Practical applications of the constructional principles for ancient pagoda

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Abstract

This article introduces the constructional principles and advantages of the pavilion type ancient pagoda created by the Chinese working people. At the same time, it expounds the practical applications in the maintenance engineering, re-constructed engineering and newly built engineering. It has also broadened the author’s way of thinking, thus making the author himself a practitioner of concrete applied project, who has done very successfully in this respect.

1 Introduction

Just like ancient urban construction of China, the traditional ancient construction of China has developed a school of its own in the world, being an example of ancient civilization, and ancient pagoda is one of them. Buddhists Pagoda originated in India is a simple solid structure, which is called ‘Sputa’ in Indian. This was brought to China together with Buddhism at about 2 century D.C.i.e. the West Wei Dynasty of China Period. Later on, its construction has been practiced again and again by the Chinese working people for a period of time, by combining with the technology of the Chinese traditional ancient construction to form an independent distinguished constructional style, namely the ancient Chinese pagoda — pavilion type ancient pagoda.

According to the earliest recorded history, the pavilion type ancient pagoda, the so-called "Zha Rong Fu Tu Pagoda" was built in South Xuzhou (now called Zhen Jiang City of Jiangsu Province) more than 1700 years ago (refer to the "Later Han Book" written by Fan Hua in the Later Han Dynasty).
2 The Constructional Principle of Pavilion Type Ancient Pagoda

The constructional Principle of pavilion type ancient pagoda is as follows: it is a multilayer frame system, mainly consisted of beams, columns and floors forming internal and external frame work and has got its name as the layers are built one on top of the other. Its load is mainly borne by the floor- beams and the columns forming the internal and external frame work to compose and decompose, while the wall only bears its own weight.

Although externally there are a cantilever eaves on each layer, by utilizing the traditional Chinese "Dougong Construction" firmly combined, which well and evenly transmits the load of cantilever eaves to the frame floor — beams and columns (as shown in Fig. 1).

This kind of structure system is tightly built and has its load reasonably transmitted to its floor — beams and columns, even if when hurricane and earthquake attack, it still has the special feature under such powerful action that is" while the wall collapses, the skeleton frame does not fall. " It finds the expression in the advantage of good completeness of reinforced concrete " .Tube-shaped Construction" .actually, it is a " frame-tubular construction" . According to the viewpoint of modern constructional principle the wall panel of internal and external the frames of the ancient pagoda being an energy consuming structure which absorbs the energy of powerful horizontal load produced by the earthquake, that causes the wall to collapse and destroy. In this way it protects the main internal and external system of the ancient pagoda which perfectly remains in good condition without being destroyed.

3 The application of constructional principle of the ancient pagoda

the above—mentioned constructional principle of ancient pagoda is very useful to the maintenance and re—construction of the building.

3.1 The application of maintenance construction

As the ancient pagoda was built in early days, it might be attacked in the midst of raging storm for hundreds, even thousands of years, and in nowadays it raging storm for hundreds, even thousands of years, and in now days it may be attacked by the acidic and alkaline gases discharged from modern factories having serious deterioration effect. If it is a wooden structure system, it may be eaten by the white ants. There is similar situation in other ancient structures. Therefore, to protect such old structures as ancient pagoda is as important a task as protecting the legacy of history of human civilization.

During maintenance, the roof and the walls can be demolished, as for the
internal and external main frame structure, it can be done only after being partially supported. Before partial demolishing, find out the peculiarity of force transmission of such structure, organize construction plan and design, from distinguishing characteristic, differentiate what is primary supporting members from what is secondary ones, carry out the maintenance work in an orderly manner; in this way it can also speed up the period of construction and cut the maintenance cost.

3.2 The application of re-constructed construction

In order to further protect such ancient buildings like the ancient pagoda, replace lower several layers of the frame work with the reinforced concrete floor — beams and columns of the structure system, thus doing away with the gone bad and decayed wooden structure, or add an additional outer layer reinforced concrete beam-column frame structure system forming a firmer outer jacketing protection layer of frame structure. Besides, this outer jacketing frame structure system can increase the number of layers and raise the height of the old structure. It not only protects this ancient building, but also enlarges the original building scope, satisfying both sides.

According to this constructional principle, the author has applied this principle and increased the 3-storeyed building of brick-cement structure to a 7 storied one for about 40 years. By including anti-seismic reinforcement, the original house after decoration both inside and outside takes on a new look, i.e. after such repair and maintenance, the floor area of building is increased by more than 1.68 times, and greatly lengthening the life of the building. It produces both social and economic benefits evidently (as shown in Fig.2).

During the process of designing the re-constructed engineering, a direct balance method of bending moment has been derived for the rigid frame structure of the floor beams and columns on the pavilion type ancient pagoda which not only guarantees calculation accuracy, but also simplifies the calculation of the internal force of beams an columns. It forms a series of design methods similar to the re-constructed engineering, to be widely used.

3.3 The application of the newly built construction

The newly built pagoda type structure can also adopt the frame — tubular construction model consisted of the internally and externally combined frame structure by imitating the constructional principle of pavilion type ancient pagoda, thus making the structure more reasonable and having its load bearing ability more improved. Those structures including tap water tower, TV tower and mar time light house can also imitate such ways of design so as to bear greater external loads and produce better economic profits. It is a new idea of design which affords much food for thought.

For further utilizing the high strength light type fine material adopted frame-tubular construction consisted internal and external frames can also use new
building wall panel material consisted of combined structure and profiled sheet building material, thus establishing the new conception with the advantage of structure system and material property making up each other, so as to let the traditional old constructional form of structure blossoming in radiant splendor.

4 Conclusion

Over the years, the Chinese working people with their long gathered practical experience of ancient building practice have continuously made ingenious combination of the traditional pavilion type ancient building and the "Dougong construction" building style and created a new structure type of pavilion type ancient pagoda.

It has both advantages of reasonable structure and good load bearing ability and the structure is capable of undertaking such actions of great external force including earthquake without being damaged. At the same time its constructional principle can be followed as an example by the maintenance construction, re-constructed construction and the newly built construction of ancient pagoda and buildings. The applications are also very successful. The author himself is the practitioner and there are still construction projects underway. This broadens engineers' way of thinking and plays a better enlightening role.

It can be believed that the structure model of the pavilion type ancient pagoda created by human civilization, after cooperating modern structural theory with the newly reformed fine quality materials, and guided by the latter would create more splendid achievements.
Figure 1a: Sectional view of internal and external frame construction of pavilion type ancient pagoda

Figure 1b: Illustration diagram of internal and external frame construction of Buddhistic pagoda
Figure 2: The sectional view of #02 dormitory increase-layer re-constructed building