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Axial and Flexural Load Test on Untreated Bamboocrete Multi-Purpose Panel

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Abstract: In this study, the axial and flexural strength of lightweight concrete panel reinforced with untreated bamboo describe as bamboocrete multi-purpose panel was investigated. Bamboo is a low cost, abundantly ready available and sustainable material used to carry load. In this research, bamboo is used to reinforce lightweight concrete to form a load bearing panel. From the test conducted, design axial strength of the panel can be up to 100kN (10 ton). The 1500 mm length, 500 mm wide, and 125 mm thick, bamboocrete panel then were subjected to four-point bending and achieved ultimate bending strength of at least 25 kN. The bamboo used in the concrete panel greatly contributed to the bending strength of the panel. Upon removal of the load, the bamboocrete panel return to almost its original form, showing flexibility and ductility of the panel.

Keywords: Axial and Flexural Load, Bamboocrete, multi-purpose panel.

1. Introduction

The sustainable development for management of scarce resources is undoubtedly crucial. Especially in the housing sector, the worldwide demand for affordable housing and development for sustainability is extremely vital. Significant reduction of overall inflation in housing costs can be achieved if the advanced construction technologies and design of the structural material is scrutinized [1].

Concrete was the most widely used material in building construction. Concrete seemed to be strong in compression but very weak in tension. Thus, it is important to have the reinforcing materials to support the tensile load on the concrete. Conventional structural building components usually used steel bars as reinforcement, but it has various disadvantages such as non-renewability and high in cost. Plus, the steel members' production may become the major source of greenhouse gas emission. An alternative for low cost, sustainable and locally available material has to be prepared in order to partially replace the need for steel bar [2].

Bamboo is known as the alternative to replace steel in concrete which its tensile strength is very high. Bamboos have been used as reinforcement on the concrete structure [3,4]. With its excellent mechanical properties, bamboo's specific gravity ranged from 0.55 to 0.75 which offer a lightness construction material [5]. Bamboo known as the fastest growing plants as a natural raw material. In fact, bamboo is stronger compared to wood and bricks. It can be as strong as steel, friendly to the environment, cheap, renewable and readily accessible. Bamboo is an environmentally friendly material; it only takes 3-5 years to reach maturity and can be harvested [6]. Further, it may be able to mitigate the global warming or offset the greenhouse gases [5,7]. Bamboo reaches its full growth in just a few months when it reaches its maximum mechanical resistance [8,9].

In the botanic world, with its very strong environmental performance, bamboo has its bright side to act as structural components which coupled with very high natural growth rate. But in most countries, knowledge and the construction using bamboo is not widespread and unregulated. Research and development on bamboo's mechanical properties play a crucial role in the quality and durability of the final structural components [10].

2. Material and Method

The bamboocrete multi-purpose panel is a new hybrid technology, which used the whole solid bamboo as a reinforcement combined with lightweight concrete. The axial and flexural test conducted referred to the test standard of ASTM E72-05 [11].

2.1 Preparation of Materials

The bamboocrete multi-purpose panel contains a Gigantochloa Scortechinii bamboo, also known as Buluh Semantan in Malaysia, it act as reinforcement in structural

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lightweight concrete. Fig. 1 illustrates the location of solid whole bamboo located in the lightweight concrete panel.

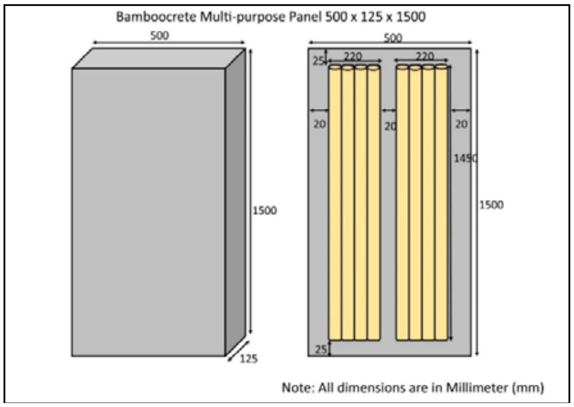


Fig. 1 Bamboocrete Multi-purpose Panel

2.2 Bamboo Preparation

The most widely used bamboo in Malaysia as structural component, Gigantochloa Scortechinii (Buluh Semantan) was used in this study. Bamboo with diameters range between 45 to 60 mm, aged from 3 to 4 years old were collected from the jungle Hulu Langat, Selangor, Malaysia. The bamboo used is in untreated condition and air-dried for 1 month. Specified length of bamboo were grouped into several pieces tied and wrapped with wire mesh to ensure proper bonding with the concrete as shown in Fig. 2.

Fig. 2 Bamboo wrapped with wire mesh.

2.3 Bamboocrete Panel Casting

Size of 1500 mm × 500 mm × 125 mm lightweight concrete panel containing bamboo as reinforcement. Wooden formworks were prepared as moulds as shown in Fig. 3. Three control samples and six bamboocrete multi-purpose panels is casted. Three control panel and three bamboocrete multi-purpose panels undergoes immediate test after 28 days curing. Another three bamboocrete multi-purpose panel were kept for future durability test. Control panel cast using perlite lightweight concrete with cube compressive strength of 10 MPa, while bamboocrete panel containing group of whole bamboos casted inside perlite lightweight concrete. Lightweight concrete and the usage of bamboo in concrete panel is to reduce the weight of panel to ease the handling in construction.

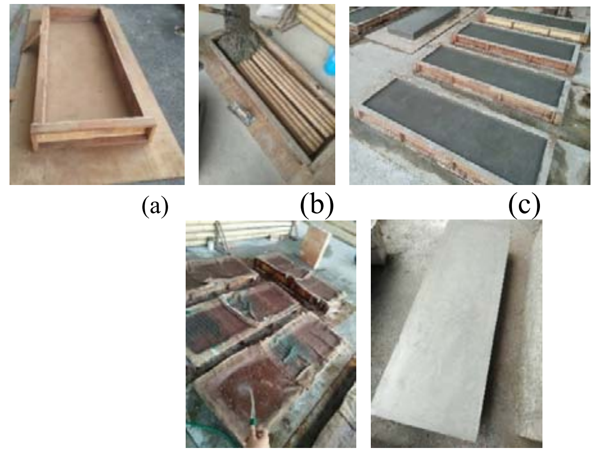


Fig. 3 Bamboocrete Multi-purpose Panel Casting. (a)Wooden formwork (b) Pieces of wrapped bamboo placed in formwork (c) Bamboo casted in lightweight concrete (d) Curing for 28 days (e) Sample Panel

2.4 Axial Load Test

A static loading regime is adopted for this testing. Load is applied manually to the panels using hand operated hydraulic pump. Data is recorded at every 0.5 kN using data logger. Expected typical design loads on the panel for double storey building is 30 kN as simulated on Fig. 4. The panel will be tested untill 100kN only, equivalent to 1.6 MPa. This is to ensure the sample will not fail and to be reuse for flexural test. General set up for axial load test is shown in Fig. 5. This is due to this bamboocrete multi-purpose panel and control panel need to be reuse on flexural test. At every load increment, the load and the deflections were recorded by the data logger. Load-deflection graph then were plotted to compare the axial load between control panel and bamboocrete multi-purpose panel.

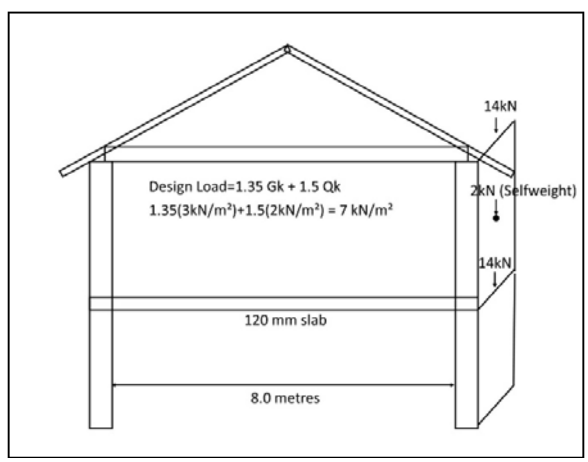


Fig. 4 Load distribution on wall panel

(a) (b)

Fig. 5 Axial Load Test. (a) General set up. (b) Load cell and LVDT to capture data.

2.5 Slenderness Ratio

The slenderness ratio were calculated by using equation (1).

$$\lambda = l_0 / i = = l_0 / (I/A)^{½} \quad (3)$$

In equation (1), λ is the slenderness ratio, i is the radius of gyration, l_0 is the effective length of the panel, I is the moment of inertia and A is thhe cross-sectional area. We will also have calculated L/h ratio to classify the axially loaded member.

2.6 Flexural Test

The flexural bending capacity of the control and bamboocrete multi-purpose panel were tested until it failed by using a Magnus Frame machine as shown in Fig. 6. The samples with 1500 mm × 500 mm × 125 mm panel were subjected to four points bending flexural tested using the Magnus Frame Machine. The deflections were measured at the mid span by using the LVDT connected to the data logger. Load-deflection diagram were plotted.

(a) (b)

Fig. 6 Flexural Load Test. (a) General set up
(b) Load cell and LVDT to capture data

3. Results and Discussion

3.1 Axial Load Test

The slenderness ratio for these rectangular panels are 41.6, with L=1500 mm, b = 500 mm, and h = 150 mm. The L/h value is 1500/125 equal to 12 which is bigger than 10, thus the panel cannot be classified as short member [12].

Axial test carried out on both control lightweight concrete panel and bamboocrete multi-purpose panel successfully exceed the axial load targeted capacity of more than 100kN (10 ton) equivalent to 1.6 N/mm². Both types of panel are not tested until failed because it will undergo flexural test. With the proven axial strength, it achieved the functional and technical requirement as structural panel as simulated earlier. Load-displacement of the control panel and bamboocrete panel were illustrated at Fig. 7.

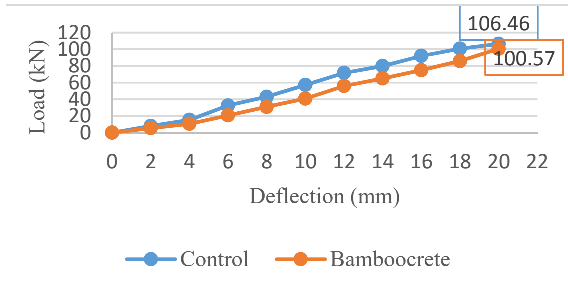


Fig. 7 Axial load test on control and bamboocrete panel

3.2 Flexural Test

The flexural test is obviously more critical for a thin concrete panel. Figure 8 illustrated the load-displacement of the bamboocrete multi-purpose panel. The average ultimate load of flexural bending test for untreated bamboocrete panel is between 26.10 kN to 34.30 kN, while for control panel, it failed with the small load applied not exceeding 5 kN, as shown in Figure 9a and 9b. When load is removed, the bamboocrete specimen return into its original straight form as shown in Figure 9c and 9d. This is an advantage as structural construction components in case of an earthquake or due to extreme force.

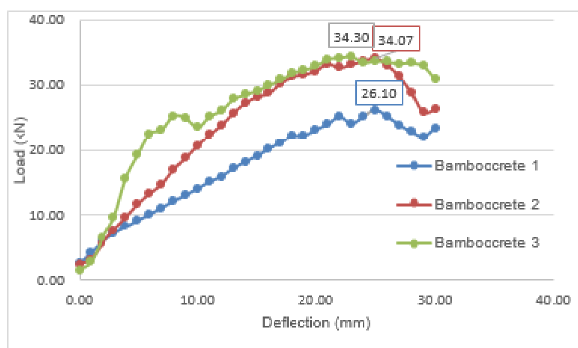
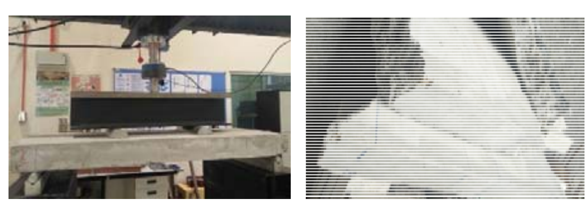


Fig. 8 Flexural bending test on bamboocrete panel



(a) (b)

(c) (d)

Fig. 9 Flexural bending test on control and bamboocrete panel, (a) Control panel before loaded. (b) Control panel failed after small load applied of less than 5kN. (c) Bamboocrete panel undergoes flexural bending test. (d) Bamboo in concrete helps panel to return its original straight form after the load is released.

4. Conclusion

The new multi-purpose panel based on bamboocrete technology developed can be an alternative for building constructions and also for other purposes such as wall panel, floor panels, pathway panels, drains and manholes cover, among other things.

Sustainable issues are the main concern in advanced structural components nowadays. Steel that usually acts as reinforcing material in concrete can be replaced by the abandon of readily available raw material. Bamboo can contribute towards sustainability in building construction. Used of steel and concrete will be reduced with more usage of bamboo in structural materials subsequently enhanced the sustainable construction activities.

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