
Ling Cai, Peter W. Ferretto and Yi Deng

1. Introduction
The Drum Tower is one of the most important and charismatic public buildings in the architecture of the Chinese Dong Minority.

Dong people have a high sense of identification with their drum towers, and consider it as the center of the settlement order in Dong society (Fig 1). It has many important social functions. It is a symbol of the clan, a place for both assembly and to have discussion on public affairs, a place for holding sacrificial ceremony and grand activities, and also a space for villagers to have daily communication.

The layout of drum towers is relative simple. The outstanding architectural characteristics are reflected from their structural system. The architecture technique becomes an important part of the Dong architectural culture. There is supposition that different structural types have been adopted, and the structure technology was developed which helped expressed a relationship between the conceptions of the Dong people and the transmission of architectural technology. Thus, the development tendency of the architectural technology can be studied through the investigation of the structural types and analyzing the geographic distribution of the drum towers.

2. Structural Typologies of the Drum Tower
The existing drum towers were mostly built from the early Qing Dynasty until the fairly recent years. Timber is the unique material used in constructing the Dong drum towers. Following the Chinese traditional categorization methodology, namely the “major carpentry” viewpoint which is based upon the structural techniques of the roof, specific drum towers are divided into two types: “Tai-liang” and “Chuan-dou” structures. The difference between these two kinds of structures is specifically the beams or lintels between the two columns (Fig 2). The structure directly leads to the different roof shapes of the drum towers, such as an overhanging gable roof, a gable-and-hip roof and a pyramidal roof. The indigenous construction techniques used by local carpenters can improve the inner space, the outer height and general façade of the tower.
2.1 “Tai-liang” Structure
The first type is the “Tai-liang” drum tower. These kinds of drum towers are very similar with the main hall of Han nationality buildings. “Tai-liang” means there is a big beam between two peristyle columns, or two hypostyle columns, on which two struts support the 3 or 5 purlin beams. The purlins – horizontal members that support the rafters – are positioned along the stepped shoulders of the skeleton. The surviving example of the 3-purlin beam is the Long Shi drum tower (Fig 3) in Yu Tou village, Tongdao County of Hunan province. Another example of a 5-purlin beam is the Ya Shang drum tower (Fig 4) in the same village. The “Tai-liang” structure can form a wider space between the two peristyle columns or two hypostyle columns, which depend on the length of the big beam. These kinds of drum towers often have some common characteristics: the first, by having a rectangular shape; the second, by having roof styles that often include an overhanging gable roof and a gable-and-hip roof, or even a composite roof style. Sometimes, huge columns are used to support the ground floor of the drum tower in order to adapt to any distinctive topography.
The structure and modeling of the “Tai-liang” drum tower is simple and clear. It is often combined with other kinds of buildings such as the village gate, the temple, an auxiliary building, thus forming a complex with special shapes along with a variable public space within the villages.

The two examples of a drum tower complex which consists of a village gate, a drum tower and an auxiliary building, are the Yang Lan drum tower (Fig 5), and the Xia Chen Tuan drum tower (Fig 6). The Heng Ling drum tower (Fig 7) complex consists of one drum tower and two village gates, which date from three different eras of the Qing Dynasty.
Another drum tower complex – Ping Tan drum tower – has two single buildings, a drum tower and a Nanyue Temple (Fig 8). The special walls were built on the both sides of the temple, to protect the building from the fire.

2.2 “Chuan-dou” Structure
The second type of structure is “Chuan-dou”. In this kind of structure, the entire skeleton of the drum tower consists of columns, purlins, struts, lintels and architraves. The purlins are located on the top of the columns or struts, which are connected by the horizontal lintels and architraves. The plans of the “Chuan-dou” drum towers are often a regular polygon. There is a central-post (touching the ground), or a king-post (suspended above the ground) being located in the geometric center of a regular polygonal plane, rising up to the top of the drum tower. Using this kind of structure, the roof style of the drum tower is a multi-eaved pyramidal roof, which makes the drum tower look high and straight.

Among the traditional buildings of the Han nationality and other minorities, the “Chuan-dou” structure is only applied in constructing dwelling
houses with no more than three floors. The “Chuan-dou” drum towers of Dong, are generally more than five stories or eaves. The drum towers take full advantage of this type of structure by expressing the creativeness and development of the traditional timber structure of China.

Whether using the central-post or king-post, the “Chuan-dou” drum tower can be classified into two types: “single core-column” drum tower and “ring-columns” drum tower.

The “single core-column” drum tower is recorded in literature for the first time in the Chinese Ming Dynasty. There are only three “single core-column” drum towers in the entire habitation area of the Dong minority. The method of construction is to put a core-column at the center of the plan, with eight horizontal lintels running in a radial direction from the core to the peristyle columns. The core-column reaches the top of the building and forms a structure of a multi-layer umbrella with those lintels (Fig 9).

To meet the evolving needs for good function within the drum towers, the core-column becomes an obstacle when using its inner space. The need to enlarge the inner space encouraged people to improve the structural method of the drum towers through time. In the original structure of the single core-column drum tower, the ring-columns structure was square, hexagon or octagonal in the plan, with two rings of columns (Fig 10). The ground touching core-column became the king-post after being elevated. So, this modification made it possible to promote the height of the drum tower, which was previously limited by the height of the core-column.
3. Techniques of expanding inner space and improving outer facade

3.1 Expanding Inner Space
The columniation in the interior is often adjusted to suit a utilitarian purpose. The inner space of the ring-columns drum tower can be expanded through different ways.

A row of columns is added to the peristyle to expand the utilization area in the Heng Ling Xin drum tower, which causes a multi-eaved overhanging gable roof emerging with the multi-eaved pyramidal roof (Fig 12).

There is a repeatable frame in the ring-columns drum tower (Fig 11): the peristyle columns and the inside columns are connected by the horizontal lintels. These first-layer lintels support the struts and the first-layer eave-purlins. The struts and the inside columns are connected by the second-layer of horizontal lintels, which support the struts and the second-layer eave-purlins. This is repeated until the struts close to the inside column.

The height of the drum tower will not be limited by the height of the inside columns, because the lintels between the inside column and king-post can support the struts and eave-purlins, until the struts close to the king-post.

In order to enhance the stability of the structure, several layers of the horizontal architrave are used to connect the struts, and the inside columns. In this way, the inner roof frames work together as a whole.

The interior treatment of the drum towers is called open-frame construction; that is, there is no ceiling and all structural members that support the roof are exposed. Here is exhibited an ingenious example of the carpenter’s art, entirely structural in function but extremely decorative in appearance.
3.2 Changing outer facade

Many kinds of techniques have been intelligently created by the local carpenters to meet the various requirements for improving the façade of the drum tower.

The common technical measure which has been adopted for changing the facade of the drum tower is to increase the number of supporting struts. That is, the upper roof of the drum tower transforms from a lower polygonal hipped roof into an octagonal pyramidal roof by using the four inside columns to form an octagonal plane, with the increased struts and the lintels. The methods for increasing the number of columns is diversified (specific examples are listed below in Fig 15).

3.3 Tou-kung

The tou-kung is used to support the overhang of the top eave and also has a strong decorative effect on the drum towers (Fig 16).
4. Geographical Distributing Pattern of the Structural Types of the Drum Tower

In the tou-kung of the drum tower, a basic unit consists of three familiar configurations, which make use of the tenon and mortise joint (Fig 17). But structurally, the most important and longest member is the hua-kung (named after the terms of the tou-kung of Han nationality buildings), which extends to form cantilevers to both the front and rear, at right angles to the façade of the building.

This basic unit is repeated many times along the horizontal lines. A long transverse kung intersects the units and joins them in their entirety. The units may be used in successive tiers, each extending front and rear a certain distance beyond the tier below. Such a tier and extension is called a “jump”. Small tou or long plates are placed between the tiers of the hua-kung (Fig 18). Generally, there are three or five jumps in the tou-kung of the drum tower, which form dense and ornate decoration.

The three diagrams demonstrated the general regularities as below (Fig 19):

The Zeng Chong drum tower, the earliest one in existence, which is located in Zeng Chong village, Congjiang County, was built in 1672. Currently, even the latest constructed drum-tower is still being constantly updated. If we investigate the geographic distribution area of the Tai-liang and the Chuan-dou drum-towers from three continuous eras respectively, the diagrams below could be concluded.
The first era (from the early Qing Dynasty-1911), the geographic location of Tai-liang and Chuan-dou drum-towers illustrate relative centralization and independence;

The second era (from 1912-1980), the construction of Tai-liang and Chuan-dou drum-towers both dramatically decreased;

The third era (from 1980 till now), the Tai-liang drum-towers were rarely constructed, and in fact, the Chuan-dou towers came to be the main type selected in this era.

These three distribution diagrams also reveal a phenomenon that beginning in 1672, when the earliest drum-tower in existence was established, until now, the geographic distribution of Chuan-dou drum-towers has been continuing to expand. There are no Tai-liang structural drum-towers in Guizhou; while in Hunan, two types of drum-towers coexist in the Qing dynasty. However, the Tai-liang drum-tower, which was used to overwhelm the Chuan-dou ones by numbers in the Hunan province, has gradually been abandoned during the later stages of the development process. And the Chuan-dou drum-towers evolved to become the only choice to be built. This kind of situation was more remarkable after the 1980s. This is exactly the development trend of construction technology for drum towers.

While having various types of complexity, the Tai-liang drum-towers are limited in height. Although the Chuan-dou ones are limited to the regular polygon on the plane, craftsmen had been attempting to achieve certain structure innovations to enhance the possibility of developing additional height and transforming the façade. With fascinating contour shapes as well as having a flexible façade, the Chuan-dou drum-towers have advantages over the Tai-liang ones in their symbolic significance.

In conclusion, the gradual disappearance of the Tai-liang drum-towers in modern times, as well as the development of the Chuan-dou ones on the façade with its continuing expansion in the geographic space, all reflect the Dong people's choice. It means the selection of the characteristics within the drum-towers is culturally and symbolically significant. The towering Chuan-dou drum-towers, with complicated and flexible façades, are considered as the buildings more representative of the Dong minority.

5. The Evolution of the Structural Technology of the Drum Tower and the Cultural Transmission in Dong Minority

By reviewing corresponding geographic spaces of Tai-liang and Chuan-dou drum-towers based on the evolutionary trend of the structure, we may find that the diversity of culture within the architecture is closely connected with the difference of the social culture in various geographic spaces.

5.1 Border Areas Development
The governance and time period in which the central dynasties governed the Dong regions are significantly different. It is important to explain the cultural differences in the Dong minority's habitation regions. The development of border areas by the central government stretched from the northeast Dong residential areas to the southwest hinterland. The northern area of the Dong minority's habitation regions has been included in the jurisdiction and scope of the central government as early as the Tang dynasty. While for counties such as Liping, Rongjiang and Congjiang inhabited by the Dong minority in Guizhou province, the system of the central government appointing officials for the direct management has been implemented since the Song dynasty and really established during the Qing Emperor Yongzheng reign.

The development of border areas directly caused the influx of a large number of Han nationality immigrants. The Han went into the Dong minority's habitation regions by acting as officials, defending soldiers and by spontaneous immigration. The most prosperous period for immigration was during the Ming and the Qing dynasties. The army and the people going into the Dong minority's habitation regions for cultivation and were mostly the Han from Jiangxi and Hunan provinces. The immigration direction from east to west has helped to determine the direction for cultural transmission of the Han. Therefore, the immigration at the Ming and Qing dynasties is an important cause for the distinguishing of the east-west architectural culture in the Dong minority's habitation regions.
In the Dong minority habitation regions of the Hunan and Guizhou provinces, Hunan is closer to the habitation regions of the Han from a geographic perspective and the Tai-liang structure is therefore affected by the hall-type buildings of the adjacent Southern Han nationality. Accordingly, the Chuan-dou drum towers appear mainly in Guizhou, which is relatively more remote. Because of this, the more native structural techniques of the minority are maintained in this area.

5.2 Cultural Revitalization Movement
Why did the geographical distribution space for specific types of structural technology of the drum tower change as time goes by? In other words, why did the “chuan-dou”drum tower replace the “tai-liang” drum tower and become the only choice when building a drum tower now?

In the past, conditions that limited travel and the resulting limited ability to communicate any kind of change, helped to ensure that there was a herd mentality among those building drum towers. The carpentry methods stayed primarily similar and little effect on the surrounding villages. After 1980, though, the drum tower experienced a process of renaissance, which is relative to the “Cultural Revitalization” movement of rediscovering, rearranging and carrying forward the national culture at that time. A large number of previously neglected rural minority villages were discovered. The “Chuan-dou”drum towers in the Guizhou province have been widely reported by the modern media as a symbol of Dong minority architecture or even the culture of Dong. Gradually, values have been formed that this type of drum tower represents the culture of Dong Minority. Pointedly, the “Chuan-dou”drum tower in the village of Zhao Xing in Liping county of Guizhou frequently has appeared in many physical media pieces. This kind of drum tower strengthens the belief that it represents the Dong minority through the cultural transmission. Once formed, values become a kind of mind-set and the belief is cemented that all drum towers should be built like this. According to the statistics of the 1992 edition of <Sanjiang Dong Minority Autonomous Annals>, the number of the “Chuan-dou” drum towers increased from two (2) in the late Qing dynasty to six (6) during the period of the Republic of China and 28 after the founding of P. R. China. Twenty of them were built after 1980.

Of additional interest, the local carpenters have played the role of communicators. The construction methods of the drum tower have inevitably been affected by those of other regions because of improved travel abilities and the shared communication among the carpenters from different places. This can be proved from the construction process of specific drum towers. According to the carpenter SHI Yinxiu, after being invited to repair the Diping bridge in Guizhou in 1981, he built the Baxie Drum Tower in 1985 in Guangxi and followed the technique of the drum tower used in Guizhou. He used the tou-kung to support the top roof of the building. The carpenter then went to Guizhou to learn the techniques used in the drum towers before he built the drum tower of the Pingpu village in Guangxi province in 2000. According to my interview with the villagers and craftsmen in the Dong villages in Tongdao county, Hunan province, they generally have preferred the “Chuan-dou” drum tower because of its supreme height and beautiful look. Furthermore, this perception will influence the activities of reconstructing and expanding the drum tower. During my visit in Liping county, Guizhou in 2003, architect LU Wenli was invited to expand the old drum tower by the Zhuping village. He retained the ring columns of the old one, but added more struts and purlins to make the new drum tower have more layers of roof and tou-kung after his expansion.

The “Chuan-dou” drum tower became a cultural representation of the Dong minority through the national cultural renaissance movement and was promoted by the modern media. At first it may have been looked upon as just a technique used and expressed in the regional art. But it has gradually been formed to a more accurate standard in the whole habilitation region of the Dong. The role of the identification standard also adapts to the demand of the tourism business in the remote Dong area. Due to the popular aesthetic preference of the “Chuan-dou” drum tower, it has been used in many tourist or governmental projects, such as folk custom villages, natural scenic areas and even the ethnic style buildings in the squares of many a city. Therefore, this accepted type has played a guiding role in the technique transmission and development of the drum towers.

Conclusion: There is an east-west difference in the geographical distribution between the “Tai-li-
ang” and the “Chuan-dou” drum towers. The “Tai-liang”
drum towers affected by the Han building are concen-
trated in the east of the Dong area (Hunan Province),
while the “Chuan-dou” drum towers are mainly distribut-
ed in the west of the Dong area (Guizhou Province). In
the process of development, the number of “Tai-li-
ang” drum towers decreased but the “Chuan-dou” drum
towers became more popular. This process reflects the
gradual process of the development of the structural
technique. Due to the cultural revitalization movement,
the drum tower with a “Chuan-dou” structure has
become the mainstream of structural types in the Dong
area.

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