Summary of the Characteristics of Ancient Chinese Architecture and Exploration of Its Modernization Possibilities

Ruofei Tong

Shenzhen Middle School, Shenzhen, 518001, China

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Abstract: Ancient Chinese architecture is a typical representation of traditional Chinese cultures. Some modern designers have tried to integrate ancient Chinese architecture with modern architecture, but it didn't go smoothly and some of the designs turned out to be very rigid. Therefore, this study aims to summarize the stylistic features of ancient Chinese architecture in an effort to find possible ways to incorporate these features into modern architecture on the basis of existing successful cases. The study summarizes seven structural characteristics of ancient Chinese architecture including extended roof forms, Dougong brackets arranged in order, wood as the main material, straight timber joints and rational framing, squareness and symmetry, repetition and, superimposition, reconfiguration of the same motif, clever mortise and tenon joints. Based on the structure presented by the building itself, the building types in the history of Chinese architecture are comprehensively sorted out, and a reasonable hierarchical framework system is established to fully and concretely understand the expression characteristics and system structure of Chinese building types. Focused on three of Kengo Kuma's masterpieces. Taking Kengo Kuma's masterpieces as examples, I take an in-depth analysis of the integration of ancient architectural features into modern architecture such as the simplification of the timber frame, the echoing of colors and materials, the repetition and rhythm of motifs and reproducing straight timber joints and brackets. Finally, I recreates the East Hall of the Foguang Temple with the features summarized above to demonstrate the rationality of the above conclusions.

1. Introduction

As a typical representative of traditional Chinese cultures, ancient Chinese architecture has a long history and a consistent architectural system beginning as early as primitive society to the end of the Qing dynasty; unlike the Western architectural system which is mostly stone based, ancient Chinese architecture is based on timber construction and has typical oriental characteristics. Ancient Chinese architecture has also profoundly influenced the forms of ancient architecture in Japan and Korea through the cultural exchanges along the history. The "ancient Chinese architecture" in this paper refers to ancient Chinese architecture and ancient wooden architecture in other Asian countries that have been influenced by ancient Chinese architecture.

This unique oriental style of ancient Chinese architecture has attracted a large number of architects to imitate it. Since modern times, there have been some successful attempts to fuse ancient Chinese architecture with Morden architecture, such as some works by Kengo Kuma and other architects. Unfortunately, most of the other attempts have failed. Therefore, this study is intended to summarize the stylistic features of ancient Chinese architecture and find possible ways to incorporate these features into modern architecture on the basis of existing successful cases. Firstly, I studies the characteristics of ancient Chinese architectural timber structures; then I analysis the cases that well combine traditional Chinese architectural features with modern architectural design systems and concluded the methods to combine Chinese and Western architectural design systems; finally, on the basis of above conclusions, I design a modernization of the roof frame of the East Hall of the Foguang Temple.

2. Seven Characteristics of Ancient Chinese Architectural Timber Structures

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Timber structure is one of the largest characteristics of ancient Chinese architecture. Based on document analysis and typical ancient building features, this chapter summarizes the seven characteristics of ancient Chinese architectural timber structures including extended roof forms, orderly arranged Dougongs, wood as the main material, straight timber joints and rational framing, squareness and symmetry, repetition and reconfiguration of the same motifs and clever mortise-and-tenon joints.

2.1 Extended Roof Forms

The roof is one of the clearest features of the ancient Chinese architecture, especially its transformations and expressions, which is known for the roof curve of the Tang and Song dynasties. The curved eaves come into existence for objective residential needs rather than ornaments. The eaves can be extended as long as three to four meters in early Dougongs (as in the case of the East Hall of the Foguang Temple), which is particularly unique in the history of ancient architecture. For instance, the stone buildings prevalent in Europe are not as light and extendable as wood because of the solidity of their building materials. In addition to the far-reaching eaves, sloping eaves were constructed in a concave curved shape during the Wei and Jin dynasties in response to rainy seasons, as recorded in the Rites of Zhou as “the roof is higher and the eaves are lower allowing water to drain out quickly and further away from the building”. The ancient people regarded this as beauty and particularly admired the elegance and vividness of the curves. The Holy Mother Hall of the Jinci Temple (Fig. 1) built during the Northern Song dynasty is renowned for its elegant roof curves (Yao Yuan, 2014). This is one of the reasons why Liang Sicheng praised the “soft and magnificent” sloping eaves of ancient Chinese architecture and categorized the Song and Ming as “Elegant Time”.

Fig.1 Roof Curves of the Holy Mother Hall in Jinci Temple

2.2 Dougong Structures

Dougong is also one of the most distinctive features and unique structure in Chinese architecture. Dougong is a system of brackets in Chinese building; wooden square blocks inserted between the top of a column and a crossbeam (Chinese Dictionary Compiling Department, 1957; Liang Fei, Liu Shaoshuai, Zhou Yiqing, 2021). In the early stage, the shape of the Dougong was not as complex as that in the Ming and Qing dynasties. For example, the one-way Dougong of pottery buildings in the Han dynasty (also named as One-Dou-with-Three-Sheng structure of pottery buildings) means that the Dougong only has a horizontal groove that holds upwards a three-arch structure (Fig. 2) (Wang Yan, 2020). Later on, the Dougong evolved into the crossed two-way form, creating a diffusion of the structure from point to surface. The role of the Dougong in the structure of ancient Chinese timber buildings became less important. For instance, the Lan’e prevalent in the Qing dynasty greatly enhanced the stability of buildings (Zhu Zheng, 2019). It is believed that more Dougongs of decreased size were used in Qing dynasty’s buildings, an ornamental element derived from a

necessary structure. In the process, wooden elements were cut to mimic the structure and form of the original Dougong. The evolution from Real Ang to fake ones proves the ancient Chinese recognition of the form of Dougong (Fig. 3) (Zhou Miao, 2020; Wang Yan, 2020).

Fig.2 One-Dou-with-Three-Sheng Structure of the Pottery Building in Han Dynasty

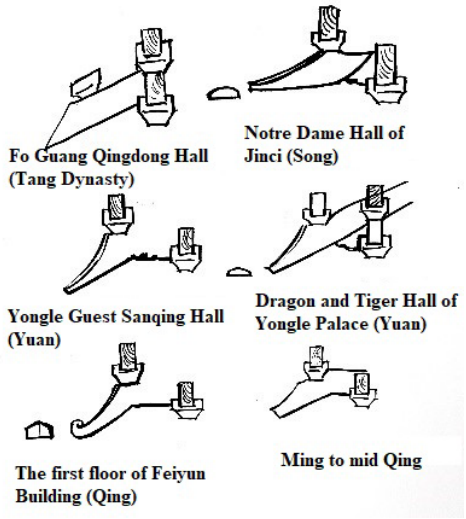

Fig.3 The Different Shape of Fake Ang

2.3 Wood as Main Material

Stone is rarely used in existing ancient buildings. In fact, wood is the most prevalent primary building material, which is largely due to a tendency towards more environmentally friendly buildings. Earth, brick and wood were more easily accessible than other materials in ancient China. The ancient building frames were very adaptive to a wide range of materials. Compared to other materials, wood was in better alignment with the Chinese philosophy of the natural way of thinking, that is facing up to changes and not to force everything to survive. Naturally, it is also argued that the preference for wood in ancient Chinese architecture also depended, to some extent, on the lack of stone craftsmanship among Chinese (Liang Sicheng, 2005). This preference for wood has been retained over the course of civilization and development and has gradually converged and integrated with Chinese cultures and minds, eventually forming the characteristics of ancient Chinese architecture.

2.4 Frame with Straight Timber Joints

An overview of the frame of ancient Chinese buildings shows that whether in beam-lifted frame or through-type frame or others, the overall structure is made up of straight timber arranged either horizontally or vertically. The simple interlocking of layers has given rise to a variety of different forms due to diverse demands. However, before the advent of the diagonal corner tie-beams, the limited length of timber (limited to 10 meters) made it difficult to realize large interior spaces in

ancient Chinese architecture. To enlarge the overall space of a house, the volume of the house had to be increased therefore requiring larger pillars. Meanwhile, these columns occupy a great deal of space which divided the overall space, making it look small and untidy. The diagonal corner tie-beams can enlarge the interior space, as in the case of the Biyong in the Directorate of Education to the west of the Confucius Temple in Beijing, where the hall is big (the interior span reaches 16 meters) without columns, avoiding a conflict between the structure of large and small spaces (Liang Sicheng, 2005). Thus, a prominent feature of ancient Chinese architecture is that it usually applies wooden structures with rectangular frames but is not limited by them. Modern designs are available with structural variations (such as rectangular or circular frames).

2.5 Squareness and Symmetry

Ancient Chinese architecture presents tremendous momentum, partly due to the absolute symmetry principle that most buildings follow (Fig.4-6). Absolute symmetry has not only the mechanical advantage of balance and uniformity of forces, but also the traditional Chinese concept of harmony and the doctrine of mean. Absolute symmetry fits well with wooden materials, the core of ancient Chinese architecture. Because ancient buildings cannot be immune to the limitation of wood itself whether in beam-lifted frame or through-type frame. Defects in timber can be offset by construction techniques. For instance, after a single timber beam has been changed the way to get through the roof frame by clever design, the East Hall of the Foguang Temple effectively avoided some of the limitations of timber length. In general, the way in which ancient Chinese buildings are constructed as well as their form is still largely constrained by the timber itself. With such limitations, the fact that the segment was the shortest between two points gives Chinese architecture the need to be horizontal and vertical in order to expand the volume, eventually evolving into a symmetrical form.

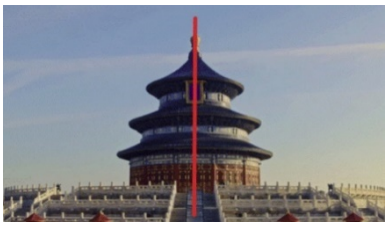

Fig.4 Central Symmetry of the Hall of Prayer for Good Harvests of Temple of Heaven

Fig.5 Central Symmetry of Ancient Chinese Architectural Complex

Fig.6 Central Symmetry of the Hall of Nanchan Temple

2.6 Repetition and Reconfiguration of the Same Motif

For ancient Chinese architecture, some basic structural frameworks were basically unchanged and formed complexes after superimpositions and reconfigurations. Forms such as layered buildings, annexes and double eaves, all evolved from the improvement of simple structures to compound repetitions (Zhou Miao, 2021; Zhuang Lixin, 2021; Zhang Jie, Xia Shengxue, 2013). For

example, several sets of selected parts of a simple original structure added to the original complete structure became an annex, Baosha; the one-way One-Dou-with-Three-Sheng structure used in the pottery building in the Han dynasty (Fig. 2) later evolved into a two-way crossed Dougong using mortise-and-tenon joints (Fig. 7); the double eaves of the Hall of Prayer for Good Harvests of Temple of Heaven (Fig. 4) were formed by the highest wooden beam going right to the top and down layer by layer with shorter vertical wooden beams distributed over an arc with a larger diameter, which completed the evolution, while retaining the logical premise of motif repetition, from rectangular frames to curved frames. Thereby, these seemingly different forms of expression are simple distortions and repetitions of the original ones.

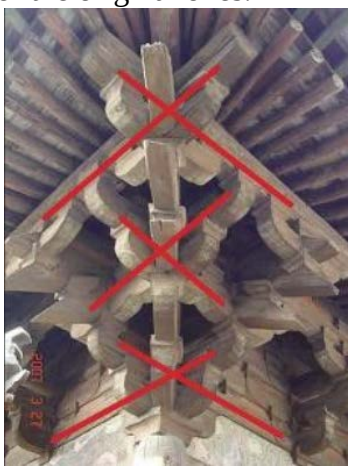

Fig.7 The Repetition of the Crossed Structure in Dougong

2.7 Mortise-and-Tenon Joints

Most of the above structures are joined together with mortise-and-tenon joints. Mortise and tenon is a type of joint structure where the concave and convex parts of two elements are tightly occluded with each other through a clever conception, forming a strong, stable and resilient frame that can allow timber-frame buildings to stand firmly for a thousand years without a single nail or screw (Liu Jiahui, Song Shasha, 2019). Mortise-and-tenon joints enjoy outstanding advantages such as architectural variability, seismic resistance (Pan Yi, Chen Jian, An Renbing, Yi Duhang), and efficient handling of spatial junctions-saving excess timber height and allowing timbers of the same supporting level to be at the same height. This image of timber occluding each other is also a visual characteristic of ancient Chinese architecture. Based on the rectangular frame of the timber structure described above, the mortise-and-tenon joint is usually based on a basic form, a right angle. At the same time, the mortise-and-tenon joint can also be realized in other shapes of frames such as a circular or octagonal ones. In the following section, the author will analyze, more details, the variation of mortise-and-tenon joint in Nihondaira Yume Terrace (the work of a well-known Japanese architect, Kengo Kuma).

3. Typical Case Studies

This paper cites three examples of buildings designed by the Japanese architect Kengo Kuma that, the author believes, combine the characteristics of ancient Chinese architecture with modern architectural design systems.

3.1 Tao

The first is a Taoist mausoleum located in the Xinpu Mountains, 70 km south of Taipei. It combines the characteristics of ancient East Asian architecture in three aspects:

(1) The simplification of the timber frame of ancient Chinese architecture. Tao simplifies the way it was built from a layer-by-layer concept to a waffle structure, greatly incorporating the original horizontal and vertical arrangement of the timber structure and the purpose of forming curved surfaces (Fig. 8).

(2) The vertical and horizontal order alongside with the form of the four-way flying eaves is reminiscent of the internal framing and sloping eaves of ancient Chinese timber structures. Instead of the layer-by-layer arrangement of semi-circular tiles and flat tiles in ancient Chinese architecture Tao applies continuous smooth curves as well as partly raised texture to offset the over-softness of curves. This is a restatement of previous forms in a modern language.

(3) The traditional architectural color scheme. The color matching of burlywood and grey also echoes the color scheme of traditional Chinese architecture (Fig. 9).

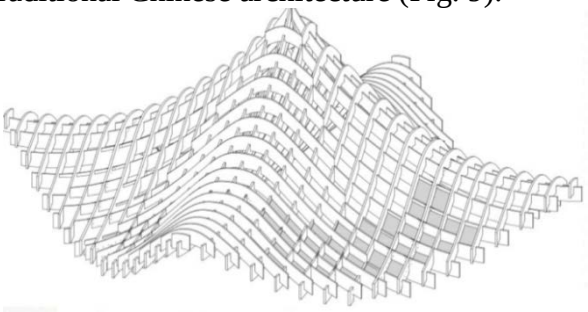

Fig.8 Simplified Frame of Tao

Fig.9 Color Matching and Sense of Order of Tao

3.2 Yusuhara Wooden Bridge Museum

The second structure is the Yusuhara Wooden Bridge Museum located in Taro-gawa Yusuhara-cho, Takaoka-gun, Kochi Prefecture, Japan. This museum is consistent with five of the characteristics of ancient Chinese wooden architecture mentioned above.

(1) The repetitive superimposition of motifs. Unlike the structure of ancient Chinese buildings, the basic units of the Yusuhara Wooden Bridge Museum are straight timber blocks with simple mortise-and-tenon joints without cutting such as the Huagong, or the principle of entasis. The superimposition of the blocks perpendicular to each other is in accordance with the logics of ancient Chinese architectural framing.

(2) Presenting the squareness and symmetry of ancient Chinese architecture. This museum is symmetrically arranged along a long axis and has the dignified and balanced air of ancient Chinese architecture (Fig. 10).

(3) Using straight timber joints. Similar to the first characteristic, the museum uses a through-type frame with straight timber layers. Although it does not generate other ways of organization, it still changes the proportions and forms of the mortise-and-tenon joints, simplifying the original traditional framing.

(4) Wood is the main structure and the burlywood Color is retained. The whole wooden bridge has four main pillars. Except for the wooden pillar in the front view, the rest are weakened by the use of glass, visually highlighting the solid wooden pillar in the middle extending the exaggerated length of the structure with one fulcrum. By creating the visual impression of numerous horizontal and vertical wooden blocks overlapping on a single fulcrum, the overall visual trend of the museum is extremely tense (Fig. 11); the cross-sectional view (Fig. 10) shows that the central section of the wooden bridge is mainly built with traditional wooden structures.

(5) Taking Dougong as the main form. Although Dougong is not a concrete element of the framing, the museum itself is in the form of a complete abstract Dougong. The application of a series of elements from ancient Chinese architecture mentioned above, such as the inverted pyramid shape and the from point to surface, gives the whole building an imagery of Dougong.

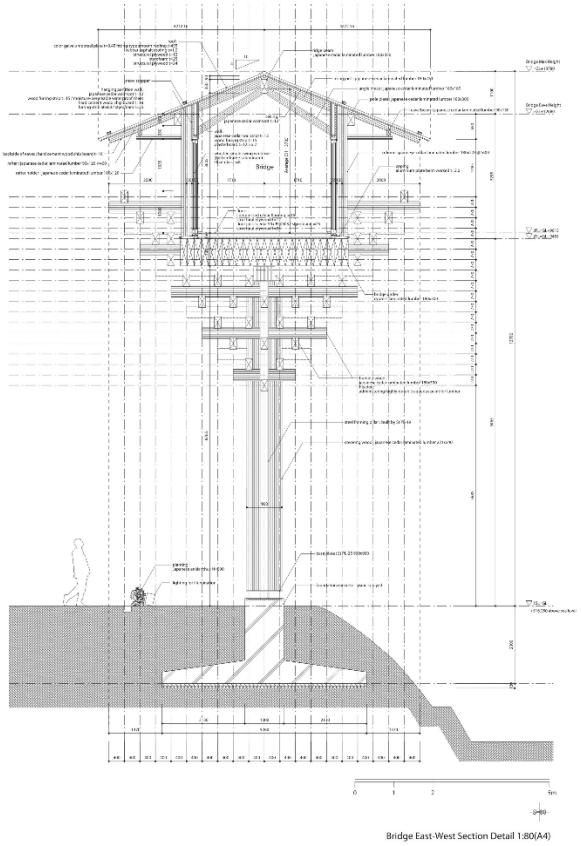

Fig.10 Design Drawing of Longitudinal Section of Yusuhara Kibashi

Fig.11 Dougong Shape of Yusuhara Kibashi

3.3 Nihondaira Yume Terrace

The final piece is the Nihondaira Yume Terrace in Shizuoka, Shizuoka Prefecture, Japan. This work conforms with four of the characteristics of ancient Chinese wooden architecture mentioned by the author.

(1) Motif repetition. Similar to the Yusuhara Wooden Bridge Museum, the Nihondaira Yume Terrace does not have curves or exclusive and delicate designs. It builds a highly orderly architectural framework with simple wooden blocks instead of a variety of structures.

(2) A distortion of the structural framework of ancient Chinese architecture. Nihondaira Yume Terrace applies a more modern construction method and retains the orderly nature of its ancient structural framework. In contrast to the rectangular and square frames of traditional Chinese architecture, this structure uses a radial and distorted grid with the same starting point on each outer edge extending up and down to form a supporting structure with a convex roof (Fig. 12). In addition, for a portion of the construction, instead of using the Dougong to achieve extended eaves, Nihondaira Yume Terrace uses a simple triangular support with a sloping timber. This method was also used in ancient China, but was abandoned because of the hidden problems behind the excessive pressure it exerted on the main beams of the frame. However, this structure has been revived with the support of modern construction techniques.

(3) Wood as the main material. Although steel is used as the main structure of most part of the building, the wooden structure is applied to weaken its visual intensity and enhance that of wooden structures.

(4) The octagonal motif (Fig. 13). The octagon has been a common element in the ancient expressions of China, from the stone pillars under One-Dou-with-Three-Sheng structure of coffins in the Han Dynasty to larger ones such as the Wooden Pagoda of Yingxian County. A large proportion of ancient Chinese towers applied the octagonal motif as well. It even spread to Japan during the Tang Dynasty and can be seen in many of the surviving ancient Japanese buildings. With the octagonal shape of its overall plane, Nihondaira Yume Terrace also echoes the traditional architectural form.

Fig.12 Distorted Mortise-and-Tenon Joints of Nihondaira Yume Terrace

Fig.13 Combination of Steel and Wood in Nihondaira Yume Terrace

3.4 Attempts Based on the Above Theories

Based on the above features and their practice, the author conducted a case experiment and completed the Eastern Light whose motif is the Foguang Temple, a genuine Tang architecture discovered by Mr Liang Sicheng during his travels around China. Known for its extended eaves,

solemn looking and sound preservation, it is the only top-class Tang architecture found in China. Apart from the research value of the building, the East Hall of the Foguang Temple is a representative breaking the widely held belief among liberal scholars that there are no wooden buildings with an over-thousand-year history in China.

The author has restored the roof structure of the East Hall of the Foguang Temple, preserved the typical traditional construction methods such as the inverted-V-shaped trusses and reconstructed the original timber frame by cutting, copying and rotating it on the basis of horizontal and vertical translation. Therefore, the framework of the East Hall of the Foguang Temple has been restored with modern designs and an art installation with traditional Chinese timber-frame architecture characteristics.

Following the principle of “motifs repetition”, the distortion of ancient architectural features applied with the design motif of the East Hall of the Foguang Temple has been briefly explained. When observed from a horizontal plane, the timber frame of the East Hall of the Foguang Temple can be divided into two planes and a lifting plane with inverted-V-shaped trusses. Along the axis on the lateral view, the frame of the lowermost horizontal level of the East Hall is divided into two parts which are used as basic units with variations to replicate and rotate on the basis of the original building framework in both the horizontal and vertical directions to break the shape. At the same time, more basic units were selected and used in the same way. It is worth noting that the author has not shifted the original center of gravity of the building during the shape-breaking process. Although some exaggerated extensions exist, which lead to a more flexible looking installation as a whole and shifts the building's center of gravity to one side, the author has lengthened the vertical supporting columns of the building frame to become longer than the two sides so that the center of the building is visually back to the middle, better aligning with the squareness and symmetry of Chinese timber-frame architecture.

Fig.14 Rendering Image of Eastern Light

Fig.15 Left View of Eastern Light

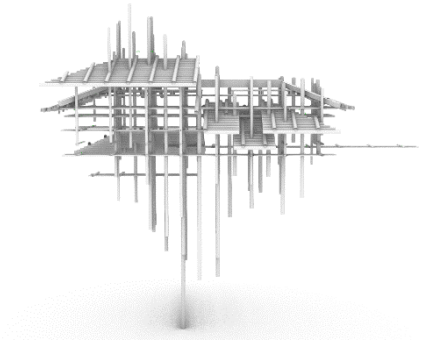

Fig.16 Front View of Eastern Light

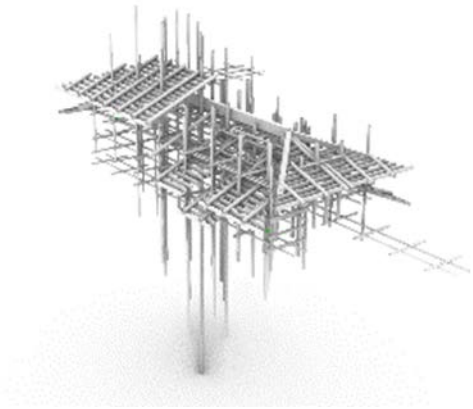

Fig.17 Perspective View of Eastern Light

4. Conclusions

By analyzing the structural features of ancient Chinese architecture, seven features are summarized as extended eaves, Dougong brackets, using of wood as the main material, straight timber joints and rational framing, squareness and symmetry, repetition and reconfiguration of the same motifs , mortise-and-tenon joints. It also analyzes three masterpieces by Kengo Kuma which are rare cases that successfully fused ancient and modern architectural designs, as well as the techniques, such as simplifying timber frames, echoing of colors and materials, repetition of motifs, straight timber joints and Dougong brackets, of integrating ancient architectural features into modern architecture. Finally, the author takes the Foguang Temple as an example and applies the above features to recreate it, demonstrating the rationality of the above conclusions.

Ancient Chinese architectures cover a wide range of extensive and profound knowledge. The structural features of ancient Chinese architecture and the methods of integrating them into modern architecture summarized in this paper can help Chinese architects to integrate the essence of ancient architecture into current urban construction and renovation, thus facilitating the modern architecture with regional characteristics and providing cities with more profound cultural heritage.

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