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THE UTILIZATION OF LAMINATED PETUNG BAMBOO FOR DOOR FRAME

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Abstract

Petung bamboo is one of the alternatives to wood that is needed due to the decreased availability of wood in the forest for construction. The objective of this research was to determine whether Petung bamboo could substitute wood in door frame. Research has been carried out to propose alternate methods of using bamboo to produce door frame that are environmentally friendly. Engineering research using experimental methods is conducted. The data collection technique was carried out using test specimens for specific gravity test, compressive strength test, and flexural strength test to obtain the strength value of the petung bamboo laminated door frame product which will later be compared with door frames made of wood on the market. Based on the findings of the research, Petung bamboo laminated door frame, which also made from petung bamboo laminated beam, had the specific gravity value of 0.646 g/mm2, the compressive strength of 51.34 MPa, and the optimum flexural strength of 87.6708 MPa. The values of specific gravity test, compressive strength test, and flexural strength test are comparable to the class II of wood strength and applicable to use as door panels based on PKKI 1961.

Keywords: Petung Bamboo, Laminated Bamboo, Door Frame

Introduction

As reported by the Central Bureau of National Statistics, wood production in Indonesia has increased by cultivating companies. From 2013 to 2017 there was a shortage of wood raw materials of ±23.2 millions m^3/year, while in fact wood harvesting activities are still wasteful because waste potential estimated 17% of the annual production allotment target of 9.1 millions m^3/year (Sharma & van der Vegte, 2020; Soenarno et al., 2020).

Bamboo is a locally available material that is frequently utilized in construction in Indonesia. According to the data, within the 1200-1300 species of bamboo found worldwide, 143 species or 11% of them, is indigenous to Indonesia. This data genuinely demonstrates the bamboo's potential in Indonesia. However, the use of bamboo as substitute of wood in construction projects is still not well acknowledged (Muhsin et al., 2020). In fact, bamboo might well be utilized to used as sustainable building material (Aniegbuna & Okolie, 2021; Irawati et al., 2021; Manandhar et al., 2019; Yadav & Mathur, 2021). Building which emploting the bamboo has the potential to decrease carbon dioxide emissions during the construction process (Iroegbu & Ray, 2021; P. Xu et al., 2022; X. Xu et al., 2022).

Compared to other bamboos, Petung bamboo has a mechanical characteristics of modulus of elasticity or flexural strength of 86550 kg/cm^2, which is significantly greater than other bamboos like Apus bamboo (60,126 kg/cm^2) and Black bamboo (85,170 kg/cm^2) (G. Chen et al., 2020; Dauletbek et al., 2021; Maulana, 2018; Yang et al., 2020). Because Petung bamboo has a substantially higher flexural strength than other bamboo, it is extremely ideal for usage as a beam component (Alfiandi, 2021; Belatrix et al., 2022).

According to a study on bamboo laminates by Nurmalasari & Goestav (2020), which tested and classified the material, the mechanical characteristics of bamboo laminates can be divided into class I and II of wood species. In accordance with this study, bamboo laminates have a lifespan of more than 30 years, are stronger, more flexible, and resistant to termites. According to research findings from UPT BPP biomaterials LIPI, the bending strength of composite bamboo was very good and might surpass teak wood. This leads to the conclusion that bamboo laminate can be applied and is appropriate as a substitute for wood in a construction project (Priyanto & Yasin, 2019).

When compared to other varieties of bamboo, has a comparatively big diameter, and its bamboo segments are shorter than those of other bamboos (Chin, 2021; Hong et al., 2020). Due to this, Petung bamboo is a good choice for laminating. Petung bamboo has rather thin and hollow stems, so lamination or gluing technology is needed if it is to be utilized for wider, longer, or thicker purposes (Arsad, 2015).

Bamboo laminated beams are made from layers of the material that have been shaved and glued together in the same direction of the grain to create substantial blocks (S. Chen et al., 2022; Kumar & Mandal, 2022; Mahdavi et al., 2011; Wang et al., 2021). The bamboo is sorted, grouped according to thickness, and then shaved in order to perform the bamboo lamination process. This task was completed to make the subsequent procedure easier – gluing each piece of bamboo with adhesive and flattening it into a block with the required dimensions – simpler (Nugraha, 2014).

More frequently than it seems, bamboo laminates are employed in construction projects as an interior product or non-structural component (Manik et al., 2022; Saputro et al., 2021). Because bamboo laminates have the same properties as wood where it does not have a large compressive strength like concrete which generally used in construction project (Nor Intang Setyo et al., 2006). The cost-effectiveness of structural components, which require far larger quantities than those of non-structural or interior products, is another argument in favor of this (Nugraha, 2014).

The following steps can be applied to produce Petung bamboo laminates, according to Faruq dkk. (2017):

1. Laminates making. The length of the bamboo slats that will be utilized to create the laminate is determined by the intended purpose.
2. Drying and selection of lamina. Drying and aerating the bamboo slats can be accomplished naturally by stacking the boards on a platform that is about 30 cm off the ground. Artificial drying can also be accomplished by placing bamboo inside the container and then blowing hot air into it.
3. Gluing/bonding. A crucial step in the process of producing bamboo laminates is the gluing/bonding stage. The laminate needs to be clamped on both surfaces prior to glueing in order to provide a smooth, parallel, and bondable surface.
4. Finishing. Following the bonding, the surfaces of the laminated beams are polished and the glue leaked between adjacent laminate is removed.

The constituent materials must be taken into consideration in order to obtain high quality Petung bamboo laminate. The Petung bamboo laminate frame's construction material has a significant impact on the quality of the bamboo and the adhesice that will be applied later.

More frequently than not, bamboo laminates are applied in construction projects as an interior product or a non-structural component. This is possible because bamboo laminate shares tha same mechanical characteristics as wood, unlike concrete, which generally employed in construction projects and has a much higher compressive strength. The cost-effectiveness of structural components, which require far larger quantities than those of non-structural or interior components, is another argument in favor of this. Petung bamboo laminate will be applied in this research as a building material for interior components, specifically door frames.

Research Methodology

The production of test materials and specimens was a part of this research, which was done at the Materials Testing Laboratory, Faculty of Engineering, Universitas Negeri Jakarta. The research was conducted from February 2022 to July 2022. The research method used is an experimental method with laminated bamboo beams with dimensions of 50 x 50 x 760 mm for the flexural strength test, 50 x 50 x 50 mm for the specific gravity test, and 50 x 50 x 200 mm for the compressive strength test. The following standards are followed when conducting tests: (1) ISO 22157:2019 for testing bamboo's physical and mechanical characteristics for the specific gravity tests; (2) SNI 03-3958-1995 for testing wood's compressive strength in a laboratory setting for the compressive tests; and (3) SNI 03-3959-1995 for testing wood's flexural strength in a laboratory setting for flexural tests. The results of each test will be compared with the wood strength class data based on PKKI 1961.

Table 1. Class of wood strength

Class	Absolute Flexure Stress (kg/cm$^{3)}$)	Absolute Compressive Stress (kg/cm$^{3)}$)	Specific Gravity (g/mm^2)
I	≥1100	≥650	≥0.90
II	1100 – 725	650 – 425	0.90 – 0.60
III	725 – 500	425 – 300	0.60 – 0.40
IV	500 – 360	300 – 215	0.40 – 0.30
V	≤360	≤215	≤0.30

Results and Discussion

Based on the research that had been conducted, the design of Petung bamboo laminate products can be seen on the figure below.

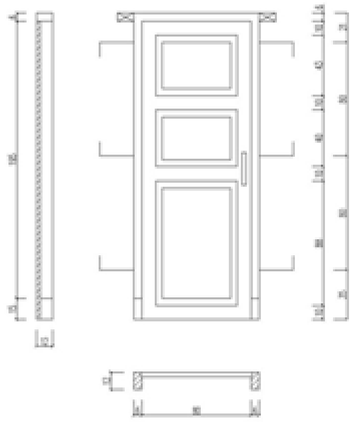

Figure 1. Design of door frames

Five sample objects with dimensions of 50x50x50 mm were used to determine the specific gravity of Petung bamboo laminates. The following table shows the outcomes of the test.

Table 2. Spesific gravity test results

Sample Weight (gr)	Volume b (mm)	h (mm)	t (mm)	Specific Gravity (g/mm²)
85.4	49.0	49.6	49.4	0.631
85.1	49.4	49.6	49.9	0.618
91.6	49.7	49.8	50.00	0.628
88.0	50.00	49.4	49.9	0.674
93.2	49.2	49.4	49.6	0.676
Average				**0.646**

The Petung bamboo laminates tested had the highest specific gravity of 0.676 and the lowest specific gravity of 0.618. From these results, it may be inferred that the test object's specific gravity appears to be equal at 0.600 and that, according to the research by Luhur P, et al. (2017), the average specific gravity also tends to be the same, i.e., 0.6368. According to PKKI (1961) the Petung bamboo laminate has a specific gravity that matches within the wood strength class II.

Table 3. Compressive strength test results

Sample Object	Dimension b (mm)	h (mm)	Max Load (N)	Compressive Strength (MPa)
LBP 01	50	200	553,000	55.3
LBP 02	50	200	485,000	48
LBP 03	50	200	501,000	50.1
LBP 04	50	200	523,000	52.3
LBP 05	50	200	505,000	50.5
Average				**51.34**

The Petung bamboo laminated beams' maximum compressive strength, determined by testing it parallel to the fibers, is 55.3 MPa, with an average compressive strength of 511.34 MPa or 523.514 kg/cm2, according to test results data collected on five sample objects.

In previous research conducted by Manik et al. (2022), testing the compressive strength parallel to the laminated bamboo which had an average yield of 65.67 MPa. Also, in a research conducted by Nurmalasari & Goestav (2020) the bamboo laminated test specimens has a strong compressive strength of 62.48 MPa. Although the results show that the compressive strength of this specimen is lower than that of previous studies, the strength produced by this specimen still fulfills the PKKI 1961 specification.

The sample objects can act as a representation of the compressive strength that can be applied to Petung bamboo laminated rails because the manufacturing procedure for both the sample objects and the Petung bamboo laminated frames is the same. According to the PKKI 1961 class of wood strength, class II has a compressive strength between 425 and 620 kg/cm^2. Because of this, the laminated Petung bamboo frames that have been produced have a strength comparable to that of wood strength.

Table 4. Flexural strength test results

Sample Object	Dimension b (mm)	Dimension h (mm)	Max Load (N)	Flexural Strength (MPa)
LBP 01	50	760	10,100	86.052
LBP 02	50	760	10,900	92.868
LBP 03	50	760	10,200	86.904
LBP 04	50	760	9,950	84.774
LBP 05	50	760	10,300	87.765
Average				**87.6708**

The test findings showed that an average flexural strength of 87.671 MPa or 893.979 kg/cm2, was achieved, with an optimal flexural strength of 92.868 MPa. The bamboo laminated beams tested in the prior research by Manik et al. (2022) had an average flexural strength of 106.61 MPa, and the tests conducted by Nor Intang, et al. (2006) had an average flexural strength of 130.98 MPa.

It is evident from the results of the two tests used in this research that the flexural strength results are often lower than those of the average test used in the prior research. This can be partly attributable to the glue used in the lamination procedure (Darwis et al., 2021; Khadafi, 2019; Syafii & Sabariman, 2019). In a reseach by Manik et al. (2022), epoxy resin was employed as the adhesive for each layer and in between the bamboo slats. The way sampe object products are manufactured, which is done manually using clamps, might also have an impact on the flexural strength results. This also in line with other research conducted by Pratama (2021) and Azmy (2021).

According to the test results, the laminated Petung bamboo beams used as frames for the research's product are similar to wood strength class II according to PKKI 1961. The production budget to create the door frame is cheaper compared to the door frame marketed which is IDR 65,880. This also in line with research conducted by Saputro et al. (2021).

Conclusion

For door frame products, Petung bamboo laminate can be utilized as a substitute for the wood that is marketed and sold. Compared to the manufacture of wood, the bamboo laminate method is more sophisticated, but it also has a different aesthetic value and a less expensive base material price. The unit pricing for Petung bamboo laminated beams is IDR 65,880 based upon the price analysis calculation that was performed. Considering bamboo is a very inexpensive basic material, the production cost of Petung bamboo laminated beams is lower. To ensure a stronger bond throughout the laminating process, Petung bamboo laminated should be produced using a felt machine.

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