

Preliminary study on the manufacture of bamboo panel components for prefabricated house

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1. Introduction

Bamboo is a fast growing renewable resource. It is cheap and locally available. Compared with wood, bamboo has higher strength/ weight ratio and can be a good substitute for wood. Bamboo has long been traditionally used as building materials for both structural and decorative uses. There is a big potential for bamboo based panels to be used for prefabricated houses as engineered building materials with controlled strength and structural properties from a renewable resources.

In late 2004 INBAR and The Nature Conservancy (TNC) signed a MOU on Project “*Promotion and Commercialization of Bamboo Building Materials*” to enhance the use of bamboo as an alternative to building/structural materials such as wood and steel by business demonstrations.. This paper presents the outcome of the study on the manufacture of bamboo panel wall/roof components for pack-flat prefabricated module houses for the emergency relief and temporary use targeting mostly disastrous areas and developing markets.

2. Manufacture of bamboo panel components

The structure of bamboo panel components for walls and roof are basic the same, as is shown in Fig 1. All bamboo panel walls and roof components in this study are made at Fustar Company.

2.1 Manufacture of bamboo plywood panel

The process for making bamboo plywood panel is as follows:

- Cross cutting bamboo culms to desired length;
- Cutting into long pieces and scraping nodes and removing both outer surface and inner surface and converting into slivers of 0.5~0.8 mm thickness and 20~30 mm width;
- Weaving slivers into curtains/mats;
- Air drying curtains/mats to 10~12% moisture content (m.c.);
- Dipping into 37% PF glue at a rate about 200 g/m²;

- Drying the glued curtains/mats to 10-15% m. c;
- Assembling the curtains crossed with the adjacent layers, and the whole assembly is faced with one mat each at the top and bottom.
- Hot pressing at 130~140 °C, pressing time 1.5~2 min/mm, hot pressing pressure 3-3.5 MPa.
- Trimming.

The final dimension of the bamboo plywood panel is 122 cm×244 cm× 0.9cm.

Table 1 Physical and mechanical properties of bamboo plywood panel

Density g/cm ³	Thickness swelling (%)		MOR MPa	MOE GPa	Compression Strength MPa
	24h Cold water	2h Boiling water			
1.00	2.5	17.1	135.78	10.50	71.99

Table 1 shows that MOR / MOE of the panel are higher than that of OSB (22Mpa/3.5 Gpa) (BS EN 300:1997, Load bearing boards for use in humid conditions)

2.2 Assembling bamboo panel components

The process includes:

- The wooden frame(122×244X 2.7cm) is prepared through sawing/planning/cutting into sizes/nailing, as indicated in Fig1.
- Assembling two bamboo plywood panels with one wooden frame as a core by gluing and nailing.

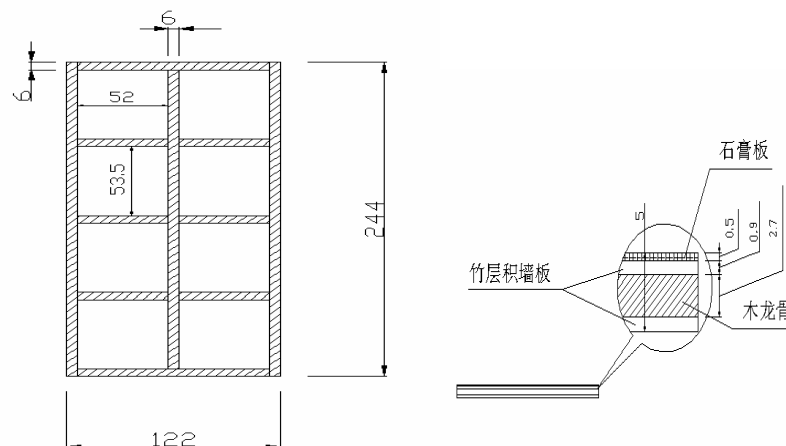


Fig1. Structure of bamboo panel components for walls and roof

- Surfacing a gypsum board ($122 \times 244 \times 0.9$ cm) by gluing and nailing.
- The final dimension of the bamboo panel component is $122 \times 244 \times 5$ cm.

3. Testing and assessment of properties of bamboo panel components

3.1 Testing of properties of bamboo panel components

Tests for sound insulation, thermal transmission and fire-resistance properties of the panel component are made at the National Center for Quality Supervision and Test of Building Engineering.

3.1.1 Sound insulation property

Chinese National Standard GBJ75-84 “Code for measurement of building sound insulation” is used.

The size of the testing sample of panel component is $2.44\text{m} \times 4\text{m} \times 5\text{cm}$, composed with one wooden frame in same size and 4 pieces of bamboo based wall panels of $2.44\text{m} \times 1\text{m}$.

The testing result of sound insulation of the panel component is 32db.

3.1.2 Thermal transmission properties

Chinese National Standard GB/T 13475-92 “Building element-Determination of steady-state thermal transmission properties-Calibrated and guarded hot box” is used.

The sample size of panel component is $1\text{m} \times 1\text{m}$.

Testing results: thermal resistance $0.29\text{m}^2 \cdot \text{K}/\text{W}$, thermal transmission coefficient $2.3\text{W}/\text{m}^2 \cdot \text{K}$.

3.1.3 Fire-resistance properties

Chinese National Standard GB/T9978-1999 “Fire-resistance tests- Elements of building construction” is used. Composed with three pieces of panel components of $2.50\text{m} \times 1.1\text{m}$, the size of the testing sample of panel component is $2.5\text{m} \times 3.3\text{m} \times 5\text{cm}$.

The Fire-resistance limit tested is 20min.

3.2 Assessment of properties of bamboo panel component

According to Chinese National Standard GB/T15225-94 “Graduation of physical performance for building curtain walls”, the testing results show that the sound insulation of the bamboo panel component reaches Class III, and the thermal insulation reaches Class IV, and both have met the requirements of performance for building wall materials.

According to GBJ16-2001 Chinese Building Industry Standard “Code for fire protection design of buildings”, fire resistance performance of the bamboo panel component higher than Class IV for non loading wall, partitions for escape passage and rooms. Further study and improvement may be needed, if the bamboo panel components are to be used for residential applications.

4. Preliminary cost analysis of bamboo based panel wall components

The building area of the demonstration prefabricated bamboo panel house is 30 m², the total bamboo panels used for both roof and walls are 220 m².

Table 2 shows the cost.

Table 2 Cost of bamboo panel components

Items	Unit price (Yuan/m ²)	Subtotal (Yuan)	Remarks
Bamboo panels (9 mm)	40	8800	Double faces
Wooden frame (40×60mm)	4	880	5 meters is used for per m ² panel wall
Adhesives, coatings	22	4840	Including fire resistant coating for inner wall, water resistant coating for exterior wall, etc.
Gypsum board	10	100	
Wood processing	5	1100	
Painting	18	3960	
Total	139	19680	Including test specimens. Total net areas of roof/wall panel components is 91.75m ²

It is estimated that in future production, the unit price of bamboo panel components could be reduced to about 70 yuan/m², mainly by (a) reducing the thickness of bamboo plywood panel from 9mm to about 4 mm; (b) improving processing efficiency.

5. Erection of bamboo panel prefabricated house

By using screws and steel connectors, the bamboo panel components are fixed with light steel frames and assembled into panel prefabricated house at Beijing Chang Dong Prefabricated House Co, as shown in fig 2-3.



Fig.2 Demonstration bamboo panel prefabricated house



Fig.3 Erection of demonstration bamboo panel prefabricated house

6. Conclusion

It can be concluded from this preliminary study that bamboo based panels can be used for making wall/roof components for prefabricated house. It can be feasible in technical/economical/environmental aspects. Further study is needed to improve design/performance of the bamboo panel components.

Reference

1. GBJ75-84 Code for measurement of building sound insulation
2. GB/T 13475-92 Building element-Determination of steady-state thermal transmission properties-Calibrated and guarded hot box
3. GB/T9978-1999 Fire-resistance tests- Elements of building construction
4. GB/T15225-94 "Graduation of physical performance for building curtain walls
5. GBJ16-2001 Code for fire protection design of buildings
6. BS EN 300:1997, Load bearing boards for use in humid conditions