Experimental Determination Of Compressive Strength Of Bamboo Panel Made From Bamboo Grown In Southwest Of Nigeria

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ABSTRACT: This work investigates the compressive strength of bamboo panels made from the locally grown bamboos in Osun State of Nigeria. There are five different species of bamboo grown in Nigeria but the specie commonly found in the Southwest of Nigeria in large quantity is Bambusa Vulgaris. Despite its versatility in the construction of low cost houses, little is made use of it other than as scaffolds and shoring of concreting of slabs in building. As structural elements such as reinforcement, it s use is non-existent despite its high tensile strength in excess of 400MPa stronger than mild steel as reported by Xiaobing (2007). Although, bamboo is not as good in compression but this is only ascertained for some variants of bamboos in the Asia but such is not available for the species grown in the Southwest of Nigeria. The current work focuses on the compressive capacity of short panels with and without reinforcements. It is interesting that bamboo panels of various dimensions of 350mm, 300mm, 250mm and 200mm in height and constant width of 200mm exhibited compressive strength decreasing with reduction in slenderness ratio. The average compressive strength ranges from 14MPa to 19.67MPa for 200mm panel and from 18.1 MPa to 22.56MPa for 350mm panel. With improved infill, the panel strength improves considerably with over 40% for the stockiest type and about 25% increase for the slender panels.

1.0 INTRODUCTION

Throughout the world, developing countries are facing several problems with regard to the supply of building materials, the core of the construction sector. As populations grow and interactions improve and as aspirations to higher living standards rise, so the demand for buildings both quantitatively and qualitatively grows even more rapidly. The hindrance to the abundant provision of shelter is linked to the rising cost of building materials has made it impossible to provide affordable housing for the low-income residents (Oruwari et al, 2002). The pressure on the environment due to high consumption of wood is enormous. The rate of deforestation is growing at alarming rate. This is experienced across the globe and Nigeria is not exempted from this menace. Unfortunately, Nigeria is very slow in sourcing alternative resources that will relieve the pressure on the rain forest. Bamboo, being an alternative material for construction has been grossly neglected in the country. Despite the abundant availability of bamboo in the Southwestern Nigeria, little or no use of the bamboo resource is used for building construction. Oyewole et al (2013) reported that Bambusa Vulgaris out performs steel in tension with tensile strength of about 295 MPa, yet, the only reinforcing bars consumed in the country is steel. However, Ogunbiyi et al (2015) reported the tensile strength of bamboo in the Southwestern Nigeria, about 94 MPa. According to Zhang (2001), treated plybamboo performs better than any other materials. Architects such as McQuaid (2005) and Rogers (2006) have used bamboo extensively in their architectural design of buildings. Bamboo mechanical properties are majorly determined experimentally and the results show a remarkable range based on species, age, moisture content, locations, soil and climatic condition as reported by Xiaobing (2007).

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The low cost of producing bamboo for the consumption of building industry has generated interest in investigating bamboo as alternative material for building construction. This is evident in many developing countries. However, in Nigeria, this phenomenon is yet to be taken on board effectively. Although, many researchers are searching for low-cost materials as a substitute or alternative to the existing building materials, bamboo stands out. According to Shinde & Karankal (2013), of all the low-cost building materials, a natural material available in bulk and easy to grow and use in the rural areas in the developing countries is bamboo. The abundance of bamboo in many developing countries such as Nigeria is well established by many researchers over the years. Also, Amada and Untao (2001) confirmed that bamboo is the most effective material in construction because of its superior character of being physically powerful, tough, and a low-cost material.

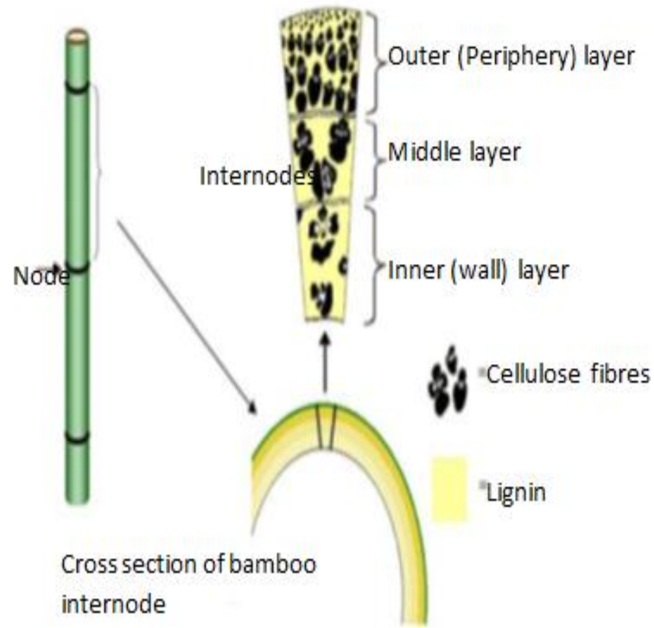

Figure 1: *Diagram of bamboo and cross section of bamboo*

The bamboo physical and general structural make up are shown in Figure 1 and the longitudinal fibrous lining has contributed to its high tensile strength. However, the compressive strength is relatively low compared to many building materials. The large variation of the characteristic strength from location to location and among various species necessitates the determination of characteristic compressive strength of bamboo grown in Nigeria and most especially in Southwestern Nigeria.

2.0 MATERIALS AND METHODS

The main material of investigation is bamboo grown in Osogbo, Osun State of Nigeria. Matured and competent bamboo material is of interest in this study because that will be the most probable choice for consumption. The considered is of about 70mm in diameter and culm wall thickness of about 10mm. For some test specimens, weak concrete mortar is added to the panels in order to investigate the effect of such material on the compressive strength of bamboo panels. A98 BRC steel wire mesh of 5mm diameter with 200mm spacing in both horizontal and longitudinal directions of 5mm in diameter.is also added to the panels with some weak concrete mortar. The typical weight of the mesh is 8.3kg/pc of 1.8m by 3.0m Sharp river quartzite sand that is free of clay, loam, dirt and any organic or chemical matter passing British Standard 4.75mm sieve size. The hydraulic binder used is the Ordinary Portland Cement (OPC) conforming to BS 12 (British Standards Institution, 1971) and the Standard Institute of Nigeria (NIS) 1974.

2.1 Material Preparation

The freshly harvested bamboo stems were cleaned and air dried before being split into equal halves mechanically. The panels height ranges from 200mm to 350mm with constant width of 200mm. The panels were built in a kind of corrugated format with the load distribution wooden plates at top and bottom. For each of the panel sizes, three samples for panel without infill, with mortar infill and with mortar and mesh infill.

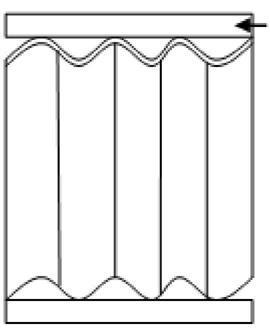

Fig 2 *Sketch of Bamboo Panel*

2.2 Compressive Strength Test

The compressive test arrangement is shown in Figure 3 and 4 for the plain bamboo and bamboo panel filled with weak concrete mortar. The failure load for each specimen was recorded and the compressive strength calculated as presented in the next section.

Figure 3: *Test setup for compressive strength test for panel without infill.*

Figure 4: *Test setup for compressive strength test for panel with mortar infill*

3.0 RESULT AND DISCUSSION

The compressive strength results are presented in Table 1, 2, 3 and 4. These results were obtained from a different dimension of bamboo panel. The cross sectional area of 4 half bamboo culms with an average diameter of 70 mm and average thickness of 10 mm can be estimated approximately using the formula below. A typical cross section of half the tube is shown in figure 5.

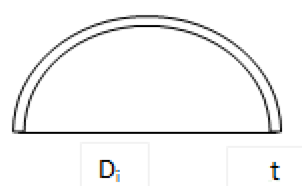

Figure 5: *Cross section of bamboo culm*

Cross Sectional Area, $A = Npt(D_i + t)/2$ (1)

Where D_i is internal diameter and t is the thickness of the culm wall.
N is the number of half section.
Taking N = 4, D_i = 70 mm, t = 10 mm
Area of Bamboo Panel cross section
$A = 4 * 3.141592654 * 10 *(70 + 10) / 2 = 5026.6\ mm^2$
Compressive Strength = crushing load / A

Table 1 *Result of Compressive Strength of Plane Bamboo Panel without mortar*

Dimension (mm)	Specimen	Weight (kg)	Load (kN)	Compressive Strength (N/mm^2)	Mean Compressive strength (N/mm^2)
	A	1.40	89.8	17.87	18.11
350 X 200	B	1.45	90.2	17.95	
	C	1.45	93.1	18.52	
	A	1.25	81.2	16.15	
300 X 200	B	1.38	83.9	16.69	16.59
	C	1.41	84.5	16.81	
	A	1.15	79.9	15.90	
250 X 200	B	1.10	80.1	15.94	15.87
	C	1.15	79.2	15.76	
	A	1.03	70.4	14.01	
200 X 200	B	1.00	70.6	14.05	14.02
	C	1.09	70.4	14.01	

The compressive strength shown in Table 1 is for the plain panel without any infill. The strength increases as the mass of the panel increases. This is line with evidence presented by Jules (2008) that the compressive strength increases with panel mass and that the compressive strength is a function of mass of the panel. The same results are presented in Figure 5 in form of bar charts.

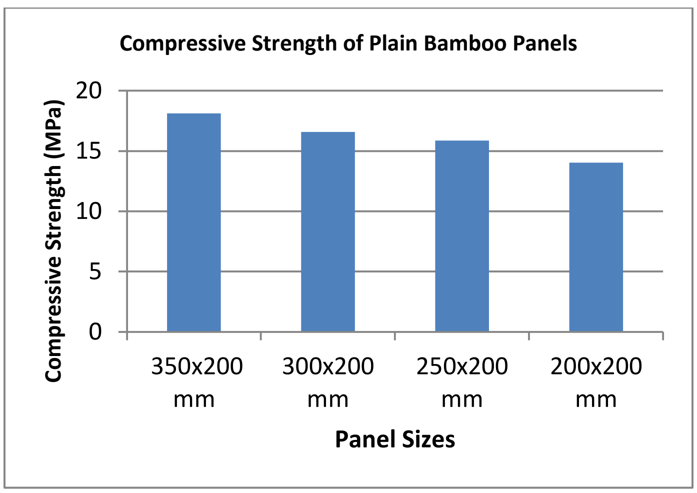

Figure 5 *Bar Chart of Compressive Strength against Dimension of Bamboo Panel*

Table 2 shows the compressive strength variation when filled with mortar. The same trend of increasing compressive strength with mass of the panel is exhibited. Also the same results are presented in Figure 6 in form of bar charts.

Table 2 *Result of Compressive Strength of Bamboo Panel with Mortar*

Dimension (mm)	Specimen	Weight (kg)	Load (kN)	Compressive Strength (N/mm^2)	Mean Compressive strength (N/mm^2)
	A	3.028	103.1	20.51	20.73
350 X 200	B	3.145	105.3	20.95	
	C	3.089	104.2	20.73	
	A	2.592	93.1	18.52	
300 X 200	B	2.754	93.9	18.68	18.74
	C	2.961	95.6	19.02	
	A	2.410	90.1	17.93	
250 X 200	B	2.500	88.5	17.61	17.87
	C	2.450	90.9	18.08	
	A	2.250	87.1	17.33	
200 X 200	B	2.390	86.4	17.18	17.23
	C	2.280	86.3	17.17	

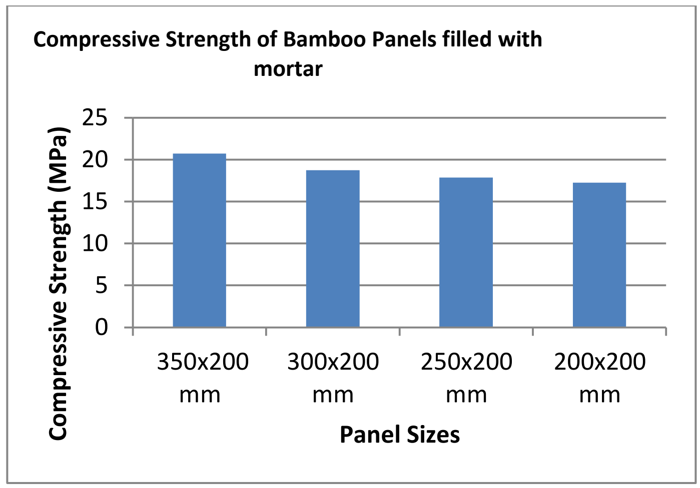

Figure 6 *Bar Chart of Compressive Strength against Dimension of Bamboo Panel*

When the mesh and mortar are added to the panels, the result trend is the same as other two cases with the compressive strength increasing with the panel mass. The same results are presented in Table 3 and Figure 7 in form of bar charts.

Table 3 *Result of Compressive Strength of Panel with Mortar and Wire Mesh*

Dimension (mm)	Specimen	Weight (kg)	Load (kN)	Compressive Strength (N/mm^2)	Mean Compressive strength (N/mm^2)
350 X 200	A	3.720	113.6	22.60	22.56
	B	3.548	113.2	22.52	
	C	3.610	113.4	22.56	
300 X 200	A	3.452	103.4	20.57	
	B	3.500	103.3	20.55	20.53
	C	3.481	102.9	20.47	
250 X 200	A	3.385	100.1	19.91	
	B	3.320	100.0	19.89	19.89
	C	3.340	99.90	19.87	
200 X 200	A	3.150	99.0	19.69	
	B	3.141	98.7	19.64	19.67
	C	3.138	98.9	19.68	

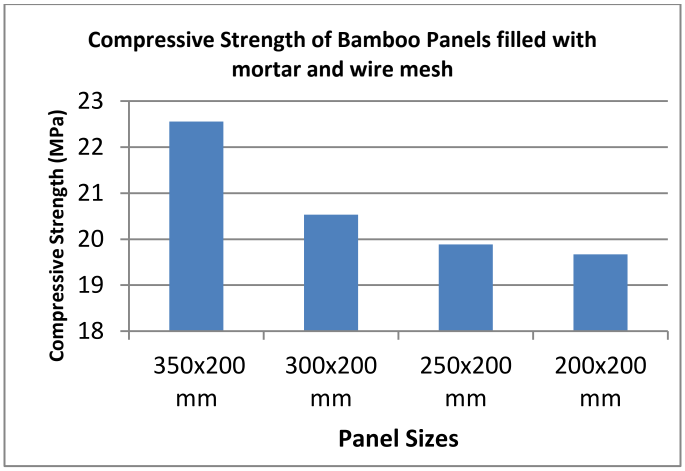

Figure 7 *Bar Chart of Compressive Strength against Dimension of Bamboo Panel*

Table 4 and Figure 8 show that comparative results of each panel with infills. It is evident that wire mesh with mortar shows the most improved performance of about 24.6%, 23.7%, 25.3% and 40.2% for 350mm, 300mm, 250mm and 200mm. It is observed that the stockier the panel the more the effect of infill on the compressive strength. It is clear that stocky panel with infill would exhibit more compressive strength over a plain panel. Although, the heavier the panel the more the compressive strength and it is interesting to note that increase slenderness ratio of the panel improves the performance of the panel.

Table 4 *Mean Compressive Strength of Bamboo Panels and their Dimensions*

50x200 mm	300x200 mm	250x200 mm	200x200 mm	
Mean Comp. MPa	Mean Comp. MPa	Mean Comp. MPa	Mean Comp. MPa	
18.11	16.59	15.87	14.02	No Mortar
20.73	18.74	17.87	17.23	With Mortar only
22.56	20.53	19.89	19.67	With Mortar and Mesh

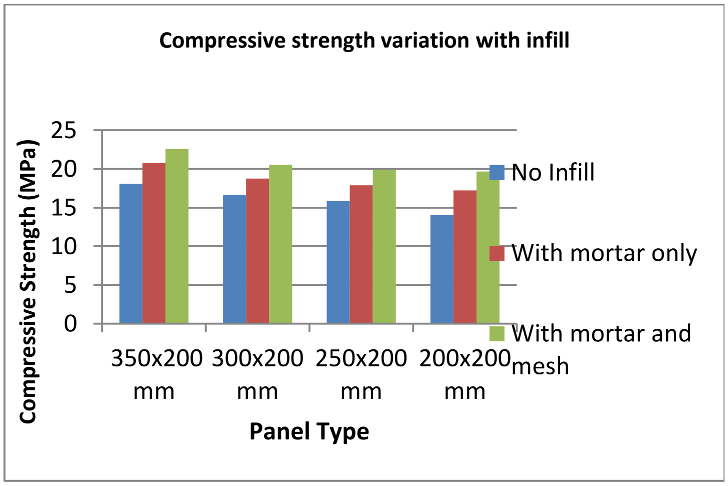

Figure 8: *Bar Chart of Compressive Strength variation with in fill material for various panel sizes.*

4.0 CONCLUSION

From this in-exhaustive study, bamboo panels appear to be very suitable for external and internal walls in the building. The average compressive strength of most of the locally produced sandcrete blocks used in the construction of building is in the range of 0.5 to 2 MPa. In sharp contrast to the compressive strength of plain panel of about 14MPa and the potential to improve the compressive strength to about 17 MPa with weak mortar infill. This clearly demonstrates the prospect of bamboo as building material in Nigeria. Invariably, bamboo is very good in tension, the use of bamboo as floor construction is a possibility.

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