

Characteristics of Petung Bamboo as the Main Structure of Wide Span Bamboo Hall Building at Gubukklakah, Poncokusumo, Malang

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Abstract- *Dendrocalamus asper*, or commonly known as “petung bamboo”, is one of the local bamboo varieties that has a thick and wide stem perimeter. Based on its characteristics, petung bamboo has always been the ultimate choice to be utilized as the primary structure of bamboo buildings from a small span building until a wide span building. Nevertheless, there is limited access to the literature which studies the petung bamboo as the primary structure of wide span buildings. This problem had gained our attention to conduct examination and further study. The examination and analysis of petung bamboo as the primary structure in Gubukklakah Hall building is crucial, due to the structural material recommendation for the architectural design in the future. This study was focusing on the examination of petung bamboo’s characteristics as the primary structure of wide span buildings. There are several methods used in this study such as the qualitative method, literature studies, and case studies. Three important aspects will be discussed in the petung bamboo as the primary structure of the wide span building study framework: characteristics, strength, and on-site application. Hopefully, the study framework can give a positive contribution to Indonesian architecture development in terms of analytical data and documentation from petung bamboo as the primary structure in the Bamboo Hall Building.

Keywords—Structure; Wide Span; Petung Bamboo; Characteristics

I. INTRODUCTION

In the era full of science development and renewable technology, the bamboo has its special place in architectural design, where bamboo has its own value in the eyes of observers and enthusiasts. Petung bamboo has its special characteristics, such as it has a wide stem, thick stem wall, and short internodes that makes it a durable material and not easily get curved. Based on its characteristics, petung bamboo has become the ultimate choice to be utilized as a sustainable building material. Building with bamboo structure has good flexibility where the structure durable against shock, such as an earthquake.



Figure 1. Gubukklakah Bamboo Hall
(Source: Personal Documentation, 2019)

The case study object that will be discussed further is The Bamboo Hall in Gubukklakah, Poncokusumo, Malang Regency. The building is shown in **Figure 1**.



Figure 2. Gubukklakah Bamboo Hall Existing Data
(Source: Personal Documentation, 2019)

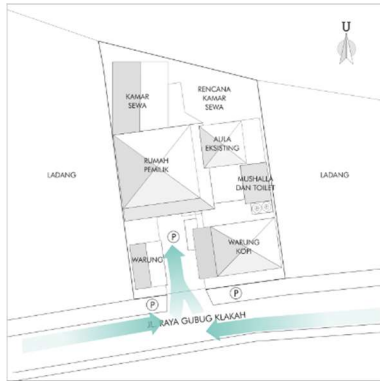


Figure 3. Gubukklakah Bamboo Hall Existing Data
(Source: Personal Documentation, 2019)

It's located at an altitude of 1400 meters above the sea level in the Bromo Tengger Semeru National Park area or commonly known for the BTS National Park area. The existing data are shown in **Figure 2** and **Figure 3**. The hall is designed as an open space that was built using petung bamboo as the material, both for the main structure and supporting parts. Petung bamboo was chosen as the main material of building structures because it's a local commodity in the Gubukklakah region. There are several stages of building a bamboo hall. There are designing, collecting, transporting, and constructing process. The first stage is designing a bamboo hall. The design process has several aspects to be considered such as existing conditions, locality, views, and local human resources. The existing condition of the site is the hall will be constructed above a concrete plate of second-floor building. Then, the building is designed by prioritizing the value of locality. It is using the local material and makes the building form out of the composition and transformation of a traditional house of Dayak Tribe, namely Betang House. After that, the hall is designed to respect nature by capturing the landscape as a main view in the building. To give the excellent view out of the building, the openings face to the north to get a mountain view. The last design aspect is human resources. When designing a good building, the ability of builders needs to be considered too. It becomes important because bamboo has a different construction system than any traditional wood building system. Thus, the building needs to be designed with simple yet strong connections to be easily applied by local craftsmen. The second stage is collecting the materials. In this phase, petung bamboo is harvested directly from the nearest cultivation site. For one segment of petung bamboo, the stem has a length of up to 22 meters. Regarding this situation, transportation can only be done by cutting the bamboo stems per 10 meter long. After the collecting and transporting process, the third stage is the preservation process. Generally, bamboo must go through a drying period, it takes up between six to twelve weeks after being harvested [1]. But in the case study, the drying process only lasts on two to three weeks. It happens because the media is unavailable and the building needs to be functioned

immediately. So, the material collection process only takes less than two weeks. The fourth stage of building the bamboo hall is the construction process.

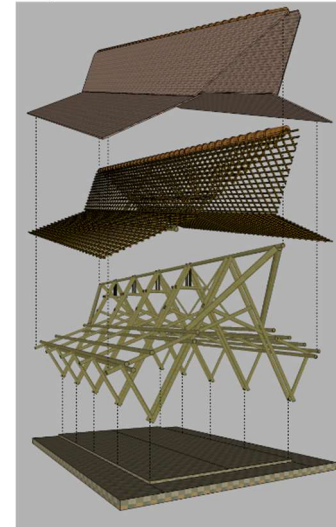


Figure 4. Gubukklakah Bamboo Hall Design
(Source: Personal Documentation, 2019)

At this stage, the bamboo is assembled into 5 modules as shown in **Figure 4**. Next, the modules are joined together. Later, the modules will be strengthened together by adding bamboo bracing at four endpoints. This is intended to strengthen and provide rigidity for the structural system. The next step is installing roof battens and rafters to withstand the roof weight. The last step is installing clay roof-tile to the structure.



Figure 5. Bamboo Cracks in The Post-Construction
(Source: Personal Documentation, 2019)

There are certain issues that needed to be observed further during the pre and post-construction process of the bamboo hall in Gubuklakah. The first issue is the lack of special treatment for petung bamboo before it is used as the main structural material. The bamboo cracks are shown in **Figure 5**. This issue later will impact on the durability, preservation, and post-caring process of the building. The second issue, regarding the construction process, the structure's strength of both the main structure and detail connections has not been tested. The third issue is the post-construction is known to have several problems, such as bamboo cracks, rusty butts, and bolts, and also the bamboos are unstable due to the shrinking issue because they skipped the drying and preserving process. The fourth issue is the effectiveness of bamboo material used as the main structure needs to be studied further. It's because there are some parts of the structure that are added or subtracted because of the aesthetic and strength of the post-construction process.



Figure 6. The rust on Nuts and Bolts
(Source: Personal Documentation, 2019)

The importance of study the bamboo hall building in Gubuklakah is to know the quality, advantages, and weakness of the bamboo petung as the main structure on the object. The several aspects that need to be studied further are the special treatment that should be done for petung bamboo; the simple structure strength test analysis with SAP 200 program; the reason that causing cracks on bamboo stem, the nuts and bolts rust, and expand-shrink character; also to the effectiveness of using bamboo petung as the main material. The nuts and bolts ruts are shown in **Figure 6**.

II. METHODS

In this study, there are certain methods that are applied, namely qualitative method, literature study method, and case study method. The qualitative method is used to discover and analyze the characteristic of petung bamboo as the main structure in wide span building. In this method, there are a few

stages that need to be followed up. The first stage is collecting density data and the model of elasticity from petung bamboo. The second stage is inputting structure and materials data. The certain data that will be entered are bamboo dimension data to be analyzed; bamboo structure model according to the case study (Gubuklakah Hall); material types, density, and model of elasticity according to the case study; the analysis process with SAP 2000 program; and the last is final analysis result. The next method is the literature study method. In this part, the process of finding data based on the references. The last method is the case study method. The method works to find out the original data based on a direct observation process which later will be compared with literature data that has been obtained previously.

III. RESULT AND DISCUSSION

1. Petung Bamboo Processing Stage

Bamboo is a natural material that can be utilized to be handcraft, furniture, and also as a main structure for the building. One type of multipurpose material is petung bamboo. The use of petung bamboo as the main structure material can be found in various Indonesian iconic buildings. As time passes, the use of bamboo stems can be maximized by going through a preservation process. Bamboo without special treatments can only last one until three years, for bamboo that is protected from the weather can only last four until seven years, whereas in ideal conditions the bamboo structure itself can last up to ten until fifteen years [2].

Petung bamboo is one of the strongest bamboos, but it has a weakness once it faces the destructive microorganism that later will require the preservation process [3]. The preservation process is intended to provide resistance from the destructive organisms. The method can be carried out by utilizing BBC liquid that contains 27.5% boric acid, 43.9% sodium dichromate and 28.6% copper sulfate, in the form of paste containing 96% active ingredients made a solution with a concentration of 3% [3]. The results of these experiments show that bamboo which has been given a BBC Solution could last longer against any pest. The bamboo that given by BBC preservative relatively has low levels of damage by pests than the bamboo that is not going through any preservation. The durability of bamboo is due to the high concentration of bamboo preservative which can enter through the bamboo fiber [4]. Hunt and Garratt (1986) stated that the material which immersed with a long time on the diffusion process will produce more concentrations of the preservative solution in the material. This happened in the bamboo long preservation with BBC liquid. This process makes the preservative solution will diffuse through the pores of bamboo and enter the bamboo fiber with a high level of preservative solution. The greater the amount of preservative, the increase of bamboo retention and penetration will follow [3].

Another method that can be applied is by soaking the bamboo with borax fluid. In bamboo-part, it has around 7.25%

moisture content, it makes bamboo can easily destruct by termites and other pests. While in the bottom side of bamboo has a higher concentration of moisture content, the result of the soaking process is bamboo has a higher concentration of liquid too. It is a good thing because the level of the preservative solution is higher too and makes the bamboo more durable. In line with Abdurrohim and Martawijaya's opinions (1983) in Sumaryanto (2013), which states that one of the factors that affect the bamboo's durability is the concentration of the preservative solution. Generally, the higher the concentration of the preservative solution, the greater the amount of preservative that can be absorbed by bamboo [5].

2. The Materials on Gubuklakah Bamboo Hall

The utilization of petung bamboo in the Gubuklakah hall case using bamboo with an age of more than six years with a diameter of 20-25 centimeters. The bamboos on Gubuklakah Hall are used without any preservation. The bamboo only through a drying process that takes up only two weeks before any further preservation process. The drying process is used to reduce the amount of water in the bamboo stem that later affects the reduction of bamboo weight. Later, its process made the building construction process easier that provide convenience during the construction process. Another thing that has to be considered is the environmental condition in Gubuklakah. It's a hilly area of high humidity conditions that can give a negative impact on the bamboo structure. Where the bamboo has high water content, it gives a high potential to be attacked by termites and other pests.

3. Petung Bamboo Structure Analysis



Figure 7. The Triangular-Shaped Module for Gubuklakah Hall
(Source: Personal Documentation, 2019)

The bamboo structure on the Gubuklakah hall is done without going through any preservation process. This case, makes the strength of the bamboo structure questioned whether the structure can withstand heavy loads. The hall building is

constructed by combining triangular-shaped modules as the basic shape. The structure appears as in **Figure 7**.

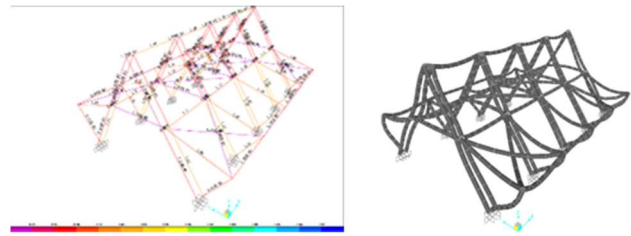


Figure 8. SAP 2000 Program for Gubuklakah Hall Structure Analysis
(Source: Personal Documentation, 2019)

The analysis is processed by the SAP 200 program which tests the load of the bamboo structure. The analysis process appears as in **Figure 8**. The load that comes from the roof will be simply analyzed the condition of the bamboo structure after bearing the load. It is shown that the horizontal structure received a heavy load. It has an impact of deflection on the vertical structure. The problem due to the lack of structure from a smaller surface that holding the roof loads.



Figure 9. The Retaining Beams on Bamboo Structure
(Source: Personal Documentation, 2019)

In the study case, there were only two retaining beams which received heavy loads from the roof. The retaining beams are shown in **Figure 9**. It happens differently on the main structure conditions, the structure can hold the load from the roof. It can suffer from the structure deflection because the roof load can be distributed directly to the ground.



Figure 10. The Bamboo Crack on Retaining Beams
(Source: Personal Documentation, 2019)

The other damage that found is the bamboo cracks. It found majorly on the connection between the main structure and the retaining structure of the side roof. In this area, the bamboo cannot be able to withstand the load from the roof and it caused an enormous pressure that makes the bamboo is broken. The crack on the retaining beams is shown in **Figure 10**.

According to Professor Andrew W, Chalerson (2019), the author of Structure as Architecture book, the structure of Gubuklakah Bamboo Hall has a less secure where the positioning of the bracing is less precise which the placement is right on the top area of the roof system. The bracing is not directly related to the main structure, so it is still prone to shock or excessive loads that affect the building. The cracks of petung bamboos which used as a structure are a form of bamboo that tries to distribute the load evenly. On the ground, the bamboo that is used is not really straight but has a slightly curved shape. So, that the loads received by bamboo must be equal. The equality of load causes cracks on the bamboo which makes the load evenly distributed on the whole structure.

4. The Solutions for Bamboo Structure

To overcome the initial structure condition which quite vulnerable, the structure needs further structure additions, such as:

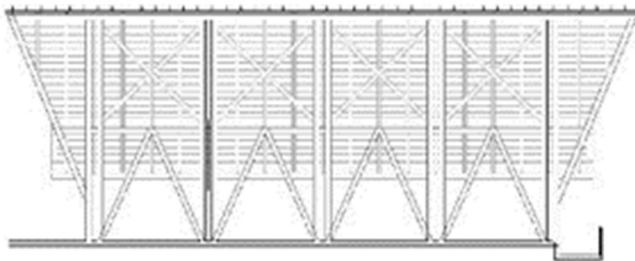


Figure 11. The Solutions for Bamboo Structure
(Source: Personal Documentation, 2019)

- As shown in **Figure 11**, the addition of bracing structure on the main structure which directly related to the main structure. The addition also aims to retain the horizontal loads that happen in the building structure.
- As shown in **Figure 11**, the addition of bamboo as beams and retaining columns on the roof structure are necessary to withstand the area that has a huge gravity load.

IV. CONCLUSION

Based on the result of studies and building observation, it can be concluded that petung bamboo needs through a drying and preservation process before it can be used as a building structure material; the environmental condition can affect the age of the building because it affects the resistance of petung bamboo; utilization of petung bamboo in Gubuklakah hall

requires further consideration for its structure durability, structure stability and the last is utilization of petung bamboo in Gubuklakah hall requires additional care to maintain the durability of petung bamboo material as the main structure.

Several solutions for structure addition which can be done are bracing addition in the main structure and beams and columns addition on the retaining area of the roof system.

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