

Research and Development Evolution of DouGong Structure in Ancient Chinese Architecture

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Abstract: The wooden structure DouGong has become a typical structural component of Chinese wooden architecture due to its unique structural system and rich historical and cultural heritage. This article introduces the structural characteristics, origin, and development of DouGong, and analyzes the value of DouGong structure. DouGong is widely used in ancient architecture and is a reflection form and carrier of traditional Chinese culture. As a major component of traditional ancient architecture, DouGong has certain load-bearing and decorative functions.

Keywords: DouGong structure; Ancient architecture; Development and evolution

1. Origin of DouGong

From the late Shang Dynasty to the early Zhou Dynasty, the bronze manufacturing process was very developed, and the appearance of large bronze ritual vessels had already been decorated with the image of DouGong on the building, which was an important symbol of the origin of DouGong. They solemnly declare to the world: 3000 years ago, in the early Zhou Dynasty, the ancient Chinese architecture DouGong was officially born! The image of DouGong in bronze artifacts reflects the spatial framework of DouGong in the upper part of the front eaves of very early Chinese architecture, the supporting and connecting DouGong structure and its laying and production functions, and the origin and role of DouGong in the large wooden framework of ancient Chinese architecture. The perfect combination of Dou shaped components and arch shaped components has created a precedent for the development of the DouGong system of complete sets of complex modules of Chinese wooden buildings for thousands of years. It is an important origin sign of the formation of the complete DouGong system of Chinese characteristic wooden Building code and the mature technology of tenon and mortise. It has epoch-making significance in the history of Chinese architecture, and will have an extremely far-reaching impact on future generations of architecture.

In the early Zhou Dynasty, the bronze technology of the Shang Dynasty was inherited and many bronze artifacts were made. Among them, one bronze artifact appeared with a similar architectural image of DouGong, which archaeologists believe is an important symbol of the origin of DouGong.

2. Composition of DouGong

DouGong is a very special component in the wooden structure of Chinese houses. In order to support the eaves of the roof, ancient craftsmen used arched short wood to pick out from the top of the pillars. One layer was not enough, and another layer was added. A small square wooden pad was used between the two arched short wood layers, with the bow shaped wood called "gong". The shape of the small square wood was similar to that of Dou, a weighing tool in ancient China, Therefore, this combination of components is called "DouGong". When used under the eaves, DouGong can increase the depth of the eaves and also serve as a support and cushion between the two ends of the crossbeam and the two floors of the crossbeam. DouGong not only has distinct characteristics of classical architecture, but also is an important symbol of changes in the form of wooden architecture. DouGong is mainly composed of five parts: dou, gong, ang, fang, shuaitou, etc.

2.1 Dou

Dou is a cubic shaped wooden block with grooves on the top and oblique lines on the bottom. The earliest image of DouGong can

been in the large dou on the bottom of the “minggui” bronze ware of the Zhou Dynasty in China. Big Dou is the most fundamental, important, and largest Dou among DouGong. All other Dou, gong, ang, fang, etc. are placed on top of Dou and supported by it, bearing the maximum load. The cross-section of a large Dou is generally square, and only the Song Dynasty’s large Dou had various cross-sectional forms such as circular, multi petal, and polygonal shapes. The large Dou in the Han Dynasty had the largest overall proportion in history, with flat Dou and groove Dou. The existence of the groove was designed to connect the gong placed on the Dou. The large Dou without grooves only existed in the Han Dynasty and the Southern and Northern Dynasties.

The large Dou sits directly at the top of the column, beam, etc., while the other Dous, which are much smaller than the large Dou and have a large number, are located above the head of the gong. Dou has different names due to its location, but it is basically divided into two categories: Dou and Sheng. Dou is located in the inner and outer positions of DouGong, and rises to the left and right positions:

In every era, except for the Big Dou, the volume of Dou and L is consistent, but there are many names. The grooves on both sides of Dou are called “Dou ears”, followed by “Dou flat”, and those that retract downwards are called “Dou yi”. There are two types of Douyi: oblique straight and concave. The proportion of these three parts of Dou was set at 4:2:4 in the Song Dynasty of China, and there was no significant change in subsequent dynasties.

The Dou base of the Song Dynasty was slightly wider than the Dou mouth, while the Dou base of the Qing Dynasty was as wide as the Dou mouth, but the Dou base of the Great Dou throughout history was significantly wider than the Dou mouth. From the Han Dynasty to the Tang Dynasty, sometimes a wooden board was placed under Dou, a design that has not been seen in other dynasties.

On the top of the Han Dynasty pillars, there was no need for a large Dou, but instead an Ioni pillar hat resembling a vortex in ancient Greece, which can also confirm the cultural exchange between the two ancient countries of China and the West.

2.2 Gong

Gong is a type of arched wooden strip with a straight center and two ends bent upwards. Gong is embedded in Dou’s mouth, and its two upper ends also support Dou. Gong is an important component for DouGong to increase the range of load-bearing space. The length of a gong within a DouGong is different, usually gradually increasing from bottom to top. Therefore, the basic shape of the entire DouGong is an inverted triangle with a large top and a small bottom. Gong also has complex name changes due to different positions, generally referred to as “qiao” for forward and backward, and “gong” for left and right. In short, the larger the building volume, the larger the materials used, in order to maintain a harmonious proportion and load-bearing needs among various parts of the building volume.

2.3 Ang

An ang is a downward sloping, usually straight bar component in the outer eaves of DouGong, and was once the largest volume on DouGong. The front of the ang overhangs and supports the eaves, while the rear supports the bottom of the beam frame. The entire ang is like a lever, lifting the front weight with the back weight, and the big Dou is its lowest fulcrum.

Ang first appeared in the Tang Dynasty, and its appearance meant that DouGong had matured by the Tang Dynasty. The size of ang was the largest in history during the Tang Dynasty, so the eaves of the Tang Dynasty were also the largest in history. With the development of the times, the volume of ang gradually decreased to the smallest in the Qing Dynasty. The volume of ang is not only gradually decreasing, but its function is also gradually changing. Until the Yuan Dynasty, false ang appeared. In terms of appearance, false ang had an ang head on the outside but no upturned ang tail on the inside. False ang could not serve as a lever. The emergence of false ang has transformed it from a mechanical structural component to an aesthetic decorative component. From the Song Dynasty to the Qing Dynasty, DouGong in the corner used ang, whether it was a real ang or a false ang.

2.4 Fang

The fan placed in Dou’s mouth is mainly used to connect many DouGong into a whole, making the dispersed ones more sturdy and stable. For example, if the fan inside the Dou mouth is supported under the crossbeam, then this type of fan has a certain load-bearing effect. The evolution of these two types of DouGong has undergone certain changes, but there are basically no characteristics of the times in terms of shape.

2.5 Shuatou

Shuatou is located above the top layer of gong or ang, intersecting with the gong and extending outward. It is a straight wood that is parallel to and of similar size to ang and above the gong. The front and rear ends of shuatou are exposed outside, most of them are in the shape of grasshopper head outside, and the inside is in the shape of cloud-shaped frusta.

There were no instances of shuatou before the Tang Dynasty, and shuatou only appeared on DouGong since the Tang Dynasty. The styles of shuatou in DouGong can be divided into the following types: firstly, it is not decorated. Secondly, there are various types of

shuatou, which were mostly carved with curly petals from the Tang Dynasty to the Yuan Dynasty, with structures similar to the shape of wings: Qing Dynasty sculptures such as dragon heads and elephant noses. Thirdly, it is a standard style, which was stipulated in both the Song and Qing dynasties, and the style is also similar, known as the "grasshopper head": it only differs in terms of materials.

3. The role of DouGong can be summarized as follows

3.1 Extend the eaves outward

In buildings without DouGong, the eaves require nails to be nailed to the roof beams. From the crossbeam outward is the suspended part. With DouGong, each additional DouGong can extend outward by three "chutiao" (as shown in the following figure). The more DouGong, the more the eaves extend outward, which will make the eaves farther and farther away. The protruding eaves can prevent rainwater from wetting the walls. Before the Yuan Dynasty, most of the walls were adobe walls, especially for fear of rainwater erosion. The extended length of the eaves increased to prevent rainwater from wetting the walls.

3.2 Transfer load and seismic action

It is located between the columns and beams, and the load transmitted from the roof and upper structure is transmitted to the columns through DouGong, and then to the foundation through the columns. Therefore, it plays a role of connecting the top and bottom, and transmitting the load. The key to seismic resistance of DouGong's splicing structure. When encountering a strong earthquake, the spatial structure using DouGong splicing structure may become loose, but it does not lead to looseness, consuming the energy transmitted by the earthquake and greatly reducing the seismic load of the entire house, playing a seismic role.

3.3 The decorative role of DouGong

DouGong is a representative decorative component in ancient Chinese architecture. Its structure is exquisite and its overall appearance is beautiful. DouGong extends outward by overlapping with each other, and this alternating connection itself has a strong visual effect. In ancient feudal society, the decoration of buildings represented the level of residents, and DouGong was a symbol of status in ancient architectural

construction and was not allowed to be used privately in folk architecture. At the same time, from the royal palace to the houses where officials reside, all correspond to different styles of DouGong structures, so DouGong is an important symbol of the classification of royal and official residences. With the current changes in building materials and construction methods, DouGong has emerged as a decorative component in modern antique architecture and no longer has the function of load-bearing support.

4. Conclusion

DouGong is the most charming and profound part of ancient architecture in China. With extremely simple and standardized components, it forms a variety of shapes. In China's traditional buildings, DouGong reflects the seamless combination of force and Plastic arts in buildings, whether from materials to styles, or from the construction of overall to local components. It is precisely because of the wise creation of past craftsmen that DouGong has completed the evolution from load-bearing to decoration, from function to form. Although DouGong's function has undergone fundamental changes in historical evolution, even if it only serves as a decoration, the historical and cultural heritage it represents is profound. The structural beauty, styling beauty, and color beauty that DouGong has evolved over thousands of years, as well as the unique culture of Chinese civilization spanning five thousand years, endow it with rich and unique charm, highlighting the value of Eastern aesthetics and historical culture.

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