Multidisciplinary Applied Research and Innovation Vol. 4 No. 4 (2023) 13-19


**MARI**

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/mari
e-ISSN :2773-4773

# Design Simulation of a Pedestrian Bridge Using Staad Pro Software for 2 Type of Common Bamboo Species

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DOI: https://doi.org/10.30880/mari.2023.04.04.002
Received 01 September 2023; Accepted 15 October 2023; Available online 01 December 2023

**Abstract** : The study of design simulation using Staad Pro Software of a pedestrian bridge that 2 type of bamboo is being used as the main material. Ordinary materials like steel, concrete and timber particularly have been use in buildings and structures construction, thus this study focused on bamboo as the main material in construction. Bamboo is a species of flowering perennial plants in the Poaceae family in the subfamily of Bambusoideae. The bamboo tree's structure is hollow and lacks xylem. The objective of this study was to do a simulation of pedestrian bridge using Staad Pro and knowing the usability of bamboos in structural construction, particularly pedestrian bridge. Moreover, the method of the simulation starts with design of the bridge, set up of material properties of the bamboo, loading and supports set up, and running the analysis. The preparation of the simulation design includes obtaining as much properties of the bamboo. Based on the findings, the bamboo is suitable to be use as the material of the pedestarian bridge based on the results, the results includes stresses of each beam in the Staad Pro which both type of bamboo does not exceed the tensile strength but exceed the compressive strength. The deflection of Dendrocalamus Asper's bridge is 31.691 mm. Meanwhile, Bambusa Vulgaris's bridge has deflection value of 45.049 mm which is higher than the evaluated limit, 40 mm. These means that Dendrocalamus Asper pass the most results than Bambusa Vulgaris despite both having the potential to be success.

**Keywords**: Bamboo, Dendrocalamus Asper, Bambusa Vulgaris, Staad Pro

## 1. Introduction

Bamboo is a species of flowering perennial plants in the Poaceae family in the subfamily of Bambusoideae. The bamboo tree's structure is hollow and lacks xylem. Because of its unique rhizome-dependent system, bamboo is one of the world's fastest growing plants. Cellulose fibers are aligned along the length of the bamboo providing maximum tensile flexural strength and rigidity in that

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direction. Bamboo grows from lowlands to 4,000 metres above sea level in the tropical, subtropical, and temperate zones of all continents, excluding Europe and Antarctica [1]. There are more than 88 genera and 1642 species of bamboo in the world, from which, 28 genera and 120 species are herbaceous bamboo [2].

Thus, in this era Bamboo has the potential to be a low-cost alternative to conventional materials like timber. Bamboo has been used wildly across the world for many things including food, medicine, furniture, scaffolding and the list keeps on going. Moreover, there are approximately 100 species of bamboo that is suitable for construction [3]. It could cut the cost of construction and provide the same amount of thoughness, strength or safety as other materials. This study is significant to identify the potential of bamboo in construction as the structure material. The aim of this study is to examine the suitability of bamboo as construction material by simulating a pedestrian bridge design using Staad Pro Software.

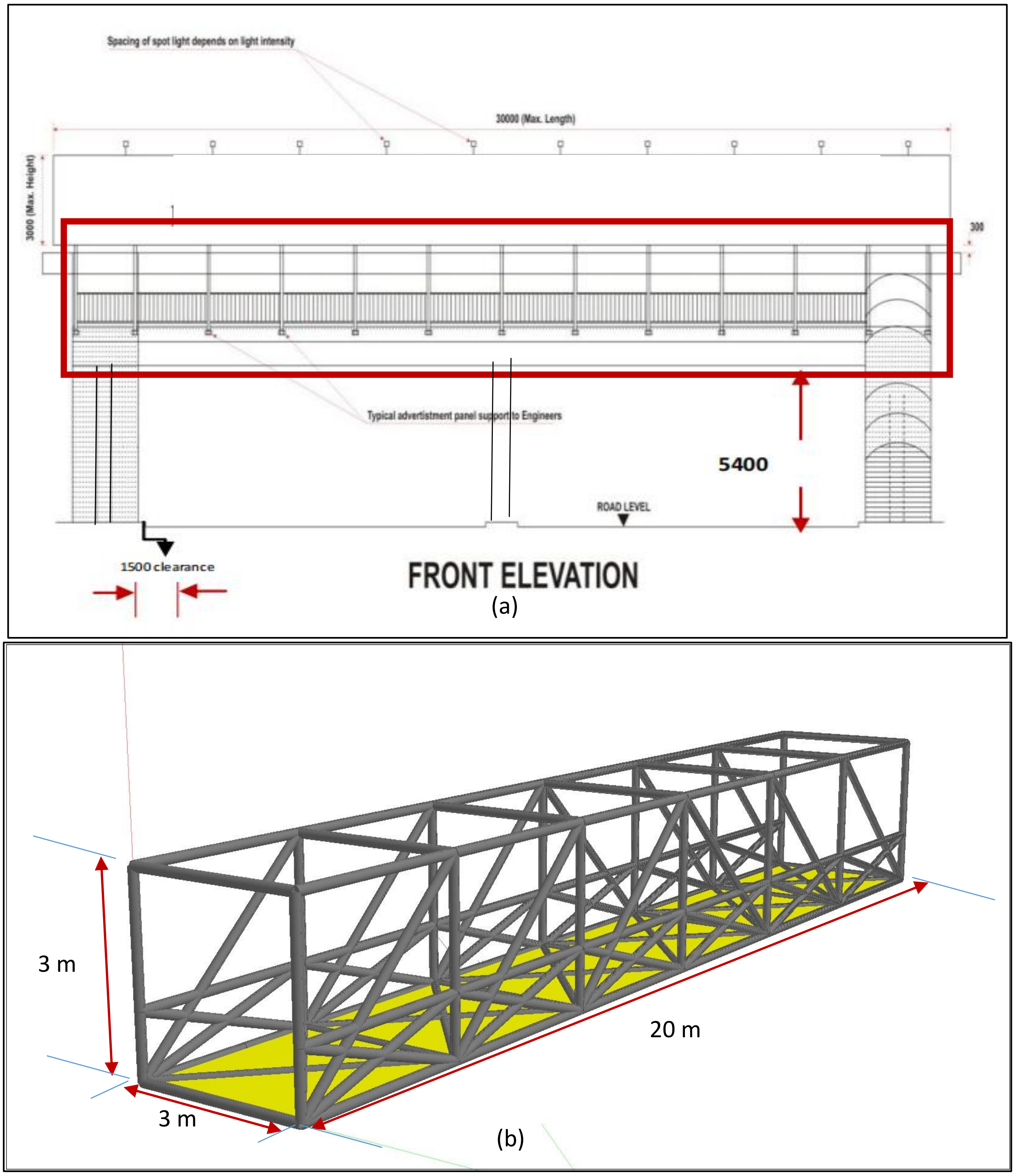


**Figure 1: a) Pedestarian bridge dimensions and specifications and b) The design that was used in this project**

**Figure 1**,**a**. The part that is being highlighted is the main focused in this study which is the structure of frames or trusses of the bridge and the path of pedestrian to walk and the length of the bridge in the simulation is decided to be 20 m × 3 m × 3 m as shown in **Figure 1,b**. This decision was made based on the specification from the Pedestrian Bridge Guide by '*Dewan Bandaraya Kuala Lumpur'* [4].

## 2. Materials and Methods

To conduct the study, materials and methods of the study must be planned thoroughly. This study started with the study of properties of bamboo and design of the pedestrian bridge, which has been discussed in previous part. The rest of the detailed explanation of the method will be discussed in this materials and methods part.

### 2.1 Materials

Bamboo, particularly Dendrocalamus Asper and Bambusa Vulgaris has been chosen to be the main focus in this study and the types of bamboo that has been simulated in the Staad Pro Software.

**Table 1: Properties of Dendrocalamus Asper and Bambusa Vulgaris**

| Properties | Bamboo Type | |
|---|---|---|
| | Dendrocalamus Asper (A) | Bambusa Vulgaris (B) |
| Density (kg/m$^3$) | 781.000 | 543.000 |
| Young's Modulus (kN/m$^2$), E | $1.2875\times10^7$ | $6.960\times10^6$ |
| Tensile Strength (N/mm$^2$) | 221.950 | 191.650 |
| Compressive Strength (N/mm$^2$) | 62.190 | 59.120 |
| Shear Modulus, G (kN/m$^2$) | $7.7221\times10^7$ | $7.7221\times10^7$ |
| Poisson's Ratio, nu | 0.278 | |

**Table 1** above shows the properties value of bamboo (A) and (B) all this based on literature review of research papers and study of bamboo properties from Dinie Awalludin, Abdul Latif Mohmod, Caori Takeuchi and Kubojima [5], [6], [7] and [8]. The value was used to produce the result in the Staad Pro to simulate the simulating structure of pedestrian bridge using the bamboo.

### 2.2 Methods

The method that was used in this study can be show as the following:

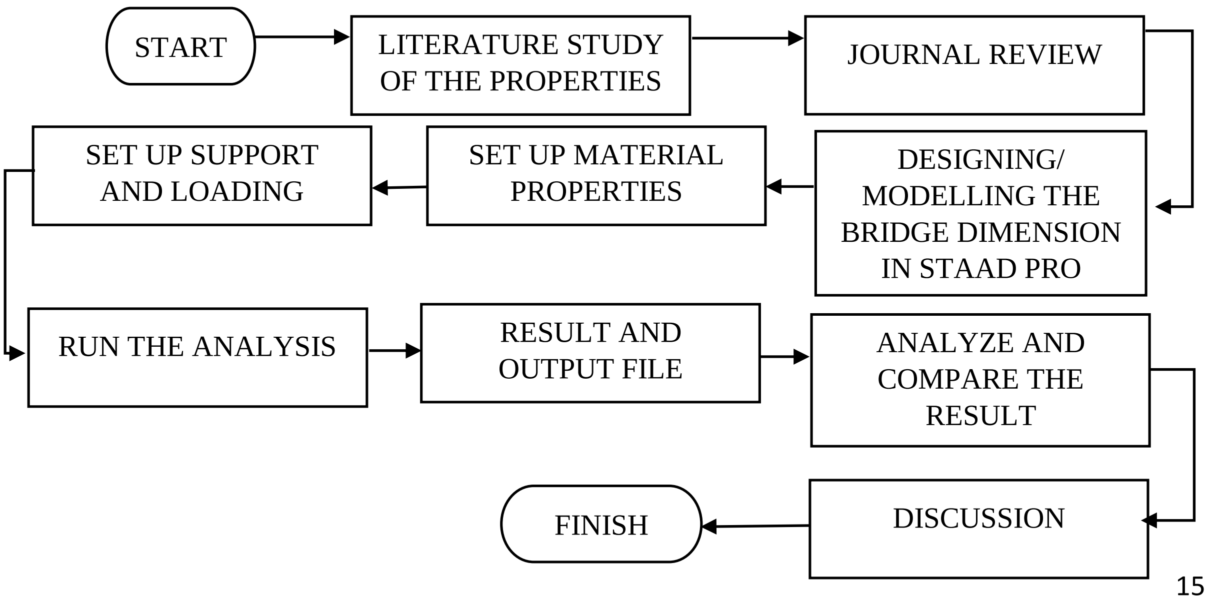


**Figure 2: Staad Pro pedestarian bridge analysis workflow chart**

The method that is being used in this study is simply by designing a pedestarian bridge and build it in the Staad Pro Software and also using the data of properties that has been obtained. When the design, and the data has meet every specification and no errors made in the analysing processing, the results from the analysis can be observe and can be export to a report file. The result can also be compared since two type of bamboo has been used. **Figure 2,** shows the procedure or workflow process of analysing the pedestarian bridge design with bamboos as the material using Staad Pro Software. The process was done twice with 2 types of bamboo, Dendrocalamus Asper and Bambusa Vulgaris to be compare with each other.

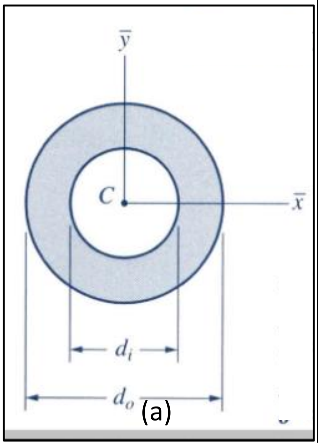
2.3 Material Properties Set Up

Every value of mechanical and physical properties that has been obtained must be set up into Staad Pro to get the simulation working and every properties are significant to produce accurate results. As example the dimensions of the bamboo that is being keyed-in to the properties is 0.15 m in diameter with the wall thickness of 0.01 m. This information is important because it will produce the area moment of inertia of the bamboo which can be define as the formula in **Eq. 1** [9] below:

$$I_x = \int y^2 \, dA \qquad \textbf{Eq. 1}$$

$$I_{hollow\ cylinder(tube)} = \frac{1}{64}\pi(d_o^4 - d_i^4) \qquad \textbf{Eq. 2}$$

The area of cross section of a bamboo is identical to the tube of which can be define as $\frac{1}{4}\pi(d_o^2 - d_i^2)$. The equation then can be simplified to **Eq. 2** where $d_o$ is the diameter of the outer circle and $d_i$ is the diameter of the outer circle. This can be illustrated as the bellow:



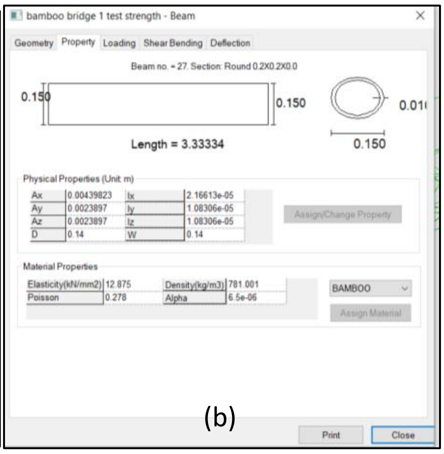




**Figure 3: (a) Typical cross section of bamboo and (b) The properties of material**

**Figure 3,a** , as shown are the illustration of the typical cross sectional of a bamboo that is similar to the tube. The moment of inertia is important to produce most of the results in the Staad Pro design and it is the same case for the other properties as shown in **Figure 3(b)**.

2.4 Loading and Support Set Up

The support choice of the pedestrian bridge that has been design was a total of six fixed supports, which placed and arranged in the position of 2 supports and each ends for both sides and 2 supports at the middle for both side of the beam to represent the column of the pedestrian bridge.

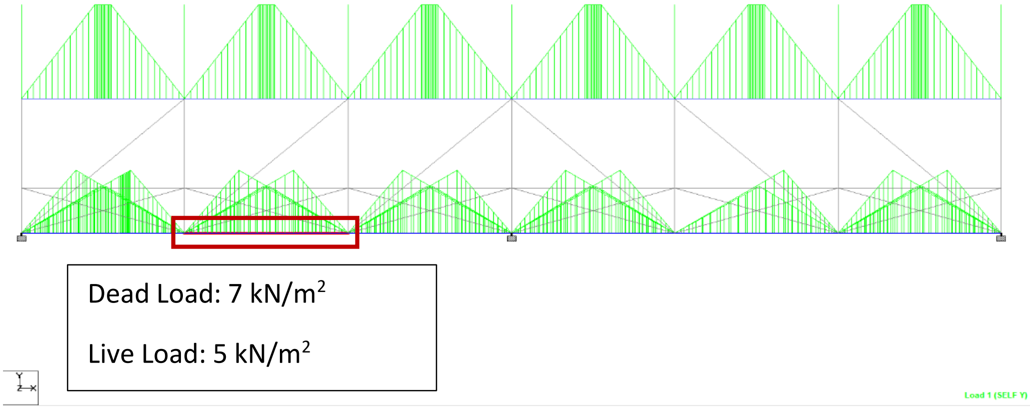



**Figure 4: Loading and Supports diagram of the bridge in Staad Pro Software**

**Figure 4**; The loadings that were assigned on the pedestrian bridge were dead loading of 7 kN/$m^2$ and live loading of 5 kN/$m^2$. The dead loading was including the selftweight of the plate and bamboo and the dead load were also assigned to the top beams to represent the roof of the pedestrian bridge. Meanwhile, live loading is representing the people that will be walking on the plate. Considering the weight of a single person in Malaysia is 62.65 kg [10] that equivalent to approximately 0.61 kN, the 5 kN/$m^2$ across the bridge is more than enough to simulate people walking on the bridge.

## 3. Results and Discussion

After the analysis prosess with the load and live load that has been set is done, the output report was downloaded and being examined. The post-processing part of Staad Pro software can summarize the results data and this has been utilize to discuss the result swiftly and easily.

### 3.1 Result

The data are collected, recirded, discussed and evaluated.The result might be represented as tables, figures or charts to ease the understanding. The results that will be discussed further is the stresses and deflection of the highlighted beam in previous part.

**Table 2: Summarized Result from Staad Pro Analysis**

| Type of Bamboo | Deflection of Highlighted Beam (mm) | Highest Value of: Compressive Stress (N/$mm^2$) | Highest Value of: Tensile Stress (N/$mm^2$) | Highest Value of: Shear Forces ( kN) |
|---|---|---|---|---|
| Dendrocalamus Asper (A) | 31.691 | 82.262 | 82.582 | 18.414 |
| Bambusa Vulgaris (B) | 45.049 | 68.475 | 68.572 | 16.572 |

From **Table 2**, the value of every stress value of bamboo (A) Bridge seems to be higher than (B). On the other hand, the Deflection of the highlighted beam, which is the middle beam between 2 support of (A) is less than (B).

### 3.2 Deflection

In Staad Pro Software, there are also a lot of features that can be use to get the better understanding of the results, one of them is the graphical deflection diagram.

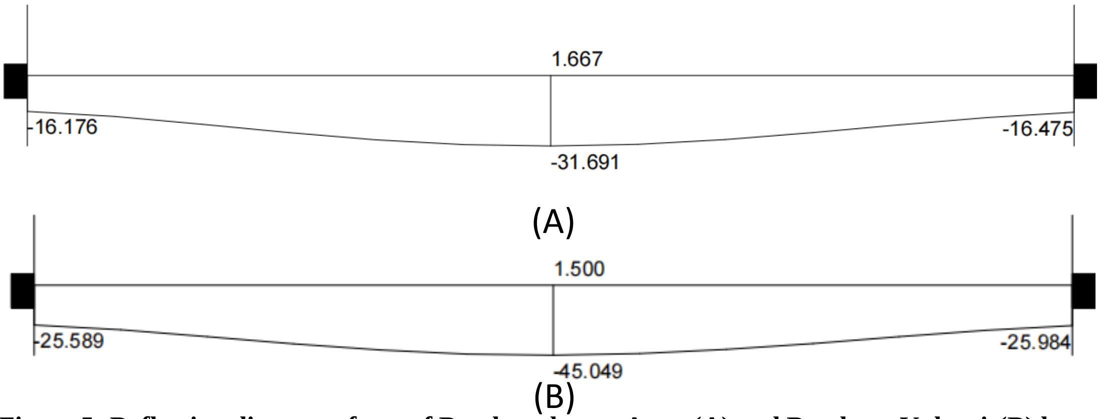



**Figure 5: Deflection diagram of one of Dendrocalamus Asper(A) and Bambusa Vulgaris(B) beam**

**Figure 5,** as shown 2 diagram of deflection from the highlighted beam of each bridges. The bridge that use (A) has less deflection of the beam than the one that use (B). Although the difference is just mere milimeters, it still has impact on the result that will be discussed in the discussion part.

3.3 Discussions

The analysis has been run and the result that has been examine and summarized to be simplified. From the guide of pedestrian bridge specification, the allowable deflection of the members in the structure can be evaluated using the formula in the equation bellow [11]:

$$Allowable\ Deflection = \frac{L}{500} \qquad \textbf{Eq. 3}$$

**Eq. 3**, where, L is the length of the span. From the designed bridge, the length of the span was 20 m, so,the value then being substitute into **Eq. 3** and the allowable deflection for the bridge was 0.04 m. The value is equivalent to 40 mm and the displacement of both bamboo (A) and (B) bridges are 31.691 mm and 45.049 mm respectively. This shows that bamboo (A) pass for deflection limit while (B) fail.

Next, for the maximum compressive and tensile stress of the beams in both bridge, both type of bamboo bridge does not exceed their limit of tensile strength but both bamboo exceed the limit of compressive strength. But, the analysis was conducted with high loading. In real life scenario, people walking on the bridge will not put on such high loading. Thus it is safe to believe that both of the bridge simulation was a success but Dendrocalamus Asper has the upper hand for deflection limit.

These shows that bamboos, particularly in this study Dendrocalamus Asper and Bambusa Vulgaris, have the potential to be the alternative materials in structural construction. Furthermore, bamboos also has been fully used and utilized in structures and even buildings, as proof, there were mass usage of 3 type of bamboo for building a mosque that named Turtle Mosque in Kuala Nerus, Terengganu in Malaysia [12] and also usage of bamboo another mosque in Chandan Puteri, Kuala Kangsar, Perak, Malaysia [13] .

## 4. Conclusion

To conclude the the study that has been conducted, Dendrocalamus Asper bridge has the results that is higher than the Bambusa Vulgaris in the aspect of beam stresses. However, Dendrocalamus Asper have the value of deflection less than both Bambusa Vulgaris and the limit of deflection. Moreover, the deflection animation features does not shows significant movement of the graphical bridges. This shows that bamboo have high potential to be alternative materials for construction, structurally. Beside that, Dendrocalamus Asper seems to be better than Bambusa Vulgaris since it pass through more aspects. Also, bamboo usage can cut the cost of construction while maintaining the structure strength. Besides, it has high tensile strength and can be aesthetically pleasant in design.

Based on the findings, suggestion that can be expressed is to make more research of more type of bamboo for the construction purposes. Besides, treatment or reinforcement researches for bamboo can also helps to provide better quality of bamboo in the aspect of strength and resistance to be use in the construction safely. For the closure, more bamboo usage as the main materials in construction in future is also a good concept since it has been done successfully in small projects.

**Acknowledgement**

Special thanks to the University Tun Hussein Onn Malaysia's Centre for Diploma Studies (CeDS) for providing this outstanding project study opportunity. Also, thank you to the supervisor, Tuan Mohd Jahaya Bin Kesot, for all of your help and support while this study was being carried out.

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