



Potential of Bamboo-based Panels Serving as Prefabricated Construction Materials

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Outline

- **Comparison of Mainstream Construction Materials**
- **Potential of Bamboo-based Panels serving as Construction Materials**
- **Existing Problems and Possible Solutions**

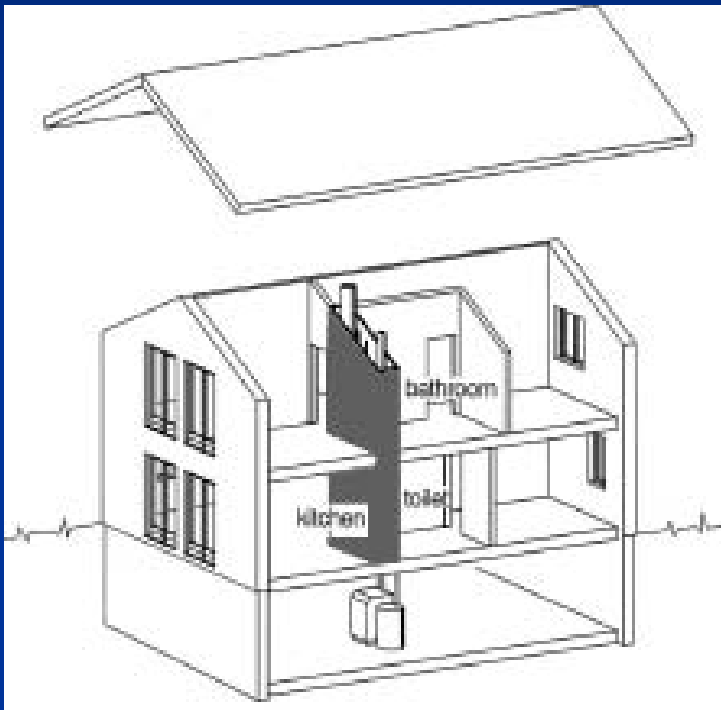
1. INTRODUCTION

1.1 Prefabricated Construction

At present, prefabrication, as a modern construction technique, which means making the whole or part of an unit in some other place rather than its final position, is attracting ever-increasing attentions worldwide. In some developed countries, such as Japan, Canada, USA, and some EU countries, prefabrication is becoming more and more popular.

Prefabricated Construction





Prefabricated house. All installations are pre-assembled in the plant.

1.2 Importance of Construction Materials in Prefabrication

One of the major concerns that influence the development of prefabrication is the selection of construction materials. Not only do the construction materials influence the efficiency and smoothness of the prefabrication process, but also decide the quality and life expectancy of prefabricated houses.

2. THE COMPARISON OF MAINSTREAM CONSTRUCTION MATERIALS

2.1 Traditional Materials

Traditional materials such as steel, concrete and clay brick may be not suitable for making modules in prefabricated construction.



The main reasons are as follows.

1. Their self weights are relatively high;
2. Their raw materials are unrenewable resources;
3. The manufacturing process of these construction materials will consume large amount of energy resources, such as fossil fuel and electricity. It also generates lots of CO_x and SO_x;
4. Disposal of wastes is also a problem.

2.2 Sandwich Panels

Sandwich panels, consisting of two metal or wood faces positioned on either side of a core of a synthetic thermally insulated materials, have been widely utilized in prefabricated construction.



However, there are also existing some problems:

1. The prices of these materials are relatively high;
2. The raw materials of the core usually come from crude oil which is unrenewable;
3. Disposal is a problem since it may need specially technique to separate the surface and core, and also, they are difficult to biodegrade (especially for the core materials).

2.3 Wood-based Panels

Wood-based panels with good properties are relatively proper materials which can be used in construction industry. Prefabricated manufacturing and assembled construction can reveal advantages of wood-based panels remarkably. The application of wood-based panels in construction industry has a broad potential market.

Further studies should focus on:

1. Enlarge the sources of raw materials;
2. Enhance the production;
3. Develop various construction panels with multifunction.

Wood-based panels used in construction



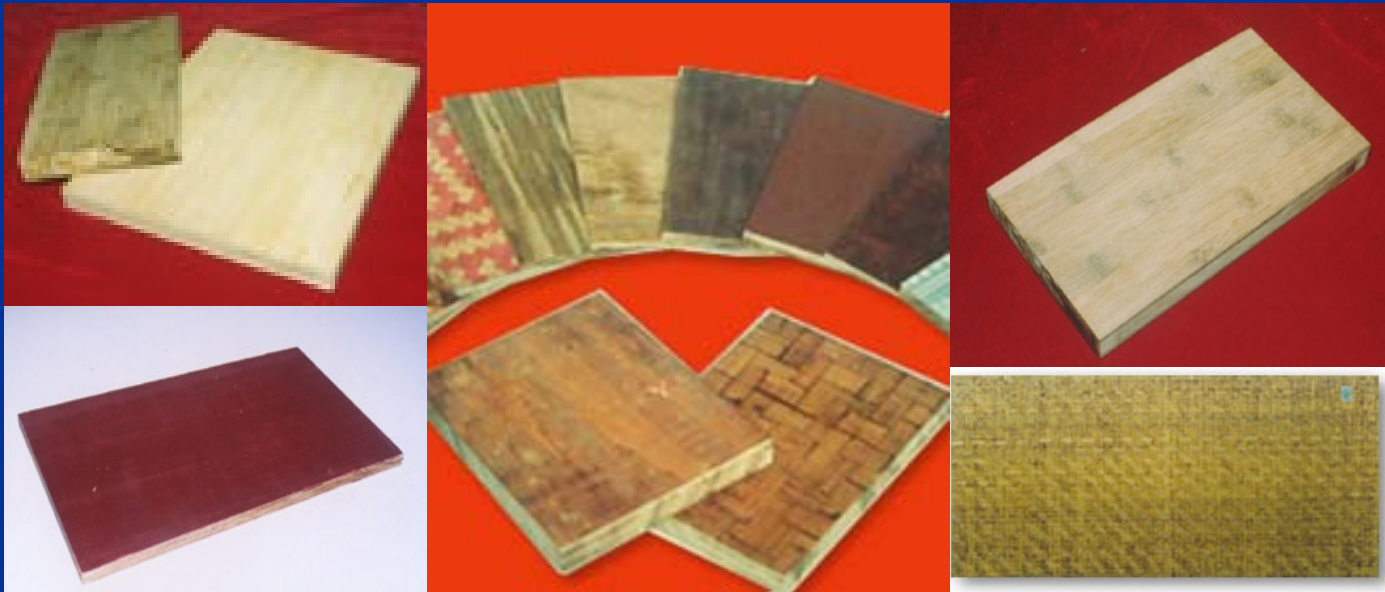
3. POTENTIAL OF BAMBOO-BASED PANELS AS CONTRUCTION MATERIALS

Recently, the price-rising of wood and declining availability of wood resources have turned people to some other similar alternative.



Similar to wood, bamboo is a kind of natural organism, which is strong, lightweight, renewable, and with a strong adaptability to the environment. This plant is widespread. The speed of its growth far exceeds that of most growing trees, but its properties are superior to most juvenile fast growing wood.

The best way to utilize bamboo on a large scale is to design and produce a series of bamboo-based panels with different structures and functions according to the properties of bamboo.

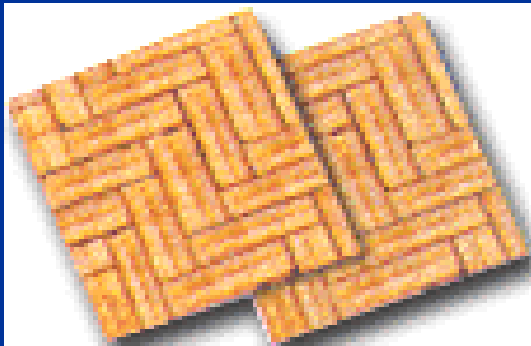


Bamboo-based panels are products made from raw bamboo through a series of mechanical and chemical procedures, such as spraying glue, laying up, and hot pressing. Bamboo-based panels are relatively ideal prefabricated construction materials. However, the application of bamboo-based panels for this utilization is still very limited.

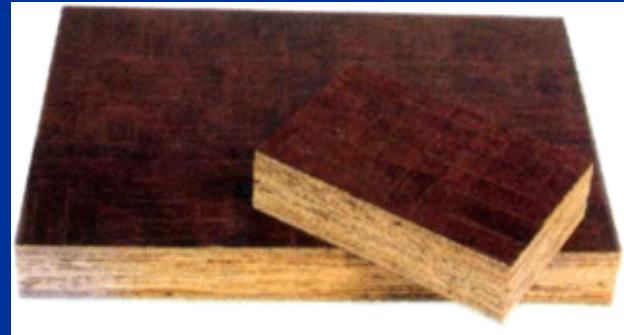
3.1 Different Types of Bamboo-based Panels Used in Construction

At present, the main sorts of bamboo-based panels which can be developed in the construction field are as follows.

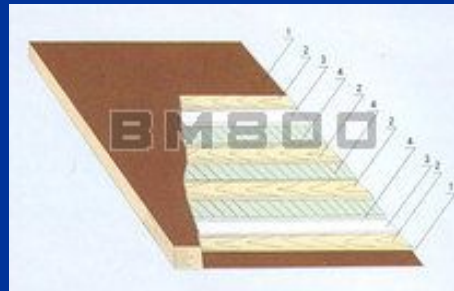
Mat Plybamboo



Laminated Bamboo of Strips



Curtain Plybamboo



Plybamboo



Bamboo Composite Board



Bamboo Particleboard



3.1.1 Mat Plybamboo. Mat plybamboo is a product made of mats weaved with bamboo sliver, then with the mats assembled and pressed after drying and gluing.

In terms of the lightweight, flexibility, and good impact resistance of this panel, it is a good substitute for gypsum and asbestos to be used as wall and roof materials in prefabricated construction

3.1.2 Curtain Plybamboo. Strips are arranged in parallel order, connected with strings to be made into curtains. After gluing and drying, curtains are to be assembled and pressed into curtain plybamboo. The thickness and width of strips can be adjusted according to the requirements of end products. In addition, Its consumption of adhesives is smaller compared with mat plybamboo, but it has a better dimension stability and better mechanical properties. As a construction material, curtain plybamboo can be used as wall, roof, and partition materials.

3.1.3 Laminated Bamboo of Strips. Strips are glued and dried, then assembled and pressed into laminated bamboo of strips. The strips are arranged in parallel order, for this reason, the lengthwise strength of this panel is high, but the crosswise strength is relatively low.

Laminated bamboo of strips can be used as load bearer, such as girder, pillar, door panel, banister, and wall materials in prefabricated construction.

3.1.4 Plybamboo. Soften bamboo fragments under high temperature, press and flatten them, then assemble them in lengthwise and crosswise direction alternately, and make into plybamboo by means of gluing and hot pressing. Plybamboo is excellent engineering material of great dimensions, high strength, small deformation and stable form.

As construction material, plybamboo with good properties can lessen the self weight considerably, and be suitable as wall, roof and door panel materials.

3.1.5 Bamboo Particleboard. For the sake of improving the availability ratio of bamboo resources, the stems of small diameter and of less known species, stem tops and all bamboo processing residues are used to make bamboo particleboard. The manufacturing process is designed similar to the technology of wood particleboard .

The biggest advantage of this product is that the supply of raw material for making bamboo particleboard is abundant. It will be a good material to replace wood based panel in prefabricated construction, serving as wall panel, partition, and door panel.

3.1.6 Bamboo Composite Board. In order to improve the product quality, increasing the resources of raw materials, and decrease the producing cost, two or more than two kind of materials are selected to make composite boards, including bamboo-wood composite, bamboo-cement composite, and bamboo-gypsum composite, etc.

Bamboo composite contains merits of different raw materials. Various bamboo composites can be utilized as wall, partition, roof, and pillar materials, and it is a promising materials in prefabricated construction.

3.2 Properties of Bamboo Based Panels

3.2.1 Mechanical Properties. The materials used in the construction should be of sufficient mechanical resistance, to be able to bear the stresses resulting from self-weight, structural loads, snow, wind, and walking-on if they are used as roofs. Bamboo-based panels can bear more load and have higher value of MOR than wood and common concrete. Bamboo based panels, with the characteristic of high strength/weight ratio, may be more suitable to be used in multi-storey buildings, and it can also enhance the resistance of lateral load.

Table1 Comparison of properties among some construction materials

Types of Materials	Properties		
		MOR (MP)	MOE (MP)
Bamboo Based Panels	15mm	113	10584
	25mm	126	9896
Common Timber		13-17	10000
Concrete(C25)		11.9	28000

3.2.2 Density. In the prefabrication process, the self-weight of materials should be as small as possible in order to allow easy assembly and delivery. Bamboo based panels, similar to wood-based panels, are relatively light construction materials. The average density of bamboo based panel is about 7.5 kg/m³, which is equivalent to 1/4 of that of concrete, or 1/3 of that of clay brick. It can lessen the weight of buildings by about 30%.

3.2.3 Coefficient of Thermal Conductivity.

Compare with clay brick and concrete, bamboo-based panels have a lower coefficient of thermal conductivity. The average value is $0.640 \text{kJ/m h}^\circ\text{C}$. This property makes bamboo-based panels an ideal material for heat insulation. it can reduce the energy requirements for air-conditioning. As the shortage of energy supply is intensifying, the energy-saving function of panel materials is more and more valued.

3.2.4 Dimensional Stability. As their external using properties, construction materials should have the ability to withstand the stresses of shrinkage or swelling due to the changes of temperature and moisture. If we adopt the special hot-press technology, waterproof adhesives and make best of the physical properties of bamboo, bamboo-based panels will have a better stability in shape and size compared with concrete and clay bricks.

Table2 Coefficient of thermal expansion of various construction materials

Types of Materials	Coefficient of Thermal Expansion (1/° C)
Concrete	1.08×10^{-5}
Steel	1.17×10^{-5}
Woody Materials	0.65×10^{-5}
Polyvinyl Chloride	7.0×10^{-5}

3.2.5 Sound Insulation. Bamboo-based panels can meet the requirement of the sound insulation if designed properly, since they are very good materials to absorb sound waves and impacts. For example, to meet the requirement of special function, the wall will be designed to be a structure with two layers of composite board, and the air layer in the middle. This structure can improve the effect of sound insulation dramatically, functioning better than that of clay-brick structure.

3.2.6 Flame Retardancy. Compared with steel or clay brick, bamboo-based panels have a poorer performance on flame retardancy, but perform better than most other synthetic materials such as Polystyrene and Polyurethane. And once burnt, bamboo-based panels will not release noxious chemicals as those synthetic materials do. if inorganic gluing materials are adopted (such as cement) as “adhesive”, the panels will exhibit better ability of fire retardancy.

4. EXISTING PROBLEMS AND POSSIBLE SOLUTIONS

4.1 Enlargement of Raw Materials Supply

Despite the fact that bamboo has an extensive distribution worldwide, the total amount of bamboo reserve is lower than that of wood resources. Thus, the establishment of bamboo plantations is strongly required in those places suitable for the growth of this plant. At the same time, bamboo-wood composite may be also a good solution to solve this problem.

4.2 Development of Special Adhesives for Bamboo Based Panels

Now, the adhesives for producing bamboo-based panels are UF and PF, which are widely applied in wood based panel production. However, since the structure and chemical composition of bamboo have some differences from that of wood, these adhesives may be not so suitable for bamboo products. how to develop new formulations or improve the existing formulations of adhesives to make them more environmental friendly and more appropriate for bamboo-based panels are goals for researchers worldwide.

4.3 Upgrading Undeveloped Producing Technology

At present, the companies and enterprises engaged in the production of bamboo-based panels are usually small-scale ones which apply few advanced techniques. this will affect the quality of the end bamboo products, increase the energy consumption and decrease the efficiency of production. In addition, panels serving as construction materials usually have high values of thickness, but studies on the thick panels about 50mm is far from enough. How to improve the methods of processing and technologies of hot press is becoming one of the major concerns of companies and institutes.

4.4 Recycling

Firstly, bamboo-based panels can be recycled as the raw materials of particle board. Secondly, these wastes can also be provided as raw materials of bamboo charcoal, which is a good purifying agent, and also has a good health-care function. Thirdly, bamboo is biomass, which can be biodegrade in the natural condition. It can also burned as fuel without generating SO_x and NO_x. All these methods will greatly decrease the cost on disposal of waste, and swing the balance between economy and the recycling of materials, which is perfectly consistent with the requirement of sustainable development.

4.5 Strategy and Standards Establishment on Bamboo-based Panels Industry

Although the number of companies and enterprises engaged in the production of bamboo-based panels is increasing, many of them lack the far-sighted prediction of market want. And a low-level management is commonly existing. In addition, except for mechanical index, many other indexes also need to be met, like corrosion resistance, weather resistance and creep resistance etc. Thus the establishment of long-term development strategies and the improvement of existing standards for the industry of bamboo-based panels are acutely needed. In addition, the national macroscopic readjustment and government's instruction are also expected in the future.

5. CONCLUSION

Bamboo-based panels have similar properties to wood-based panels. If bamboo-based panels can be well utilized in the construction industry, they will contribute a lot to the sustainable development of the prefabrication industry. However, lots of popularization work needs to be done to make bamboo-based panels better accepted by people all over the world.

On the other hand, the development of bamboo-based panels manufacturing can provide many job opportunities for local people and increase the local fiscal income, accelerating the development of local economy.

A low-angle photograph of a bamboo forest. The bamboo stalks are tall, thin, and light-colored, creating a strong vertical rhythm. The leaves are a vibrant green, filling the upper portion of the frame. The sky is visible through the canopy, appearing bright and slightly overcast. The overall mood is serene and natural.

Thank you!