Behaviors of the Axial Load Carrying Capacity of the Bamboo Encased with Concrete Column in Low-Rise Structures

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1. INTRODUCTION

The housing industry is one of the most energy-consuming sectors on earth. Due to the high energy consumption of the building construction industry, many of the materials their use is not economical and the rapid growth of the population has raised the demand for cheaper housing solutions [1]. Concrete provides various advantages for building construction such as low cost, durability, fire resistance, etc. But we can't use it alone everywhere because it has low tensile strength. But generally, steel is used to reinforce concrete structures because steel has a high tensile strength to complement the low tensile strength of the concrete problem [2]. Nowadays in the construction industry, steel is difficult to obtain because of increasing costs and due to the rapid development, the production of steel is currently limited heavily. Steel is non-renewable material, the production cost is high, and increases the carbon footprint in the environment during production and its energy-consuming manufacturing process affects air pollution.

This costly steel is not affordable in most low-income countries. Thus, a suitable material must be used to substitute steel in construction. That material must provide available at a low cost, environmentally friendly, and less energy-consuming in its manufacturing process. It has led researchers to investigate alternatives for steel reinforcement. So, as an alternative to overcome this problem, bamboo material has been used as a replacement for reinforcement in concrete [2]. Bamboo is a suitable material because it is a natural material, cheap and available material around the world. It is a renewable plant with a short rotation period plant. This plant is fully mature at an age of three to four years. However, the compressive bearing capacity of bamboo is relatively low, which limits its applications only in structures under light loads. So, to increase the compression capacity of the bamboo column, a composite bamboo column filled with concrete is the best option to use in a low-rise building under only axial load. Some advanced techniques should be taken into consideration to increase the axial load-carrying capacity, ductility, fire resistance, and other physical properties.

From the structural point of view, the reinforced concrete encasement is the best-advanced technology to increase the compression and bending capacity of the bamboo filled with the concrete column. Even structures that are heavily loaded and subjected to high lateral loads are not structurally sound to perform with bamboo filled with the concrete composite column [3]. Therefore, this research was carried out to find the variation in the axial load-carrying capacity of the conventional bamboo column compared with the encased concrete column. Using these outcomes, it can be chosen the best techniques which can be applied to improve the axial load-carrying capacity of the bamboo column which is suitable for low-rise concrete structures. In this study, various buckling length was considered for the estimation of the axial load-carrying capacity of the column.

2. MATERIALS AND METHODS

2.1 Selection of bamboo geometry

The diameter of the specimen was selected by testing the 600mm height bamboo column with different diameters. For the conventional bamboo test, the selected diameter was used to prepare 600, 650, 700, and 800mm heights of the bamboo column with two types of bamboo.

Figure 1: Bamboo specimens

Figure 2: Arrangement of encased concrete

From the conventional bamboo test, observed many types of failure modes under compression loading. To overcome these failures, encasement with concrete is the best technique, by increasing the stiffeners of the column. The overall methodology flow chart is shown in Figure 3.

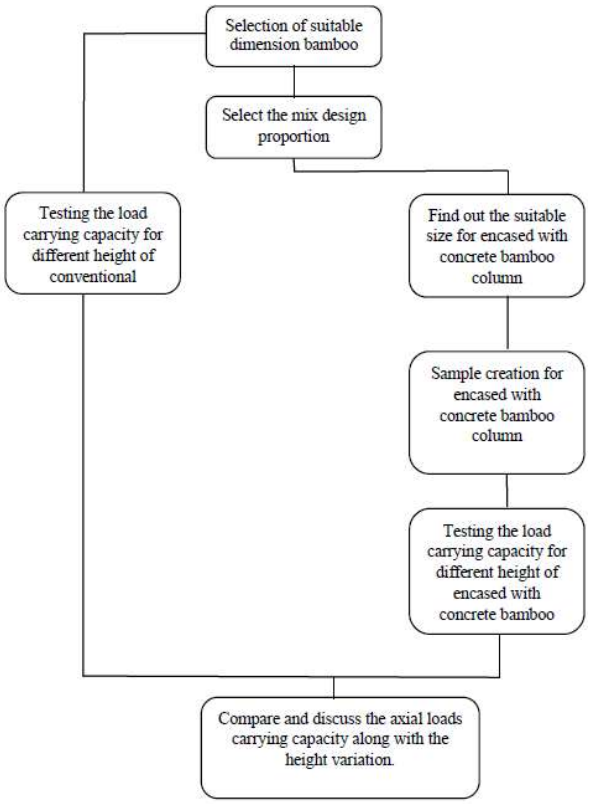

Figure 3: Methodology Flow chart

2.2. Different types of Bamboo

Table 1: Results of selection of bamboo dimension

Specimen	Outer Diameter (mm)	Inner Diameter (mm)	Effective Area (mm^2)	Max Load (kN)	Stress (kN/mm^2)	Length (mm)
S1	53.00	29.00	1546.29	34.55	$2.2 * 10^{-2}$	600
S2	47.75	23.75	1348.29	41.00	$3.0 * 10^{-2}$	600
S3	53.50	30.50	1518.00	20.63	$1.3 * 10^{-2}$	600
S4	67.75	43.75	2102.57	109.58	$5.2 * 10^{-2}$	600
S5	72.75	57.75	1538.04	91.00	$5.9 * 10^{-2}$	600

As shown in Table 1, 70mm diameter conventional bamboo shows a higher axial load-carrying capacity of 110kN. This size was selected for the detailed study.

3. RESULTS AND DISCUSSION

Bambusa Vulgaris and Bambusa Blumena types of bamboo were studied for the various D/T and height. Results are shown in Table 2.

Table 2: Compression capacity of the conventional bamboo

Specimens	Max Load (kN)	Area (mm^2)	Thickness (mm)	D/T	Node Distance (mm)	Node Distance/T	Heights (mm)
S1	34.55	1546.29	12	4.417	240	20.00	600
Y700	53	1184.61	6.37	10.28	210	32.97	700
S5	91	1538.04	7.5	9.7	340	45.33	600
S4	109.58	2102.57	12	5.646	300	25.00	600
G800	28	3485.38	20.87	3.545	180	8.62	800
G700	53	3355.74	21.62	3.283	170	7.86	700
G600	55	3617.04	24.75	2.878	180	7.27	600
G650	83.78	3547.01	44.075	1.661	190	4.31	650

From this study, it is realized that Diameter / Thickness ratio (D/T) highly effect on the compression capacity of the conventional bamboo column, and axial load carrying capacity is decreased with the increasing D/T ratio of the conventional bamboo, due to the increment of stiffness.

3.1 Young Modulus of the bamboo

Young's modulus is one of the important mechanical properties which decide the quality of bamboo. In order to find the young's modulus for each species under buckling failure mode, Euler column formula was used to estimate the critical buckling load of a column with pinned ends.

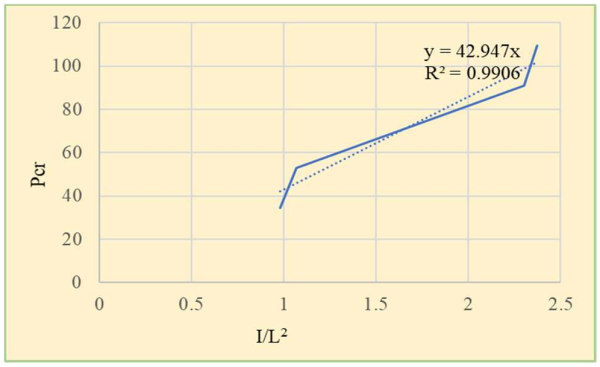

Figure 4: Variation of P_{cr} vs I/L^2
Bambusa Vulgaris (Yellow bamboo)

The Young's modulus of the "Bambusa Vulgaris" was obtained as 4.351 GPa which is shown in Figure 4.

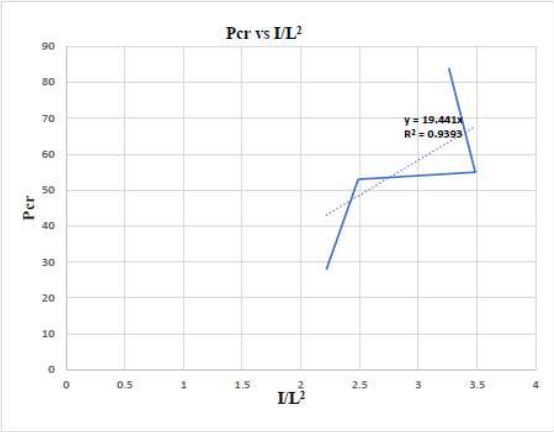

Figure 5: Variation of P_{cr} vs I/L^2 Bambusa Blumeana (Green bamboo)

The Young's modulus of the "Bambusa Blumeana" was obtained as 1.969GPa which is shown in Figure 5. Also, based on the young modulus which was obtained from the buckling analysis, buckling loading capacity under different loading is shown in Table 3.

Table 3: Compression load-carrying capacity with the height

Height (m)	Pcr Value for Bambusa Vulgaris (kN)	Pcr Value for Bambusa Blumeana (kN)
0.5 m	146.9	66.5
1.0 m	36.7	16.61
1.5 m	16.3	7.4
2.0 m	9.2	4.15
2.5 m	5.9	2.6
3.0 m	4.1	1.85

From this study, it can be concluded that, axial load carrying capacity of the slender bamboo column is much lower than the short column. Therefore, infilled or encased with concrete to the conventional bamboo techniques are required to obtain the high axial load carrying capacity for slender column.

3.2 Encased with Concrete to the Bamboo Column.

The encased concrete to the conventional untreated bamboo is not possible and many cracks were observed and cracks were initiated from the surface of the bamboo column. Therefore, proper treatment should be conducted before the encasement.

Figure 6: Cracks specimens with encased concrete

4 CONCLUSIONS

- The elastic modulus and load-carrying capacity of the Bambusa Vulgaris is higher than the Bambusa Blumeana.
- Due to the increment of stiffness and fiber content, the maximum load-carrying capacity is higher for Bambusa vulgaris than for Bambusa blumeana.
- The treatment process is mandatory for the encasement of the bamboo column.

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5. REFERENCES

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