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Analysis of the Innovative Applications of the Traditional Bamboo Material and Related Technology in Architectural Design

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Abstract. Bamboo, a kind of natural, fast-growing material with a similar texture to wood, is very abundant in China. The rational development and utilization of bamboo materials can alleviate the domestic wood supply pressure, and has very important economic, social and ecological advantages. At the same time, bamboo is more environmentally friendly, which absorbs four times more carbon dioxide than ordinary trees. It has machining performance of turning, milling and cutting during machining. And it can be fully recycled after using. Bamboo is also a low-energy building material. If the building area is equal, the energy consumption of bamboo and concrete is 1:8, while that of steel is 1:50. The special cultural importance of bamboo also cannot be ignored. With the rapid development of modern industrialization, people living in concrete structure jungles are eager to return to nature. The 21st century is a fusion of nature and architecture.

Keywords: Traditional Materials and Techniques; Bamboo Material; Innovative Applications; Regional Architectural Design.

1. Introduction

Architectural culture needs to convey its regional style through traditional materials and original craftsmanship. However, with the rapid development of the building materials industry in modern society, many traditional materials and techniques have been replaced by more advanced modern means. In fact, traditional materials can also be innovatively applied to modern buildings through the transformation of characteristics and the adjustment of technological practices, and even its comprehensive benefits can be no less than modern ones, which is of great significance to the regional cultural inheritance and development of modern architectural design.

At present, the innovative use of bamboo has begun to be widely concerned in architectural design. Architectural designers are trying to use bamboo, a simple and traditional architectural language, to express modern architecture, constantly breaking through technical threshold and expressing their understanding of bamboo. In this article, I will summarize my knowledge and understanding of bamboo as a building material, in order to provide some enlightenment for readers.

2. Physical and Chemical Properties of Bamboo

As an all-natural material, bamboo is used in all aspects of production and life, such as building houses, pavilions and fences. It can be seen that as a building material bamboo has its physical and chemical advantages properties.

First of all, bamboo can replace wood. Known as the most versatile plant in the world, it is a renewable resource with a short growth cycle. And it is an important element for balancing carbon dioxide and oxygen in the natural environment. Bamboo products can dry quickly and are not easy to breed bacteria and mold. The use of bamboo in agriculture is more common. Because of its smooth, hard and straight texture, it can be greatly bent after firing. It can be used to weave various agricultural tools or make musical instruments, arts and crafts. When made into a bamboo raft, it has the characteristics of large buoyancy, and bamboo raft is still a traditional means of transportation in the upper reaches of inland rivers in southern China. In terms of water conservancy projects, treated bamboo can be enclosed on the bank to prevent washing away and consolidate the dike.'

To sum up, as a building material, bamboo does have many advantages. However, it also has some disadvantages. For example, the dried bamboo is easier to crack and has poor durability, and can only last for one to two years if placed outdoors. In addition, the growth size of bamboo is also very non-uniform, and if used as a large-scale construction, the uniformity is not very good compared with conventional materials such as steel pipes.

3. Mechanical Properties of Bamboo in Use

Bamboo has the advantages of good toughness, high tensile strength and high hardness in mechanical properties. Experimental data shows that the elasticity and toughness of bamboo are high and the shape variable is small. The tensile strength parallel to grain is 170M Pa, and the compressive strength parallel to grain is up to 80M Pa. However, bamboo will have the risk of cracking after drying, so bamboo is rarely used as a structural component of the main building in traditional buildings.

In the fifties and sixties of the last century, China was relatively short of steel materials. At that time there was some senior scientists and practitioners carrying out a lot of research work for the various characteristics of bamboo. But this is actually very difficult, because from the perspective of material, the research in bamboo structure is more difficult than concrete structure. There are only two parameters in reinforced concrete and steel elastic, while bamboo, with its anisotropy, has nine parameters.

4. Aesthetic Characteristic of Bamboo

Bamboo has its natural value and cultural value in terms of landscaping. On the one hand, we focus on the ecological characteristics of bamboo, its adaptability to the surrounding environment and its positive influence in improving environmental quality. On the other, bamboo is loved for its tall, hollow, green figure and other characteristics. From ancient times to the present, people often personify the characteristics of bamboo, as a symbol of nobility, humility, indifference to fame and wealth. It is these cultural added values that make the landscape value of bamboo further enhanced.

5. The Process Treatment of Bamboo

There are two main uses of bamboo, one is directly used to manufacturing, and the other is processing and reuse. The traditional bamboo utilization method is mainly to be woven and used as building components. According to different bamboo units, arrangements and manufacturing techniques, here are mainly six divided types: integrated bamboo material, bamboo recombination, converged bamboo wood material, winding bamboo composite material, bamboo fragment slate proximate matter, bamboo-plastic composites.

In addition to these methods of using bamboo as the main product, some researchers have combined engineering bamboo with one or multiple kinds of raw bamboo, straw, steel, wood, FRP, plastic, and concrete to generate new composite materials and composite components, and then use them in technology, which also expands the scope of engineering bamboo.

6. Structural Design and Construction Points of Bamboo

There are five structural nodes in the construction of raw bamboo architectures: colligation, colligation and joggle joint, connections using simple metal, prefabricated metal parts plus raw bamboo or plus concrete and raw bamboo. Among them, the most primitive and basic structural node connection method is colligation. In such a node structure, the connection is a brown rope or iron wire, and the raw bamboo is used as a connected part, whose basic force principle is to rely on the friction of the node position to resist other external forces. At present, among these raw bamboo architectures with the scale and use of modern public architectures in China, few are simply built in the form of colligation. The reason is that although the connection method, production process and production

process of colligation method are relatively simple and easy, they also have a lower cost and counterfeiting situation. But its structural strength does not meet the requirements, and the brown rope as a connector is usually directly stored in the external environment, which is easy to cause corrosion and falling off, etc. Therefore, the raw bamboo architecture that completely relies on colligation as a node structure can only be used for temporary purposes and structures that do not bear much load, and the colligation joints need to be frequently overhauled and replaced.

By improving the simple colligation joint, the structural node of the raw bamboo architecture is produced by combining colligation and joggle joints. Its construction principle is an imitation of the mortise and tenon nodes in the traditional wooden structure. But in view of the characteristics of raw bamboo material and its processing difficulty, it is different from the mortise and tenon joints of the wooden structure. It is not possible to ensure that the node is completely secure by simply interspersing the components, so it is necessary to introduce bamboo nails and wooden chucks as auxiliary fixtures, and then strengthen the fixing nodes with colligation parts such as brown rope and iron wire. The force principle of this method is based on the compression resistance and shear resistance to raw bamboo grain and the tensile ability of the connecting parts such as bamboo nails and brown rope to resist other external forces.

With the development of the use of metal, the raw bamboo architecture also began to use simple metal connectors, and this method can achieve balance between cost and structural effect, which is one of the most commonly used connection methods in the node construction of the raw bamboo architecture in modern times.

The construction method of prefabricated metal parts plus raw bamboo makes better use of the material characteristics of raw bamboo and effectively avoids the shear force in the direction of raw bamboo grain caused by perforation. And the metal throat can adjust the size within the range, which can also well avoid the excessive variety of components caused by the difference in the diameter and size of the raw bamboo, and can easily achieve the non-orthogonal form intersection between raw bamboo, so as to obtain diversified architectural forms.

The last one is the method of prefabricated metal parts plus concrete and raw bamboo. The main structural node uses a number of raw bamboo intersecting at one point, cutting the end of the raw bamboo and fixing it with spring metal prefabrication, which can well unify the material specifications. In addition, the metal prefabricated part used in the architecture foundation structure also has a waterproof and moisture-proof effect.

7. The Development Trend of Bamboo Material in the Future

In recent years, the world's area of forest land has been greatly reduced. Bamboo vegetation, due to its unique biological and natural environmental characteristics, has a good economic, ecological engineering and development effect. In the meanwhile, the land area of bamboo forest is increasing at an average annual rate of three percent. As a result, bamboo is considered to be the vegetation with the most room and potential for development in the 21st century.

Due to its excellent residential performance and ecological benefits, bamboo architectures have set off a green wave. Bamboo is present in almost all areas of modern residential architecture, from basic structures to frame structures, from frame systems to roof frames, from floors to furniture, and even to its exterior decoration, interior decoration and wardrobe. After processing, bamboo can also be used as structural components.

Bamboo has also been developed for many innovative uses on the basis of traditional use. And one of the development directions of domestic and overseas wood industry has also changed to bamboo instead of wood, using modern composite and reconstruction technology, replacing logs with bamboo, and we can produce modern high-grade building materials with diversity properties. At the same time, it can meet the requirements of different types of houses and their structural characteristics. In addition, the development and application of this new material combination can also bring new opportunities

for the poor in bamboo-producing areas, which can become a new direction for the development of the bamboo industry. And at present, governments and international organizations are actively encouraging the use and development of bamboo as a green building material.

As one of the most original building materials, bamboo is a high-quality green building material. It has several advantages in terms of mechanics and aesthetics. Under the eternal theme of environmental protection, steel-concrete structures and steel structures gradually exposed their respective shortcomings. In order to create a good ecological circulation system between people, architecture and ecological nature, it is inevitable to study the construction of bamboo structures. We must push the boundaries of traditional materials and technologies and increase the usage rate and usable range of bamboo as a building material.

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