

Research and Development of Bamboo Glulam Furniture

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Abstract: China is the one of the origins of bamboo plants and distribution centers in the world, is one of the most abundant bamboo resources countries, and is known as the "kingdom of bamboo". According to authoritative department statistics show that China's bamboo species has accounted for about 37% of the world total. With the increasingly shortage of wood resources, the sustainable development of the high, Bamboo Glulam Furniture, as a kind of processing is better than wood, without being limited by the resources of new materials, gradually entered the market. While the development of Bamboo Glulam Furniture not only can alleviate lumber supply gap, but also can make full use of bamboo resources in China, very fit the "two-type society" and "sustainable development" theme. This article will from Bamboo Glulam to sexual characteristics, processing characteristic, analyzes how to make use of its advantages, show the characteristics of bamboo timber, exploring the road of the development of new composite materials design.

Keywords: Bamboo glulam furniture, development and design, material property.

INTRODUCTION

Bamboo is one of the important forest resources and second only to wood. It takes around 3-4 years to grow to full size, and is the ideal renewable plant resources with excellent physical and mechanical properties. According to the statistics of the State Forestry Administration, there are more than 70 genera and over 1200 species of bamboos worldwide. In 2000, the global bamboo forest area covers about 22 million hectares [1]. In recent years, with the world experiencing a serious shortage of wood resources and dropping dramatically supply, forest resources professionals have begun to focus on the fast-growing wood research while bamboo resources have been increasing at a rate of more than 3 percent a year. In the 21st century, the global bamboo forest area is expected to increase 3.5-4 times and reach 55-65 million hectares [2]. In recent years, our country advocates the "furniture industry transformation" and the "market segmentation drive". Under the background of calling for the sustainable development of the society, bamboo, characterized by its abundant resources, hard texture, portability and environment friendly, is becoming a new fashion in international market and timely solves the shortage of wood supply at the present stage.

Glued-laminated bamboo is a new type of base material in furniture design. It is rectangular bamboo strip with a certain specification and controlled-size by processing the

original bamboo with antiseptic, mouldproof, moth-proofing and gelatinizing according to the design requirements of gluing together in the same fiber direction [3]. In terms of the varieties, glued-laminated bamboo can be subdivided into carbonized bamboo spell planks, ecrú bamboo spell planks and zebra grain bamboo spell planks, etc. According to its structure types, glued-laminated bamboo can be classified into flat plates, side-compression plates and I-shaped plates. Specific production specifications can vary with the requirement of design, similar to the original wood processing with high flexibility. At present, glued-laminated bamboo has been widely used in furniture design. So, it's important to study how to expand the development direction by using the wood property features of glued-laminated bamboo.

1. THE WOOD PROPERTY FEATURES OF GLUED-LAMINATED BAMBOO

1.1. The Physical Property of Glued-laminated Bamboo is Better Than That of Wood

As a new type of furniture base material, glued-laminated bamboo retains the mechanical properties of the original bamboo. Through repeated experimentation and comparison of mechanical properties among glued-laminated bamboo, cedar wood, oak and pine, scientists found that in the process of the experiments, glued-laminated bamboo not only remains the original wood property features of bamboo, its strength of extension, bending and compression are far better than those of the other three kinds of materials. So, in practical application, those features of glued-laminated bamboo can be embodied in big breadth, small deformation and stable size. It has the characteristics of hard intensity, good rigidity and large wear resistance. To some extent, glued-laminated bamboo has greatly improved the anisotropy of bamboo itself, and can be comparable with broad-leaved wood. In addition, the traditional experiment of drying shrinkage

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Table 1. Comparison of the physical and mechanical properties.

Mechanical Properties	Dry Shrinkage Coefficient (%)	Tensile Strength (Mpa)	Bending Strength (Mpa)	Compressive Strength (Mpa)
glued-laminated bamboo	0.267	189.32	112.53	70.76
oak	0.396	156.65	110.12	62.79
pine	0.463	98.23	66.12	32.83
cedar wood	0.542	82.2	79.94	39.23

coefficient shows that glued-laminated bamboo has a lower deformation rate after the water absorption. All of these characteristics are beneficial to the glued-laminated bamboo as a base material in interior design, and the improvement of its physical properties can also drive the significant social and economic value. (The experimental data are shown in Table 1).

1.2. Glued-laminated Bamboo has Good Processing Performance

At present, glued-laminated bamboo is widely used in furniture design, decoration and other fields. In comparison with wood and bamboo, it has more convenient processing production performance. Currently in the process of preservation of bamboo products, the hardest problem to solve is the mould and crack while glued-laminated bamboo will be more optimized than wood and bamboo in these aspects due to its good processing performance. For example, the above experiments have shown that tensile strength, bending strength and compressive strength of glued-laminated bamboo are far better than those of traditional woods, and also have proved that it is suitable to make saw cutting, shaping, ornamental engraving and milling, tenoning, drilling, sanding, surface finishing and other subsequent processing, which is one of the most favorable performance guarantees as furniture base material. Secondly, after six to eight hours heat treatment or carbonized technology in the production process, glued-laminated bamboo can effectively prevent moths and mildew [3]. In addition, the bending performance is the key point of modeling as the base material of furniture design. Glued-laminated bamboo can be processed into sheets of various sizes according to different standards, replace larger and thicker solid wood planks, and satisfy various special requirements of different types of furniture.

1.3. Glued-laminated Bamboo has a Higher Environmental Protection Standard

In terms of furniture, whether its materials are beneficial to environmental protection and our health has already been widely concerned in the furniture industry. As far as environmental protection inspection of glued-laminated bamboo is concerned, there are two main indexes to control. The first one is that adhesives during processing are eco-friendly or not. Lots of companies invest huge research and development capitals and try to improve adhesives or reduce their use to enhance environmental performance. For example, in the processing of adhering, modified urea-formaldehyde resin is in common use, which has been identified as a kind of special virulent cement. It is in complete conformity to the

specification of green and eco-friendly processing. Tests showed that the release amount of free formaldehyde becomes less, as shown in Table 2. Secondly, whether the coating on the base material surface is environmentally friendly may also affect the entire test index. Currently, the protective agents used on the glued-laminated bamboo surface are divided into two, water-borne and macromolecule water-borne, both of which are tasteless non-toxic chemical preparations. And coating can better meet the high standard and demand of environmental protection.

Table 2. Comparison of free-formaldehyde release between glued-laminated bamboo and wood artificial panels (source: www.szfa.com)

Materials	Free-formaldehyde Release	Note
glued-laminated bamboo	0.8	up to E1
block board	3.2	up to E2
plywood	3.6	up to E2

2. THE DESIGN ELEMENTS OF BAMBOO GLULAM FURNITURE

2.1. The Modeling Design of Bamboo Glulam Furniture should Reflect its Material Property and be Simple, Slender and Graceful

The combination of materials and modeling is a key node for furniture design. There are two aspects to discuss how to use the physical and mechanical characteristics of materials to design furniture modeling. First, designers can utilize the better strength of extension, bending and wear resistance of glued-laminated bamboo to make the fracture surface of furniture components slender and more exquisite. For instance, Ming-style furniture in ancient China preferred imported hardwood, such as padauk, rosewood, catalpa and palisander. One advantage of hardwood is to combine frame structure under the principle of mechanics and beautiful concise overall outline. However, the high cost of base materials makes this kind of furniture more expensive. In the design of new Chinese style furniture, glued-laminated bamboo not only can solve the problem of cost, but also can fully embody the texture and natural beauty of the classical furniture itself, with the "hard, smooth, plain and neat" effects and the simple but elegant lingering charm.

Secondly, make full use of the tensile properties of glued-laminated bamboo in modern furniture design. Modern furniture stresses exquisite modeling and exaggerated size. More than 100 years ago, Michael Mr. Knight used bent wood craft and the method of hot bending pressure to design furniture. In recent years, some designers in Japan and South Korea have designed a lot of works by using its bending performance. For example, in Fig. (1) is a representative work of JUFUKU series bamboo furniture designed by Kenyon Yeh. Glued-laminated bamboo can be processed into plate or sheet according to customization and also can be formed by hot bending, which leaves much room for modeling.



Fig. (1).

2.2. The Surface Treatment should be Authentic and can Cause Emotional Resonance

Most of Chinese have the "bamboo complex". Bamboo would rather break than bend and is unyielding, elegant, quiet and pleasurable. In his poem *Green Bamboo*, the Chinese poet Su Dongpo once wrote, "I can live if my food is without meat, but I cannot if my house is without bamboo. Without food, we will be thinner. But without characters of bamboo, we will become vulgar." Obviously, since ancient times, bamboo is the symbol of modesty and unyieldingness in the minds of Chinese scholars. Compared to ordinary panel-type furniture, bamboo glulam furniture has the surface with dense natural straight texture, and orderly bamboo joints, and dense edge, those features of which not only show the natural texture of bamboo but also can reduce the production cost. At present, the main surface colors of glued-laminated bamboo can be divided into charring color and natural color. Common texture effects are shown in Fig. (2). Distinguishing from the visual effects, the natural color refers to the remained light yellow of original bamboo meat in integrated plank furniture, which leaves people a feeling of appetency and affinity. Surface coking process is texture after charring bamboo by the high temperature and high pressure saturated steam technology, which can be divided into flat pressing and vertical pressing, so the resulting colors, similar to brown, also shows charry flat pressing and charry vertical pressing, the main difference of them is that flat pressing texture is sparse while vertical pressing texture is dense.

The surface treatment should be as original as possible in the furniture design and let the bamboo color and texture expose to the outside. Such furniture can cause good emotional resonance in great social pressure, and also can create a simple space effect which is conducive to help people alleviate and calm the mood.

2.3. The Modeling should Fit the Need of Industrial Production and have a High Degree of Standardization

At present most of bamboo glulam furniture still keep the traditional form of mortise and tenon in the structure. The domestic market has widely adopted the modular design principle for bamboo glulam furniture. This method of processing greatly extends the utilization rate of bamboo, at the same time also eases the difficulty of plate production. In addition, due to its homogeneous texture, glued-laminated bamboo is suitable for the requirements of modern industrial production in the design, production, storage, transportation, sales and installation services. The standardization of components processing makes bamboo glulam furniture broaden the market, and even compete with plate or plate-wood furniture.

2.4. Boldly Combine New Materials and Create a Sense of Fashion Mash

Combining glued-laminated bamboo with metals, organic plastic in design is the popular trend nowadays. The blended design of bamboo with new material has a great market prospect. In the mode of design, there are two major considerations: firstly, the mashup of structures. Bamboo and wood are always inferior to metal and plastic materials in compression and bending, anticorrosion, anti-insect and distortion prevention. And metal can be used to strengthen the structure of bamboo glulam furniture to solve the disadvantages of bamboo property and extend its function. Secondly, the visual contrast. For example, the plain natural bamboo and metal can be designed together for a sense of fashion mash. Designers can utilize other materials to make strutting piece, legs or frame structure, and even similar to the design features of the ancient Greek furniture Klismos chair. Overt metal structure will make striking contrast with the affinity of bamboo, form a visually striking image and create a more fashionable modeling feeling. Similarly, transparent and changeable plastic with rich colors is a good match for bamboo plate and will easily solve the problems of monotonous color and simple forms of bamboo glulam furniture.

3. THE DEVELOPMENT DIRECTION AND APPLICATION PROSPECT OF BAMBOO GLULAM FURNITURE

3.1. Effective Ways to Solve the Problem of Structural Connection

Bamboo has a low transverse tensile strength and is prone to crack in the process of use and processing. So for furniture production, the combination mode and structural connection of bamboo glulam furniture becomes one of the technical points which must be addressed. Bamboo core board structure and horizontal piecing material structure are two typical structures of bamboo glulam furniture. In the mode of combination, there are many choices, such as the glue joint, mortise and tenon joint, fitting joint structure, bamboo and pin joint as well as 32mm system design [4]. One thing to note here is that designers had better choose screws with narrow thread and small pitch in nailing panel components together, or drill holes in advance and then connect them with screw thread [7]. Besides, bamboo glulam furniture has similar design methods and principles with

panel-type furniture, so the effective solution to structural connection of this type of furniture can satisfy the sales, installation and maintenance to a greater degree, and broaden the sales channel of bamboo glulam furniture.

3.2. Develop New Fields of Chinese Style Furniture

In recent years, new Chinese style furniture is favored by consumers with its elegant modeling. Its base material mainly includes rosewood, Brazilian rosewood, wenge, sandalwood and other hardwood, which has exquisite texture, full luster and is easy to process. However, this kind of wood has low yield and is rare, together with a growing furniture market, the price of raw materials has been rising. New Chinese style furniture on the market today is prohibitively expensive and forms an invisible price barrier. The new Chinese style furniture integrated with glued-laminated bamboo can make its color and visual effect closer to those of annatto furniture by the coking technology on the surface, so as to enhance the added value of products. In addition, the new Chinese style furniture is the continuation of the classical Chinese furniture in exquisite skill and employs local carving and inlaying. On the other hand, the bamboo carving arts in our country have several thousand years of history. The fine processing performance of glued-laminated bamboo can satisfy the traditional manual requirements of metal, jade and other adornments, and also can adapt to modern CNC machining or laser engraving machine, just like other hardwood.

3.3. Develop in the Direction of Ecological and Environmentally Friendly Furniture

And with diminishing forest resources worldwide, as a furniture manufacturing power, China has been experiencing the worsening of supply-demand imbalance of timber resources, especially many precious wood species have been endangered. By contrast, bamboo has a short growth cycle and strong regeneration ability. If the abundant bamboo resources can be used effectively, it not only meets the demand and supply market, but also can reduce the utilization of tim-

ber, conducive to the protection of the ecological environment and the regeneration of natural resources. In addition, the state vigorously promotes the sustainable resource-economical and environment-friendly society, and takes steps to support and encourage the research and innovation of enterprises products. Bamboo glulam furniture, with its unique materials and non-toxic harmless processing technique, is consistent with the national policies. If the special design of bamboo glulam furniture can promote its product performance, use range and value in use, it will become a necessary trend of the development of the market, also can provide enterprises with high value-added products, thus bring considerable market benefits.

CONFLICT OF INTEREST

The author confirms that this article content has no conflict of interest.

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