glulam beams by 50 percent and the lowest in the ratio of bamboo to glulam beams by 0 percent.

Keyword : Composite, Bamboo, Laminated, Flexural Strength.

Introduction

The physical properties of sengon wood have a moisture content above 140 percent, dry air (ready to use) water content of 12 percent to 14 percent and specific gravity between 0.24 to 0.49 (average 0.33). From the water content, sengon wood can be classified as large but dries quickly, and from its specific gravity, sengon wood can be classified in light to mild wood groups. The shrinking properties of sengon wood are quite low, namely in the tangential direction of 5.2 percent and in the radial direction of 2.5 percent. From this depreciation rate, sengon wood is a type of wood that is less stable, which is easily curved and slightly cracked (Kasmujo, 1996: 4). Sengon wood is a strong class IV to V, with a specific gravity of 0.24 to 0.49 (an average of 0.33), and includes a durable class IV to V. The results of Kasmudjo's research (1995), state that the age of the sengon wood affects the magnitude specific gravity and mechanical properties. Judging by its adhesive strength, sengon wood is included in the category of very good (strong), so that the sengon junction is adequate to be applied using an adhesive. According to Kasmudjo (1995), sengon wood from the age of 6 to 10 years provides good adhesion strength and is increasing.

Keruing wood includes strong wood class I to II with an average specific gravity of 0.79 and durable class III (Building Problems Investigation Foundation, 1961: 41). In the process of gluing this keruing wood is easily bonded so it is good for laminated beams. The amount of shrinkage in the radial direction of 2.8 percent to 4.7 percent, tangential direction shrinkage of 4.7 percent to 5.9 percent. Keruing wood has a common characteristic of brown-red, brown, gray-brown or red-brown-gray terrace wood. Poppy wood is yellow or light brown pseudo gray and younger than the terrace wood. The boundary between sapwood and patio wood is clearly visible. The texture is rough, sometimes
somewhat coarse with the direction of straight fibers, sometimes integrated. The surface of the wood is rather slippery, often sticky. Keruing wood has a rather striking resin odor (Martawijaya and Kartasujana, 1977: 36).

Morisco (1999), conducted a test with the result that the tensile strength of Ori bamboo peels is quite high at almost 5000 kg/cm², or about twice the yield stress of steel, while the average tensile strength of petung bamboo is also higher than the yield stress of steel, but there is a specimen that has a tensile strength lower than the yield stress of steel. For dry conditions the petung bamboo oven has an average tensile strength of 1900 kg/cm² without books and 1160 kg/cm² with books. Average compressive strength of petung bamboo is 2769 kg/cm² for the base, 4089 kg/cm² for the middle and 5479 kg/cm² for the end. Boundary strengths and permits for bamboo permits are presented in Table 1.

<table>
<thead>
<tr>
<th>stress</th>
<th>Limitation (kg/cm²)</th>
<th>Tension Strength (kg/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile</td>
<td>981-3920</td>
<td>294.2</td>
</tr>
<tr>
<td>Flexural</td>
<td>686-2940</td>
<td>98.07</td>
</tr>
<tr>
<td>Compression</td>
<td>245-981</td>
<td>78.45</td>
</tr>
<tr>
<td>Elasticity</td>
<td>98070-294200</td>
<td>196.1 x 10³</td>
</tr>
</tbody>
</table>

If wood and bamboo species are used as composite beams, it is expected to be able to save on the use of high quality wood and lower costs. Based on the description above, the study aims to determine the effect of tensile strength of bamboo on the strength and stiffness of composite beams.

**Methodology**

The research materials are sengon wood, keruing wood and petung bamboo. The adhesive is in the form of Urea Formaldehyde with the trademark UF-104 cold setting, NH4Cl hardener and flour. The research was carried out as in the flowchart of Figure 1.
Glulam beam specimens were made as many as 12 pieces. The variation of cross section of glulam beams is based on the number of dimensions of thickness of bamboo lamina against glulam beams. The bamboo lamina is placed on the top and bottom edges of the glulam beam as shown in Figure 2. The ratio of bamboo to glulam beams (RBB) is RBB-0.00, RBB-0.25, RBB-0.50 and RBB-0.75.

Glulam beams are tested on a roller-joint pedestal, by giving symmetrical concentrated two-load loads to the span. On the side of the glulam beams are given lateral restraints to prevent the influence of lateral torsion buckling. Glulam beam test setup is shown in Figure 2.

![Fig. 2. Setting up Experimental Testing of Glulam Beam Bamboo Composite](image)

**Result And Discussion**

The average water content of keruing wood is 12.66 percent, the average water content of sengon wood is 13.53 percent and the average water content of petung bamboo is 12.83 percent. Moisture control with a moisture meter shows an average of 12 percent for keruing wood, 13 percent for sengon wood and 12 percent for petung bamboo. The average density of keruing wood is 0.76 gr/cm$^3$, the average density of sengon wood is 0.32 gr/cm$^3$ and the average density of bamboo lamina is 0.88 gr/cm$^3$.

In the preliminary test results the average laminated shear block of the test sample showed an increase in strength along with an increase in the amount of adhesive bonded. The more glue the adhesive strength between the layers of wood making up the glulam beam the higher as shown in Figure 3.

![Fig.3. Result of Shear Strength Experimental Testing](image)

For pure sengon sliding blocks the highest percentage of wood damage in the amount of adhesive is 50 / MDGL. For the sengon-keruing sliding block the most wood damage in the amount of adhesive
is 50/MDGL. For the pure keruing sliding block and the keruing-bamboo sliding block, the most wood damage is the amount of coated adhesive of 40/MDGL. For the pure bamboo sliding block the highest percentage of wood damage in the amount of adhesive was 50/MDGL.

The results of tests on all glulam beams produce graphs of load-deflection relationship Figure 4. The highest average strength of glulam beams is found on RBB-25 and RBB-50 beams, this is due to the comparison between bamboo lamina, keruing wood and wood Sengon is proportional. The highest comparison result between the experimental elastic limit with the average elastic limit is found in the RBB-50 beam and the lowest comparison is the RBB-0 beam.

In testing the glulam beam bending there were two failures, namely bending and shear failure. Bending failures are in accordance with the expected results for testing, but other types of failures occur mainly due to imperfect gluing processes and asymmetrical forms. The average test specimen suffered initial damage or initial cracks in the sengon wood area, and was followed by cracks in other parts.

Conclusions

Keruing wood and bamboo petung used in testing have a fairly high strength and density. Keruing wood density of 0.76 gr/cm$^3$ and density of bamboo lamina 0.88 gr/cm$^3$, where in PKKI-1961
belong to wood with strong class II. Sengon wood used in testing has a strength and density of 0.32 gr/cm$^3$, which in PKKI-1961 belongs to wood with strong grade IV. The more the amount of adhesive is anchored, the higher the adhesive strength of the glulam beams. The highest average strength was achieved in the ratio of bamboo to beams by 25 percent, and the lowest in the ratio of bamboo to beams by 75 percent. But in general the increase in the strength of the glulam beams is influenced by an increase in the ratio of bamboo to glulam beams. For beams with a ratio of 50 percent bamboo and 75 percent, sengon wood collapses first. Glulam beam stiffness factor has increased, where the highest stiffness factor is achieved in the ratio of bamboo to glulam beams by 50 percent and the lowest in the ratio of bamboo to glulam beams by 0 percent.

**Reference**


Kasmudjo, 1996, Teknologi Pengolahan Kayu Sengon, Bagian Penerbitan Fakultas Kehutanan Universitas Gadjah Mada, Yogyakarta

